

Unconscious Acquisition of Complex Procedural Knowledge

Pawel Lewicki
University of Tulsa

Maria Czyzewska
University of Warsaw, Poland

Hunter Hoffman
University of Tulsa

This research demonstrates a process of acquisition of information about a complex pattern of stimuli and the facilitating influence of this knowledge on subjects' subsequent performance. In two experiments, subjects were exposed for 12 hr to a sequence of frames containing a target, and their task was to search for the target in each frame. The sequence was divided into logical blocks of seven trials each. Locations of the target in the seventh trial of each block were predictable on the basis of the specific sequences of target locations in four out of the previous six trials. Pilot studies and extensive postexperimental interviews indicated that none of the subjects noticed anything even close to the real nature of the manipulation (i.e., the pattern). However, the predicted patterns of latency of their responses to the critical trials indicate that they had, in fact, acquired some intuitive (unconscious) knowledge about how the pattern of prior trials was related to the critical trial. The phenomenon is discussed as a ubiquitous unconscious process involved in the development of both elementary and high-level cognitive skills.

There is evidence suggesting that "mind is better construed in terms of what it can do than in terms of descriptions of what it 'knows'" (Kolers & Roediger, 1984, p. 440). Measuring subjects' cognitive skills (i.e., procedural knowledge) is often a more sensitive method of learning about the effects of past experiences than measuring subjects' explicit (i.e., declarative) knowledge (Brooks, 1978; Jacoby & Dallas, 1981; Jacoby & Witherspoon, 1982; Kolers, 1975, 1976; Reber, 1986; Tranel & Damasio, 1985).

It has recently been argued that learning various kinds of basic cognitive skills and procedural knowledge involves acquisition of complex processing rules of which the subject is not aware (Lewicki, 1985, 1986a, 1986b). In other words, the subject acquires some form of intuitive knowledge about patterns of stimuli and how to process them, although the subject is unable to articulate these processing rules. For example, most people are unable to articulate semantic and syntactic rules of the language they use, although at the same time, they doubtless have intuitive knowledge of those rules (e.g., when asked by a foreigner they can always say *which* form is correct, but usually cannot say *why*; all they can say is that "it sounds better," Lewicki, 1986a).¹ The same is true about elementary perceptual phenomena. For example, most people have no idea how they go about determining distances between objects in three-dimensional space, although everybody has perfect processing

(inferential) rules that do the job "automatically" (Hochberg, 1978; Kaufman, 1974).

The same pertains to the area of social cognition. For example, very few people are capable of articulating any of the rules that they use to determine whether a human face is attractive, but everybody has such intuitive rules computing such information automatically. People are unable to articulate even the most basic proportions of the human face, but they have some knowledge of these proportions. It has been shown that people are sensitive to even small violations of the proportions, and in such cases they instantly "feel" that something is wrong (Lewicki, 1986a). In one study, subjects were exposed to a set of schematic sketches of human faces, some of which slightly violated one of the proportions. Most subjects had no difficulty with correctly pointing out the "less realistic" faces, but none of them were able to specify on what, in particular, they based their judgment.

A number of studies have suggested that subjects are able to acquire specific procedural knowledge (i.e., processing rules) not only without being able to articulate what they had learned, but even without being aware that they had learned anything (Lewicki, 1986a, 1986b). In the learning phase of those studies subjects were exposed to stimulus material that consistently followed some pattern. The pattern (e.g., a covariation between two features) was not salient and the subjects were unable to detect it even when they were explicitly asked and motivated to do so. In the testing phase, subjects performed a task that was relevant to the pattern. It appeared that, although the subjects were unable to articulate the pattern manipulated in the learning phase stimulus material, they still had acquired some

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Correspondence concerning this article should be sent to Pawel Lewicki, Department of Psychology, University of Tulsa, Tulsa, Oklahoma 74104.

¹ This area is relevant to the research on "implicit learning of artificial grammars" (Reber, 1976, 1986). For the recent discussion on implicit learning, see, Dulany, Carlson, and Dewey (1984, 1985) and Reber, Allen, and Regan (1985).

knowledge about it, because their performance in the testing phase showed a response bias that was consistent with the pattern (e.g., their interpretation of stimuli was biased by the covariation acquired in the learning phase).

One series of studies used a matrix-scanning paradigm (Lewicki, 1986a, Experiments 3.1–3.4). Subjects were asked to view a succession of frames of visual distractor characters (matrices of digits) and search for the location of a target character (the digit 6) within each frame. The manipulated pattern was the relation (i.e., co-occurrence) between locations of the target within the frame and certain incidental cues presented with each frame (e.g., subliminally exposed strings of characters, pitch level of the warning tone, or some properties of the frames). For example, there were four possible locations of the target in the frame, and each exposure of the frame was preceded by a subliminal exposure of one of four strings of characters. The subliminally exposed strings systematically co-occurred with the locations of the target, so that they could serve as cues as to where (i.e., in which quadrant) to look for the target in the subsequent frame. The manipulated pattern (i.e., the covariation between the strings and locations of the target) varied across blocks of trials. Response latency served as the dependent measure. Although subjects were unable consciously to detect the patterns, they did acquire some information relevant to the patterns: Subjects' performance across blocks of trials was predictably affected by the manipulated patterns (i.e., covariations between the strings and locations of the target).

The response bias observed in those studies was hypothesized to reflect a kind of unconscious priming effect in which the knowledge about the pattern primed specific responses (i.e., those consistent with the pattern). If the testing-phase stimulus material was consistent with the learned pattern, then the priming facilitated subjects' performance in the testing phase, that is, it decreased response latency. However, if the testing-phase material was inconsistent with the learned pattern, then the priming was found to interfere with the task: The wrong responses were primed and response latency eventually increased.

Some results obtained in those studies also indicated that the acquired information relevant to the pattern was transferred to long-term memory and could be selectively used depending on whether the pattern fit the particular stimulus material (Lewicki, 1986a, Experiments 3.3 and 3.4). This suggests the possibility that not only simple co-occurrences but also more complex (e.g., conditional or higher order) relations between some elements of stimulus material can be unconsciously processed and stored in the form of procedural knowledge like that involved in encoding of visual stimuli (Hochberg, 1978) or used in speech production (Lewicki, 1986a). This possibility is explored in the present research. The experiments to be reported address directly the issue of unconscious processing information about very complex patterns of stimuli and acquisition of respective knowledge capable of influencing perceivers' performance.

The procedure of the present experiments is a modification of the matrix-scanning paradigm. Subjects were exposed to a long sequence of frames presented on a computer screen. Each frame consisted of a target character displayed in one of four quadrants of the screen. There were four buttons that corresponded to the quadrants, and the subjects' task was to locate

the target and then press a button corresponding to its location. The entire sequence of locations of the target followed one consistent, but very complex and nonsalient pattern, and the subjects were expected to acquire knowledge about this pattern. In other words, the gradual improvement in subjects' performance (i.e., decrease in response latency) over the entire sequence of trials was expected to be due not only to the effect of nonspecific training, but also to acquisition of a rule capable of "predicting" subsequent locations of the target (according to the pattern) and thereby priming appropriate responses.

The difference between the procedure of the previous matrix-scanning experiments and the present one is that in the present study the entire sequence of trials was logically divided into blocks of seven, and only in the last trial of each block was the target exposed on the background of distractor characters (i.e., it was one of the elements of the matrix). In the first six trials of each block, the target was not accompanied by any distractor characters and therefore, in those trials the search for the target was very easy. The pattern of the stimulus material that predicted the location on the complex seventh trial was manipulated by varying the sequence of locations of the target in a selected four out of the six preceding simple trials.

This manipulated pattern predicting the target location was changed near the end of the sequence of trials. If the subjects had acquired knowledge about the pattern, their performance was expected to deteriorate after the change because their knowledge about the pattern would then prime an incorrect response and produce interference.

Experiment 1

Method

Overview and subjects. Because the pattern manipulated in this experiment was much more complex than the one used in the previous matrix-scanning studies, the total amount of stimulus material presented was much greater. The experiment consisted of 12 sessions. Each session lasted about 1 hr and was divided into four segments separated by short breaks. Each segment consisted of 96 blocks, and each block consisted of six "simple" trials followed by one matrix-scanning trial. Thus, each subject in this experiment was exposed to 4,608 blocks of seven trials, and he or she made a total of 32,256 responses.

The manipulated pattern (i.e., the relation between sequences of target locations in the simple trials and specific locations of the target in the matrix-scanning trials) was changed in the middle of the penultimate 1-hr session. The change consisted of replacing the manipulated contingency with a new one.

The subjects were one male and two female undergraduate University of Tulsa students, aged 19–22. There was no special selection of subjects. They were the first three volunteers (recruited in the student cafeteria) who agreed to meet the systematic schedule of the experiment. The subjects were tested for 6 days, two times a day, and the hours of the sessions were the same each day (although somewhat different for each subject). The subjects were paid \$60 for completing the 12-hr project.

Procedure and stimulus material. In order to minimize the variance of subjects' performance between the sessions, the schedule of the sessions was determined individually for each subject, so that when starting a session he or she was always relaxed and not tired. All sessions took place before 3:00 p.m., were always after meals, and were neither right before nor right after classes. There was always at least a 1-hr break between the first and the second session every day.

Subjects were tested individually in a small, quiet lab room. Before

the session began, subjects were asked to relax and then to concentrate on the task. To help them concentrate, there was a white background noise played throughout the entire session. Before each session, the instructions were briefly reiterated.

The subjects' task was to react to the appearance of the target (the digit 6) by pressing one of four keys corresponding to its location on the screen. In the "simple" trials, the screen was divided by one vertical and one horizontal solid line into four quadrants of equal size (see Figure 1). The target could appear in any of the quadrants. The keys used to respond to the target were 4, 5, 1, and 2 on the numeric keypad, which form a 2×2 square corresponding to the four quadrants of the frame. Subjects were asked to fix their sight on the intersection of the lines. This allowed them to see the target without moving their eyes from the center of screen. Both speed and accuracy were stressed in the instructions, and subjects were informed that both would be recorded by the computer.

The matrix-scanning trials were similar to the simple trials, except that the target was more difficult to find, because it was displayed as one of elements of a matrix of digits. The same type of matrix was shown to the subjects in all 4,608 matrix-scanning trials: It consisted of 36 (6×6) single-digit numerals, and it was divided into quarters (see Figure 2). All possible digits were represented in the matrix more than once except for the target digit 6, which was represented only once in each matrix, replacing one of the other elements of the matrix.

Unlike the simple trials, the matrix-scanning trials were designed so that the search for the target required subjects to move their eyes and therefore involved a decision as to where to look first. In order to eliminate trials that would not require eye movement, the target never appeared in the foveal area (Nelson & Loftus, 1980), that is, in any of the 12 locations that were closest to subjects' fixation point in the middle of the matrix. These (impermissible) locations for the target are marked with the dotted line in Figure 2. Throughout the succession of frames the target was randomly located in different quarters and in different locations within the quarters.

Each exposure (i.e., a simple or matrix-scanning trial) was preceded by a 50-ms warning tone. A subject's response terminated the exposure of the matrix (or the cross and the target in the simple trials) and triggered exposure of a mask which was a matrix consisting of 36 Xs substi-

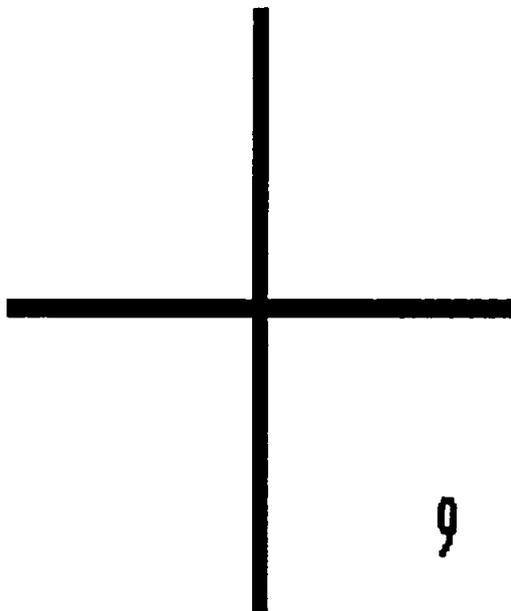


Figure 1. One of four simple frames exposed to the subjects.

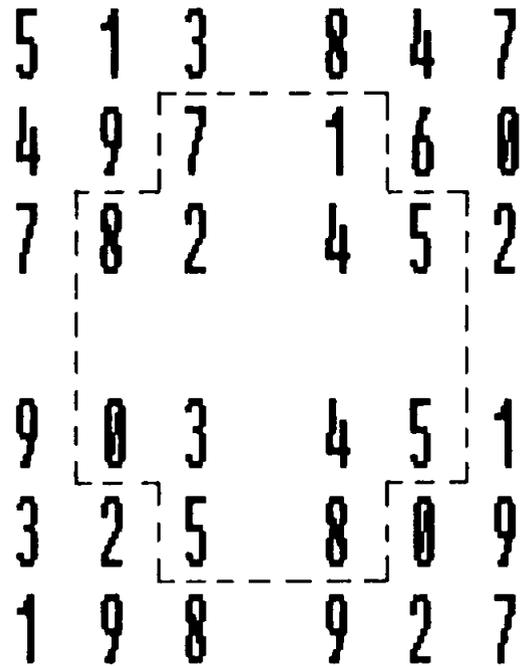


Figure 2. A basic matrix frame exposed to the subjects. (Targets were never placed in positions inside the dotted line; the line did not appear on the display.)

tuting for all digits of the original matrix. The mask remained on the screen for 100 ms.² There were 250-ms intervals between the end of the mask and onset of the next exposure, during which the display was blank. The breaks between the blocks (of seven exposures) were the same as breaks between all other exposures.

Manipulated pattern. The manipulated pattern was a relation between the sequence of target locations in four out of the six simple trials and the specific location of the target in the subsequent matrix-scanning trial. These four crucial simple trials were the first, the third, the fourth, and the sixth one. The locations of the target in the remaining simple trials (Trials 2 and 5) played the role of distractors and they were generated randomly by the computer. Within one sequence of the crucial simple trials (Trials 1, 3, 4, and 6), the target never appeared twice in the same quadrant, so there were 24 possible sequences. For each of these 24 unique patterns, one target location in the complex matrix trial was consistently displayed. In other words, there were 24 possible locations of the target in the matrix-scanning trial and each of the 24 unique sequences of the simple trials corresponded to one unique location of the target in the matrix-scanning trial (Table 1).

We intended by this design of the manipulated pattern that for subjects to predict the exact location of the target in the matrix-scanning trial, at least three target locations in the preceding crucial simple trials had to be learned in sequence.³ There were some other constraints put

² The ordinary 60-Hz computer CRT was used, so the accuracy of display control was limited to the length of the refreshing cycle (± 16.66 ms).

³ Within one sequence of the crucial simple trials (Trials 1, 3, 4, and 6), the target never appeared twice in the same quadrant. If subjects had learned about this "sampling without replacement," then the sequence of any three crucial simple trials was sufficient to predict the target location in the matrix scanning trial because the target location in the fourth simple crucial trial could be always predicted from the three other locations.

Table 1
Pattern of Target Locations: Experiment 1

		Trial						
1	2	3	4	5	6	7		
3	R	1	4	R	2	1		
3	R	4	2	R	1	1		
2	R	4	3	R	1	1		
4	R	1	2	R	3	1		
1	R	2	4	R	3	1		
2	R	3	1	R	4	1		
2	R	4	1	R	3	2		
1	R	3	4	R	2	2		
1	R	2	3	R	4	2		
4	R	3	1	R	2	2		
4	R	2	3	R	1	2		
3	R	1	2	R	4	2		
4	R	1	3	R	2	3		
1	R	3	2	R	4	3		
4	R	2	1	R	3	3		
3	R	2	1	R	4	3		
2	R	3	4	R	1	3		
1	R	4	3	R	2	3		
3	R	2	4	R	1	4		
3	R	4	1	R	2	4		
1	R	4	2	R	3	4		
2	R	1	3	R	4	4		
2	R	1	4	R	3	4		
4	R	3	2	R	1	4		

Note. 1 = upper left quadrant; 2 = upper right quadrant; 3 = lower left quadrant; 4 = lower right quadrant; R = random location; Each row represents 1 of 24 blocks of seven trials. The sequence of 4,608 blocks was randomly generated for each subject.

on the design of the pattern. The sequence of target locations was designed so that there was no systematic contingency between any particular simple crucial trial and target locations in the matrix-scanning trial.

The pattern manipulated in this stimulus material was obviously very complex and objectively very difficult to learn. In order to acquire intuitive knowledge of the pattern, subjects had to learn not only specific and relatively long sequences of target locations, but also which particular trials should be attended and which should be ignored. Moreover, the to-be-ignored trials were randomly generated by the computer and therefore created additional confusing effects. Some of those possible random effects could be salient and attract subjects' conscious attention. For example, the target could appear two times in the same quadrant on consecutive trials (e.g., 5 and 6), it could appear a total of four times in the same quadrant in one block of seven trials, or it could move consistently clockwise or counterclockwise over trials.

The change of the manipulated pattern was introduced in the second half of 11th session, in the middle of the 43rd segment. The change consisted of switching to a new relation (i.e., contingency) between simple trials and matrix-scanning trials. This new relation was produced by a systematic transformation of the previous contingency. The relation was "reversed": After the change, all the sequences of simple trials that used to predict target locations in the upper left quadrant of the matrix (in matrix-scanning trials) were now related to the analogous (i.e., symmetrical) target locations in the lower right quadrant of the matrix, and vice versa. The sequences that had predicted the target locations in the upper right and lower left quadrants were "exchanged" in the analogous way. Thus, after the change, the hypothesized intuitive knowledge about the pattern acquired by the subjects not only was of no help, but could even slow down their responses by priming the search in wrong quadrants of the matrix.

The entire sequence of 4,608 seven-trial blocks (i.e., the sequence of pairs: "six simple trials—one corresponding matrix trial") was randomly generated for each subject and the seed for the random generation was also different for each subject (so, the actual sequence was not only random but also different for each subject). However, each of the 24 unique patterns occurred 168 times on average, before the contingency was shifted in the 11th session.

Postexperimental interviews. After the last experimental session, subjects were extensively interviewed on whatever they could say about the task. They were also asked specifically about any patterns they had noticed in the stimulus material. Because none of the three subjects remembered any patterns, they were informed that the stimulus material followed a consistent pattern that allowed prediction of target location in the matrix-scanning trial on the basis of a sequence of target locations in a subset of six simple trials, and they were asked whether they had noticed anything more specific about this systematic pattern. The subjects were surprised that such a pattern even existed in the material to which they had been exposed. None of the subjects noticed anything even close to the real nature of the manipulation.⁴

Pilot study. A total of 45 subjects (male and female undergraduates) were exposed to the complete set of stimulus material used in this study for as long as they wanted in attempting to discover the pattern. They were informed that the material would follow a consistent pattern and that their task was to discover the pattern. They were also told that the pattern would allow them to predict the target location in the matrix-scanning trials on the basis of "some information that is included in target locations in the preceding simple trials." Subjects were promised a high cash award (\$100) for specifying correctly at least one pair of co-occurring elements (i.e., something specific about the target locations in simple trials and the corresponding location of the target in subsequent matrix-scanning trial). Time was not limited but the subjects were not allowed to take notes.

None of the subjects succeeded in discovering the pattern. Eighty percent of participants gave up after less than 1 hr of work. Interviews with the subjects suggested that none were even close to the correct solution (i.e., none of them were trying to separate subsets of informative simple trials).

Results and Discussion

The main measure of subjects' performance in this task was response latency on matrix-scanning trials. Subjects' performance on those trials was predicted to be facilitated by learning the predictive pattern from simple trials. If so, then after the pattern was changed in the 11th session, performance should deteriorate.

The means of subjects' response latencies on matrix-scanning trials in each of 48 segments of the stimulus material are displayed in Figure 3. Each segment contained 96 blocks of seven trials, so each point is based on 96 observations (i.e., the 96 matrix-scanning trials). The means indicate an effect of training, because in each subject, response latency decreased over the segments, reaching asymptote between Sessions 33 and 40 for the various subjects. Consistent with expectations, the change of the manipulated pattern in the 43rd segment of the

⁴ It should be noted that there were, in fact, two different rules (i.e., patterns of the material) used, and they were switched in the 43rd segment. This might make the task of reporting the rule more difficult. However, it seems very unlikely that the subjects noticed the rule in the first part of the task and then (after the rule was changed) forgot completely that there was any rule whatsoever.

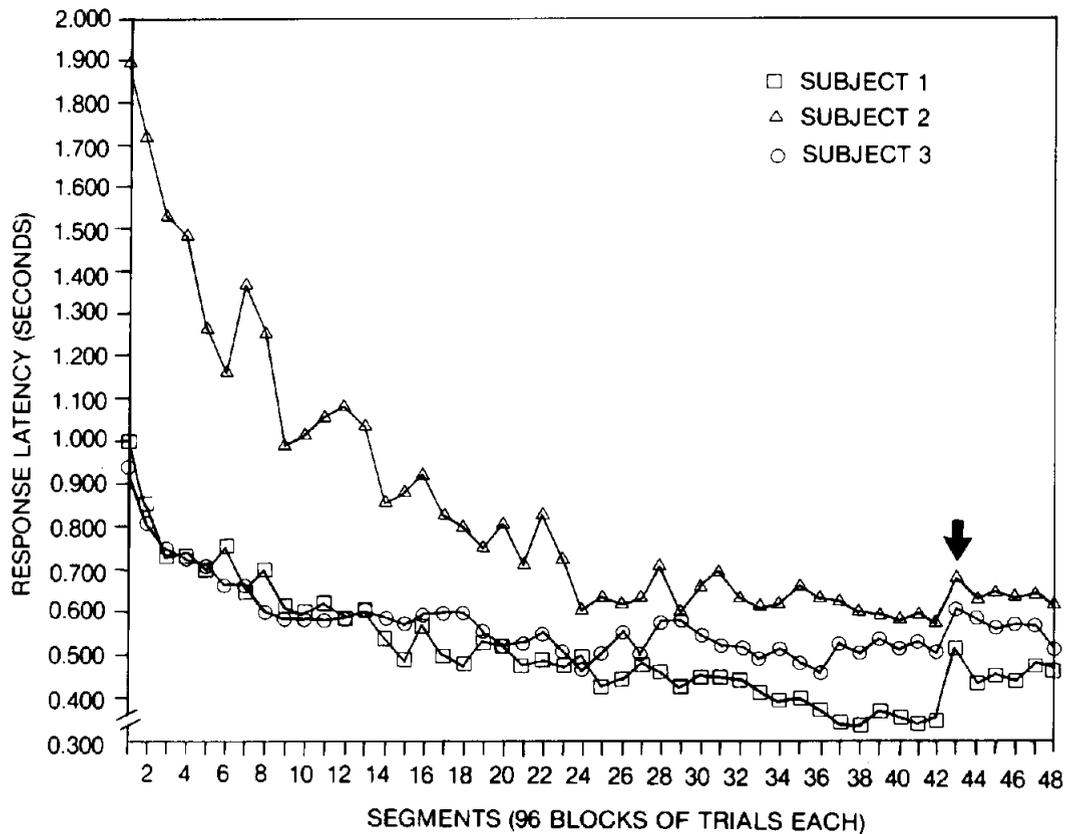


Figure 3. Means of response latency in 48 segments of Experiment 1. (Each point is based on 96 observations.)

task caused a clear increase of response latency in each of three subjects. A one-way analysis of variance (ANOVA) performed to compare response latency in the five segments preceding the change of the pattern (Segments 38–42) and the five segments following the change (43–47, see Table 2) revealed a reliable main effect, $F(9, 18) = 12.44$, $MS_e = 468.57$, $p < .0001$.

The subjects' responses were almost perfectly accurate and not affected by the change of the pattern introduced in the 43rd segment. The mean overall accuracy indexes for the three subjects were, in order, 98% ($SD = 1.4$), 98% ($SD = 1.2$), and 99% ($SD = .8$). Apparently the subjects tried to follow the instruc-

tion to be accurate and, after the change of the pattern, needed more time to find the target.

These results are consistent with expectations and indicate that subjects acquired some form of knowledge about the complex relation between the sequence of target locations in crucial simple trials and the location of the target in the matrix-scanning trials. When the pattern was changed, this knowledge interfered with correct responding and subjects' performance deteriorated.

The amount of this interference provides an estimate of the part of subjects' overall improvement across segments that was accounted for by their using the knowledge about the pattern. However, it is also possible that this index provides an overestimate of the rule's facilitative effect, because the observed interference may be due partly to some "misleading" effect of subjects' knowledge. No neutral or baseline condition existed in Experiment 1 against which to measure positive transfer. However, by either interpretation, the amount of improvement from learning the contingency was quite small relative to improvement from general practice.

The design of Experiment 1 also did not allow determination of how many blocks of trials were necessary to acquire intuitive knowledge about the pattern (i.e., at which point of the entire sequence of trials subjects' performance started to benefit from the acquired knowledge). This issue was addressed directly in

Table 2
Mean Response Latencies (in Milliseconds): Experiment 1

Subject	Mean response latency		Difference
	Segments 38–42 ^a	Segments 43–47 ^b	
1	349	464	115
2	521	581	60
3	591	648	57
<i>M</i>	487	564	77

^a Five segments before pattern change. ^b Five segments after pattern change.

Experiment 2, in which the stimulus material was redesigned to explore the development of unconscious knowledge about the pattern.

Experiment 2

The stimulus material used in the previous study was modified to allow more direct assessment of how much subjects' performance across the segments of trials benefited from using the knowledge about the pattern. The procedure used in this experiment was exactly the same as the one used previously, but the pattern of simple trials that predicted the location on the complex trials was redesigned.

Method

Overview. In this experiment, only 16 out of 24 possible sequences of crucial simple trials were consistently followed by respective target locations in matrix-scanning trials (according to the pattern used in Experiment 1). The remaining 8 sequences were unrelated to matrix-scanning trials in this new stimulus material, and they were followed by random target locations in matrix-scanning trials. Thus, in this experiment subjects could still acquire knowledge that would allow them to "predict" target locations in matrix-scanning trials based on the sequences of simple crucial trials, but this knowledge was helpful in only $\frac{1}{3}$ of cases (i.e., 16 of 24). Thus, this new stimulus material consisted in part ($\frac{1}{3}$) of blocks of trials that potentially evoked the process of learning ob-

served in Experiment 1, and in part of blocks that did not follow any consistent pattern ($\frac{1}{3}$).

Comparing subjects' performance on predictable and unpredictable matrix-scanning trials over the segments of the material should permit assessment of the acquisition of knowledge about the pattern. Specifically, this comparison allows determination of the point at which subjects start to benefit from the knowledge and how the size of this benefit increases over the segments.

Subjects. Subjects were three undergraduates (male and female) from the University of Warsaw. They were recruited and paid in the same way as in Experiment 1.

Procedure. The schedule of experimental sessions, and all details of the procedure were the same as in Experiment 1. The only change was the pattern manipulated in the stimulus material and a different postexperimental interview.

Postexperimental interview. After the last experimental session, subjects were informed that the 42 segments of the stimulus material to which they were exposed followed a consistent pattern and that in $\frac{1}{3}$ of blocks of trials this pattern allowed prediction of target location in the matrix-scanning trial based on the sequence of four out of the six simple trials. Subjects were promised a high cash award (equivalent of \$100) for specifying correctly at least one pair of co-occurring elements (i.e., a sequence of four target locations in simple trials and the corresponding location of the target in the subsequent matrix-scanning trial). To make the task easier, subjects were allowed to specify the target location in the matrix-scanning trial in terms of quadrants (not exact locations). Subjects were given 10 min to respond; they were allowed to specify up

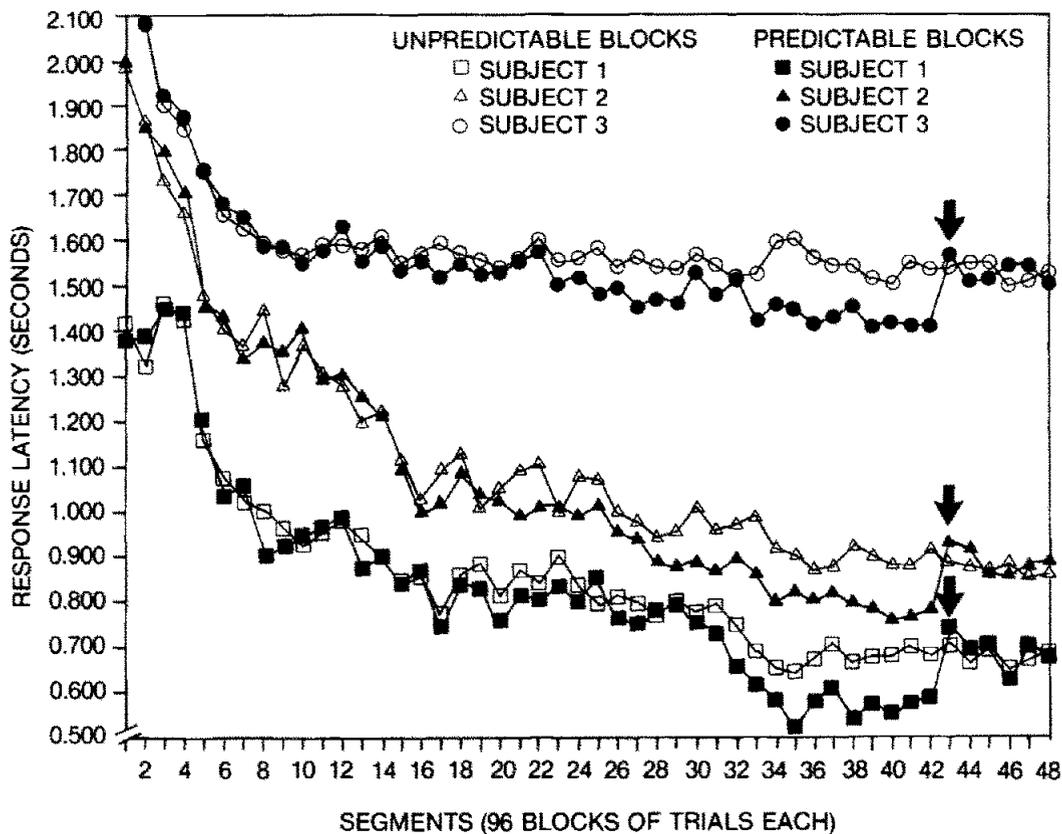


Figure 4. Means of response latency in 48 segments of Experiment 2. (Each point is based on either 64 [predictable blocks] or 32 [unpredictable blocks] observations.)

Table 3
Mean Response Latencies (in Milliseconds): Experiment 2

Subject	Mean response latency					
	Unpredictable blocks			Predictable blocks		
	Segments 38-42 ^a	Segments 43-47 ^b	Difference	Segments 38-42 ^a	Segments 43-47 ^b	Difference
1	681	675	-6	564	692	128
2	902	877	-25	775	890	115
3	1,529	1,530	1	1,417	1,535	118
<i>M</i>	1,037	1,027	-10	919	1,039	120

^a Five segments before pattern change. ^b Five segments after pattern change.

to five pairs and were promised to get the reward if at least one of the pairs they specified was accurate.

All three subjects were surprised that the material to which they had been exposed for 12 hr followed any consistent pattern. Finally, all of them guessed. The guesses were not only inaccurate, but none of subjects were even able to correctly specify which four out of six simple trials were the crucial ones.

Results and Discussion

The means of subjects' response latency on predictable and unpredictable matrix-scanning trials in each of 48 segments of the stimulus material are displayed in Figure 4. The means indicate that, as expected, subjects' performance on predictable trials was initially at the same level as their performance on unpredictable trials. However, their performance on predictable trials increased faster, was better overall, and when the pattern was changed in the 43rd segment it was more affected by the change (i.e., it decreased more).

The plots of means show that after about 15-20 segments of the task (1,440-1,920 seven-trial blocks), subjects' performance on the predictable trials had become consistently superior to that on the unpredictable trials. An ANOVA (2×42 : Predictable vs. Unpredictable Trials \times Segments 1-42) revealed a main effect of trial, $F(1, 2) = 412.46$, $MS_e = 315.99$, $p < .01$, which indicated that the responses on predictable trials were overall faster than responses on unpredictable trials, and an interaction between the two factors, $F(41, 82) = 4.73$, $MS_e = 707.59$, $p < .0001$, which indicated that the difference between unpredictable and predictable trials increased over the first 42 segments.

A separate ANOVA (2×10 : Predictable vs. Unpredictable Trials \times Segments 38-47) was performed to compare response latency in the five segments preceding the change of the pattern (38-42) and the five segments following the change (43-47; see Table 3). There was a significant interaction found between the two factors, $F(9, 18) = 20.76$, $MS_e = 353.15$, $p < .0001$. Planned comparisons (contrasts between Segments 38-42 and 43-47) revealed that the response latency on predictable trials decreased after the change of the pattern, $F(1, 2) = 991.58$, $MS_e = 109.40$, $p < .008$, whereas the response latency on unpredictable trials did not change significantly, $F(1, 2) = 1.63$, $MS_e = 442.92$, $p = .33$.

Consistent with the results of Experiment 1, subjects' re-

sponses were almost perfectly accurate and not affected by the change of the pattern introduced in the 43rd segment. Apparently the subjects tried to follow the instruction to be accurate and after the change of the pattern they needed more time to find the target. The mean overall accuracy index for the 3 subjects computed for the predictable trials is 98% ($SD = 1.2$) and is equal to the index computed for the unpredictable trials 98% ($SD = 1.1$).

General Discussion

The results obtained demonstrate the acquisition of intuitive knowledge about a complex pattern of stimuli. The process was unconscious in the sense that subjects were neither aware that they were learning the rule nor aware of how the acquired knowledge facilitated their performance. The data in Figure 4 suggest that after being exposed to roughly 2,000 blocks of the stimulus material, subjects had acquired enough knowledge about the pattern to facilitate performance. However, this knowledge was procedural, not declarative. That is, the knowledge facilitated subsequent performance, but unlike declarative knowledge, it was inaccessible to conscious examination.

The specific influence of the knowledge on subjects' performance was automatic in the sense that it was not mediated by consciously controlled processes. However, this learning appears different from automatic processes studied before (e.g., Shiffrin & Schneider, 1977), which involved the use of knowledge that was at one time consciously controlled and that only later, because of extensive training, had gradually become automatic. The learning observed in this experiment influenced subjects' performance without apparently ever being consciously recognized or controlled.

Subjects in this experiment seemed to have little choice or control over whether or not they learned the pattern and, after they had acquired some knowledge, whether or not to use it. This is an important feature of the phenomenon observed. The cognitive system appears capable of storing more information about events than can be processed through the consciously controlled channels.

The processes observed in this study exemplify a general property of information processing, by which some aspects of unconsciously learned information automatically prime appropriate responses when relevant stimuli are encountered. This property of the cognitive system presumably permits a person to process more information than could be handled by the consciously controlled channels and releases the controlled processing from the responsibility of dealing with numerous tasks supporting every act of consciously controlled cognition, like recognition of shape and location of objects in three-dimensional space (Hochberg, 1978), speech production (Lewicki, 1986a), or forming first impressions of social stimuli (Nisbett & Wilson, 1977).

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1988 APA Convention "Call for Programs"

The APA "Call for Programs" for the 1988 annual convention will appear in the October issue of the *APA Monitor*. The 1988 convention will be in Atlanta, Georgia, from August 12 to August 16. Deadline for submission of programs and papers is December 21, 1987. This early deadline is required because the 1988 convention is earlier in August than in the past. Additional copies of the "Call" will be available from the APA Convention Office in October.
