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Nonconscious Indirect Inferences in Encoding

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Indirect (transitive) inference (i.e., *if A is related to B, and B is related to C, then C is related to A*) is a ubiquitous component of thinking and reasoning. This research demonstrates that a mechanism at least functionally similar to drawing indirect inferences can also be observed in unintentional processes of encoding. The 2 studies followed the same design and used modified versions of procedures tested in previous research on nonconscious information processing (P. Lewicki, T. Hill, & M. Czyzewska, 1992). In the first learning phase, Ss acquired an encoding algorithm relating Variables A and B. In the second learning phase, Variable A was removed from the material and replaced with Variable C, allowing Ss to acquire the second encoding algorithm (relating B and C). Consistent with the original studies, Ss were not aware that there were any consistencies in the material. In the testing phase material, Variable B was removed, and Ss were asked to make intuitive judgments regarding Variable A. The data from both experiments confirmed the expectation that Ss would implicitly draw indirect inferences (A on the basis of C). This process is discussed as one of the mechanisms that may trigger the development of various components of procedural knowledge.

Research on the processing of information about covariations has demonstrated that encoding of stimuli (translating stimuli into subjectively meaningful experiences and storing information about them in a memory-compatible code) can be modeled as a sequence of complex inferences drawn according to encoding algorithms (Lewicki, 1986; Lewicki, Hill, & Czyzewska, 1992). The algorithms contain inferential rules that can be represented in the form "If an object is A then it is also B." The covariations between attributes or events involved in those rules (e.g., A and B) result from processes of acquisition of procedural knowledge that are involuntary and that require very little or no conscious attention (Lewicki et al., 1992).

Evidence has demonstrated that information about covariations can be acquired and begin to affect subsequent relevant encoding processes even though the person who has acquired the information cannot articulate the newly acquired encoding rule and is not aware of learning any new information (Hill et al., 1989; Lewicki et al., 1989; Musen & Squire, 1993). Empirical data and lay observation have indicated that a considerable part of cognitive skills is based on procedural knowledge (such as encoding algorithms) that cannot be articulated and that was acquired or developed outside of the person's attention and conscious control. For example, small children use complex semantic and syntactic rules of language long before they are capable of articulating or understanding any such rules even in their simplest form (Rozin, 1976; Small, 1990). Many inferential rules that are involved in the encoding of social stimuli, judgments, or even the identification of shapes and locations of objects in three-dimensional space are based on advanced procedural knowledge that cannot be articulated by the perceiver (Hochberg, 1978; Kaufman, 1974; Kihlstrom, 1987; Lewicki, 1986; Lewicki et al., 1992; Reber, 1989).

The apparent complexity and sophistication of this procedural knowledge suggest that it may result from the operation of other mechanisms in addition to the mere acquisition of information about simple covariations encountered in the environment. In support of this reasoning, recent research has demonstrated that without mediation of conscious awareness, inferential algorithms of considerable complexity can be acquired (Lewicki, Czyzewska, & Hoffman, 1987; Stadler, 1989), and that the body of procedural knowledge available to the perceiver may spontaneously develop through processes of so-called self-perpetuation of encoding biases (Hill et al., 1989; Hill, Lewicki, Czyzewska, & Schuller, 1990; Hill, Lewicki, & Neubauer, 1991; Lewicki et al., 1989).

The research we present in this article deals with another mechanism hypothesized to contribute to the development of procedural knowledge: indirect inference based on the logical rule of transitivity (if A is related to B, and B is related to C, then C is related to A). There are at least three kinds of reasons for expecting that such indirect, transitive reasoning can take place with no mediation of conscious attention and may contribute to the development of encoding algorithms.

One argument that supports the implicit indirect-inference hypothesis can be derived from theories of semantic mem-

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ory and previous research on semantic concept formation as a result of acquisition of information about covariations (Lewicki, 1986, Experiments 4.3, 4.4, 4.5, and 4.6). The results of these previous studies indicate that newly (nonconsciously) acquired information about a covariation between variables A and B does specifically influence the respective semantic memory representations of concepts A and B. The changes in semantic memory (registered by means of reaction time measures in the semantic judgment paradigm) indicated that, as a result of acquisition of information about the covariation between A and B, the memory representations of the respective concepts A and B become more closely related (Lewicki, 1986), thus automatically facilitating the indirect links between representations of concepts A and B and representations of other concepts.[1] Therefore, it can be proposed that the process of indirect inference in encoding (hypothesized in the present research) does not require a designated mechanism of nonconsciously drawing indirect inferences; instead, one can say that the expected process may represent a natural consequence of the organization of semantic knowledge.

The second kind of argument that supports the implicit indirect-inference hypothesis is the evidence for the existence of functional (i.e., implicit) indirect inferences in small children who are unable to apply the rule of transitivity on the level of their explicit (i.e., consciously controlled) thinking (Rozin, 1976; Small, 1990). For example, many types of linguistic errors that small children make when (on the functional level) they act as if they had tried to apply various syntactic rules of language indicate that they use indirect, transitive reasoning (obviously, without knowing that this is what exactly they are doing). For example, common mistakes such as "I put-ed it down" or "He break-ed it" demonstrate that some forms of verbs that children use are not directly learned but instead are indirectly inferred using the rule of transitivity. For example, if *to paint* in the past tense is called *paint-ed* (i.e., "past" is related to the suffix *-ed*), and *to put* took place in the "past," then it should be called *put-ed*. Needless to say, 2- or 3-year-olds are not capable of articulating any inferences of that kind or of drawing such inferences on the level of their conscious thinking. Similar observations have been made in research on number processing in 3- and 4-year-olds (Gelman, 1982).

Finally, the transitive inference is one of the most common, elementary, and indispensable components of almost any type of reasoning; thus, it is reasonable to expect that it can be performed automatically (empirical evidence and observation indicate that very complex knowledge structures can develop with no mediation of conscious attention, see, e.g., Lewicki et al., 1987; Stadler, 1989).

In addition to the arguments mentioned in the previous paragraphs, a comprehensive body of empirical evidence supporting the general hypothesis of implicit indirect inference has been collected in the research tradition of behavior analysis (for a recent review, see Hayes & Hayes, 1992). The phenomenon, later called *stimulus equivalence*, was first described more than 60 years ago, when Hull (1934) observed that "stimulus–response habits" may spontaneously form novel sequences ("chains of reactions," Hull, 1934, p. 36) involving relations between elements that were never associated in the process of learning. This research (which now includes more than 50 published studies) indicates that when subjects are taught a series of related conditional discriminations, "the stimuli that enter into those discriminations can often become connected to each other in new ways, not explicitly taught" (Hayes & Hayes, 1992, p. 1386), which also involves the development of transitive relations. For example, after a person has been taught (i.e., conditioned) "given X1, pick Y1" and "given Y1, pick Z1," he or she will derive the relation "given X1, pick Z1" (Fields, Verhave, & Fath, 1984). Some of this research (conducted in the tradition of behavior analysis) supports the general cognitive notion we propose in this article that the ability to use indirect inferences is one of the fundamental properties of the cognitive system, and that this ability is necessary to acquire basic linguistic skills and other elementary knowledge structures (Hayes & Hayes, 1992). For example, the development of conditioned transitive relations has been demonstrated in infants as young as 22 months old (Lipkens, Hayes, & Hayes, 1993).

The experiments presented in this article were designed to explore the possibility that indirect transitive reasoning contributes to development of new encoding rules resulting from nonconscious acquisition of information about covariations. These studies were based on extensions of experimental procedures that have been used in previous research on nonconscious processing of information about covariations (Hill et al., 1989; Lewicki et al., 1989). In the learning phase of those previous studies, subjects were exposed to stimulus material consisting of a sequence of trials. The material contained a "hidden" (i.e., nonsalient) covariation between features or events A and B across the trials (e.g., all trials that were high on A were also high on B). In the testing phase, subjects were exposed to similar stimulus material, however, only information about A (and not about B) was provided, and subjects' task in each trial was to infer B based on their intuition. The results consistently indicated that subjects' intuitions followed the covariation (between A and B) that had been nonconsciously acquired in the learning phase, although tests of subjects' consciously controlled knowledge did not reveal any trace of subjects' knowledge about the crucial (i.e., manipulated) aspects of the material. Subjects were not aware of anything even remotely related to the role of A in the task, let alone the covariation between A and B.

The experiments we report in this article followed the general design of the previous studies on processing covariations, with the following extensions: There were three variables (A, B, and C), not two, involved in the procedure, and there were two learning phases. In the first learning phase, subjects were exposed to stimulus material contain-

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[1] This reasoning is consistent with both the computational and pre-storage types of theories of semantic memory (Smith, 1978; for a discussion of those models of semantic representations in the context of acquisition of information about covariations, see Lewicki, 1986, Chapter 4).

ing a covariation between A and B; no information about C was provided. In the second learning phase, variable A was entirely removed from the material and variable C was introduced such that it covaried with B across the trials. In the testing phase, variable B was removed and the subjects were asked to guess, based on their intuition, about variable A. Thus, the first phase allowed the subjects to acquire information about the covariation between A and B, and the second phase allowed them to acquire information about the covariation between B and C. In the third phase, only C was present, and subjects were expected to correctly infer A on the basis of the transitively developed relation between C and A.

Experiment 1: Learning to Judge Likability From Kinematics

Method

We used the *kinematics* procedure in this experiment (this procedure has been tested in previous studies, see Hill et al., 1989). The general idea for this stimulus material was taken from research by Runeson and Frykholm (1983) on the kinematic specification of dynamics as an informational basis for person-and-action perception. Runeson and Frykholm found that subjects who had been exposed to nothing more than a very limited amount of information about the dynamics of movements of a stimulus person could still make relatively accurate judgments about the person's gender, intentions, and so on.

Overview

We exposed subjects in the present experiment to a videotape that presented the motion of stimulus persons (walking, lifting objects, etc.). However, all that was visible on the videotape were small strips of fluorescent tape fixed to the stimulus person's forehead and joints; both the background and the person's body were completely dark and indistinguishable. There were two learning phases and one testing phase in the experiment.

The first learning phase contained a consistent but not salient covariation between two features (variables A and B) of the "costumes" of the stimulus persons. In the second learning phase, Feature A was removed, and information about the "likability" of the persons (variable C) was introduced such that it systematically covaried with the Feature B of the costumes. In the testing phase, Feature B was removed and was replaced by Feature A, and subjects were asked to make intuitive judgments about the likability of the stimulus persons (C). We hypothesized that subjects' intuitions would be affected by the indirectly inferred relation between C and A (on the basis of the previously acquired information about the relations between A and B and B and C).

Subjects

Twenty-eight male and female volunteers from undergraduate psychology courses participated for course credit.

Stimulus Material

The stimulus material was prepared by videotaping 1 actor performing various simple tasks (e.g., opening a jar, tying a necktie, drinking a canned beverage, lifting a heavy box, etc.). The actor was dressed in completely black clothes with fluorescent markings (as described above) and was filmed in front of a black background. Thus, only these marked points were visible on the videotape. The tape was recorded in negative mode (i.e., the black background was recorded as white, and the white markings as black), so that the final videotape showed a white background with black markings identifying the actor's limb joints and forehead. To control for any unintended relations between the nature of activities and manipulated features (A, B, and C), each of the three phases of the procedure (40 trials) contained 20 activities, each of which had been recorded twice (in each of the two arrangements of the manipulated features).

Procedure and Design

Subjects were tested in small groups (2–5 persons each). The material was presented on a video monitor and followed the design described in Hill et al. (1989). Before we exposed subjects to the experimental procedure, we explained the idea of the kinematics study to them. Also, to make this cover story even more believable, we gave them a copy of the first page of the *Journal of Experimental Psychology: General* article reporting Runeson and Frykholm's (1983) original experiment. The experimenter (who was unaware of the experimental condition) explained that the current study was an extension of Runeson and Frykholm's research. Specifically, the experimenter told the subjects that the current experiment was an attempt to determine whether people, using their intuition, can identify personality characteristics of individuals "based solely on how they move." Subjects were then exposed to stimulus material similar to that from the original kinematics study.

First learning phase. During the first learning phase, there were 40 episodes. Each episode was about 10 s long and presented a stimulus person engaging in a single, simple activity (e.g., opening and drinking a canned beverage, throwing a Frisbee). Subjects were told that the activities were performed by different actors (although in fact the same actor performed all activities throughout the material). The learning phase was introduced to them as a warm-up designed to help them get used to the material. To keep subjects' attention focused on the display, we asked them to mark on a response sheet whether or not they could identify each activity (by circling *Y* or *N*). No information about the stimulus persons was provided in this phase; however, the size of dots on the actor's arms (either 1.375 in. [3.493 cm] or 1 in. [2.54 cm]; Feature A) systematically covaried over the trials with the distance between the bands on their ankles and knees (either 10 in. [25.4 cm] or 7.75 in. [19.69 cm]; Feature B). The variation of the manipulated aspects of the stimulus material (differences between the sizes of dots, or the distances between bands) were hardly noticeable, especially given the fact that each episode was slightly different with regard to the distance between the stimulus person and the camera (and thus the absolute size of the stimulus person varied from episode to episode).

There were two experimental conditions. In Condition 1, all stimulus persons with long distances between leg bands had small dots on their arms, and all stimulus persons with short distances between leg bands had large dots on their arms. In Condition 2, the reverse covariation was present.

Second learning phase. The first learning phase was followed by brief instructions introducing the second phase, which also consisted of 40 trials. In this phase the third feature (C) was introduced: at the beginning of each episode, a recorded message described each stimulus person as either "likable" or "not likable."

These ratings of likability were ostensibly based on "scientific case studies confirmed by peer ratings of each person." In this part of the material, the stimulus person wore a different costume: The dots on the arms (Feature A) were entirely removed, and information about likability covaried with the distances between leg bands. All stimulus persons with short distances between leg bands were presented as "likable," and stimulus persons with long distances between leg bands were presented as "not likable." We asked subjects to view the tape "to gain a feel for the different personality types."

Testing phase. The testing phase stimulus material consisted of 40 additional episodes, in which Feature B (bands on legs)—used in the second learning phase—was removed, and Feature A—(dots on arms) used in the first learning phase—was reintroduced. Also, unlike the second learning phase, during this testing phase, subjects were not given any information about the likability of the stimulus persons but instead were asked to rate (separately for each episode) the likability on the basis of their intuitions. At the beginning of each episode, the respective person's activity was identified by the recorded voice of the announcer (e.g., "This person is lifting a heavy object," or "This person is drinking a Coke"). The experimenter instructed subjects how to use the response booklets and how to rate the likability of the stimulus person depicted in each episode on an 8-point scale that was labeled *not likable* to *definitely likable* at its endpoints. The instruction did not stress subjects' own (i.e., personal) feeling for the stimulus persons (i.e., subjects were not asked to say how well they themselves liked each stimulus person); instead, it implied that likability pertains to some general, objective characteristic of a person.

Postexperimental questionnaire. After the testing phase of the experiment, subjects were instructed to write down any observations or feelings that they had regarding the stimulus materials, in particular, what they paid attention to when making their ratings. The experimenter urged subjects to write down as many observations as possible; presumably, it was important for the investigators to learn on which aspects of the stimulus material subjects focused their attention. Finally, to encourage subjects to reveal any potential strategies they might have used, the experimenter said that "Often participants in this task try to use some more or less systematic 'strategies' or 'consistent patterns of responding;' did you use any such methods of responding?"

Results

Table 1 shows the means of subjects' average ratings of stimulus persons with large and small dots for each of the two experimental conditions.

The pattern of means is consistent with our expectation that subjects' ratings of likability (Feature C) would follow the covariation between Features C and A (dots), indirectly inferred from previously acquired information about the relations between Features A (dots) and B (bands), and Features B (bands) and C (likability). A 2 (condition: 1 vs. 2) × 2 (dots: large vs. small) analysis of variance (ANOVA, with repeated measures on the second variable) of those ratings yielded a reliable interaction between the variables, $F(1, 26) = 20.06$, $MS_e = .0449$, $p < .0001$. Planned comparisons revealed that, consistent with our expectations, subjects in Condition 1 rated stimulus persons with large dots as reliably more likable than stimulus persons with small dots, $F(1, 26) = 11.19$, $p < .005$. At the same time, subjects in Condition 2 rated stimulus persons with large dots as reliably less likable than stimulus persons with small dots, $F(1, 26) = 8.92$, $p < .05$.

Table 1
Ratings of Likability of Stimulus Persons With Large and Small Dots (Experiment 1)

	Type of stimulus person	
Condition	Large dots	Small dots
1	4.64	4.37
2	4.28	4.5

The analysis of subjects' responses in the postexperimental questionnaire and interviews revealed that, consistent with the results from Hill et al.'s (1989) study, none of the participants mentioned anything even close to the manipulated covariation. Not a single subject mentioned anything related to markings on the costumes of the stimulus persons; subjects clearly focused on the dynamics of movements of the stimulus persons.

Experiment 2: Learning to Judge Intelligence From Brain Scans

Method

In this experiment we used the "brain scans" procedure, which was used in Lewicki et al.'s (1989) study. In the learning phase of Lewicki et al.'s experiment, subjects were exposed to computer-generated graphical displays resembling the shape of a human brain; subjects were told that those displays represented digitized brain scans of actual people. Hidden in that stimulus material was a subtle covariation between the relative frequency of a particular nondistinctive graphics character and the intelligence ascribed to the individual supposedly associated with the brain scan. Each brain scan consisted of approximately 500–600 graphics characters; the relative frequency of the crucial character in each brain scan was either 13% or 17%. In the testing phase, the subjects were presented with a new series of brain scans and were asked to make intuitive judgments of the intelligence of the respective individuals. As predicted, subjects' judgments were specifically influenced by the covariation manipulated in the learning phase.

Overview and Design

To test for the hypothesized indirect-inference effects in the current experiment, we added one more variable to the stimulus material: a warning tone (at one of two different pitch levels), which preceded the onset of the brain scan in some parts of the material. The design was analogous to the one used in the kinematics study (see the previous section) and included two learning phases and one testing phase. The first learning phase was almost identical to the one from the original brain scan study (Lewicki et al., 1989). Subjects were exposed to a sequence of 36 graphical displays—described to subjects as "digitized brain scans"—presented on a high-resolution computer screen. Each scan was displayed for 11 s and was accompanied by information about the intelligence of the person (associated with the respective brain scan). There was a systematic covariation present in this part of the material between information about intelligence of the person (A) and the hidden (nonsalient) graphical aspect of the scan (B). In the second learning phase, the subjects watched a new series of 36 scans; however, no information about the intelligence of the person was provided. Instead, a short warning tone was introduced before the onset of each scan. In this phase of the material there was a systematic covariation between the hidden graphical aspect of the scans (B) and the pitch level of the warning tone (C).

In the testing phase, we asked subjects to make intuitive judgments of the intelligence of 36 new brain scans. However, we told them that in order to create conditions for purely intuitive judgments, the scans would be displayed "subliminally, that is, for a very short period of time." The scans were in fact not displayed subliminally, but the exposure time was so short (100 ms, no mask) that subjects could not see any details of the scans and could not know that the scans were constructed of a somewhat different set of graphics characters (i.e., the scans did not contain the nonsalient feature that had been manipulated in the learning phases). Warning tones (introduced in the second learning phase), however, were still present in this part of the material. Therefore, assuming that in the first learning phase the subjects acquired information about the covariation between intelligence (A) and the manipulated graphical feature of the scans (B) and in the second learning phase they acquired information about the covariation between the graphical feature (B) and the pitch level of the warning tone (C), then subjects, following the rule of transitivity, could indirectly infer intelligence of the person (A) on the basis of pitch level of the warning tone (C).

Subjects

Forty-three male and female volunteers from undergraduate psychology courses participated for course credit.

Procedure

Subjects were tested individually. On each subject's arrival at the laboratory, the experimenter (who was unaware of the experimental conditions) explained that the study was concerned with "how people form intuitive impressions of digitized brain scans." Subjects were told that some people had been found to possess a particular intuition that allows them to interpret digitized brain scans without the long and complex formal training that usually is necessary. Presumably, the experimenter explained, the nature of this ability was not well understood, but it was not related to perceptiveness or to any specific ability to articulate or notice particular features of the brain scans. Subjects were told that they would be shown several digitized brain scans from actual people on a computer screen. Supposedly, those brain scans (along with a variety of additional information) had been collected as part of a large research project conducted by a "major medical school."

Stimulus material. The brain scans were actually computer-generated patterns of graphics characters, that resembled the shape of a brain. Figure 1 shows an example of one of the brain scans. The brain scans were displayed on an amber monochrome screen (Packard Bell, Model 1218M; 348 × 720 pixels), and some characters (determined randomly) were displayed in double intensity (i.e., they were brighter; this detail is not reproduced in Figure 1).

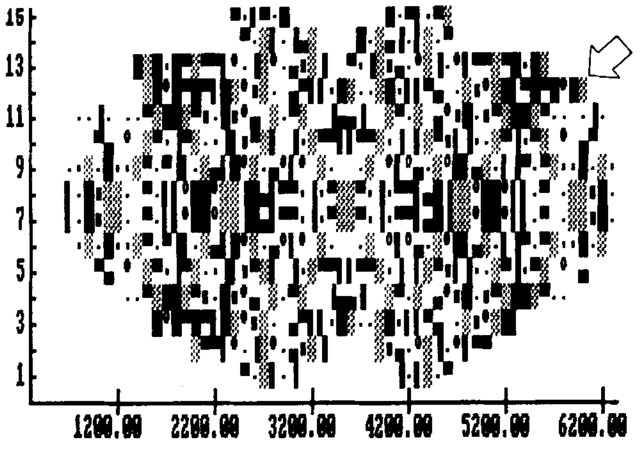

Figure 1. An example of a brain scan as used in Experiment 2.

There were two types of brain scans, distinguished by a subtle difference regarding the frequency (proportion) of a particular (special) character (IBM extended graphics character, ASCII code 178). This character is indicated in Figure 1 with an arrow. In Type 1 brain scans, the proportion (of all characters that made up the brain scan) of special characters was 17%; in Type 2 brain scans it was 13%. Previous testing had determined that the difference between the two types of brain scans was barely noticeable and was not salient: Even pilot study subjects who had been specifically instructed to focus on the manipulated aspect of the graphics (the ASCII code 178 character) had difficulty correctly assigning brain scans to the two categories (Lewicki et al., 1989).

Subjects' task during the first learning phase. Subjects' task in this phase was to look at the brain scans, one by one, and to listen to a brief description (supposedly prepared by a psychologist) of the respective individual to whom the brain scan belonged. The descriptions were prerecorded and were played to subjects over headphones from a tape recorder synchronized with the computer (the recording started at the beginning of each brain scan presentation). Each description began with an explicit statement regarding the individual's intelligence, followed by a short narrative description (e.g., "Intelligent—This person enjoys solving challenging crossword puzzles," or "Not intelligent—This person has trouble concentrating for an extended period of time"). After looking at the brain scan and listening to the description, subjects were asked to rate the person's intelligence on an 8-point scale. Subjects made their ratings by pressing one of eight adjacent keys on a control box (made from a modified computer keyboard). The scale was explicitly labeled and color-coded (on the control box) so that the responses 1, 2, 3, or 4 (coded blue on the control box) denoted nonintelligent brain scans (individuals); and the responses 5, 6, 7, and 8 (coded red) denoted intelligent brain scans (individuals). Subjects were instructed to make their judgments quickly; each brain scan was displayed for a duration of 11 s. Subjects were exposed to 36 brain scans during the first learning phase.

Across trials, the stimulus material contained a covariation between the verbal description of a person as intelligent or not intelligent and the type of brain scan. In one experimental condition, Type 1 brain scans (and therefore the respective individuals) were described as intelligent, and Type 2 brain scans were described as not intelligent; in the other experimental condition, Type 2 brain scans were described as intelligent, and Type 1 brain scans were described as not intelligent.

Subjects' task during the second learning phase. We introduced the second learning phase to subjects as training designed to prepare them for a subsequent segment of the procedure in which the brain scans would be displayed for a very short period of time. Each picture was displayed for only 4 s, and there were 2-s breaks between trials. In this phase no information was provided about intelligence of the stimulus persons; instead, we introduced a warning tone at the onset of each display. There were two pitch levels of the warning tone: One was at the level of a D note, the other at the level of one third of the distance between D and E flat. Subjects were warned that the exposures would be quick and were asked to concentrate on the scans (they did not have to rate the scans in this phase). One half of the subjects were exposed to material in which Type 1 brain scans were paired with the lower pitch warning tone and Type 2 brain scans were paired with the higher pitch tone, the other half of the subjects were exposed to the reversed relation between brain scan type and pitch of warning tone (these conditions were crossed with the two conditions manipulated in the first learning phase).

Subjects' task during the testing phase. After the second learning phase, the experimenter explained to the subjects that they would see several additional brain scans of actual people, and that their task would be to use their intuition to rate the intelligence of the individuals to whom the brain scans belonged. The experimenter told the subjects that it was important for the current study that they follow their initial intuition, without trying to make any analytic judgments, and, to create conditions for such purely intuitive judgments, the scans would be displayed "subliminally, that is, for a very short period of time." The scans were in fact not displayed subliminally, but for 100 ms[2], and they were not masked. This exposure time was so short that subjects could not see any details of the scans and could not know that the scans did not contain the ASCII code 178 characters that had been manipulated in the two learning phases. Warning tones (introduced in the second learning phase), however, were still present in this part of the material. Therefore, assuming that in the first learning phase, subjects acquired information about the covariation between intelligence (A) and the manipulated graphical feature of the scans (B); and in the second learning phase subjects acquired information about the covariation between the graphical feature (B) and the pitch level of the warning tone (C), then subjects, following the rule of transitivity, could indirectly infer intelligence of the person (A) on the basis of pitch level of the warning tone (C).

Postexperimental interviews. After the experiment, the experimenter extensively interviewed each subject. The first part of each interview was semi-structured to elicit subjects' responses to the following questions: (1) "How did you go about making your ratings?", (2) "Which particular aspects of the brain scans did you attend to?", and (3) "People sometimes use some 'systems' or 'strategies' to make judgments like those that you were asked to make in this experiment. Did you use any 'system' or 'strategy' to make your ratings?" In the second part of the interview, subjects were asked to express any comments or observations they might have about the stimulus material and the procedure. The experimenters always encouraged subjects to continue expressing additional impressions and observations and explained that it was very important for the investigators to learn from participants as much as possible about the procedure and about how the stimulus material was perceived. In fact, the experimenters had been instructed to give the impression that the subject could and was expected to voice various (even "ridiculous") observations or suspicions about the stimulus materials. The interview was conducted by 1 of 3 experimenters (each of whom interviewed about one third of the subjects). All of the subjects' responses were recorded and later reexamined.

Table 2
Ratings of Intelligence of Brain Scans Accompanied by the Low-Pitch and High-Pitch Warning Tones (Experiment 2)

Condition	Warning tone pitch level	
	Low	High
1	4.87	4.50
2	4.49	4.80

Results

The main dependent variables in this analysis were the average intelligence ratings of the testing phase brain scans accompanied by the lower and (separately) higher pitch warning tones. The two counterbalancing conditions (see the second learning phase) did not affect the pattern of the ratings. Table 2 shows the average ratings for the two types of scans (those accompanied by the lower and higher pitch warning tones) in subjects who were expected (on the basis of the indirect-inference hypothesis) to rate the scans with the lower pitch warning tones as belonging to an intelligent person (Condition 1) and those subjects who were expected to rate the scans with the higher pitch warning tones as belonging to an intelligent person (Condition 2).

The pattern of means is consistent with our expectations. A 2 (Condition: 1 or 2) x 2 (Brain scans accompanied by lower vs. higher pitch warning tone) ANOVA (with repeated measures on the second variable) of the ratings yielded a significant interaction between the variables, $F(1, 41) = 7.64$, $MS_e = .321$, $p < .008$. Planned comparisons revealed that, consistent with our expectations, subjects in Condition 1 rated the brain scans that were accompanied by lower-pitch warning tones as belonging to people who were more intelligent than they rated brain scans that were accompanied by higher-pitch warning tones, $F(1, 41) = 4.86$, $p < .03$. At the same time, subjects in Condition 2 rated the intelligence of assumed people whose brain scans were accompanied by the higher-pitch warning tones as higher than the intelligence of assumed people whose brain scans were accompanied by the lower-pitch warning tones, $F(1, 41) = 2.98$, $p < .09$.

The analyses of subjects' comments during postexperimental interviews revealed that (consistent with the results from Lewicki et al.'s [1989]) study, none of the subjects mentioned anything even remotely relevant to the true nature of the manipulated covariation. Subjects who reported experiencing intuitive feelings about the intelligence level represented by the brain scans (i.e., in the individuals to whom the scans belonged) had difficulty articulating the origins of those feelings.

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[2] An ordinary 60 Hz microcomputer monitor was used, so the accuracy of display control was limited to the length of the refreshing cycle (±16.66 ms).

Discussion

The data we obtained in this research provide consistent support for the expectation that the cognitive system is capable of not only directly registering relations between variables encountered in the environment but also acting as if, in the process of encoding, indirect (transitive) inferences are drawn from the previously registered relations. As we mentioned in the introduction, the process of indirect inference observed in this research does not require a designated mechanism for nonconscious integration of knowledge; rather, the drawing of indirect inferences may simply represent a natural consequence of the organization of semantic memory. However, this does not change the fact that the observed process provides a potentially powerful means of expanding the system of encoding algorithms beyond those that result from covariations registered directly in the environment and for creating new knowledge structures.

It appears that the phenomenon observed in the present studies may play a particularly important role in the development of procedural knowledge because of the ubiquitous tendency of the cognitive system to spontaneously self-perpetuate encoding algorithms, even those that were initiated incidentally (Hill et al., 1989; Hill et al., 1990; Hill et al., 1991; Lewicki et al., 1989). Evidence from the experiments (on nonconscious self-perpetuation) based on a wide variety of stimulus materials consistently indicates that, once initiated, even encoding algorithms that are extremely weak and objectively unsubstantiated by external evidence may start to grow in a snowball-like manner and gradually exert more influence on a person's interpretation of incoming information. In light of the data we obtained in the present studies, it is reasonable to expect that inferential algorithms initiated through the processes of indirect (transitive) inference such as those observed in the present research may provide an abundance of starting points for the processes of self-perpetuation and eventually may be responsible for triggering the development of large portions of procedural knowledge structures used in encoding.

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