Chapter 2

Perception without awareness of what is perceived, learning without awareness of what is learned

John F. Kihlstrom

Beginning in the 1980s, psychology (and cognitive science generally) has undergone a dramatic shift in its attitude towards the psychological unconscious – that is, towards the idea that mental states and processes can influence experience, thought and action outside of phenomenal awareness and voluntary control. Once rejected out of hand as too deeply embedded in psychoanalysis or other forms of pseudoscience, or at least as too vague to be scientifically useful, the notion of unconscious processing is now taken seriously by most researchers and theorists in the field. At this point, the debate has shifted from questions about the very existence of unconscious states and processes to debates about the nature and extent of unconscious processing. Credit for this state of affairs goes to four rather different lines of research (for a more extensive discussion of this recent history, see Kihlstrom, 1987, 1995).

First, cognitive psychology now embraces a distinction between automatic and controlled processing (e.g. Hasher and Zacks, 1979, 1984; Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977; for updates, see Bargh, 1989; Logan, 1989; Shiffrin, 1988). Whether they are innate or routinized by extensive practice, automatic processes are inevitably engaged by specific inputs, independent of any intentionality on the part of the subject, and they cannot be controlled or terminated before they have run their course. We have no conscious awareness of their operation, and we have little or no awareness of the information which they process. All that enters awareness is the final product of the automatic process. Thus, automaticity represents unconscious processing in the strict sense of the term: we have no introspective access to automatic procedures, or their operations; these can be known only indirectly, by inference.

Further contributions came from the emergence of cognitive neuropsychology (Rozin, 1976).[1] Studies of the amnesic syndrome associated with bilateral lesions in the hippocampus and other medial–temporal structures, for example, revealed a distinction between two expressions of memory, explicit and implicit (Moscovitch *et al.*, 1993; Schacter, 1995). Explicit memory is conscious recollection of the past; implicit memory is reflected in any influence of past events on subsequent experience, thought and action. We now know that explicit and implicit memory can be dissociated in many different ways, indicating that

implicit memory is in some sense independent of explicit memory (Roediger and McDermott, 1993). In the present context, the importance of the discovery of implicit memory is that it legitimized discussions of unconscious memories – a topic which had been virtually taboo among nonclinical psychologists.

A third influence was from research on hypnosis, producing many phenomena which seem to involve a division of consciousness (Hilgard, 1977; Kihlstrom, 1984). For example, in hypnotic analgesia (Hilgard and Hilgard, 1975), highly hypnotizable subjects appear insensitive to normally painful stimuli (such as immersion of the forearm in circulating ice water); similar phenomena can be observed in hypnotic blindness and deafness. In posthypnotic amnesia, hypnotizable subjects are unable to remember the events and experiences which transpired while they were hypnotized. In posthypnotic suggestion, they respond to cues established in hypnosis, without realizing that they are doing so, or why. Experimental studies of these and other phenomena, trying to understand them using concepts and methods appropriated from modern cognitive psychology, have provided new insights into the difference between conscious and unconscious mental life.

The fourth source, and one of central interest in this chapter, is research on subliminal influence, a subtype of implicit perception (Kihlstrom *et al.*, 1992). Modelled on the explicit–implicit distinction drawn in memory, explicit perception is conscious perception, as reflected in the subject's ability to identify the form, location or movement of an object; implicit perception is reflected in any influence of such an object on the subject's ongoing experience, thought and action, independent of conscious perception. The evidence for implicit perception is of the same sort as that for implicit memory, including various types of priming effects, except that the event in question is in the current stimulus environment, or was so in the very recent past. And it is here that our story begins.

WHEN THE SUBJECT IS CONSCIOUS BUT UNAWARE OF THE EVENT

The problem of subliminal perception, initially raised speculatively by Leibniz (1981 [1704]), was addressed experimentally by Pierce and Jastrow (1885) in what may have been the earliest psychological experiment performed (or at least published) in America. In a series of studies of weight and brightness discrimination, Pierce and Jastrow reduced the difference between standard and comparison stimuli until they[2] were at zero confidence in choosing which object was the heavier or the brighter. Yet, when forced to guess, they proved to be more accurate than chance. Apparently, some stimulus information was registering below awareness in the perceptual-cognitive system. Pierce and Jastrow concluded that their experiments disproved the existence of a sensory threshold (limen); at the very least, they showed the influence on behaviour of subliminal stimuli – that is, stimuli which apparently were below the threshold for conscious perception.

For the better part of the twentieth century, a large number of investigators (themselves mostly ignorant of Pierce and Jastrow's work) have attempted the same sort of demonstration (for general coverage, see Bornstein and Pittman, 1992). For example, in a study by Poetzel (1960 [1917]) subjects were exposed to brief tachistoscopic presentations of a complex landscape. When asked to reproduce the stimulus by drawing, the subjects omitted many details; however, Poetzel reported that many of these details appeared in the subjects' subsequent dreams. A number of other investigators (e.g. Fisher, 1960, 1988; Haber and Erdelyi, 1967) replicated and extended these results. However, a further series of studies by Erdelyi (1970, 1972; see also Ionescu and Erdelyi, 1992) suggested that these results may well have been an artefact of shifts in the response criterion adopted by subjects in the various tests.

In a line of research that constituted part of the New Look in perception (Bruner, 1992), Bruner and his colleagues uncovered evidence for a phenomenon of perceptual defence (e.g. Bruner and Postman, 1947; McGinnies, 1949; Postman *et al.*, 1948). For example, the thresholds for perceptual identification were higher for words with threatening (or at least socially undesirable) sexual and aggressive content than for non-taboo words. This raised the paradox of the 'Judas eye' – the peepholes in Prohibition-era speakeasies, through which a bouncer could determine who could be admitted, a determination that required that the person be identified. Similarly, if thresholds for identification were determined by the content of the stimulus, then the content of the stimulus had to be processed before it could be admitted to consciousness. In other words, a great deal of cognitive analysis, including the analysis of meaning, had to take place outside of conscious awareness. Thus it was not merely detection (as in Pierce and Jastrow's experiments) but semantic processing which could take place on subliminal inputs.

The Eriksen challenge

The psychology of the 1950s had little patience for such ideas, and publication of such work elicited a host of friendly and hostile critiques. For example, Solomon and Howes (1951) argued that the threshold differences between taboo and non-taboo words were related to frequency of usage, rather than taboo content *per se*. Certainly the most powerful and influential criticism of subliminal perception came from C.W. Eriksen (1956, 1958, 1960); see also Goldiamond (1958). Perhaps reflecting the influence of functional behaviourism, Eriksen was extremely critical of any definition of awareness in terms of verbal reports or confidence ratings, and he was equally critical of the methods used to determine thresholds in subliminal perception experiments (as was Goldiamond, 1958). For example, in a typical experiment in which subjects were found to make a discriminative behavioural response to stimuli in the absence of verbal report, Eriksen noted that the thresholds in question were established on the basis of the verbal reports, but not on the basis of the discriminative response. Proper

demonstration of subliminal perception would require that thresholds be determined from both dependent variables, and that the latter be lower than the former. Eriksen noted that when this was done, the two thresholds were essentially equivalent. This is indeed a difficult empirical problem for demonstrations of subliminal perception. However, Eriksen went further than this, because he evidently distrusted verbal reports as indices of conscious experience, and instead preferred discriminative behaviour for this purpose. This created a paradox (Bowers, 1984; Merikle and Reingold, 1992), because above-chance discriminative responses are the means by which perception without awareness is documented in the first place. If conscious perceptual experience is to be inferred from any discriminative response, this would seem to mean that subliminal perception is ruled out by fiat.

Interest in subliminal perception would have died there, in the 1960s, and it almost did. The phenomenon was kept on life support by Dixon's (1971, 1981) efforts, as well as those of some investigators who were influenced by psychoanalytic ideas (for reviews, see Shevrin, 1988, 1992; Shevrin and Dickman, 1980; Silverman, 1976; Silverman and Weinberger, 1985; Weinberger, 1992).[3] However, this neo-neo-Freudian research did not reach much beyond a small circle of like-minded investigators. The reasons for this state of affairs are not clear, since on the surface the studies appear to have met reasonably stringent methodological standards. Certainly the historical distrust on the part of experimental psychologists towards anything smacking of psychoanalytic theory must have played a role.

The turning point came in the early 1980s, with a new round of demonstrations of subliminal perception by Marcel (1980, 1983a, 1983b) and Kunst-Wilson and Zajonc (1980). Marcel's experiments employed a semantic-priming paradigm in which the prime was masked. When the prime and the target were semantically related, priming was observed on lexical decisions concerning the targets, even though the subjects did not detect the prime itself. Kunst-Wilson and Zajonc (1980) employed an adaptation of the mere exposure paradigm with extremely brief tachistoscopic exposures of the stimuli, which in this case were nonsense polygons. Subjects showed an enhanced preference for stimuli which had been repeatedly exposed, even though they had not detected the exposures themselves. In short order, both results were replicated by other investigators: Marcel's by Fowler and her colleagues (Fowler *et al.*, 1981) and by Balota (1983); those of Kunst-Wilson and Zajonc by Seamon and his colleagues (Seamon *et al.*, 1983, 1984) and by many others (for a review, see Bornstein, 1989). By presenting evidence that meaning (denotative in the case of Marcel, connotative in the case of Kunst-Wilson and Zajonc) could be processed subliminally, these experiments moved beyond the pioneering study of Pierce and Jastrow (1885), which involved only the discrimination of stimulus qualities such as brightness and weight, and seemed to fulfil the promise of the New Look.

Just when we might have thought it safe to study subliminal perception again, Holender (1986) weighed in with a vigorous criticism of studies purporting to

show semantic processing in the absence of conscious awareness. Some of these experiments were in the Marcel tradition, employing masks to render the stimulus subliminal, while others employed paradigms like dichotic listening or parafoveal viewing, in which a supraliminal stimulus is merely unattended; this latter category, while of considerable interest, is not relevant here because I am concerned with awareness, not attention. With respect to ostensibly subliminal stimulation, Holender's critique closely resembled Eriksen's (1960), with an emphasis on the difficulty of establishing thresholds for stimulus detection (for other critiques of the threshold-setting procedures, see Cheesman and Merikle, 1985; Merikle, 1982; Purcell *et al.*, 1983). In particular, Holender equated conscious processing with discriminative response:

> This paper has proposed an analysis of the data relevant to the issue of SA/CI [semantic activation without conscious identification]. . . . In order to demonstrate the existence of such a phenomenon, a twofold condition, referred to as criterion 1, must be met. At the time of presentation of the critical stimulus, (1) there must be indirect measurable effects of semantic activation, and (2) the identity of the stimulus must be unavailable to the subject's consciousness, that is, he must be unable to give direct evidence of identification (e.g. through verbal report or any kind of voluntary discriminative response).
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> (1986: 23)

Or, in the words of Merikle and Cheesman:

> Holender accepts without question the widely held assumption that perceptual awareness or consciousness is best defined as better than chance-level discriminative responding. In fact, Holender states that discriminative responding provides the only essential criterion for establishing perceptual awareness or consciousness. Thus, if an observer can respond discriminatively to a stimulus, then, by definition, the observer is aware of the stimulus; and, conversely, if an observer cannot respond discriminatively to a stimulus, then, by definition, the observer is unaware of the stimulus.
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> (1986: 42)

Thus the literature on subliminal perception was brought full circle. And because discriminative response provides the evidence for the 'indirect measurable effects' (Holender, 1986, p. 23) in the first place – how else are we to know that the stimulus has been perceived? – subliminal perception was defined out of existence. For this reason, Holender's criterion should simply have been rejected out of hand – and, as discussed below, Merikle and Cheesman (1986) did specifically reject it. However, other investigators rose to the challenge, and sought to demonstrate subliminal perception on terms defined by Eriksen (1960) and Holender (1986) – at least so far as threshold-setting procedures were concerned.

By far the most diligent of these attempts to meet the Eriksen challenge were studies performed by Greenwald *et al.* (1989). They distinguished between

attentionless processing, in which a supraliminal stimulus is not attended to because attention is directed elsewhere (e.g. dichotic listening or parafoveal viewing), and detectionless processing, in which a subliminal stimulus cannot be detected because it is not available to attention in the first place. Their experimental paradigm involved semantic priming of lexical decisions – except that, rather than deciding whether a letter string was a word, subjects were asked to decide whether a word was evaluatively positive or negative in (connotative) meaning. Positive and negative targets were preceded by positive, neutral or negative primes, which in turn were rendered undetectable by the dichoptic pattern masking technique employed earlier by Marcel (1980, 1983a, 1983b), Fowler *et al.* (1981) and Balota (1983). In this technique, the prime and the mask are presented to different eyes, so that the masking occurs centrally rather than peripherally. In contrast to the earlier studies, which defined subliminality in terms of the subject's ability to report the presence of the prime, Greenwald *et al.* (1989) adopted a stricter criterion: the subject's ability to report whether the prime appeared on the left or right of the fixation point. Note that this criterion does address Eriksen's (1960) and Holender's (1986) challenge, in that the subjects were apparently unable to make a discriminative response based on the position at which the prime appeared (but see Doyle, 1990, for a critique). Across three experiments, response latencies on the evaluative decision task were speeded when the prime and the target were evaluatively congruent, and slowed when they were evaluatively incongruent – even though the subjects were unable to detect where the prime was presented.

Although the results obtained by Greenwald *et al.* (1989) provide convincing evidence of subliminal perception, in terms of detectionless semantic processing, other results set limits on the effect which are important for theory. In Experiment 3, which employed simultaneous (rather than backward) dichoptic pattern masking, primes presented for 80 milliseconds (msec) affected evaluative judgements, but primes presented for 40 msec did not. Apparently, the perceptual system is unable to extract evaluative meaning from primes which are given only extremely brief exposures. Moreover, subsequent research reported by Greenwald and Liu (1985; see also Greenwald, 1992) failed to obtain evidence of subliminal perception when the primes were two-word phrases rather than single words. For example, 'enemy loses', a positive phrase constructed from two negative words, primed negative, rather than positive, targets. Apparently, the conditions which render stimuli undetectable permit meaning to be extracted from single words, but they do not allow the meaning of two or more words to be combined.[4] At least for the near future, Greenwald's (1992: 775) 'two-word challenge' – 'the task of demonstrating that attentionless unconscious cognition can extract the meaning of a two-word sequence' – has replaced Eriksen's challenge as the agenda for research on subliminal perception.

Another perspective on the limits of subliminal perception is to be found in the work of Merikle (1982, 1992) and his colleagues (Cheesman and Merikle, 1984, 1985, 1986; Merikle and Cheesman, 1986; Merikle and Reingold, 1990, 1992;

Reingold and Merikle, 1993). Merikle essentially abandoned the Eriksen challenge altogether, and defined awareness in terms of confidence levels rather than discriminative response. Thus he defined the *subjective threshold* as the point at which the subject's confidence in his or her discriminations drops to zero, and the *objective threshold* as the point at which the subject's actual discrimination performance drops to chance levels. In a typical experiment (Merikle and Reingold, 1990, Experiment 1), subjects were presented with a word accompanied by forward and backward masks. For the detection task, they were presented with two unmasked words and asked whether either was the word which had been presented previously (a question which requires only a yes or no response); for the recognition task, they were presented with the same two words again and forced to choose which one had been presented. The general finding of the research is that subjects showed above-chance recognition of words which they had failed to detect. Of course, from Eriksen's (1960) and Holender's (1986) point of view, the subjective threshold, as defined in Merikle's experiments, is just a poor index of conscious awareness. However, Merikle and his colleagues have also shown qualitative differences in the processing of stimuli presented above and below the subjective threshold. Thus recognition without detection is possible for words, but not for nonwords. Such differences strongly suggest that the subjective threshold creates qualitative rather than merely quantitative effects on processing. With respect to the limits on subliminal perception, we may speculate that semantic processing is possible for items presented near the subjective threshold, but that only perceptual processing is possible for items presented near the objective threshold.

Implicit perception

Subliminal perception does not exhaust the circumstances under which subjects process stimulus information without being aware of the stimulus. Such effects crop up in the neuropsychological literature on blindsight (Weiskrantz, 1986). Patients with lesions in the striate cortex report a lack of visual experience in regions of the field corresponding to their scotoma; but when forced to make guesses, they make better-than-chance conjectures about the presence, location, form, movement, velocity, orientation and size of the objects which have been presented to them. Note that Campion and his colleagues offered a critique of the blindsight literature which reflects some of the same issues raised earlier by Eriksen (Campion *et al.*, 1983).

Similar effects are very familiar in the clinical literature on the so-called *conversion disorders* (which are better construed as types of dissociative disorder; see Kihlstrom, 1994a), and in the experimental literature on hypnosis (for a review, see Kihlstrom, 1984; Kihlstrom *et al.*, 1992). For example, Brady and Lind (1961) reported a case of functional blindness, in which the patient denied any visual awareness; none the less, his behaviour in an instrumental conditioning situation was clearly influenced by visual cues (for a more recent

case, see Bryant and McConkey, 1989b). Similarly, Bryant and McConkey (1989a) have shown that the choice behaviour of highly hypnotizable subjects who have received suggestions for total blindness is influenced by visual cues, even though the subjects deny awareness of these cues; moreover, visual presentation of disambiguating cues biases the performance of hypnotically blind subjects when they are asked to spell homophones presented aurally (Bryant and McConkey, 1989c). Similarly, Spanos *et al.* (1982) found that subjects who received suggestions for unilateral hypnotic deafness nevertheless showed intrusions from the affected ear in a dichotic listening task.

In these types of studies, the stimuli in question, while processed outside awareness, are in no sense subliminal. Rather, it is something about the subject – suffering brain damage or being in a dissociative state – which produces the impairment in conscious perception. Hypnotic blindness is not the same as blindsight: hypnotic subjects show no evidence of altered brain function (at least in the sense of lesions to the striate cortex), and hypnotic blindness may be reversed when the suggestion for it is cancelled. Blindsight may be limited to gross perceptual properties, of the sort that can be mediated by a secondary visual system, while processing in hypnotic blindness seems to extend to rather complex semantic analyses. Still, as in the truly subliminal case, perception is implicit in the subject's experience, thought or action.

WHEN THE SUBJECT IS AWARE OF AN EVENT BUT NOT OF THE KNOWLEDGE ACQUIRED FROM IT

Another variant on the unconscious acquisition of knowledge is provided by studies of *implicit learning* (Reber, 1967), in which subjects appear to learn from experience without being aware of what they have learned, or even of the fact that they have learned anything at all. Although the question of learning without awareness has a long history going back to the distinction between intentional and incidental learning (Jenkins, 1933; Thorndike and Rock, 1934; for reviews, see Adams, 1957; Razran, 1961), the modern era of this research began with Reber's (1967) studies of the learning of artificial grammars (for an overview, see Reber, 1993). In a typical experiment, Reber asks his subjects to study, in anticipation of a later memory test, a list of twenty three- to eight-letter strings, such as TSXS, TSSXXVPS and PVV, which have been generated by a finite-state artificial grammar. After the strings have been memorized to a strict criterion of learning, the subjects are informed that they conform to a particular set of grammatical rules. Finally, the subjects are presented with a set of fifty new letter strings, only some of which conform to the grammar, and asked to indicate which are legal and which are not. The general finding of Reber's experiments is that subjects show above-chance levels of performance on this task (baseline = 50 per cent accuracy), despite the fact that they are generally unable to report the grammatical rules by which the legal strings were generated. Reber claims that

while subjects were consciously trying to memorize the letter strings, they also unconsciously induced the grammar which generated them.

According to Reber (1993), the cognitive structure which enables subjects to induce the artificial grammar is not a language-specific cognitive module, as Chomsky (1980) and other psycholinguists might suggest, but rather comprises a general learning system which enables both humans and nonhuman animals to pick up a wide variety of regularities in their environments. As opposed to what he calls the 'consciousness stance' characteristic of most modern cognitive psychology, which asserts that consciousness has priority and that awareness and self-reflection are the central features of human cognitive function, Reber (1993: 24–25) asserts 'the primacy of the implicit' and adopts an *implicit stance* which holds that unconscious learning processes are axiomatic: we cannot get along cognitively without them, and more information is available for unconscious use than is accessible to conscious introspection. As Reber puts it (1993: 86), 'Consciousness is a late arrival on the evolutionary scene. Sophisticated unconscious perceptual and cognitive functions preceded its emergence by a considerable margin.'

Since Reber reported his initial experiments, a number of other investigators have confirmed his essential results and have developed alternative paradigms for demonstrating and analysing implicit learning (for comprehensive reviews, see Berry, 1994, 1995; Berry and Dienes, 1993; Dienes and Perner, 1995; Lewicki, 1986; Reber, 1993; Seger, 1994). Among these is the *control of complex systems* paradigm developed by Broadbent (1977; see also Berry and Broadbent, 1995), and the *sequence learning* and *matrix scanning* paradigms invented by Nissen (Nissen and Bullemer, 1987) and Lewicki (1986; see also Lewicki *et al.*, 1987), respectively. In one version of the control of complex systems paradigm, known as the sugar-production task (Berry and Broadbent, 1984), subjects take the role of factory manager and are asked to control the production of sugar, varying only the size of the workforce. In fact, the system is programmed so that production on any given trial (after the first) is a function of the number of workers employed on that trial and the amount of sugar produced on the previous trial. Subjects typically learn to control this system fairly readily, although they are generally unable to specify the formula which governs it. Sequence learning is a variant on a serial reaction time task, in which subjects must respond to a light appearing in one of four locations on a screen. Rather than varying randomly, the location of the light is actually governed by a complex sequential pattern. Subjects learn this pattern, as indicated by decreasing response latencies as trials go on, even though they are generally unable to predict where the stimulus will occur on any given trial.

Implicit learning is sometimes categorized informally as a form of subliminal perception, but this is an error because the stimuli in question are clearly supraliminal, and the subject is in no sense unconscious of them. Reber's subjects are aware that they are memorizing letter strings, just as Berry and Broadbent's subjects know they are reading sugar-production figures and Nissen and Bullemer's are aware of the lights flashing on the screen. In fact, the term

'implicit learning' is properly applied only to instances where conscious subjects are unaware of what they have learned from supraliminal stimuli. Based on the canonical definition of implicit memory, we can say that implicit learning is manifested when a subject's experience, thought or action reflects knowledge acquired during a learning experience, in the absence of conscious awareness of this knowledge. The fact that the knowledge acquired in implicit learning consists of rules has sometimes led proponents to categorize implicit learning as procedural learning. While the distinction between declarative and procedural knowledge is valid (Anderson, 1976; Winograd, 1975), some of the knowledge acquired in these procedures can be represented in propositional format. Therefore, it seems that the distinction between declarative and procedural knowledge should be kept separate from the distinction between explicit and implicit learning.

In any event, the fact that subjects are at least conscious *of something* while they are learning has led to some scepticism about the claim that these same subjects are simultaneously *not conscious of learning*, or *not conscious of what they have learned*. Dulany (1968, 1991, 1995; Dulany *et al.*, 1984, 1985) has been a particularly vigorous critic of Reber's claims concerning artificial grammar learning, and Shanks and St. John (1994) have recently offered an analysis of learning without awareness which, in its scope and negativism, rivals the earlier work of Eriksen (1960) and Holender (1986). According to the Shanks and St. John view, most ostensible demonstrations of implicit learning fail to meet two criteria: according to the Information Criterion, 'it must be possible to establish that the information the experimenter is looking for in the awareness test is indeed the information responsible for performance changes'; according to the Sensitivity Criterion, 'we must be able to show that our test of awareness is sensitive to all of the relevant conscious knowledge' (Shanks and St. John, 1994: 373). Put another way: if the subjects are asked the wrong questions about their conscious mental states, we cannot conclude from what they say that they do not know what they are doing, or why.

The importance of the information and sensitivity criteria can be illustrated with respect to the learning of artificial grammars (e.g. Reber, 1967, 1993). To begin with, it is probably too much to expect subjects to give a full verbal account of a Markov process or finite-state grammar. So, for example, one of the grammars most frequently studied by Reber (see Reber, 1993, Figure 2.1) is captured approximately – but only approximately – as follows:

A1. The first letter of the string can be either P or T.
A2. If the first letter was P, go to C1; otherwise go to B1.
B1. If the first letter was T, the next letter must be S.
B2. If the next letter was S, it can be repeated an infinite number of times.
B3. If S was not repeated, the next letter must be X.
B4. If the next letter was X, then the next letter can be either X or S.
B5. If the next letter was S, the string ends.
B6. If the next letter was X, the next letter must be T.

B7. If the next letter was T, go to C2.
C1. If the first letter was P, the next letter must be T.
C2. If the next letter was T, it may be repeated an infinite number of times.
C3. If T was not repeated, the next letter must be V.
C4. If the next letter was V, the next letter must be P or V.
C5. If the next letter was V, the string ends.
C6. If the next letter was P, the next letter may be X or S.
D1. If the next letter is S, the string ends.
D2. If the next letter is X, the next letter must be T.
D3. If the next letter was T, go to C2.

This is an awful lot to ask a subject to verbalize.

It turns out, however, that subjects do not have to verbalize all of this grammar, or even most of it, to achieve above-chance performance on Reber's grammaticality judgement task. It is entirely possible that conscious appreciation of a few rules, like 'There can't be an S, V or X at the beginning, or a T at the end, and there can't be too many Ts in the middle', may be enough to do the trick. But subjects probably know that this isn't the full extent of the grammar, and may not recite it in response to the experimenter's postexperimental queries. In any event, an emerging body of research strongly suggests that subjects in implicit learning experiments *do* have conscious access to at least a portion of the knowledge acquired during the acquisition period, and that this knowledge is enough to mediate above-chance performance on tests of implicit learning (Dienes *et al.*, 1991; Dulany *et al.*, 1984; Mathews *et al.*, 1989; Perruchet and Pacteau, 1990, 1991). Thus tests which at least approximate to Shanks and St. John's (1994) information and sensitivity criteria indicate that explicit learning – the subject's ability to gain conscious access to what he or she knows – plays a major role in ostensibly implicit learning.

WHEN THE SUBJECT IS SIMPLY UNCONSCIOUS

Subliminal perception and implicit learning are demonstrated in subjects who are conscious, in the sense that they know who they are where they are and that they are performing some sort of task at the behest of the experimenter. They are simply unaware of some stimulus event, or of what they are learning from episodes of which they are aware. Enough controversy has swirled about claims for subliminal perception and implicit learning to fill a book; now we add to this the more controversial claim that subjects can engage in perception and learning when they are not conscious at all – for example, when they are asleep or anaesthetized. Of course, the lack of conscious awareness precludes collecting on-line evidence of perception and learning. Aside from psychophysiological measures such as event-related potentials (ERPs) (see Kutas, 1990; Plourde and Picton, 1991), the only evidence of implicit perception during these states is the subject's memory afterwards.

Sleep

Sleepers are hard to arouse, and once awakened they remember little or nothing of what transpired while they were asleep. Thus, at least superficially, sleep seems to represent an interruption of normal waking consciousness; if sleepers are not strictly unconscious, at least they do not seem to be conscious of events in the world outside their own dreams. Nevertheless, *prima facie* evidence for information processing during sleep comes from documented cases of somnambulism, in which the sleeper engages in some activity resembling that of waking life (Kales *et al.*, 1966; Jacobson and Kales, 1967). Navigating around a room or a house, turning lights and appliances on and off, manipulating doorknobs and cabinet latches, and the like, all require some ability to perceive objects in the environment and make appropriate (if perhaps rather automatic) responses to them. So does conversational sleeptalking (Arkin, 1982).

More convincing evidence of information processing during sleep would come from studies of hypnopaedia or sleep-learning. Unfortunately, sleep-learning has proved extremely difficult to document convincingly (for reviews, see Aarons, 1976; Eich, 1990; Evans, 1979; see also Ellman and Antrobus, 1991; Bootzin *et al.*, 1990). Most formal studies of sleep-learning have yielded negative results, and the few positive findings available are troubled by improper controls or inadequate psychophysiological monitoring. For years, conventional wisdom has held that sleep-learning is only possible to the extent that the subject stays awake (Simon and Emmons, 1955).

Of course, as Eich (1990) has noted, this conclusion only held when learning was assessed in terms of explicit memory, because the studies in question examined only the subjects' ability, when awake, to consciously remember material presented while they were asleep. If there is implicit perception during sleep, perhaps traces of this perceptual activity are only retrievable as implicit memories.

Until recently, this hope was kept alive by a series of dramatic experiments conducted by Evans and his associates in the late 1960s (for a review, see Evans, 1979, 1990), which appeared to show that some subjects could respond appropriately, while sleeping, to cues set up by hypnosis-like suggestions. For example, subjects might scratch their noses when they heard the word 'itch'. Although these subjects had no waking memory of the suggestions or their response to them, Evans and his colleagues reported that in many instances they continued to respond to the cues on subsequent nights, even though the suggestions were not repeated – a form of sleep-state-dependent memory. Because discriminative response to suggestions requires perception, and the carry-over of the response to subsequent nights requires memory, Evans's sleep-suggestion phenomenon constitutes evidence for the acquisition and retention of memories – albeit memories expressed implicitly – while the subject is unconscious.

Unfortunately, a detailed critique by Wood (1989; see also Kihlstrom and Eich, 1994) has revealed a number of flaws in these experiments, including the

absence of baseline information and the coding of behaviour by judges who were not blind to the suggestions which the subjects received. Particularly critical was the failure to follow conventional standardized criteria for sleep-staging: sleep was defined in terms of electroencephalogram (EEG) and electrooculogram (EOG) criteria only; unfortunately, without the electromyogram (EMG), it is difficult to differentiate Stage REM from (drowsy) waking. A follow-up study by Perry *et al.* (1978) corrected many of these problems – in fact, all except the sleep-staging – and found no difference in response to critical and control cues. Thus, regardless of the issue of sleep-staging, the failure to confirm discriminative response means that the sleep-suggestion studies do not provide evidence of implicit perception.

In the light of these results, Wood and his colleagues (Wood *et al.*, 1992) conducted a formal search for evidence of implicit memory for material presented during sleep. During either Stage REM or Stage 2 (i.e. early Stage NREM) sleep, defined in terms of conventional criteria, sleeping subjects were presented with two lists of paired associates consisting of either a homophone and a disambiguating context cue (e.g. *hare/hair–tortoise*), or a category label and exemplar (e.g. *metal–gold*). After five presentations of each list, the subjects were awakened and given tests of cued recall and free association or category generation. Compared to waking subjects who received the same presentations, sleeping subjects showed no evidence of either explicit or implicit memory of the list.

In summary, the study by Wood *et al.* (1992) echoes the conclusions offered forty years ago by Simon and Emmons: when adequate precautions are taken to ensure that subjects are truly asleep while material is presented, there is no evidence of sleep-learning in terms of either explicit or implicit memory. It is possible that subjects who are partially aroused by (or during) stimulus presentations might show some implicit memory later – a phenomenon which Wood *et al.* (1992) termed 'quasi-sleep learning'. But this is not the same as learning during sleep, and cannot count as convincing evidence of perception without awareness.

General anaesthesia

Certainly the most severe test of the hypothesis that perception and learning can occur without awareness comes from studies of surgical patients (and, on occasion, nonpatient subjects) who undergo general anaesthesia (for reviews, see Andrade, in press; Caseley-Rondi *et al.*, 1994; Cork *et al.*, 1995; Ghoneim and Block, 1992; Kihlstrom, 1993b; Kihlstrom and Schacter, 1990; see also Bonke *et al.*, 1990; Sebel *et al.*, 1993). Even more than sleep, anaesthesia is defined by lack of consciousness: adequately anaesthetized patients are unresponsive to surgical events (e.g. incisions), cannot remember them after the operation is over and have no memory of experiencing pain or distress during the procedure. Still, as in the case of sleep, the suspicion has lingered that surgical events might be processed outside awareness, stored in memory and be available postoperatively. Explicit

memory for surgical events is, of course, ruled out by the definition of adequate anaesthesia. However, the possibility remains that events perceived implicitly during anaesthesia might be retained as implicit memories.

This hypothesis was initially tested by Eich *et al.* (1985), who found no evidence of implicit memory using the homophone-spelling paradigm. However, Kihlstrom and his colleagues were more successful (Kihlstrom *et al.*, 1990). Patients received repeated presentations of a list of paired associates consisting of a cue and its closest associate (e.g. *ocean-water*). In the recovery room, tests of free recall, cued recall and recognition gave no evidence of explicit memory. However, a free-association test revealed a significant priming effect, evidence of implicit memory. Significant priming in free association has since been confirmed by a number of other investigators (Bethune *et al.*, 1992; Humphreys *et al.*, 1990; Schwender *et al.*, 1994), although Cork *et al.* (1992, 1993) failed to replicate this result in an experiment in which the anaesthetic agent was changed from the inhalant isoflurane to the narcotic sufentanyl.

Shanks and St. John (1994), in a recent review, were not persuaded by evidence of subliminal perception and implicit learning, but they were especially dismissive of the findings obtained from studies of anaesthetized subjects. They asserted that evidence of 'small but reliable amounts of learning' is 'matched by a comparable number of negative results' (p. 371). They went on to suggest that the positive results obtained were due to 'inadequately administered anesthetic that left some or all of the patients at least partially conscious' (p. 371). The first statement, while roughly true, is irrelevant. The second is simply false.

We have long since passed the time when box scores, totting up positive and negative results, can have any value except as informal expository devices. As Rosenthal (1978) demonstrated elegantly, it is quite possible for an effect to be present even when only a minority of studies yield significant positive results. In fact, a comprehensive review of the literature by Kihlstrom (1993b) concluded that nine out of sixteen studies (56 per cent) published since 1977 (when this literature effectively began) yielded significant effects; Merikle and Rondi (1993), counting dependent variables rather than studies, reported a ratio of thirteen out of eighteen (72 per cent); Cork *et al.* (1995), also counting dependent variables, obtained a ratio of twenty out of forty-seven (43 per cent).[5] Moreover, the effects obtained are not necessarily weak – especially when one considers that the subjects were unconscious during the presentation phase! In the experiment by Kihlstrom *et al.* (1990), the overall magnitude of the priming effect was 10 per cent over baseline; among those subjects for whom the implicit test was not contaminated by the earlier explicit test, the priming effect was 18 per cent, with eleven out of thirteen patients in this group showing priming.

It is true that Cork *et al.* (1992) expressed uncertainty about the extent of implicit memory after anaesthesia, but they were not voicing doubts about the effect obtained by Kihlstrom *et al.* (1990). Rather, they were asking a more analytical question about the conditions under which such effects could be obtained – a question that can only be answered by more, and more systematic,

research than is available to date. For example, holding the implicit memory task constant, some anaesthetic agents (e.g. isoflurane) might spare implicit memory, while others (e.g. sufentanyl) might not. Such a finding might tell us something interesting about the biological substrates of memory and consciousness (for a sustained argument along these lines, see Polster, 1993). Alternatively, holding the anaesthetic agent constant, some implicit memory tasks (e.g. repetition priming) might be spared, while others (e.g. conceptual priming) might not. In this respect, it is important to note that the unsuccessful experiment by Eich *et al.* (1985) focused on semantic priming; while the procedure employed by Kihlstrom *et al.* (1990) superficially resembles semantic priming, in fact it was a case of repetition priming, because both cue and target were presented during the study phase. This pattern of results, if confirmed in subsequent research, would seem to indicate that implicit perception under anaesthesia is analytically limited to perceptual rather than semantic processing (for a related argument about the limitations of subliminal perception, see Greenwald, 1992).

Of course, the best way to discount the positive findings on anaesthesia is to claim that the subjects are partially awake. With respect to the studies performed in our laboratory, Shanks and St. John (1994) are simply wrong to suggest that our subjects were inadequately anaesthetized. In our initial study (Kihlstrom *et al.*, 1990), we ran thirty patients, none of whom reported any memory for the tape or specific words; in our follow-up study (Cork *et al.*, 1992, 1993) we excluded three out of twenty-eight subjects on these grounds. *None* of the remaining subjects had any explicit memory of the wordlist, as is clearly indicated by the fact that there was neither any evidence of free recall, nor any differences in cued recall or recognition between critical and neutral targets. Those of us who investigate implicit perception in general anaesthesia take great care to ensure that our subjects are adequately anaesthetized by all standard criteria. Otherwise, what would be the point in doing the studies? The whole purpose of the anaesthesia research, from a theoretical point of view, is to determine the far limits of information processing outside of awareness. In most studies of implicit perception and learning, the subjects are conscious, even if they are not aware of what they are perceiving or learning. But in anaesthesia, the subjects aren't even conscious. If we can find evidence of implicit perception under these conditions, this should tell us something interesting about the processing demands of certain kinds of mental functions.

Why the difference in outcome between anaesthesia and sleep? Shanks and St. John (1994) note the seeming incongruity in claiming that implicit perception is possible during general anaesthesia, but not during sleep. However, these authors fail to recognize potentially important differences in the implicit memory tasks employed by Kihlstrom *et al.* (1990) and Wood *et al.* (1992). As noted earlier, Kihlstrom *et al.*'s paradigm involved repetition priming, while Wood *et al.*'s involved semantic priming. Perhaps Wood *et al.* would have obtained positive results with a repetition priming task; based on the currently available literature, it seems almost certain that Kihlstrom *et al.* (1990) would have obtained negative

results with a test of semantic priming. In the final analysis, the situation noted by Shanks and St. John (1994) is only a paradox if one assumes that sleep actually 'renders a person less unconscious than general anesthesia' (Shanks and St. John, 1994: 371). This assumption is unlikely to be tested until someone produces a unidimensional, quantitative index of degree of consciousness. For the present, however, it is important to understand that sleep and general anaesthesia have almost nothing in common physiologically, and these qualitative differences make any comparison between the states extremely difficult.

THE LIMITS OF PRECONSCIOUS PROCESSING – OR, YOUR UNCONSCIOUS IS STUPIDER THAN YOU ARE

The question of whether nonconscious mental processes are as analytically powerful as, or even more powerful than, conscious processes is a very old one in psychology. Von Hartmann (1931 [1868]) argued for the Romantic notion that 'the Unconscious can really outdo all the performances of conscious reason' (vol. 2, pp. 39–40). More recently, a survey of research on unconscious processes published in a leading newspaper informed readers that 'Your Unconscious Mind May Be Smarter Than You' (*New York Times*, 23 June 1992). Evidence for this latter proposition came chiefly in the form of studies of implicit learning, in which complex, abstract, rule-based knowledge is apparently acquired outside of awareness. Unfortunately, at least in so far as artificial grammars are concerned, the evidence favouring unconscious procedural learning is not as compelling as evidence that the subjects' performance is mediated by consciously accessible declarative knowledge structures (Dienes *et al.*, 1991; Dulany *et al.*, 1984, 1985; Mathews *et al.*, 1989; Perruchet and Pacteau, 1990, 1991). Similar considerations appear to apply to other paradigms in which implicit learning has been claimed, such as the control of complex systems, sequence learning and matrix scanning. The subjects in implicit learning experiences may not be attending to what they are learning, and they may not have noticed that they have learned what they have learned, but this is not the same thing as truly unconscious learning. Nor, even if implicit learning should some day prove to be truly unconscious after all, is there any reason to think that it is superior to conscious, explicit learning. When it comes to learning, it is probably better to be conscious than unconscious.

Similar considerations apply to subliminal perception and general anaesthesia. These topics will probably be forever bedevilled by questions about whether subjects might not have been, even just for a moment, conscious of what was being presented to them. But the best research in this area has gone to great lengths to rule out this possibility, and enough experiments have yielded positive results for the phenomena in question to be taken seriously. Subliminal stimuli can be processed perceptually, and so can supraliminal stimuli presented during general anaesthesia. However, there appear to be strict limitations on the extent of this processing. With respect to subliminal stimulation, the general rule seems to be that the further the stimulus moves from the subjective threshold, the less

likely it is to be subject to semantic analysis. And even for stimuli presented very close to the subjective threshold, semantic processing may be limited to very elementary operations, under the limits specified in Greenwald's (1992) two-word challenge. Similarly, it does appear that surgical patients (and nonpatient subjects) can process environmental events while they are under an adequate plane of general anaesthesia, and for this perception to leave a lasting trace in implicit (but not explicit) memory. However, it seems likely that this processing is limited to perceptual, rather than semantic, operations. It is unlikely that subjects process the meaning of what they have 'heard'. If intraoperative suggestions for improved postoperative recovery are effective (and this is by no means certain; see Cork *et al.*, 1995), this is most likely attributable to their prosodic character (e.g. the use of a quiet, soothing voice) rather than any particular semantic content. When it comes to perceiving and remembering, too, it is probably better to be conscious than unconscious.

In their dealings with the psychological unconscious, psychologists have had to navigate between the Scylla of Von Hartmann, with his Romantic notion of an omnipotent and omniscient unconscious, and the Charybdis of sceptics, including Eriksen, Holender, and now Shanks and St. John, who wish to limit the unconscious to the unattended and unprocessed. As with most binary choices, there is a third way: a way which is open to the idea that unconscious percepts, memories and thoughts can influence conscious mental life, but which is also prepared to concede that the extent of this influence may well be limited. In the final analysis, it is probably the case that the limits on unconscious processing are set by the means by which the stimuli are rendered consciously inaccessible. In the case of preconscious processing, where the percept or its memory trace has been degraded by masking or by long retention intervals, or the processing capacity of the subject has been limited by divided attention, nonsemantic orienting tasks, sleep (or sleepiness), or general anaesthesia, we would naturally expect the percept or memory to be limited to information about perceptual structure, or simple semantic features at best. Unconscious perception – perception without awareness of what is perceived – can occur, but it is almost certainly limited to what can be accomplished with elementary, automatic processes. To get more than that out of perception, attention, and thus conscious awareness, are probably necessary.

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NOTES

1 Some prefer the term 'cognitive neuroscience', but I prefer to stick with the traditional label, with its emphasis on the functioning of the whole human organism, rather than the molecular and cellular analyses which preoccupy so much of neuroscience; I also like to make clear that the mental states and processes of interest to psychologists include emotional and motivational as well as cognitive ones.
2 Actually, Jastrow, who was at that time Pierce's graduate student, seems to have done most of the judging.
3 Whatever its liabilities as a scientific theory and therapeutic method, psychoanalysis has always served the important function of keeping interesting topics in psychology alive until the field is ready to address them (Kihlstrom, 1988, 1994b).
4 The only published exception to this of which I am aware is work by Silverman (1976) and others on subliminal symbiotic stimulation, in which subliminal presentation of the phrase 'Mommy and I are one' appears to have a wide variety of effects on experience, thought and action (for a review, see Weinberger, 1992). The discrepancy between Silverman's ability to show the effects of such a prime, which obviously requires considerable processing to understand, and Greenwald's inability to find priming for two-word stimuli, remains to be resolved.
5 Both figures exclude studies of postsurgical therapeutic suggestions, which are not directly relevant to the issue at hand. This is because such suggestions require both processing of the suggestion itself (which is what the debate about implicit perception and memory is all about) and positive response to the suggestion (which might not occur even if the suggestion had been heard by a subject who was wide awake).

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The Science of Consciousness

In *The Science of Consciousness* leading researchers examine how consciousness is being investigated in the key areas of cognitive psychology, neuropsychology and clinical practice. Within cognitive psychology special focus is given to the function of consciousness, and to the relation of conscious processing to nonconscious processing in perception, learning, memory and information dissemination in the human brain. The investigation of consciousness in neuropsychology includes examination of the neural conditions for consciousness and the effects of brain damage. Finally mind/body interactions in clinical and experimental settings are considered, including the somatic effects of imagery, biofeedback and placebo effects. Individual chapters, presenting the latest research findings from pioneers in the field, combine to form a stimulating and accessible overview of this emerging science. *The Science of Consciousness* will be invaluable for students, researchers and clinicians interested in the developments and direction of this rapidly growing field.

Max Velmans is currently Reader in Psychology at Goldsmiths, University of London. His extensive publications on consciousness include 'Is human information processing conscious?' in *Behavioral and Brain Sciences* (1991), and 'A reflexive science of consciousness' in *CIBA Foundation Symposium 174* (1993).