Contextual relations: The influence of familiarity, physical plausibility, and belongingness*

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Individual differences were obtained in a task requiring the same-different comparison of multiobject scenes. For some Ss, performance depended only on whether the objects were in a physically plausible arrangement. It was inferred that these Ss used internalized rule systems to interrelate arrays of objects into organized scenes. For the other Ss, performance depended on whether the objects belonged together, and whether their arrangement was familiar. It was inferred that these Ss dealt with each object on an individual basis, using information concerning belongingness and familiarity of arrangement to anticipate which objects would be present and where they would be located.

Recent research (De Groot, 1965; Chase & Simon, 1973) has demonstrated that chess masters are superior to amateurs in reproducing previously seen arrangements of chess pieces. The superiority, however, was obtained only when the arrangements followed the rules of chess (i.e., when they were selected from actual games); it disappeared for random arrangements of the pieces. This finding suggested that the master's perception of the game-generated arrangements may have been guided by an internalized rule system. Relational structures based on the rule system of chess have been described by computer scientists (Michie, 1972). These structures provide schemes for interrelating arrays of chess pieces, organizing them into chunks or units. For example, an array of three pieces—a black knight, a white pawn, and a white rook—can be organized into a chunk if the array is perceived as “the rook defending the pawn that is being attacked by the knight.” The use of rules to structure or organize the individual pieces into chunks could therefore be the basis for the superior reproduction performance of the chess master.

Although the amateurs knew the rules of chess, their training was apparently insufficient for the knowledge to have more than a minimal influence on their performance in the reproduction task. Without a rule system for structuring the chess pieces into chunks, there was no alternative but to memorize the locations of individual pieces. As Chase and Simon (1973) conclude, the main difference between the master and amateur lies in the former's ability to organize the chess pieces into larger chunks of information.

Although chess masters have intensively studied the rule system of their game, it seemed reasonable to assume that the informal experience of most normal adults is sufficient for them to master the rule system of

the physical environment. But what of the individuals who out of ignorance or choice do not use the rules that determine the physically plausible relations between the objects in a scene? In effect, these Ss would be functioning like amateur chess players, dealing with each object on an individual basis rather than interrelating the objects into organized scenes. The performance of these Ss, however, would be improved if, upon recognizing some objects, they could anticipate what other objects might be present. This would be the case only if the objects in the scene were commonly found together. Furthermore, Ss who are not using a rule system would perform better still if, upon recognizing some objects, they knew where to look for the other objects in the scene. This would be the case only if the objects in the scene were in a familiar arrangement. It was hypothesized, therefore, that both the “belongingness” and the familiarity of arrangement of an array of objects would facilitate the performance of Ss who do not use physical rules to interrelate the objects into an organized scene.

It was expected, for Ss using a physical rule system, that the Ss' knowledge of the rules would be general to all stimuli generated by the rule system (Franks & Bransford, 1971). For this reason, performance for rule-following Ss was expected to be the same for both familiar and novel arrangements of objects, providing the arrangements conformed to the rule system of the physical environment.

The basic experimental manipulation for the examination of these hypotheses was the comparison between physically plausible and physically implausible arrangements of objects. An arrangement was considered plausible if it was realizable within the normal physical properties of the objects—if it could actually be constructed using real objects. Since a given set of objects could conceivably have a virtually unlimited number of novel, realizable arrangements, it was considered unlikely that an S could have any knowledge specific to each of the possible arrangements. It was postulated, therefore, that perceptual knowledge related

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Fig. 1. Samples of one scene, with each type of contextual relation represented.

to the physical plausibility of arrangements of objects must take the form of a system of rules governing object relations within the physical environment. A particular arrangement is physically plausible if it conforms to this rule system.

Whether or not the Ss in the present research used a rule system to interrelate the objects in a scene was inferred from a comparison of their performance on the physically plausible and physically implausible arrangements. It was inferred that Ss with a large effect of physical plausibility used an internalized rule system to interrelate the objects in a scene, while Ss with a small effect of physical plausibility made little use of rules. For Ss using a rule system, it was hypothesized that performance would be the same for both the familiar and novel arrangements. For Ss ignoring physical rules it was hypothesized that performance would be better for familiar than for novel arrangements. Taken together, this dual hypothesis took the form of a negative correlation between the effects of physical plausibility and familiarity of arrangement.

METHOD

Stimuli

The stimuli used in this experiment were hand-drawn scenes, each scene comprising three different familiar objects. There were four types of contextual relationship among the objects. Type I comprised objects in a familiar arrangement, and Type II, the same objects arranged in a novel, but physically plausible, manner. Type III used the same objects, but arranged in a novel, physically implausible, manner. Type IV was composed of objects that did not belong together, in a novel arrangement that violated the rules of physical plausibility. The four types of contextual manipulation were applied to eight different scenes. The four types for one of the scenes is illustrated in Fig. 1. The objects in the Type IV arrangements, which did not belong together, were selected from the eight different scenes. As can be seen from Table 1, each "type" eliminated different aspects of contextual information. Successive comparisons therefore indicated the influence of familiarity of arrangement (II-I), the rules of physical plausibility (III-II), and belongingness (IV-III) on performance in the experimental task, which is described below.

Design

The experimental paradigm was the same-different

comparison task. "Same" pairs were identical scenes from the same context type; "different" pairs were scenes from the same context type, but differing in only one object (see Fig. 2). Thus, there were two versions of each scene, differing by the same object in all context types. The two versions appeared equally often in "same" pairs and were equally represented in the left and right positions of "different" pairs. A total of 128 stimuli was presented to each S, with stimuli from all 8 experimental conditions (4 context types by same-different) appearing in a randomly mixed sequence. These trials were preceded by 24 practice stimuli, representing all the experimental conditions, that were derived from two scenes not used in the experimental trials.

Procedure

Each stimulus was a simultaneously presented pair of scenes. The overall visual angle intercepted by the stimuli was 5.4 deg, and the visual angle intercepted by each scene was 2.4 deg. The stimuli were back-projected onto a translucent screen by a Carousel projector. They were presented for a duration of 3.0 sec, unless the S responded, whereupon the display was terminated. The Ss were instructed to press a button whenever the two scenes were the same; when the scenes were different, they were not to respond in any way. Thus, latencies were collected only on "same" trials. The Ss were instructed to respond as quickly as possible, while keeping their errors to a minimum. They were cautioned that, when "different," the two

Table 1
The Contextual Information Inherent in Each of the Four "Types" of Stimuli Used in This Experiment

	Type			
	I	II	III	IV
Objects in typical or familiar relationship	Yes	No	No	No
Objects in physically plausible relationship	Yes	Yes	No	No
Objects belong together	Yes	Yes	Yes	No

scenes in a pair differed with respect to an entire object and not a small detail.

Subjects

Thirty-two Ss, all students at Florida Atlantic University, were paid \$1.75 for their participation in an experimental session lasting 30 min.

RESULTS

The mean reaction times and percentage errors for the

Fig. 2. Example of a "same" and "different" pair for a Type II arrangement. The critical differentiating objects, the flowers and rubber tree, remained the same for all four "types" involving this scene.

Table 2
Mean Reaction Times (in Milliseconds) and Percentage Errors for All 32 Ss

	RT	Errors
Type I Familiarity, Plausibility, Belongingness	1182	0.6
Type II Plausibility, Belongingness	1209	2.3****
Type III Belongingness	1292	3.1**
Type IV No Contextual Information	1304	3.5***

Note—The contextual information inherent in each stimulus "Type" is indicated. Each asterisk denotes the inclusion of one error of omission.

four context types are presented in Table 2. The effect of context type on "same" reaction time was significant, $F(3,93) = 22.59$, $p < .005$. Subsequent Newman-Keuls comparisons indicated that the effect of familiarity of arrangement (II-I) fell short of significance, $p > .05$, the effect of physical plausibility (III-II) was significant, $p < .01$, and the effect of belongingness (IV-III) was insignificant, $p > .05$. The overall error rate of 2.4% consisted almost entirely of commission errors. Error rates tended to increase as more contextual information was eliminated from the scenes. There was no indication that differences in reaction times between the four experimental conditions were due to differences in speed-accuracy criteria.

The primary hypotheses for this experiment involved individual differences in the extent to which the rules of physical plausibility influenced performance in the same-different task. The individual differences were determined from the effect of physical plausibility (III-II) computed individually for each S. It was inferred that Ss with a large (III-II) difference used an internalized rule system to interrelate the objects in a scene, while Ss with a small (III-II) difference made little use of physical rules. For Ss making little use of rules, it was hypothesized that performance would be improved if the objects in a scene were in a familiar arrangement. That is, it was predicted for these Ss that a small effect of physical plausibility (III-II) would be accompanied by a large effect of familiarity of arrangement (II-I). For the Ss using an internalized rule system, it was hypothesized that the rules would be general to all arrangements, familiar or novel, that conformed to the rule system. It was predicted, therefore, that a large effect of physical plausibility (III-II) would be accompanied by a small effect of familiarity of arrangement (II-I) for Ss using an internalized rule system. Taken together, the two hypotheses led to the prediction of a negative correlation between the effects of physical plausibility (III-II) and familiarity of arrangement (II-I).

The difference scores, (III-II) and II-I, computed separately for each S, are presented on the scattergram in Fig. 3. The correlation coefficient computed for this

scatterplot, $r = -0.43$, was significant, $p < .02$. Since the factors entering into this correlation were not independent (Type II was common to both), it was possible that the obtained correlation was enhanced by variation in the reaction times for the Type II stimuli. In order to account for this possibility, a partial correlation coefficient was computed, with each S's reaction time for the Type IIs partialled out. The resulting negative correlation increased slightly to $r = -0.45$.

In order to take a closer look at the individual differences, the Ss were divided into two groups. Those Ss whose performance was most affected by physical plausibility (the 16 with the largest III-II difference) were placed in Group 1; those Ss least affected by physical plausibility (the 16 with the smallest III-II difference) were placed in Group 2. It was assumed that the Ss of Group 1 based contextual relations on an internalized rule system, while the Ss of Group 2 ignored the rules of physical plausibility. It can be seen from Table 3 that familiarity of arrangement (II-I) had little influence on response times for Group 1, supporting the hypothesis that when the relationship between the objects in a scene is guided by an internalized rule system, the rules are general to both familiar and novel arrangements of the objects. Although the effect of belongingness was negative for the Ss of Group 1 (response times for Type III were slower than for Type IV), the difference was insignificant, $t(15) = 1.17$, $p > .05$. The indication that belongingness may have interfered with performance suggested that many Ss in Group 1, noting that the objects in the Type III arrangements belonged together, may have tried to use their knowledge of physical rules in a situation for which the rules were inapplicable.

Fig. 3. Scattergram for "same" responses. Each point represents the data for one S.

The large effect of familiarity (II-I) obtained for Group 2 supported the hypothesis that Ss ignoring physical rules would perform better when they knew where to look for the objects in a scene. Furthermore, the effect of belongingness (IV-III) was significant, $t(15) = 2.40$, $p < .05$, for the Ss of Group 2, supporting the hypothesis that Ss ignoring physical rules would perform better if, upon recognizing some of the objects in a scene, they could anticipate what other objects might be present.

DISCUSSION

The present research investigated rule systems in perceptual situations more representative of the normal, "real-world" environment, for individuals lacking the specialized training and extraordinary intelligence of the chess master. It also provided a broader scope for studying context effects. Whereas the "chess research" used only chess pieces, objects that obviously belong together, the present research also included arrangements of objects not commonly found together. Furthermore, the "chess research" used only midgame and end-game positions, for which the arrangement of pieces is almost invariably novel. The present research included arrangements for which the objects were in a familiar relationship, as well as novel, but rule-following arrangements of the objects.

It was inferred in this experiment that Ss whose performance was influenced by physical plausibility (Type II vs Type III) used an internalized rule system to interrelate arrays of objects into organized scenes. Since the essential characteristic of such rule systems is their generality to all arrangements conforming to the rule system, the inference regarding the use of rules was supported by the finding that the rule system was equally applicable to the familiar (Type I) and novel (Type II) arrangements, both of which conformed to the rules of physical plausibility.

It was also inferred that Ss whose performance was unaffected by physical plausibility ignored relational rules, and thereby dealt with each object on an individual basis. This inference was supported by evidence, for these Ss, that performance was improved by both belongingness (Type III vs Type IV) and familiarity of arrangement (Type I vs Type II). Upon recognizing some of the objects in a scene, the Ss ignoring physical rules could therefore anticipate what other objects might be present (belongingness) and could also anticipate where the objects would be located (familiarity of arrangement).

The individual differences obtained in this experiment closely resemble recent findings of Hock (1974). Hock's study, which also used a same-different comparison task, provided evidence for individual differences in the mode of processing underlying "same" responses to pairs of dot patterns. Hock contended that those Ss whose

Table 3
Mean Reaction Times (in Milliseconds) and Percentage Errors for the 16 Ss Inferred to Use the Rules of Physical Plausibility (Group 1) and the 16 Ss Inferred to Ignore the Rules (Group 2)

	Group 1 (Use Rules)		Group 2 (Ignore Rules)	
	RT	Errors	RT	Errors
Type I	1187	0.2	1177	1.0
Type II	1189	3.1***	1228	1.4*
Type III	1346	3.3*	1239	2.9*
Type IV	1318	3.5**	1289	3.5*

Note—Each asterisk denotes the inclusion of one error or omission.

"same" responses were faster for pairs of symmetrical than for pairs of asymmetrical patterns used symmetry as a rule for organizing the detailed parts of the pattern into a well-formed whole. On this basis, the effects of symmetry (in Hock's study) and physical plausibility (in the present study) could be interpreted as involving similar processes. While symmetry, and ostensibly other Gestalt-type properties, provide organizational rules within a pattern (or object), physical plausibility provides organizational rules between objects.

Hock also found that the performance of some Ss was unaffected by symmetry. These Ss were said to emphasize an analytic mode of processing that decomposes the stimulus information into features, rather than structuring it into wholes. Subsequent research has provided evidence that analytic Ss attend to the minimal number of features that will allow them to infer the identity of a stimulus.¹ Inference also seemed to be important in the present study. The Ss who ignored the rules of physical plausibility were found to perform better when they could anticipate, or *infer*, the objects that were present in the scene and where the objects were located.

The relationship between individual differences in the processing of individual objects and individual differences in the use of contextual information in multiobject scenes is currently under investigation.

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NOTE

1. Hock, H. S., Gordon, G. P., & Gold, L. Individual differences in the verbal coding of familiar visual stimuli. In preparation.

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