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Processing Information About Covariations That Cannot Be Articulated

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Processing of covariation (among features) present in stimulus material was investigated. Subjects were unable to articulate the manipulated covariation between verbally described psychological characteristics and appearance of a set of stimulus persons. Based on the two-stage question answering model (Glucksberg & McCloskey, 1981), it was hypothesized that if the information related to the manipulated covariation was processed and registered, it would result in an increase of processing time for the questions that might be considered relevant to the covariation. The pattern of response latencies obtained in each of 3 experiments conformed exactly to the predictions. In 2 of these experiments, effects of the stimulus material on subjects' subsequent judgments were found, consistent with the model. Subjects behaved as if they had "learned" the rule (implied by the covariation) and followed it in their subsequent judgments. The demonstrated phenomenon pertains to an important and presumably ubiquitous aspect of processing categorical information.

Research on "implicit learning" suggests that people can process information about complex relations between elements of stimulus material without being able to articulate these relations. In a series of studies, Reber and his colleagues demonstrated that after being exposed to a number of items (strings of letters) generated by a set of specific rules (a "grammar" that specifies permissible orders of letters), people are able to use these rules (or information related somehow to these rules) in their subsequent judgments pertaining to whether novel items obey these rules, although the perceivers are not able to articulate the rules they use (Reber, 1967, 1976; Reber & Allen, 1978; Reber & Lewis, 1977). Reber concluded that such implicit and unconscious[1] learning is a natural product of attending to structured stimuli. Although the specific mechanism of implicit learning is far from being clear, these results indicate that people are able to process information about certain rules contained implicitly in stimulus material and to use these rules (or information related somehow to these rules) in their subsequent perceptions, and still be unable to articulate the rules (see also Brooks, 1978; Gordon & Holyoak, 1983).

The research on implicit learning raises the question as to what kind of formal aspect or "hidden" structure contained in stimulus material is subject to such processing without a perceiver's being able to articulate what in particular is being processed. Recent research by Lewicki (1982, in press) suggests that one of these formal aspects might be the covariation among events or features.[2] This research seems to indicate that nonsalient covariations which are present in stimulus material but which subjects cannot articulate nevertheless may be processed and may influence the subjects' subsequent perceptions (Lewicki, 1982, 1984). It is widely accepted that much of what we know is tacit knowledge and that processes of acquisition of that knowledge are implicit (e.g., Lachman, Lachman, & Butterfield, 1979; Neisser, 1967). Very little is known, however, about these processes. The possibility that consistencies or covariations in a stream of stimuli may be processed without complete awareness or control deserves research attention because that process might be one of the major mechanisms of acquisition of tacit knowledge and semantic information in general.

However, even if the phenomenon of such detection of covariations is ubiquitous and common in real-life cognition, proving it in the laboratory will be complicated for methodological reasons (Lewicki, in press). Namely, if a manipulation providing the subjects with implicit covariation is strong, at least some subjects will be able to identify and articulate it, and thus its impact on the dependent measure (e.g., the use of the registered covariation in subsequent perceptions) could be attributed to demand characteristics or some similar phenomenon. On the other hand, if the manipulation is weak enough to ensure that none of the subjects can articulate the covariation, its possible effect might not be strong enough to show up in the subjects' subsequent perceptions. The latter does not necessarily mean that the nonsalient covariation is not processed—the measure used simply might not be sensitive enough to capture the effect.

Some recent research on retrieval of information from long-

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[1] Reber's claim that the experiments on implict learning involved unconscious processes was recently objected to by Dulany, Carlson, and Dewey (1984); see also Reber, Allen, and Regan (1985), and Dulany, Carlson, and Dewey (1985).

[2] Both everyday experience and experimental evidence indicate that people are consciously able to register and estimate consistent covariations among stimuli (Alloy & Tabachnik, 1984); however, it may happen only when the covariation is very salient.

term memory indirectly suggests that a response latency measure of processing covariation may prove more sensitive than a straightforward measure based on subjects' use of the registered covariation in subsequent judgments.

In their "question-answering model" Glucksberg and McCloskey (1981) postulated that answering questions involves a two-stage process:

> In the first stage a preliminary memory search is conducted to determine whether anything relevant for answering the question is known. If no relevant information is found, a rapid don't know decision is made. If, however, relevant facts are retrieved, these are examined in detail to determine whether they specify an answer to the question. If the retrieved information proves to be unsufficient, however, a slow don't know response is made. (p. 321)

In a series of studies, Glucksberg and McCloskey determined that, consistent with their model, the response latency was considerably longer when the stimulus material the subjects were exposed to prior to answering the questions contained any sort of information relevant to the question than when it contained no such relevant information. It was true even when the relevant information was confined to a statement that nothing relevant was known about the issue. For example, response latency to the question of whether it was true that "John has a chair" was longer when the subjects had learned that "John has a chair" or "John does not have a chair" and even when they had learned that "It is unknown whether John has a chair" than when they had not learned anything relevant to the relation between John and a chair (i.e., when they had learned only about somebody else possessing a chair and about John possessing something else).

These results suggest that latency of response to a question might provide a sensitive measure of whether anything relevant to the question has been registered by a perceiver in the stimulus material to which he or she was previously exposed.[3] If there exists in memory some relevant information, then response latency is longer. Even when the "relevant" knowledge is not informative enough to influence subjects' responses, the mere existence of that knowledge will influence (i.e., increase) subjects' response time.

The reasoning just mentioned may be applied to processing information about covariation because a covariation may also be considered a case of information relevant to some questions. Namely, if a perceiver has registered and memorized a covariation between categories x and y, and has not memorized a covariation between categories x and z, then he or she should possess information relevant to a question as to whether an exemplar of category x is y, and should not possess such information concerning a question as to whether an exemplar of category x is z. Eventually, his or her response latency to the former question should be longer than to the latter one.

A strong point of this method of determining whether a covariation has been processed is that it potentially might reveal the existence of a memory trace of the previously registered covariation that is too weak to bias subjects' subsequent perceptions directly. Thus, even if the memory trace of the processed covariation failed to influence subjects' subsequent judgments, the method was hypothesized to be sensitive enough to detect the mere existence of the trace of the covariation. This reasoning was tested in the two following experiments (1a and 1b).

The stimulus material consisted of photos and short descriptions of 6 stimulus persons. Three of them had long hair and they were presented as very kind, and three others had short hair and they were presented as very capable. The material was arranged so that these covariations were not salient, and subjects could not articulate them even when asked to do so by the instruction (see the Pilot Studies sections). In the testing phase, the subjects were exposed to photos of some other stimulus persons (either long or short haired) and asked either whether the person was kind or whether she was capable. Based on the reasoning about retrieval of information from long-term memory it might be expected that if the covariations present in the material were detected and memorized by the subjects, the response latency to the question relevant to the covariations would be longer than the response latency to the irrelevant questions. For example, response latency to the question as to whether a stimulus person was kind would be longer when the specific person was long haired (because subjects possessed the relevant knowledge that long-haired persons are kind) than when she was short haired (because nothing was "learned" about the kindness of short-haired persons). Response times for the questions about capability would be analogous (i.e., "reversed").

Experiment 1a

Method

Overview. The stimulus materials were 6 slides presenting faces of young women, accompanied by brief descriptions read by the experimenter. The women differed in their haircut: 3 had long hair and 3 had short hair. The descriptions differed in what traits they referred to: 3 of them focused exclusively on the kindness and helpfulness of the stimulus person, 3 others on her capability and effectiveness. There were two versions of stimulus material. One group of subjects was exposed to the stimulus material in which all 3 women with long hair were kind and all 3 with short hair were capable (Condition I), and the other group was exposed to the material in which all 3 long-haired women were capable and all 3 short-haired women were kind (Condition II). In other words, the former group received no information relevant to capability of long-haired women or to kindness of short-haired women; the latter group received no information relevant to kindess of long-haired women or to capability of short-haired women.

After a distractor task the subjects were asked about the kindness and capability of a different set of 4 stimulus persons presented on slides; half of them had long and half of them had short hair. Latency of responses to these questions was measured.

An important difference between Glucksberg and McCloskey's (1981) experiments on retrieval processes and the present study is that in the former ones the relevant information was explicitly stated in the stimulus material, and in the latter it was contained implicitly, that is, it could influence subjects' response time only if it had actually been registered. In this sense the present study provided a test of whether the subjects had processed information relevant to the covariation.

Subjects. Fifty-four undergraduates from the University of Warsaw participated in the study. There was an equal number of men and women; none of them were psychology majors. The subjects were recruited in various parts of the campus in order to minimize the probability that they knew each other, because it was important in the present experiment

[3] This is consistent with the spreading activation model of Anderson (1983) and has been empirically confirmed before (e.g., King & Anderson, 1976; Reder & Ross, 1983).

Figure 1. Experiment 1a: Stimulus persons.

that the subjects not know the procedure before entering the lab room. They were randomly assigned to 2 experimental conditions (i.e., the 2 versions of the stimulus material), separately by sex.

Stimulus material. The process of selecting the slides was based on anthropological advice and the opinions of a number of judges (men and women undergraduates). The aim was to obtain 2 sets of faces that would differ exclusively in their haircut and not in other characteristics (like race, anthropological type, color of hair, size and color of eyes, proportions and shape of face, general attractiveness as estimated by men and women, and type of dress). Finally, 10 photos (black and white) of women (undergraduates) were selected out of a pool of about 50 photos. Six of them were used in the learning phase and 4 in the testing phase (in different arrangements). The photos were slightly different in degree of "close-up" in order to make comparisons between them more difficult. The haircuts within each of the 2 subsets (i.e., long and short hair) were differentiated in order to make the difference between the sets less salient; that is, it was not so that stimulus persons all had either very short or very long hair. The photos are displayed in Figure 1 and they are arranged so that the 2 rows represent the 2 levels of haircut (long and short) and each column represents the pair of faces considered by the judges as similar both "physically" and "psychologically." The latter was positively verified in a pilot study with 70 undergraduates who rated each of the 10 photos on 5 six-point, bipolar trait dimensions (kind, capable, persistent, frank, physically attractive). The pilot study subjects were tested individually and the order both of photos and of trait-dimensions was randomized across the subjects. The overall means for the photos of long- and short-haired persons indicated that there was a trend suggesting that short-haired stimulus persons were perceived to be slightly more capable ($p < .11$); there were no differences, however, even approaching the .10 significance level for the other 4 dimensions).

There were 4 permutations of the 10 slides used in regard to which of them served in which phase (learning or testing) and in which order they were presented. The sets were the same in both experimental conditions and each slide served about an equal number of times in the learning phase and in the testing phase. The slides of short-haired and long-haired persons were presented alternately, both in the learning and in the testing phase. (These orders of slides appeared to affect none of the dependent measures.)

It was made clear to the subjects that the stimulus persons were psychologically unusual and that the descriptions would focus only on those special features. The descriptions were very short (3 sentences each) and pertained exclusively to either kindness or capability: The stimulus persons were presented as either very kind and helpful or very capable and effective. The descriptions are quoted fully in the Appendix.

Procedure. Subjects participated individually. The session began with training with the reaction time apparatus. Questions referring to whether certain people a subject knew (such as mother, friend, professor) possessed certain personality characteristics were presented in the rear projection screen, and subjects were asked to respond quickly and accurately by pressing either the *yes* or the *no* key on a control box.

The next part of the experiment was introduced to the subjects as "a kind of psychological training which helps you concentrate before the experiment." Slides of 6 of the 10 stimulus persons were presented in the rear projection screen (48 × 72 cm, and about 150 cm distant from a subject) by a programmed projection tachistoscope. Each slide was presented for 15 s and there were 2.5-s long intervals between the presentations, during which the display was blank. The trained experimenter read the descriptions in such a way that she finished reading each description 1–2 s after the offset of a slide. That is, the text was always a little bit longer than the exposure of a slide and subjects could never watch a slide without being distracted by the text being read. (As compared to presenting text from a tape recorder, this method has the advantage of better attracting a subject's attention.)

The subjects were also told that the stimulus persons were real and that they were chosen as remarkable (i.e., especially positive in some respect) from a large pool of extensive case studies prepared recently by students of clinical psychology. This was explained in detail to make the subjects serious about the stimulus material and to prevent subjects' becoming suspicious about the artificial pattern that was followed by the stimulus material (e.g., about the rules of matching slides and descriptions), which could be the case if subjects thought the material was fictitious.

The experimenter was blind to the sequence of slides that was exposed to each subject; thus she did not know to which slide a given description referred (long or short hair). Subjects were asked to imagine the personalities of the persons described and displayed but not to relate these images to their impressions of any real persons they knew that might resemble a stimulus person physically or psychologically. These instructions were introduced as "requirements of successful training."

It should be noted that the time sequence of the exposures (16–17 s long presentations of material and .5–1.5 s long intervals) left subjects no spare time to think, make conscious comparisons, and so forth. The descriptions had to be read fast to fit their 16–17 s limits.[4]

There was a distractor task separating the learning phase from the dependent measures, designed to interfere with subjects' short-term memory. This distractor was a standardized "conversation" initiated by the experimenter, which lasted approximately twice as long as the entire presentation of the stimulus material (i.e., about 3 min).

Next, subjects were presented with the 4 remaining slides; each of them was exposed two times: once accompanied by the one-word question KIND? and once by the one-word question CAPABLE?; thus, there was a total of 8 exposures in this phase of the experiment. The two exposures of the same slide were separated by 2–4 other exposures. The one-word questions covered the lowest $\frac{1}{3}$ part of a slide and were printed in uppercase block letters (9 cm high), black on white. The onset of the slide triggered a microprocessor timer accurate to the nearest millisecond. Measurement of the response latency ended either when the subject pressed one of two keys, *yes* or *no*, on a control box, or when a 10-s maximum had been reached (which never happened). The timer registered subjects' yes–no responses and response times. There were 3-s long intervals between the presentations, during which the display was blank. Subjects were told not to consider in detail their responses, but instead to respond as quickly as possible following only their "first thought" about the stimulus person.

At the end of the session, subjects were asked whether they were "able to discover a co-occurrence between the psychological characteristics of the stimulus persons presented during the first stage of the experiment and any of their visual characteristics." Over 75% of the subjects responded *yes* and explained that there was something special but difficult to describe in their faces (e.g., "Those intelligent girls simply looked brighter"). Most of the subjects mentioned the stimulus persons' gaze, and said that some of them possessed "those typical eyes of the dependable person" or "a sharp gaze of a bright person." Not one subject mentioned haircut or anything connected with hair.

A potential shortcoming of this measure of what the subjects were able to consciously discover was that it could be used only after the dependent measures and not directly after exposure of the stimulus material. Therefore, an additional pilot study was completed.

Pilot study. Thirty-two undergraduates, recruited in the same way as in the main study, were tested individually by the same experimenter following the same procedure up to the distractor, which was not used. Instead, the subjects were asked directly for co-occurrences between the visual and verbal data they were able to discover in the stimulus material. The results obtained confirmed exactly the ones obtained in the main study—not one subject mentioned the hair.

In the next pilot study (with the same number of participants), the same procedure was used except that prior to being exposed to the stimulus material the subjects were set by an instruction to search for covariations between the visual and verbal data. Again, not one of the 32 subjects mentioned the hair. This inability to discover the covariation might seem surprising. It is understandable, however, when taking into account the fact that the subjects believed that the stimulus material was not fabricated by the experimenters, and thus the subjects were trying to look at (or test) only the co-occurrences that made some sense to them, like bright gaze or the like. These results were also consistent with the previous study by Lewicki (in press) in which subjects were unable to discover covariation between haircut and ability in math after seeing as many as 10 stimulus persons (in the present study there were only 6 of them).

It may be expected that if subjects were asked directly whether hair length covaried with kindness and capability at least some of them would be able to "reconstruct" the crucial covariation, because subjects were probably able to recall at least a few stimulus persons. That obviously would not mean, however, that they would be able to discover the crucial covariations if they were not helped by an experimenter's specific question.

Because a number of subjects in the main experiment had mentioned stimulus persons' gaze, the question arose as to whether it was not the stimulus persons' hair that actually influenced the appearance of the eyes (e.g., short hair might emphasize the eyes, making them look larger) which, in some sense, would indicate awareness of the covariation between hair length and kindness or capability. In order to check this possibility, another group of 21 subjects rated the eyes of each stimulus person on six dimensions: size, darkness, salience (prominence), eye separation, "sharpness" of the gaze, and "trustworthiness" of the gaze (opposite to "shifty"). No differences were found between long- and short-haired stimulus persons. Obviously, it cannot be excluded that hair length influenced appearance of some other element or aspect of the stimulus persons' faces; no evidence was obtained, however, indicating that it was in fact the case, and even if it was so, subjects were unable to articulate that element or aspect.

Results

Mean yes- and no-response latencies to each of 2 questions (KIND? vs. CAPABLE?), referring to each of 2 haircut types of stimulus persons (long vs. short), in each of 2 experimental conditions (I vs. II) are displayed in Figure 2. The means indicate that regardless of the specific response (either *yes* or *no*), the subjects in each condition responded more slowly to the questions that were relevant to the covariation they were exposed to. Namely, the subjects in Condition I, who had been exposed to the version of the stimulus material in which long-haired persons were kind, responded more slowly to the questions as to whether long-haired persons were kind than to the analogous questions pertaining to short-haired persons. In this version of the stimulus material, short-haired persons were, in turn, capable and, in this group, response latencies to the question as to whether short-haired persons were capable were longer than to the analogous questions pertaining to long-haired persons. The pattern of response latencies was exactly reversed in Condition II, in which the subjects were exposed to the *reversed* stimulus material (i.e., in which short-haired persons were kind and long-haired persons were capable).

These results were analyzed by means of a 2 × 2 × 2 (Condition: I vs. II × Question: KIND? vs. CAPABLE? × Haircut: Long vs. Short) analysis of variance (ANOVA) with repeated measures on the two last factors. The yes- and no-response latencies were added together because the yes–no factor could not be included in the ANOVA design. (This factor was not controlled and thus not all of the subjects provided both *yes* and *no* responses to each of the four categories of questions.) There was a significant interaction among the 3 factors, $F(1, 52) = 10.14$, $MS_e = 138{,}698$, $p < .002$, suggesting that this predicted pattern of response latencies was reliable. Planned comparisons (contrasts) revealed that response latencies for each of the two questions (i.e., KIND? and CAPABLE?) contributed about equally to this interaction ($ps < .01$).

The aggregation of yes- and no-response latencies, which made this analysis possible, seemed justified because the patterns of the means of the response latencies were comparable for both *yes* and *no* responses (see Figure 2), and the predictions did not discriminate between the two types of response. However, the frequencies of yes–no responses were not exactly the same across the conditions, questions, and haircut of stimulus persons (see

[4] The descriptions presented in the Appendix can be read in about 12–13 s. However, they are English translations; the original descriptions were in Polish, and spoken Polish requires more words than English.

the analysis reported later) and thus it seemed worthwhile to test whether the reliability of the predicted effect could be demonstrated in separate analyses for *yes* and *no* responses. In order to do that, for each subject a difference was computed between the mean response latency to long- and short-haired stimulus persons, separately for each question, and separately for *yes* and *no* responses. The predictions of the model were that for both *yes* and *no* responses this difference would be higher for subjects in Condition I than for subjects in Condition II as far as the question about kindness was concerned, and higher in Condition II than in Condition I as far as the question about capability was concerned. All 4 differences (i.e., for each of the 2 questions and for both *yes* and *no* responses) were in the predicted directions (which could be well expected based on the means displayed in Figure 2), and all 4 of them were significant, $ts > 2.00$, $p < .05$, which indicated stability of the effect across both yes- and no-response latencies.

There was only one more reliable effect in this 3 factor ANOVA performed on response latencies, the main effect of question, $F(1, 52) = 33.75$, $MS_e = 137{,}172$, $p < .001$, indicating that the question about capability produced generally faster responses.

An analogous 2 × 2 × 2 (Condition × Question × Haircut) ANOVA was performed on yes-response frequencies (yes- and no-response frequencies correlated −1, because there was no other possible response). Similarly to the analysis performed on response latencies, this analysis also revealed a significant interaction of all 3 factors, $F(1, 52) = 5.59$, $MS_e = 0.278$, $p < .025$. As opposed to the interaction revealed for response latencies, however, this one appeared to be produced solely by responses to the question about capability. Namely, two-factor ANOVAs (2 × 2 [Condition × Haircut]) found a clear interaction for this question, $F(1, 52) = 9.08$, $MS_e = 0.665$, $p < .004$, and no interaction for the question about kindness, $F(1, 52) = 1.08$, $MS_e = 0.436$, *ns*. Means of yes-response frequencies are displayed in Table 1. The means for the question about kindness show no clear effects, the means for the question about capability, however, suggest an effect consistent with the manipulation. Namely, subjects from Condition I, who were exposed to the stimulus material in which short-haired stimulus persons were capable, responded more often *yes* to the questions about capability of short-haired persons than to the analogous questions referring to long-haired persons, whereas exactly the opposite effect was revealed among subjects in Condition II, who were exposed to the *opposite* stimulus material.

The overall ANOVA on yes-response frequencies also revealed a significant main effect of question, $F(1, 52) = 9.09$, $MS_e = 0.414$, $p < .004$, indicating that subjects responded more often *yes* to the question about kindness than to the question about capability.

Table 1
Experiment 1a: Means and Standard Deviations of Yes-Response Frequencies

Question	Condition I	Condition II
KIND?		
Long hair		
M	1.23	1.42
SD	0.70	0.69
Short hair		
M	1.27	1.19
SD	0.52	0.73
CAPABLE?		
Long hair		
M	0.81	1.31
SD	0.73	0.72
Short hair		
M	1.19	0.73
SD	0.78	0.76

Note. Subjects in Condition I were exposed to stimulus material in which long-haired persons were kind and short-haired ones were capable; subjects in Condition II were exposed to the opposite.

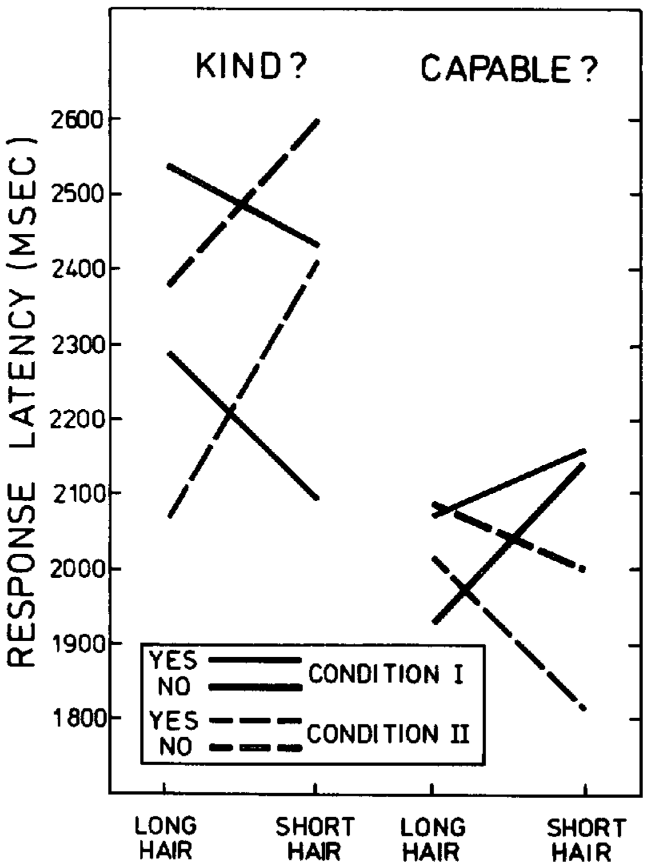

Figure 2. Experiment 1a: means of response latencies. (Subjects in Condition I were exposed to stimulus material in which long-haired persons were kind and short-haired ones were capable; subjects in Condition II were exposed to the opposite.)

Discussion

The expectations received full support. For all conditions, questions, and haircut types of stimulus persons, the subjects responded more slowly after being exposed to material implicitly containing relevant information. Because the material could provide such information only if a perceiver registered and processed the covariation it contained, these results indicate that the covariation had actually been registered and processed.

These results are consistent with the informal two-stage model discussed in the introduction. Namely, in the case of questions that were not relevant to the stimulus material a subject was exposed to (e.g., pertaining to the capability of a long-haired person in experimental Condition I), after completing a "preliminary memory search" nothing relevant was found and thus, the subject was ready to make "a rapid don't know decision" (Glucksberg & McCloskey, 1981). Such a response, however, was not allowed in the present procedure (as opposed, for example, to Glucksberg and McCloskey's task, 1981), because if it were, probably all subjects would respond that way to the majority of questions. Thus, subjects had to give a *yes* or *no* response which was either random or generated on the basis of cultural stereotypes concerning salient properties such as the eyes. In the case of relevant questions, however, in the preliminary memory search, relevant information (i.e., covariation detected in the stimulus material) was retrieved and it lead to the initiation of the second stage: evaluation of the relevant facts "in detail to determine whether they specify an answer to the question" (p. 321). This, in turn, led to an increase in response time.

The analysis of yes-response frequencies revealed a specific effect of stimulus material for one of the two traits being manipulated. Namely, the subjects seemed to "learn" about the specific covariation between capability and haircut (subjects in each condition learned something different about this covariation), and they used this knowledge in subsequent perceptions. This finding may suggest that, at least in some subjects, the memory representation of the relation between capability and stimulus persons' appearance was sufficient to permit an informed answer, or it at least produced a tendency to respond consistently with the evidence. Such a tendency appeared finally to be stronger than the opposite tendency that might be produced by some other relevant facts, not controlled in the experiment. The existence of this effect might suggest that in some instances very little evidence is needed to produce certain general dispositions capable of influencing further perceptions.

We attempted to replicate these results with different stimulus materials.

Experiment 1b

Method

The general design of Experiment 1a remained unchanged except there was no training with the reaction time apparatus. The same set of slides was used, with 6 of them serving in the learning phase and 4 in the testing phase, but the 4 versions of their order (used in Experiment 1a) were entirely different. Descriptions were completely new, and they referred to different traits: FRANK and PERSISTENT. Subjects in Condition I were exposed to stimulus material in which long-haired stimulus persons were frank and short-haired stimulus persons were persistent, and subjects in Condition II were exposed to the opposite. The stimuli were presented according to a slightly different time schedule, the screen was different, the lab room was different, and it was located in a dormitory. There were different experimenters (all women).

Participants were 80 undergraduates from the University of Warsaw.

Pilot study. Only the second version of the pilot study conducted for Experiment 1a was used. Thirty-two subjects were asked to search for covariations between the visual and verbal data during the learning phase. The subjects were tested in the same arrangements as the subjects in Experiment 1b. Except for the instruction to search for covariations, all other instructions and details of the procedure were the same. Again, not one of the subjects discovered the covariation, and again gaze was mentioned most often.

Results

Mean yes- and no-response latencies to each of the 2 questions (FRANK? VS. PERSISTENT?), referring to each of 2 haircut types of stimulus persons (long vs. short), in each of 2 experimental conditions (I vs. II) are displayed in Figure 3. All the response times appeared to be considerably longer than in Experiment 1a, which may have been due to the lack of training on the reaction time apparatus in the present procedure. The pattern of means, however, indicated that, analogous to Experiment 1a, regardless of the specific response (either *yes* or *no*), the subjects in each condition responded more slowly to the question that was relevant to the covariation they were exposed to.

The same design ANOVA as the one used in Experiment 1a was performed on the aggregated yes- and no-response latencies, with condition (I vs. II) as a between-subjects factor and question (FRANK? VS. PERSISTENT?) and haircut of stimulus persons (short vs. long) as within-subjects factors. The only significant effect was the interaction among all 3 factors, $F(1, 78) = 9.78$, $MS_e = 465{,}846$, $p < .002$, indicating that the predicted pattern of response latencies was reliable. Planned comparisons (contrasts)

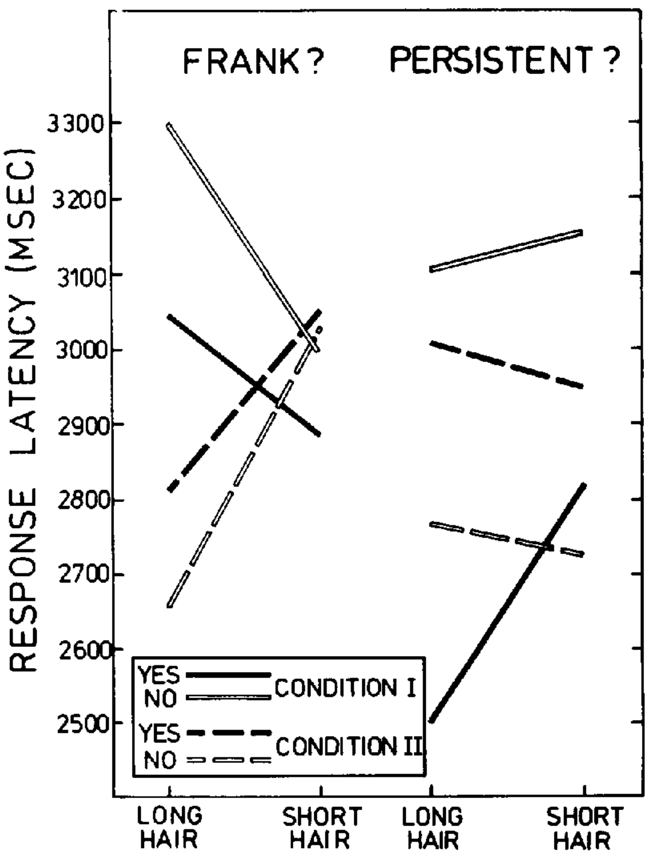

Figure 3. Experiment 1b: means of response latencies. (Subjects in Condition I were exposed to stimulus material in which long-haired persons were frank and short-haired ones were persistent; subjects in Condition II were exposed to the opposite.)

Table 2
Experiment 1b: Means and Standard Deviations of Yes-Response Frequencies

Question	Condition I	Condition II
FRANK?		
Long hair		
M	1.02	1.30
SD	0.76	0.64
Short hair		
M	0.97	0.92
SD	0.72	0.68
PERSISTENT?		
Long hair		
M	1.07	1.15
SD	0.68	0.69
Short hair		
M	0.97	1.00
SD	0.65	0.77

Note. Subjects in Condition I were exposed to stimulus material in which long-haired persons were frank and short-haired ones were persistent; subjects in Condition II were exposed to the opposite.

revealed that the effect of interaction was stable across the questions ($ps < .01$).

The same design ANOVA performed on yes-response frequencies (Table 2) revealed no effect involving experimental condition; the means for each of the 4 combinations of question and haircut were virtually the same in both conditions.

Discussion

The response latency data were consistent with the informal model in every detail, that is for each of two experimental conditions, for each of 4 traits manipulated in two experiments (i.e., kindness, capability, frankness, and persistence), and for each of two possible responses (i.e., *yes* and *no*). Additionally, the results of Experiment 1b clearly supported the expectation that the reaction time data were more sensitive than the choice data.

The question of what the subjects in these experiments were precisely aware of cannot be conclusively answered at this point, because (as stated before) there is no conclusive evidence that the haircut did not influence perception of some other aspect of the stimulus persons' faces and that the specific aspect might simply be difficult for the subjects to articulate (verbalize). At least the latter one, however, seems to be strongly implied by the data obtained: Subjects were unable to articulate the covariation that specifically influenced their retrieval processes. Their inability to articulate the covariation may be due to the fact that they process and store information about the stimulus persons' faces in some integral or global (as opposed to featural or dimensional) fashion (Garner, 1970, 1974; see also research on configural properties of faces, Sergent, 1984). "If dimensions are integral, they are experimentally not dimensions at all . . . , dissimilarity is perceived directly; selective attention to one dimension is an impossibility" (Smith & Kemler, 1978, p. 504), and "objects are compared holistically" (p. 503). This might be especially true when subjects are not instructed to make analytical comparisons between the faces. Pictures with common hair length look more alike than those with different hair length—even if hair length is not consciously coded as such.[5]

Regardless of whether information concerning the manipulated aspect of the stimulus persons' faces was stored in such an integral fashion, which seems highly probable, it can be concluded from the consistent evidence in Experiments 1a and 1b that if information exists in long-term memory about a certain covariation, it leads to increased processing time when responding to a question relevant to that covariation. Thus, it seems justified to assume that there exists a stage (or stages) of preliminary memory search for relevant information and, depending on the outcome of this stage, some secondary stage (or stages) of "reading," evaluating, or further processing of that relevant information.

Experiment 2

The question arises as to how an individual comes to acquire the information about covariation at the very beginning of the process demonstrated in Experiments 1a and 1b. In other words, how does the detection of covariation proceed? Our first, preliminary model of this process of detection was very simple and based mostly on intuitive premises.

Let us consider first the simplest possible case of abstracting information about the frequency of some events. Although we do not know how frequency is represented in memory (Zacks, Hasher, & Sanft, 1982), acquiring frequency data requires at least two kinds of information to be registered for each event: namely, recognizing the event itself, and registering that it has happened one more time (the latter process could be compared with incrementing a loop counter in Basic or Fortran). A simple model of abstracting information about covariation might be analogous; two kinds of information must be registered (with the addition that, in order to involve covariation, events in this case have to be defined by a co-occurrence of two features). However, even independent attributes will occasionally co-occur. Moreover, independent attributes that are frequent may co-occur more often than less frequent attributes that are highly correlated. It was hypothesized, therefore, that a certain number of consistent co-occurrences and a certain ratio of consistent to inconsistent co-occurrences are required in order for any covariation to be finally encoded.

In other words, one or two instances clearly provide information about frequency; however, according to this reasoning they would not provide any useful information about covariation of events, because even if 2 instances are perfectly consistent regarding covariation between 2 bipolar dimensions, its binomial probability is as high as .5. Obviously, even a single instance of co-occurrence has to be memorized, because otherwise every instance would be the first. According to this informal model, however, its memory respresentation would not be accessible to a perceiver in the form of information about general covariation, and thus it would not affect subsequent retrieval processes in the way in which information about covariation would (cf. Experiments 1a and 1b). The model predicts that the just mentioned "counter of consistent and inconsistent instances" would not register that a covariation has been detected until a number of

[5] This was suggested to me by Don Dulany.

consistent co-occurrences and a ratio of consistent to inconsistent co-occurrences reaches a certain value (which is an unknown parameter of the process). Up to this point information relevant to potential covariation is stored in a form inaccessible to a perceiver's cognitive processes as information about covariation.

In the present experiment, subjects in separate groups were exposed to stimulus materials containing implicitly different numbers of consistent co-occurrences, beginning with a very small number ($N = 2$). It was expected that the effect of "processing covariation" (found in Experiments 1a and 1b) would appear only above a certain number of consistent co-occurrences.

Method

Overview. The method was basically the same as in Experiment 1a except for the modifications necessary to manipulate the number of co-occurrences. There were 5 groups varying in the number of consistent instances the subjects were exposed to, namely 2, 4, 6, 8, and 10. The group with 2 instances was presented with only 2 slides: one with a short-haired stimulus person and the other with a long-haired stimulus person. The group with 4 instances was presented with 2 short-haired and 2 long-haired stimulus persons, and the group with 6 instances was exposed to exactly the same number of stimulus persons as in Experiments 1a and 1b. The remaining 2 groups were exposed to 8 and 10 slides, respectively. This 5-level factor was crossed by the factor of condition (I vs. II), which determined the matching between haircut (long vs. short) and traits (kind vs. capable) in the stimulus material. Thus, there were 10 experimental groups: 5 × 2 (Number of Instances × Condition).

Subjects. Eighty men and women, between the ages of 18 and 19, participated in the study. Each of them had just graduated from high school and had come to Warsaw to be interviewed at the University of Warsaw prior to being admitted as freshmen. None of them was a resident of Warsaw, and during the time of the interviews, they were located in a huge complex of dormitories. They did not know each other; what is more, each subject was recruited from a different floor or from a different building. Subjects were randomly assigned to 10 experimental groups (separately by sex). The subjects from all of the groups were run in a counterbalanced order, so that any changes in the experimenter's performance contributed equally to each group.

Stimulus material. The present design required supplementation of the stimulus material, because up to 10 descriptions and up to 14 slides had to be presented. The additional 4 slides were selected in a less formal way than before, in the sense that there were no pilot studies, although an attempt was made to follow exactly the same rules, and in making the final choices, a number of undergraduates were consulted. The missing 4 descriptions were designed to follow exactly the nature of the initial 6. Two of the new stimulus persons were described as kind, and 2 others as capable.

The order of presenting the stimulus material was determined in the following way. Because there were 8 subjects in each of 10 experimental groups, initially 8 permutations of 14 slides were designed regarding which 10 of them would serve in the learning phase and which 4 in the testing phase, and regarding the order of presentation (as before, each order followed the rule of alternately presenting short- and long-haired stimulus persons). Thus for each subject in a given group, a different arrangement of slides was prepared, although at this moment these arrangements were exactly the same in all 10 groups. The final sets of slides the subjects in each group were presented with were made by deleting the necessary number of slides from the learning phase subsets, beginning from the end, to obtain the number of presentations desired in a given group. This arrangement met the condition that subjects in a subsequent group (regarding the number of instances they were exposed to) were presented with exactly the same set and the same order of stimulus persons as the preceding group plus, at the end, with 2 additional stimulus persons. For example, the first arrangement was assigned to one subject in each of 10 groups, and each of those 10 subjects was exposed in the testing phase to exactly the same 4 slides. However, they differed regarding the number of slides presented in the learning phase. Namely, 2 subjects from groups exposed to only 2 instances (i.e., a subject from Condition I, and a subject from Condition II) were exposed only to the first 2 slides of the learning phase subset of the first arrangement. The 2 subjects from groups exposed to 4 instances were exposed to the same 2 slides plus the 2 subsequent ones, and so on up to the two subjects exposed to the entire subset of 10 slides assigned to the learning phase in the first arrangement.

Each slide was accompanied by a description. Matching between the traits on which the description was focused and the haircut of the stimulus person in each of the 2 conditions (I and II) was analogous to that in Experiment 1a. That is, subjects in Condition I were exposed to stimulus material in which long-haired stimulus persons were kind and short-haired stimulus persons were capable, and subjects in Condition II were exposed to the opposite.

Procedure. The procedure was basically the same as in Experiment 1a, except that there was no training on the reaction time apparatus, and that the experimenter was male.

At the end of the session, each subject was questioned (as in Experiments 1a and 1b) for covariations he or she had discovered between the visual and verbal data, and the responses were again the same. None of the subjects, not even the 16 subjects who were presented with 10 instances, discovered the rule.

Results

Mean yes- and no-response latencies to each of the 2 questions (KIND? vs. CAPABLE?), referring to each of the 2 haircut types of stimulus persons (long vs. short), in each of the 2 conditions (I vs. II) are displayed in Figure 4 (the means were aggregated over the 5 levels of the number of instances factor). The overall pattern of results was again perfectly consistent with the general model confirmed in Experiments 1a and 1b. Regardless of the specific response (either *yes* or *no*), the subjects in each condition responded more slowly to the question that was relevant to the covariation they were exposed to.

A four-factor ANOVA (5 × 2 × 2 × 2) was performed on the aggregated yes- and no-response latencies with number of instances (2, 4, 6, 8, and 10) and condition (I vs. II) as between-subjects factors, and question (KIND? vs. CAPABLE?) and haircut of stimulus persons (short vs. long) as within-subjects factors. Surprisingly, not one reliable effect involving the number of instances factor was found ($Fs < 1.30$). The only significant effect revealed in this analysis was the interaction between condition, question, and haircut, analogous to the one found in Experiments 1a and 1b, and of roughly similar size, $F(1, 70) = 7.80$, $MS_e = 4{,}375{,}180$, $p < .007$. The trend analyses revealed no reliable trends, indicating that this effect of interaction was not stable across the 5 levels of number of instances.

Separate planned comparisons (contrasts) were performed for each of 2 questions (i.e., KIND? and CAPABLE?). In each of the comparisons the effects of the number of instances were far from significant ($Fs < 1$). Each of the comparisons however, revealed the reliability of the predicted interaction between condition and haircut ($ps < .05$).

Planned comparisons revealed no systematic differences between cells indicating any effects of the number of instances factor, although this method could not be considered sensitive due to the very small number of observations in each cell ($N = 8$).

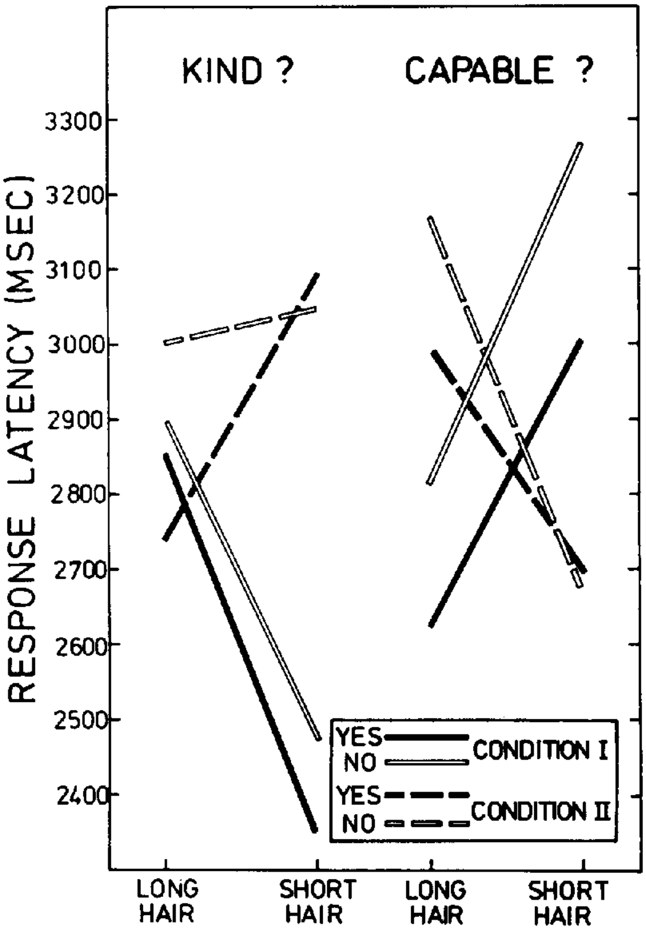

Figure 4. Experiment 2: means of response latencies aggregated over the 5 levels of the number of instances factor. (Subjects in Condition I were exposed to stimulus material in which long-haired persons were kind and short-haired ones were capable; subjects in Condition II were exposed to the opposite.)

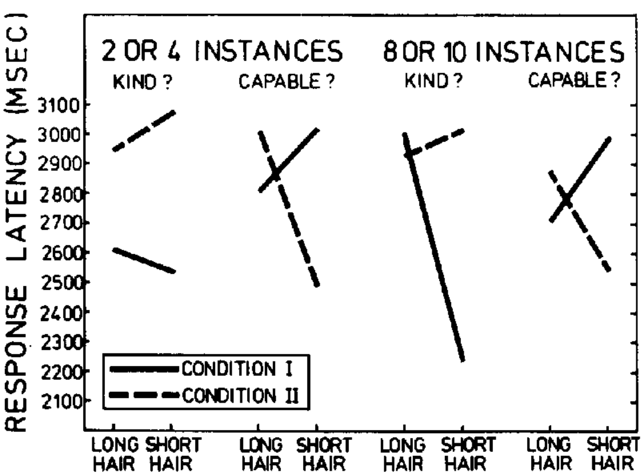

Figure 5. Experiment 2: Means of response latencies in two groups exposed to different numbers of instances (2 or 4 vs. 8 or 10). (Subjects in Condition I were exposed to stimulus material in which long-haired persons were kind and short-haired ones were capable; subjects in Condition II were exposed to the opposite.)

Table 3
Experiment 2: Means and Standard Deviations of Yes-Response Frequencies Aggregated Over the 5 Levels of the Number of Instances Factor

	Condition	
Question	I	II
KIND?		
Long hair		
M	1.52	1.25
SD	0.63	0.66
Short hair		
M	0.95	1.30
SD	0.67	0.64
CAPABLE?		
Long hair		
M	1.25	1.20
SD	0.62	0.68
Short hair		
M	1.28	1.15
SD	0.77	0.61

Note. Subjects in Condition I were exposed to stimulus material in which long-haired persons were kind and short-haired ones were capable; subjects in Condition II were exposed to the opposite.

No effect of number of instances was found even when the analysis was redesigned in order to maximize its sensitivity to the potential effect of the number of instances factor. Namely, the "middle" group (i.e., the one with 6 instances) was deleted, and the remaining 4 groups were reduced to 2 by aggregating the groups presented with 2 and 4 instances, and separately the groups presented with 8 and 10 instances. In an ANOVA (2 × 2 × 2 × 2 [Number of Instances × Condition × Question × Haircut]), again no effect of the number of instances was found, $Fs < .89$. The means in these 2 polarized groups (i.e., "2 and 4 instances" and "8 and 10 instances") conformed to the general pattern (see Figure 5), indicating that subjects detected and processed the covariation. Although in neither of these groups did the crucial interaction of 3 factors reach the .05 level of significance (clearly due to the small number of observations, $N = 32$), the tendency was salient in each of them and had approximately the same strength ($p < .12$, and $p < .09$, respectively). These results indicate strongly that the overall crucial three-way interaction present in the entire set of data obtained was not affected by the number of instances the subjects were exposed to.

An analogous set of analyses was performed on yes-response frequencies. The means, aggregated over the 5 levels of the number of instances factor, are displayed in Table 3. An overall ANOVA with number of instances (2, 4, 6, 8, and 10) and condition (I vs. II) as between-subjects factors and question (KIND? vs. CAPABLE?) and haircut of stimulus person (long vs. short) as within-subjects factors revealed again no reliable effects involving the number of instances factor. The only significant effect revealed was the interaction among all 3 of the remaining factors, $F(1, 70) = 7.55$, $MS_e = 1.354$, $p < .008$. Planned comparisons revealed that this effect was entirely due to responses to the question about kindness, $F(1, 70) = 8.95$, $MS_e = 0.873$, $p < .004$; in the case of the question about capability, $F < 1$. Examination of the means (see Table 3) indicated that this effect of interaction was consistent with the specificity of the stimulus material the subjects were presented with. Namely, the subjects presented with the stimulus material in which long-haired persons were kind (Condition I) responded more frequently *yes* to the questions about kindness when stimulus persons had long hair than when stimulus persons' hair was short. For subjects in Condition II, who were exposed to the opposite, the reversed pattern of yes-response frequencies can be found.

Planned comparisons did not reveal any systematic effects of the number of instances factor on this interaction. As noted earlier, however, the number of observations in the single cells was very small. In the analysis with two polarized groups (redesigned in the same way as has been done in the analysis performed on response latencies), again no reliable effects involving the number of instances were found. Moreover, the means suggested that the "effect of learning" found in the overall analysis is consistent over the 2 groups differing sharply in the number of instances the subjects were exposed to (i.e., "2 or 4" vs. "8 or 10"), $F(1, 70) = 4.20$, $MS_e = 1.354$, $p < .05$, and $F(1, 70) = 3.43$, $MS_e = 1.354$, $p < .07$, respectively.

Discussion

The results of Experiment 2 were perfectly consistent with the reaction time pattern obtained in Experiments 1a and 1b. They revealed that subjects' retrieval processes were systematicaly affected by the manipulated covariation even in the group exposed to as few as 2 or 4 consistent instances, and they revealed no effects whatsoever of the number of instances factor.

The data appeared, however, to be inconsistent with our preliminary model of this detection process, in that the model assumed that a certain, sufficiently high number of consistent instances is a necessary condition to register these instances in the form of information about covariation. The results obtained suggested that even if there is such a threshold number of consistent instances required to involve processing of covariation, that number may be as surprisingly low as 2 or 4 (see Medin, Altom, Edelson, and Freko, 1982, for an alternative point of view that might expect an effect of only a few instances).

The question arises at this point as to exactly what kind of knowledge about the covariation was processed and represented in subjects' memory. Was the cognitive process based on a "rule abstraction mechanism" or an "analogy (similarity to instances) mechanism" (Elio & Anderson, 1981, p. 416)? In other words, was the information about the manipulated covariation represented in terms of a relation between two abstract features (e.g., relation between being kind and having certain appearance) or in terms of exemplars?[6]

Both of these general models seem consistent with the reasoning about the retrieval process that inspired the specific experimental paradigm used in Experiments 1a and 1b, and neither of them seems inconsistent with the results of Experiment 2.

The rule abstraction mechanism assumes some process of abstraction of the relation between features (i.e., the manipulated covariation) based on a set of concrete instances. It is at least possible that this process may be initiated by a very limited amount of evidence.

This set of findings can also be easily accounted for by the exemplar model. The exemplar analogy mechanism clearly requires only a few instances to operate. Analogy may be based on even a single instance (Gilovich, 1981; Lewicki, 1985) and would not necessarily be facilitated by an increase in the number of instances presented during the learning phase. A process of analogical reasoning that does not assume subjects' ability to articulate the specific rules followed by the stimulus material was proposed by Brooks (1978). In his research on "nonanalytic" reasoning, Brooks demonstrated that his subjects behaved as if they had followed certain abstract rules although in fact they had based their judgments on some integral or holistic similarity between a test item and the items encountered in the learning phase.

One other important finding from Experiment 2 pertains to the biasing effect of the manipulated covariation on subsequent judgments (i.e., yes–no responses). Such an effect was revealed in Experiment 1a, and here it was found again. Moreover, the effect was consistent across all levels of the number of instances factor, and it was separately found to be significant even in the group exposed to as few as 2 or 4 instances. This result provides additional information about the nature of the memory representation of the manipulated covariation. Namely, it suggests that the influence of such a representation on subsequent perceptual processes is not confined to affecting the time of processing relevant stimuli. Instead, the results indicate that even if this representation is based on as few as 2 or 4 consistent instances, it is powerful enough to bias subsequent judgments, by making them consistent with the covariation.

General Discussion

The evidence obtained in these experiments demonstrates a process of acquisition of categorical information based on the processing of covariation implicitly contained in stimulus materials. Although in none of the three experiments were subjects able to articulate the covariation, in all three of them the predicted response latency pattern was obtained, indicating that in response to the testing phase questions, subjects retrieved and evaluated information specifically related to the covariation that was manipulated in the learning phase. Moreover, in two experiments not only subjects' response latency but also their explicit responses were specifically influenced by the manipulated covariation.

Subjects behaved as if they had "learned" the rule (implied by the covariation) and had followed it in their subsequent judgments. Subjects' high sensitivity to a manipulated covariation that they were unable to articulate suggests that the demonstrated phenomenon pertains to an important and perhaps ubiquitous aspect of processing categorical information.

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[6] In general terms it may be stated that subjects in these experiments acquired information about new categories, for example, a category of a person having a certain appearance and being kind. The major question that arises at this point is "whether a summary representation of [the] category attributes exists independent of individual exemplars" (Lingle, Altom, & Medin, 1984, p. 110).

It has recently been proposed that acquisition of information about covariations that cannot be articulated by perceivers is, in the long run, a self-perpetuating process (Lewicki, in press). An initial tendency to follow certain covariations will, in subsequent judgment, increase the likelihood that stimuli will be encoded in a way that would be consistent with the initial tendency, thereby supporting the covariation. Eventually, the next relevant stimulus would be encoded in an even more biased way, and so forth.

Social cognition seems especially subjected to such processes, because social stimuli are often ambiguous in nature and thus open to alternative interpretations. Additionally, social interaction may contribute to this self-perpetuating process. For example, an assumed (but not articulated) relation between introversion and aggressiveness may produce a nonconcious tendency to behave towards introverts in a manner consistent with the expectation that they are aggressive. This, in turn, makes it more likely that their responses will be consistent with the perceiver's expectations (a "self-fullfilling prophecy"), and thus their behavior would reinforce the initial assumed covariation.

Common experience and much evidence suggest that people have no access to the cognitive algorithms responsible for many of their judgments (Lewicki, 1984, 1985, in press; Nisbett & Wilson, 1977) and that they cannot say when and how they acquired these algorithms. This pertains also to cognitive dispositions responsible for generating important but uncontrollable behavioral responses (e.g., depression, anxiety, aversions). Investigation of processes by which individuals acquire knowledge that cannot be articulated is of major importance for understanding various basic aspects of human behavior. The research reported in this article seems to offer a promising approach to the study of such processes.[7]

[7] Additional evidence for the nonconscious processing of information about covariations is presented in Lewicki (in press, chapters 3–6).

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(Appendix follows on next page)

Appendix

Stimulus Descriptions Used in Experiments 1a and 2

1. She always acts in a way that makes everybody around her feel better. She does a great deal for others, and they can always count on her. She is also a real expert in helping resolve conflicts between people.

2. No one could ever call her self-centered. She does a lot for other people; she is sensitive and helpful. She knows how to treat each individual so as to make him or her feel really good.

3. She is the type of person who is always ready to make sacrifices for others. It is simply a natural thing for her to help other people and to be nice to everybody. She probably thinks more about others than about herself.

4. She is very intelligent and effective. She knows very well how to make the best use of her particular talents, so she usually wins. She likes to be on a tight time schedule and she hates to waste her time.

5. She is bright and innovative. She is better than other people in most of what she does. She is also very hardworking and this helps her in accomplishing what she decides to tackle.

6. Everything is easier for her than for other people because of her intelligence, but she still pushes herself very hard. She is never afraid of new tasks, because she is the type who is a winner. She is systematic and consistent in carrying out her plans.

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