Nonconscious Acquisition of Information

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The authors review and summarize evidence for the process of acquisition of information outside of conscious awareness (covariations, nonconscious indirect and interactive inferences, self-perpetuation of procedural knowledge). Data indicate that as compared with consciously controlled cognition, the nonconscious information-acquisition processes are not only much faster but are also structurally more sophisticated, in that they are capable of efficient processing of multidimensional and interactive relations between variables. Those mechanisms of nonconscious acquisition of information provide a major channel for the development of procedural knowledge that is indispensable for such important aspects of cognitive functioning as encoding and interpretation of stimuli and the triggering of emotional reactions.

In this article we review and summarize empirical evidence for the processes of acquisition of information outside of conscious awareness. We focus on the most common everyday life (and ubiquitous in human cognition) forms of nonconscious learning, in which the acquired information is not accessible to the perceiver's conscious control, not because of the physical properties of the stimuli (such as subliminal exposure time) but because of the relative slowness and inefficiency of the human consciousness. A considerable amount of evidence indicates that as compared with consciously controlled cognition, the nonconscious information-acquisition processes are incomparably faster and structurally more sophisticated. They allow for the development of procedural knowledge that is "unknown" to conscious awareness not merely because it has been encoded (and entered the memory system) through channels that are independent from consciousness. This knowledge is fundamentally inaccessible to the consciousness because it involves a more advanced and structurally more complex organization than could be handled by consciously controlled thinking.

Ubiquity of Nonconscious Acquisition of Knowledge in Human Cognition

Although it might appear to some to be somewhat surprising, the ability of the human cognitive system to nonconsciously acquire information is a general metatheoretical assumption of almost all of contemporary cognitive psychology. This assumption is so necessary that it is enthymemically present in almost every piece of research on human information processing published over the past two decades, and it is indirectly reflected in most of the experimental paradigms developed by cognitive psychologists (Lewicki & Hill, 1987, 1989).

In hardly any experimental procedure do cognitive researchers assume that they can directly learn how humans process information by simply asking them to report the contents of the procedural knowledge they follow. No matter how cooperative and well trained our subjects are, they cannot tell us how they go about processing information (e.g., how they encode shapes of objects in three-dimensional space or how they generate esthetic judgments). This is because subjects not only do not know how they do all those things but have never known it, and they do not have the slightest idea of how they *learned* all those information-processing algorithms and heuristics that are involved in the cognitive "software" that is indispensable for their psychological functioning. At the same time, there is no doubt that most of this procedural knowledge (Fodor, 1983) and skill results from experience and thus has been *learned* at some point.

Obviously, these trivial facts are not entirely new, and they have been observed and stated (usually in a somewhat implicit manner) by a number of researchers since Helmholtz. These facts became apparent especially to those who investigated (or tried to simulate) the processes of perception and realized the enormous complexity of those inferential encoding algorithms and heuristics that are necessary for every perception, even simple ones (e.g., Hochberg, 1978; Rock, 1975). These skills do not result from automatization through conscious experience. The complexity of those processes indicates that the perceivers' inability to tell us anything about how those processes work represents a fundamental lack of access to the nature of those algorithms and heuristics, not merely the difficulties with articulating the knowledge about them. For example, the seemingly simple act of recognizing a shape and size of an object and its location in three-dimensional space requires a set of sophisticated geometrical transformations and calculations that go far beyond what most perceivers could articulate or even comprehend.

The conscious appraisal of the final "products" of

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perception (i.e., subjectively encoded meanings of stimuli) is functionally independent from the information-processing algorithms and heuristics responsible for generating those subjective meanings. This fundamental independence is evident in virtually all areas of human cognition. Moreover, this lack of access to the nature of these processes (which are essentially responsible for most of what we see, experience, and feel) is not limited to the so-called low-level processes that support only the consciously controlled cognition (e.g., pattern recognition). People have no access to processes as high level as those involved in playing chess (deGroot, 1965), feeling love (Walster & Walster, 1978), forming impressions of people (Kihlstrom, 1987; Lewicki, 1986a), or problem solving and creative thinking (Sternberg, 1986), and when researchers attempt to learn directly from subjects anything about how such judgments or decisions are generated, subjects are usually as helpless as when they are asked to explain how they identify right angles in three-dimensional space or recognize patterns. All they know is that they just do it.

In light of those arguments, it is important to learn about the processes leading to the acquisition of procedural knowledge outside of conscious awareness, because they contribute to the very foundations of the human cognitive system.

Acquisition of Information About Covariations (Encoding Algorithms)

A considerable amount of evidence indicates that the human cognitive system is capable of nonconsciously detecting and processing information about covariations between features or events in the outside world (Lewicki, Hill, & Sasaki, 1989; Lewicki, 1986a; Lewicki, Czyzewska, & Hoffman, 1987; Reber, 1989; for a review, see Hill & Lewicki, 1991). Moreover, subjects' nonconscious ability to detect and process covariations was found to be superior to their (relatively poor) ability to detect the same information in a consciously controlled manner (see also Nisbett & Ross, 1980). Nonconscious processing occurs even if the conditions that are necessary for the consciously controlled processing of covariations (Crocker, 1981) are not met—for example, when the covariation is "hidden" (e.g., pertains to peripheral aspects of the stimulus material).

The nonconscious processing of covariations results in the development of respective procedural knowledge (Winograd, 1975) that participates in the encoding of subsequently encountered, relevant stimuli. For example, the nonconscious processing of a covariation between a facial feature x and a personality characteristic y results in the development of a tendency to interpret (encode) behaviors of subsequently encountered people who possess this feature (x) as indicative of personality characteristic y. This kind of procedure knowledge is referred to as *encoding algorithms.* The encoding algorithms provide elementary "inferential rules," used by the individual in the process of translating stimuli into subjectively meaningful experiences and converting them into memory-compatible code. Therefore, the nonconscious processing of information about covariations results in the development of the elementary functional components of the cognitive system that determine the way in which individuals interpret information, think, make judgments, form preferences, and so on.

Some basic properties of the process of nonconscious acquisition of information about covariations were investigated using the *matrix scanning* procedure. The subjects' task in matrix scanning experiments is to locate a target character (e.g., digit "6") in the subsequently presented matrices of distractor characters. It was demonstrated in a number of experiments that if there is a nonsalient but consistent covariation between some pattern of the background (distractor) characters and the locations of the target (across a number of trials), then subjects can process that covariation nonconsciously and store it in the form of procedural knowledge that specifically facilitates their subsequent encoding performance. In other words, without being aware of it, subjects in the matrix scanning experiments use the information about the background (which is easy to identify) to guide their search for the target locations.

How "Nonconscious" Is the Nonconscious Acquisition of Information?

Results from a variety of tests provide convergent evidence that subjects in the nonconscious covariation-processing experiments have no access to the newly acquired procedural knowledge. Also, they have no idea that they have learned anything from the stimulus material, even though the newly acquired knowledge consistently guides their behavior.

In one of the studies (Lewicki, Hill, & Bizot, 1988) that addressed the issue of the relation between conscious and nonconscious knowledge, an unusual sample of subjects was selected to assure that they would be sufficiently cooperative and intellectually capable enough to report any potential introspective experience (of "acquiring new information") they could have during the experiment. All of the subjects were faculty members of a psychology department. In the Lewicki et al. (1988) study, subjects nonconsciously acquired a set of encoding algorithms that allowed them to more efficiently (faster) encode locations of a target on a computer screen and, thus, to perform better in a search task. When the crucial covariation that was built into the sequence of target locations on the cathode-ray tube was changed (i.e., became inconsistent with the previous algorithm), subjects' performance, as measured by reaction times and the accuracy of responses, deteriorated. The subjects knew that the study investigated nonconscious cognition and tried hard to figure out the experiment. However, none of them came even close to discovering the real nature of the manipulation. Debriefing indicated that none of the subjects had any clue as to what kind of knowledge they had nonconsciously acquired in the experiment. Moreover, it was revealed that although subjects noticed the sudden decrease of their performance, at the point when the covariation changed, they attributed the decrease to factors that were entirely unrelated to the real cause of these changes; for example, they suspected that some distracting (e.g., threatening) subliminal stimuli were flashed on the screen.

In another experiment (Lewicki et al., 1987), subjects (college students) were given an unlimited amount of time and were offered a large monetary reward ($100) to uncover the "hidden" pattern in the stimulus material, which they had learned nonconsciously before, as indicated by the predicted pattern of changes in their performance. Some participants spent many hours trying to find the clue; however, none of them managed to come up with any ideas even remotely relevant to the real nature of the manipulation.

The results of those studies suggest that perceivers' access to the encoding algorithms that were acquired nonconsciously is limited to experiencing only the final outcomes of the nonconscious encoding processes (e.g., increased performance; liking or disliking something). Moreover, when a newly, nonconsciously acquired encoding algorithm involved some belief that had been consciously held by the subjects, the consciously held belief was never found to be affected by the nonconscious process. For example, after acquiring a nonconscious tendency to perceive people with facial feature x as also having the personality characteristic y, subjects' beliefs (i.e., declarative knowledge) concerning the relation between x and y was found to be unaffected, and subjects appeared to continue to be completely convinced that there was no relation between x and y (Hill, Lewicki, Czyzewska, & Schuller, 1990; Lewicki, 1986a).

The direct comparisons between conscious and nonconscious processing, based on the same inferential rules, were found to involve methodological problems that make the results difficult to interpret (Lewicki, 1986a). For example, the knowledge about the rules and the instructions to follow them may induce stress, performance anxiety, and other factors that are absent in situations when subjects are asked to follow their intuitions or simply to guess. However, the consistent results from the studies involving complex encoding algorithms suggest that, as compared with nonconscious processing, subjects require considerably more time to use the same encoding rules in a consciously controlled manner.

How Sophisticated Is the Nonconscious Acquisition of Information?

Several studies have shown that covariations of considerable complexity can be nonconsciously processed. Subjects in those experiments nonconsciously acquired procedural knowledge about formal structures of the material that were not only too complex and too confusing to be consciously noticed, but that even exceeded the complexity level of knowledge that one can use in any consciously controlled inferences. For example, in one series of studies, subjects nonconsciously acquired knowledge about a pattern of the stimulus material that involved a four-way interaction (Lewicki et al., 1987; see also the replication and extension of those experiments by Stadler, 1989; see also Cleeremans & McClelland, 1991). Extensive postexperimental interviews and tests indicate that the participants in those studies not only had no consciously controlled knowledge about the nature of the pattern (which they had "learned"), but they were not even aware of the existence of any pattern and were unable to detect it when they were explicitly instructed to do so and were promised a high cash award if they succeeded. Additional tests of subjects' ability to make consciously controlled inferences based on higher order interactions have revealed that the human cognitive system is not equipped to handle such tasks on the consciously controlled level. Our conscious thinking needs to rely on notes (with flowcharts or lists of if–then statements) or computers to do the same job that our nonconsciously operating processing algorithms can do instantly and without external help (e.g., infer on the basis of a four-way interaction; Lewicki et al., 1987).

Recent research with children (Czyzewska, Hill, & Lewicki, 1991) demonstrated that such encoding algorithms involving interactions between variables can be relatively easily acquired, nonconsciously, even by preschoolers (4–5-year-olds), whose consciously controlled thinking is at this stage so undeveloped that they cannot "understand" concepts of conditional relations or transivity. Those results are also consistent with common observations that all normally developed children at preschool age are capable of using complex semantic and syntactic rules, necessary to fluently use language, at the point when their conscious thinking skills do not allow them to articulate or even "understand" the simplest rules of language.

A series of studies (Lewicki, 1986a) on the process of acquisition of such conditional, or interaction-based, encoding algorithms suggests that subjects learn those complex knowledge structures through a process of *conditional elimination.* An encoding algorithm based on a simple covariation between two features or events can be abandoned and replaced by a new one when it does not fit the current stimuli well. However, the abandoned algorithm is not lost entirely but only deactivated (i.e., conditionally eliminated), and it can be reactivated and used again when stimulus material consistent with the old algorithm is encountered. If the crucial feature of the material (that determines which encoding algorithm should be used) is detected, then a higher order encoding algorithm begins to develop.

Nonconscious Semantic Abstraction and Generalization

The evidence reviewed in the previous section indicates that the mechanisms of nonconscious acquisition of information about covariations support formally complex knowledge structures. It appears that they are also capable of supporting semantic abstraction; in other words, the nonconsciously acquired covariations affect the general meanings of concepts, not only their labels, symbols, or other specific instantiations. For example, in one line of experiments (Hill, Lewicki, Czyzewska, & Boss, 1989), subjects nonconsciously learned covariations involving the feature of sadness. However, this specific label was never used in the training-phase stimulus material when subjects watched videotapes depicting their peers, some of whom expressed feelings of sadness or depression. In the testing phase, subjects showed the expected bias when they rated some of the new stimulus persons as more "pessimistic," "sad," "dissatisfied," or "lonely." These results indicate that in the process of acquisition of the manipulated encoding algorithm, subjects nonconsciously abstracted and generalized the meaning of a general concept from its specific instantiations encountered in the stimulus material.

The process of semantic abstraction and generalization in the nonconscious development of encoding algorithms was also demonstrated in studies in which verbal descriptions of activities of stimulus persons were used in the training phase to manipulate covariations between certain personality features (Lewicki, 1986a). No labels (adjectives) were used in those descriptions; instead, examples of specific behaviors instantiated the features. In the testing phase, subjects rated a sample of new stimulus persons on relevant dimensions anchored with labels that were not used in the learning phase. Subjects' responses were consistent with the manipulation, indicating that information about specific behaviors presented in the learning phase was nonconsciously abstracted and converted into general encoding concepts.

This process of nonconscious generalization was also observed in research with small children (Czyzewska et al., 1991). In a recent experiment, four- and five-year-olds nonconsciously learned a covariation between colors of clothes of children presented on posters and very general categories of their activities: "physically active" (e.g., riding a bike, jumping, playing ball, running) versus "physically passive" (e.g., watching TV, waiting, drawing, reading).

Nonconscious Development of Knowledge Structures That Are Relatively Independent From Experience

If the process of nonconscious generalization of covariations encountered in the "outside" world were the only mechanism responsible for the nonconscious development of encoding algorithms and procedural knowledge, then all of them would have to mirror the actual covariations between features, or events, in reality. This is obviously not the case. Common unreasonable biases, gradually developing irrational preferences for particular colors, places, and people, as well as various common forms of disorders (e.g., neuroses, phobias, borderline personality dysfunctions), indicate that many encoding algorithms and other elements of procedure knowledge develop in the cognitive system, relatively independent from, or at least not as a direct function of, experience with the outside world. Several mechanisms have been identified that can account for such instances of relative independence or even discrepancy between procedural knowledge and the environment.

Self-Perpetuation of Encoding Algorithms

It has been demonstrated in a number of studies that when stimuli are ambiguous, encoding algorithms may nonconsciously impose on them preexisting interpretive categories, even if the stimuli "objectively" do not match those categories. The resulting biased interpretation of stimuli, as supportive of the preexisting encoding dispositions, has been shown to become a *source* of subjective experiences that are consistent with these dispositions. This way, the encoding bias may gradually develop in a self-perpetuating manner (Hill et al., 1989; Lewicki et al., 1989). Considering the decisive role of encoding algorithms for generating the subjective meaning of what one is encountering, and given the ambiguity and openness to alternative interpretations of many, especially social, stimuli that one encounters in everyday life, the process of self-perpetuation of encoding algorithms may play an important role in the development of a variety of individual differences in how individuals encode and react to the environment (Hill et al., 1990; Hill, Lewicki, & Neubauer, 1991; Lewicki et al., 1989).

In the learning phase of a typical experiment, subjects participated in (ostensible) training in "the intuitive interpretation" of some stimuli. The stimulus material contained a hidden covariation between some subtle features or events. In the testing phase, subjects' task was to interpret a very long sequence of new, relevant stimuli based on intuition. Consistent with the self-perpetuation hypothesis, over a prolonged testing phase, subjects' responses gradually became increasingly consistent with the nonconscious encoding algorithm acquired in the learning phase, despite the fact that this testing-phase material did not include any supportive evidence. In other words, once initiated, the development of the new encoding algorithms continued in a self-perpetuating manner. The initial experiences capable of triggering such a self-perpetuating development of a bias (and starting the "snowball") may in real life be conditions that are very difficult to identify because they may be incidental, nonsalient, and not even consciously remembered as meaningful events by a perceiver (Jacoby & Witherspoon, 1982). There is evidence demonstrating that surprisingly little consistent evidence is sufficient to produce an initial encoding bias (Lewicki, 1986b), and in some circumstances even a single instance may be sufficient (Lewicki, 1985).

The self-perpetuation process was demonstrated using a variety of stimulus materials, such as videotaped social interactions, descriptions of stimulus persons, silhouettes of stimulus persons, kinematic traces of body movements, words of an artificial language, matrix scanning, and digitized transformations of human faces (Hill et al., 1989; Hill et al., 1991; Lewicki et al., 1989). The process of self-perpetuation is probably the clearest example of a cognitive mechanism capable of nonconsciously generating, or making up, new knowledge structures that are independent of, or even inconsistent with, the objective nature of the person's environment. The other two identified mechanisms (see below) appear to operate in a somewhat closer relation to what the individual encounters in the environment; however, they also nonconsciously create new encoding algorithms that can potentially be completely wrong in the sense that they do not reflect accurately what the individual is actually encountering in the outside world.

Nonconscious Indirect Inferences

There is evidence indicating that the processes of nonconscious acquisition of information about covariations (reviewed in the previous sections) may prompt a "spontaneous" development of new relations between concepts or features. Specifically, the relations can emerge between variables that have not been found to be connected in the environment and whose relation could only be inferred indirectly (i.e., by applying the rule of transitivity). In other words, if an individual acquires information about a covariation between features A and B, and independently, between features B and C, then this may result in the spontaneous development of an expectation that A and C are also related. That is, a new encoding algorithm would emerge representing the nonconscious knowledge that objects that are A are also C.

This phenomenon of nonconscious indirect inferences—generating new encoding algorithms by applying the rule of transitivity to connect existing algorithms—was recently demonstrated with different stimulus materials. Most of the studies used modified versions of procedures tested in previous research: matrix-scanning tasks, schematic pictures of stimulus persons, et cetera.

One of the experiments used the judging-personalities-from-kinematics paradigm (Hill et al., 1989), in which subjects were exposed to videotapes presenting abstracted movements of selected points on bodies of invisible stimulus persons engaged in various activities. Information about the personality of each stimulus person was provided. In the first phase of the study, subjects nonconsciously learned a covariation between the personality information (A) and a subtle variation of distances between the dots identifying the legs of the stimulus persons (B). In the second phase, dots on subjects' arms were introduced (C), and their distances covaried with distances between the dots on legs (B); however, no information about the personality of the stimulus persons was provided (A). In the testing phase, only dots on arms were shown (C), and subjects were asked to "make intuitive judgments of personality" of the persons "based on the dynamics of their body language."

Consistent with expectations, subjects' judgments of feature A were found to be based on the distances between dots on arms (feature C), although in this arrangement of the stimulus material, the relation between features A and C could be established by subjects only indirectly (i.e., "via" feature B). As usual, tests of participants' awareness revealed no trace of their knowledge about any relations between the crucial features manipulated in the stimulus material. Moreover, not a single subject noticed any variation of the systematically varied distances between dots marking the limbs of the stimulus persons.

Acquisition of Meta-Knowledge: Nonconscious Transfer or Generalization of Procedural Knowledge

The effectiveness and capability of the cognitive system to nonconsciously detect information about covariations may also be aided by its metalearning ability (i.e., the ability to learn how or where to look for information about systematic relations). This possibility was suggested in recent experiments in which participants were exposed to two segments of stimulus material, containing two different but structurally similar covariations. The results suggest that subjects' acquisition of information about the second covariation—measured by the degree to which their performance in the second phase was consistent with the manipulated pattern embedded into the material—was facilitated by the fact that they had previously acquired the procedural knowledge of the covariation in the first segment. Specifically, in the control group, in which no consistent covariation was embedded into the first segment of the material (and thus the participants could not acquire any relevant knowledge in the first phase), the acquisition of the covariation in the second segment was slower than in the experimental groups, in which a consistent covariation was present in the first segment. In one of the studies, the matrix scanning procedure (mentioned earlier) was used. The target character was 6, and the background characters were letters in the first phase and numbers in the second phase. Thus, even though the two covariations were different, and the knowledge about the first one could not directly facilitate subjects' performance in the second phase, the two covariations were *structurally* similar, in that they both involved knowledge about the relation between how the background looks and where the target is located. It was found that subjects who learned about the covariation involving letters in the first phase, learned the covariation about the numbers in the second phase quicker than those who were exposed to the control first phase with no systematic covariation present.

Is the Nonconscious Information-Processing System "Intelligent"?

The answer to this question, which appears to be at least implicitly present in most discussions on the role of the nonconscious in human cognition, depends on the meaning of *intelligence* in this context. If intelligent means having its own goals or specific motivations and being able to pursue them by triggering particular actions, such as those proposed in the psychoanalytic literature, then the answer to this question would be "no." It appears that there is no empirical evidence in the cognitive literature for any specific content built into, or otherwise involved in, nonconscious acquisition or processing of information. The mechanics of those processes may lead some researchers—especially clinicians—to the illusion that they can identify some content-specific character of nonconscious processes because some of those processes may develop in a self-perpetuating manner and eventually lead to strong content-related dysfunctions, for example, in one's emotional reactions toward some specific categories of situations or objects. However, despite their high efficiency and formal sophistication, those demonstrated processes in the experiments on nonconscious acquisition of knowledge appear to be at least initially unbiased toward any specific contents and impartial in the sense of being ready to process any type of information, regardless of the level of its consistency with the perceiver's consciously held beliefs or motivations (Lewicki, 1986a).

The answer to the question about intelligence would be affirmative if *intelligent* is understood as "equipped to efficiently process complex information." In this sense, our nonconscious information-processing system appears to be incomparably more able to process formally complex knowledge structures, faster, and "smarter" overall than our ability to think and identify meanings of stimuli in a consciously controlled manner.

In light of the evidence reviewed in this article, the "division of functions" between the nonconscious and consciously controlled aspects of human cognition appears to be quantitatively and qualitatively asymmetrical. Most of the "real work," both in the acquisition of cognitive procedures and skills and in the execution of cognitive operations, such as encoding and interpretation of stimuli, is being done at the level to which our consciousness has no access. Moreover, even if the access to that level existed, it could not be used in any way, because the formal sophistication of that level and its necessary speed of processing exceed considerably what can even be approached by our consciously controlled thinking. The "responsibilities" of this inaccessible level of our cognition are not limited to the housekeeping operations, such as retrieving information from memory or adjusting the level of arousal; they are directly involved in the development of interpretive categories, drawing inferences, determining emotional reactions, and other high-level cognitive operations traditionally associated with consciously controlled thinking.

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