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ABSTRACT

This paper is concerned with the question of whether and why individuals who know more about a particular knowledge domain acquire domain-related information more readily than individuals who know less about the domain. A conceptual framework is presented that hypothesizes differences in the memory structure of the high-knowledge and low-knowledge individuals, primarily with respect to concepts, higher ordered conceptual groupings, goal structures, and related strategies. Acquisition differences between high-knowledge and low-knowledge individuals are assumed to be a function of differences in memory structure, and the primary factor involved in the acquisition of domain-related information is assumed to be a process termed structural mapping, i.e., encoding input information in terms of one's existing memory structure. The results of six experiments using male and female college students that were designed to study various aspects of the acquisition process are reported. The findings support the general framework and also emphasize the facilitative effect of conceptual differentiation and of context in the high-knowledge individuals. (Author/CTM)

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Abstract

This paper is concerned with the question of whether and why individuals who know more about a particular knowledge domain acquire domain-related information more readily than individuals who know less about the domain. A conceptual framework is presented that hypothesizes differences in the memory structure of the high-knowledge and low-knowledge individuals, primarily with respect to concepts, higher ordered conceptual groupings, goal structures, and related strategies. Acquisition differences between high-knowledge and low-knowledge individuals are assumed to be a function of differences in memory structure, and the primary factor involved in the acquisition of domain-related information is assumed to be a process termed structural mapping, i.e., encoding input information in terms of one's existing memory structure. The results of six experiments are reported that were designed to study various aspects of the acquisition process. The findings support the general framework and also emphasize the facilitative effect of conceptual differentiation and of context in the high-knowledge individuals.

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It apparently is a widely held belief that experts in a particular field are superior to non-experts in acquiring field-related information. While our daily experiences confirm this intuition, cognitive psychologists have not systematically delineated the conditions under which this assertion may or may not be true, nor have they identified the processes underlying it. The present research is addressed to three questions about the presumed facilitative effects that previously acquired knowledge has upon learning: (a) Do experts in a particular knowledge domain acquire domain-related information more readily than non-experts? (b) What theoretical mechanisms may account for these differences? (c) What are the general implications of this line of inquiry for theories of acquisition and transfer?

The approach of the present research is contrastive, i.e., we isolated two groups of individuals, a high-knowledge (HK) group and a low-knowledge (LK) group, and then compared their performances under a variety of task conditions. Such an approach has been employed effectively in studying performance differences of individuals having good or poor reading comprehension test scores (Perfetti & Lesgold, in press), of individuals having high or low verbal and high or low quantitative aptitude (Hunt, Lunneborg, & Lewis, 1975), and of experts and non-experts in chess (Chase & Simon, 1973a, 1973b; de Groot, 1966) and "Go" (Reitman, 1976).

The knowledge domain we selected for our work was baseball.[1] Arguments could be raised, of course, for and against the use of almost any domain, but we chose baseball because we felt it had a number of desirable qualities. Since the game is such a part of the American culture, we thought that most individuals would have at least a basic vocabulary of the game, thus making it relatively easy to identify both a high-knowledge population and a low-knowledge population that would be familiar with the game. Also, since baseball information varies considerably in complexity and form, i.e., it consists of concepts and definitions, events, lists, rules, etc., we felt that the acquisition of baseball-related information could be studied via the use of standard acquisition paradigms.

This report consists of three sections. In the first, the theoretical framework for the present research is presented. The second section contains the descriptions of a number of experiments. In the third section, implications of the research are discussed.

Conceptual Framework

Differences of Memory Structure

Conceptual structure. We would expect that (of necessity) HK individuals are able to define more baseball-related terms than LK individuals. The more important factor, however, is the difference in conceptual structure that may be hypothesized for HK and LK individuals.

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[1] In the present work, the study of the acquisition of baseball knowledge is restricted primarily to the acquisition of game-related information. The work is thus not concerned with issues such as knowledge of teams, players, and baseball "trivia." The paper also is not primarily concerned with the question of how "high knowledge" in a given domain is developed, although the issue is considered briefly later in the paper.

We assume that the meaning of a concept consists of the total set of relations of that particular concept to all other concepts. This position is consistent with some linguistic theorists (e.g., de Saussure, 1959; Lyons, 1969) and with the position that memory structure consists of conceptual relationships (Moore & Newell, 1974; Winograd, 1972). With respect to the nature of the relations between any two concepts, consider an example involving the shortstop and the second baseman. On a double play, the player of one of the two positions may field a ground ball while the other person covers second base (which person does which act depends, for the most part, upon where the ball is hit). In a similar manner, when a runner from first base tries to steal second base, one player may cover second base while the other "backs him up" or maintains his position (which person does which depends upon a number of factors, such as whether the batter is right-handed or left-handed). Thus, under one set of conditions (double play) one relation exists between the second baseman and shortstop, but under another set of conditions (the attempted steal of second base) a different relation exists. What we assume is that HK individuals know more relations that exist between any two baseball concepts than LK individuals know.[2]

The position outlined thus far points to an important difference in the cognitive structure of HK and LK individuals. While both may know that a shortstop is "a player who is positioned on the left side of the infield," the conceptual knowledge of the HK individual goes well beyond

[2]The relation between any two concepts could be considered within graph theory notation (Anderson, 1976; Rumelhart & Norman, 1975). Essentially, the high-knowledge individual is assumed not only to have more nodes in his/her memory structure, but more linkages between any two concepts (nodes), with each linkage containing a node or set of nodes that depicts the condition under which that particular relation holds.

this definitional knowledge, and the memory structure of the HK individual includes knowledge of relations such as how the shortstop interacts with the players of other positions under particular sets of conditions. The position outlined also leads to the important conclusion that concepts tend to be more differentiated in the HK individual than in the LK individual. Since the HK individual knows more of the relations between any two baseball concepts and the conditions under which a given relation exists, s/he is able to differentiate any two concepts more readily than the LK individual because the conditions specifying a given concept are more likely to be known by the HK individual. For example, while both the HK and LK individual are able to define the term "bunt," the HK individual is able to differentiate the concept of "bunt" from that of "sacrifice" (or other concepts) because s/he knows when a "bunt" is or is not a "sacrifice" and when a "sacrifice" is or is not a "bunt." The LK individual, however, may not be able to differentiate the concepts of "bunt" and "sacrifice" readily because s/he does not know the relations of each of the two concepts that enable the concepts to be differentiated.

<u>Grouping of the concepts</u>. Having postulated differences in the conceptual structures of HK and LK individuals, we now consider differences of conceptual grouping, i.e., differences in higher ordered memory structures.

Chase and Simon (1973a) suggested that the superiority of chess masters in recalling gameboard positions may be attributed to the fact that the chess master has in memory many more patterns of chess piece configurations (that are encountered in actual games) than the chess novice has. Similarly, we assume that baseball experts have patterns of baseball-related information in memory. However, we assume that the patterns in memory are temporal as well as spatial.

We shall call a pattern that exists at any point in time during the play of a baseball game a <u>situational pattern</u>. Thus, the team at bat may have runners on first and third base with two out, and Ball 3 and Strike 1 on the batter. The situational pattern also may include the fact that the game is in the last half of the eighth inning, that the score is 2-1 in favor of the team in the field, that the pitcher is a left-handed fast-ball pitcher, that the batter is a fair hitter and has the reputation of being a good bunter, etc. Thus, any information in that particular situation that is relevant to the play and potential outcome of the game is regarded as situational information, and we shall define the relevant components of any given situation as the parameters of the situation. It is quite reasonable, then, to postulate that HK individuals have more situational patterns in memory than LK individuals, and that for any given situation, the HK individual typically has a much more detailed knowledge of its parameters than the LK individual.

The idea that the HK individual has a greater knowledge of situational components than the LK individual is analogous to the previously postulated difference in the conceptual structure for HK and LK individuals: whereas concepts are assumed to be more differentiated in the HK than in the LK individual because of a more highly developed relational structure, conceptual groupings are also held to be more highly differentiated in the HK individual because of a more highly developed conceptual structure, highly developed in the sense that the knowledge of the components of any situation is greater in the HK individual than in the LK individual.

Going one step farther, a baseball game typically involves a transition from one situation to another, a transition that takes place because of the occurrence of a particular action or event. Thus, with respect to the situation outlined in the previous paragraph, the batter may hit a triple, driving in two runs, and the home team goes ahead 3-2. In other words, a new situation exists as the results of a particular action. We shall refer to such patterns as situation-action-situation (SAS) sequences. We further postulate that not only does the HK individual have a greater knowledge of the parameters of any situation than the LK individual, as mentioned above, but the HK person knows more actions that may occur in any given situation and knows more of the effects that particular actions may have in producing new situations.

It is clear that the concept of SAS structures bears a strong resemblance to other concepts used in current theorizing such as scripts (e.g., Schank & Abelson, 1977) and schema (e.g., Rumelhart & Ortony, 1977). However, we shall use the expression SAS sequence because it is quite useful in describing event sequences of a baseball game.

Before continuing, we shall consider another aspect of the relation of the present formulation to other work, namely, the use of the concept of chunking. Following de Groot (1966), Chase and Simon (1973a, 1973b) centered their work on the notion of chunking, arguing that the expert chess player not only has more chunks of information in memory, i. e., more representations of frequently encountered patterns of chess pieces, but the expert also has larger chunks and is perhaps able to access the chunks more quickly than the novice. Chase and Simon further argued that the importance of the chunk is related to processes of short-term memory; the expert is better able to recall the pieces of a game-related chess board because s/he is able to chunk the information more readily in short-term memory.

Recently, however, the Chase and Simon interpretation has been questioned. Frey and Adesman (1976) doubted whether there was any significant short-term memory involvement in the performance of the chess expert, emphasizing instead the role of long-term memory. A similar question was raised by Charness (1976), and Reitman (1976) recently questioned the usefulness of the chunking concept in the game context because she found difficulty in delineating a chunk, i.e., particular pieces were sometimes members of two different chunks.

As the reader may have noted, our analysis has not included either an analysis of short-term memory operations or a discussion of chunking. We have refrained from using short-term memory concepts because our work is presumed to be primarily related to long-term memory differences. However, with respect to chunking, we would maintain that each game situation is, in a sense, a "chunk," with "chunk" defined as an interrelated set of situational components. Generally, chunk size is presumed to be bigger for the HK individual than for the LK individual for baseball-related information because, as previously stated, the HK individual knows of more components that are involved in any given situation. Our conception of a chunk thus is basically one of conceptual interrelatedness and not a memory capacity parameter independent of content.

With a chunk viewed in this way, we would expect that the movement from chunk to chunk for the HK individual would be a relatively smoothly flowing operation compared to that of the LK individual. In our analysis, SAS sequences would constitute an example of chunk-to-chunk movement and, because HK individuals are assumed to have a more complete and accurate knowledge of such contingencies, the HK person would be expected to access successive chunks more readily than the LK person. Viewed in a general way, this position suggests that for the HK person the account of a baseball game is a relatively continuous flow of information, but for the LK individual the account consists of relatively discrete units of information that may be difficult to relate to each other.

Goal structures and strategies. Since baseball is an adversary game in which each team attempts to score runs and prevent the other team from scoring runs, the game has a strategy component in which particular steps are taken by each team to help accomplish its goal. While scoring runs is the primary goal of the team at bat, accomplishing this goal often takes place via the attainment of a number of sub-goals, e.g., advancing a runner. Similarly, there are sub-goals for the team in the field, e.g., picking a runner off base. Because accomplishing goals often takes place via the attainment of sub-goals, teams employ particular strategies in given situations that are designed to attain a sub-goal, in the hope that obtaining the sub-goal will help to accomplish the goal.

The use of strategies in baseball is highly situation-dependent. Thus, in a given situation, a particular strategy may be selected that is designed to produce a more desirable situation via the occurrence of some action. For example, a runner on first base (part of a situation) may try to steal second base (action) in order to be in "scoring position" (new situation). In this case, the sub-goal is to get to second base and the strategy consists of trying to steal second base in order to increase the likelihood of accomplishing the goal of scoring a run. What we postulate regarding knowledge and use of strategies should be reasonably obvious, namely, that HK individuals have a knowledge of more strategies and have a more extensive knowledge of when particular strategies are typically used. Furthermore, the HK person would be expected to have a greater knowledge of the likely success of particular strategies. Thus, the HK person is assumed to have a greater knowledge than the LK person with respect to number and type of sub-goals, in what situations the attainment of particular sub-goals may be desirable, the strategies used to produce the sub-goals, and the likely effectiveness of the strategies.

The present formulation is, of course, related to research on goal structures in problem solving (e.g., Greeno, 1976; Simon, 1975). In problem solving, sub-goals are achieved, for example, as steps taken in a "means-ends analysis." In a similar way, our formulation of a goal structure emphasizes the idea of sub-goals and the actions needed to attain them. However, since sub-goal selection in baseball tends to be so highly contingent upon the situation, and since particular strategies and actions may not produce the desired outcome, the selection of subgoals is a process of continual re-evaluation and revision. In other words, a specific set of "moves" such as found in the Tower of Hanoi problem (Simon, 1975) is difficult to execute in the baseball context because the outcome of any particular action (the new situation) may be an outcome other than the desired one, and a modification of the goal structure is then desired.

Without belaboring the point, we do want also to note that the game situations studied to the present time have involved adversary games (chess and "Go"), which are structured in relation to successive moves, strategies, etc. Baseball, however, has a particular element that leads to a potentially greater level of uncertainty involving successive states than the level found in games such as chess. In other words, in baseball one must deal with the way "the ball bounces."

Before going on, it may be noted that the analysis outlined thus far suggests a hierarchical structure, i.e., an individual learns baseball concepts, gradually adding new concepts and establishing knowledge of the relations among the concepts. Then, as these relations are being acquired, the individual assimilates the relations into higher-ordered structures. Finally, the individual is able to identify the components of the situation that enable judgments to be made regarding strategy and learns when particular strategies may or may not work. However, while this development of knowledge appears to consist of a series of steps, it does not follow that the lower levels must be highly developed in order for the upper levels to exist. In particular, we would argue that LK individuals possess a multi-level structure such as that described, but the structure is much less developed and is relatively simplistic compared to that of the HK individuals. For example, in a number of situations, the LK person may see as the only strategy, "Hit a home run." This person does have the goal of scoring runs in mind (goal structure) and does have a strategy in mind (swing hard), but the person may not know that in a particular situation it may be better to bunt (e.g., the pitcher is batting with runners on first and second base, one out, he is a poor hitter, and has not hit a home run in four years). Thus, the difference in structure of the HK and LK individuals is presumed to be a difference of degree, not type.

Memory Structure and the Acquisition Process

We have postulated differences in the memory structures of HK and LK individuals, and Experiment 1 of the present paper involves an attempt to demonstrate structural differences in HK and LK individuals, as described by multidimensional scaling (MDS) techniques. We would expect that the postulated structural differences should provide some idea of why HK individuals may be able to acquire baseball-related information more readily than LK individuals, and this issue is now considered.

Our assumption is that the most important factor that differentiates acquisition in the HK and LK individuals is a process we shall term structural mapping. We have assumed that baseball-related concepts and groups of concepts of the HK individuals are more highly differentiated than those of LK individuals, and we would therefore expect that new information can be related more readily to highly differentiated concepts than to less differentiated concepts. This process of identifying new information in terms of one's existing memory structure is structural mapping.

We assume that information is acquired more readily in HK than in LK individuals because the more highly developed and differentiated structure of the HK individual enables him/her to map more new information onto his/her existing memory structure, primarily because identification of more new information is possible. In a general sense then, the HK individual is able to provide meaning to input information more readily than the LK individual, not simply because s/he "knows more," but because what s/he knows is highly differentiated.

As an example, consider a situation in which there are runners on first and third base, two out, last of the eighth, etc. Since we have assumed that the HK individual has a knowledge of what components of the situation are especially cogent to the outcome of the game, we would expect that as s/he hears or sees the description, the specific parameters of that particular situation are mapped onto the structure, i.e., how many outs, on which base(s) there may be a runner(s), etc. The sequence of mapping is not taken to be important; what is important is that the HK individual maps more parameters onto his/her memory structure than the LK individual does.

The present formulation is related to other work that assumes that knowledge is acquired via identification of components of situations; our formulation is essentially one of pattern matching and thus is quite similar to formulations such as the EPAM (Simon & Feigenbaum, 1964) and SAL (Hintzman, 1968). What should be mentioned, however, is that in our formulation, the HK individuals typically map more parameters of a given situation onto the memory structure than the LK individuals because of the previously mentioned differences in the memory structure.

The idea that knowledge is acquired via a structural mapping process leads to a number of hypotheses about conditions under which HK performance should be superior to LK performance. Since concepts are assumed to be more highly differentiated in HK individuals, HK individuals would be expected to be superior to LK individuals in linking new information to existing baseball concepts. This hypothesis is tested in Experiment 2.

Another hypothesis involves a verification of the notion that HK individuals have superior knowledge of SAS sequences. If a given situation is presented and one is asked to tell what is likely to come next, the HK person should make more statements than the LK individual. Moreover, the predictions made by the HK individuals should be more related to the game's goal structures. This hypothesis was tested in Experiment 3.

Our formulation also leads to the hypothesis that in an immediate memory task in which a description of a baseball-related episode is provided, HK recall should be superior to LK recall when the sequences are examples of those typically found in the account of a baseball game. However, if the baseball information is not consistent with standard accounts of game events, or when the information is not baseball-related, we would expect that HK and LK recall should be quite similar. This hypothesis is tested in Experiment 4. (This paradigm is similar to the de Groot, 1966, and Chase and Simon, 1973a, work on the recall of chess pieces.)

Another hypothesis is that, in general, HK individuals utilize context much more than LK individuals in recalling game-related information. Since we have postulated that HK individuals have a superior knowledge of SAS sequences, we would expect that if presented with an account of a series of events, cueing with the initial event(s) of the sequence would produce superior recall in HK individuals of the subsequent events of the episode. This result is expected, of course, on the grounds that the HK individual is able to map the sequence of events onto his/her memory structure and is thus able to recall the events because of the knowledge of the relations of successive events. These notions are tested in Experiment 5.

Finally, the last experiment (6 and 6A) involved presentation of a fictitious play-by-play account of a baseball game, and a number of hypotheses were tested. One manipulation involved presentation of game-related information as well as "color" information,[3] and testing was conducted not only at immediate recall, but also at delayed recall. These two manipulations thus provided for testing the hypothesis that HK individuals will recall game-related information better than LK individuals, but that the same results will not occur for color information, and the hypothesis that HK individuals would be superior to LK individuals for baseball-related information not only in immediate recall, but in delayed recall.

Summary of Experiments

The participants were college students who were selected from two populations representing different semesters of the school year. From each population, 48 qualifying students agreed to participate. The criteria for selection and the nature of the populations were as follows.

Population 1. During the Winter Term of 1976 (January-April), a 40-question baseball test that we developed and the first 40 questions of the Davis Reading Test (Form 1A) were administered to approximately 100 students from the University of Pittsburgh and Chatham College. The baseball test consisted of completion questions that primarily tested one's knowledge of the terms and principles of the game. There were no "trivia" questions, nor were there any questions pertaining to particular teams or players. Students were given 20 minutes to complete each test. Students who scored 35 points or more on the baseball test and those who scored 24 points or less were invited to participate for pay in the experiments. The 24 HK subjects who

[3] A sports commentary usually has two components--a play-by-play account of the game in progress and "color" comments. The latter involve information that is of a general background nature and is not directly related to the game.

agreed to participate had a mean score of 38.33, SD = 1.51, on the baseball test. The HK group contained 21 men and 3 women. The 24 LK subjects had a mean score of 16.63, SD = 4.44. The LK group contained 2 men and 22 women. The scores on the Davis Reading Test were 24.50, SD = 5.70, for the HK subjects and 21.33, SD = 6.45, for the LK subjects.

Population 2. During the Fall Term of 1976 (September-December), the same tests were administered to approximately 200 students of the same institutions. Students who scored 38 points or more and those who scored 25 points or less were invited to participate. We attempted to reduce the confounding of sex and baseball knowledge by attaining more women to serve as HK subjects and more men to serve as LK subjects. The 24 HK subjects (19 men and 5 women) had a mean score of 39.01, SD = .65, on the baseball test, while the LK subjects (7 men and 17 women) had a mean score of 17.33, SD = 4.05. The HK group had a Davis Test mean score of 22.58, SD = 4.12, and the LK group had a mean score of 23.13, SD = 6.87. Finally, in the description of each experiment, the subject population (1 or 2) and the number of subjects are designated. In all experiments except 1 and 1a, one-half of the subjects were LK and one-half were HK. (While, unfortunately, sex and knowledge conditions were to some degree confounded in the present studies, the fact that in a number of instances no significant differences were obtained in the high- and low-knowledge groups for non-baseball tasks suggests that the sex differences did not play a significant role in the present research.)

Experiment 1

Experiment 1 was designed to study whether conceptual differences in HK and LK individuals could be demonstrated via the use of multidimensional scaling (MDS) procedures. Such procedures have been previously employed to study concept structure (e.g., Henley, 1969; Homa & Omohundro, 1977; Rips, Shoben, & Smith, 1973), One of the most important aspects of the game of baseball is that there are two teams, each having nine players, with each player playing a particular position. During a game, the players interact in a variety of ways in order to accomplish goals and sub-goals. From the previously outlined rationale, one would expect that HK individuals would have a greater knowledge of such interactions than LK individuals and that if asked to rate the player positions with regard to the extent the players of the positions interact with each other, HK individuals should produce judgments that differ from LK individuals in at least two ways. First, HK persons should be more consistent in their judgments. Second, HK individuals should be more discriminating with respect to the relations among particular positions as, for example, the grouping of pitcher-catcher, infielders, and outfielders. Since we did suggest that the memory structures of HK and LK individuals were different in degree and not in type, however, it was not clear a priori whether the HK and LK individuals would differ in the particular MDS dimension obtained for the judgments of the concepts.

In addition to obtaining judgments with respect to position interaction, we also obtained judgments of position similarity. While this difference in instruction is relatively small, we expected that HK individuals would produce more consistent judgment across instructional conditions than LK individuals because the judgments of the former would reflect a more stable underlying memory structure.

We thus used MDS techniques to determine whether HK and LK individuals differed in how they rated the nine baseball positions (PITCHER, CATCHER, 1st BASEMAN, 2nd BASEMAN, 3rd BASEMAN, SHORTSTOP, LEFTFIELDER, CENTERFIELDER, RIGHTFIELDER) under two sets of instructions. In one case, subjects were asked to rate how frequently a player at one position interacted with the player at each other position on defensive plays, while in the second case the nine positions were rated with respect to their similarity, a somewhat more vague instruction.

Method

Subjects. A sample of 45 individuals (24 HK and 21 LK) from Population 2 participated in this experiment.

Procedure. In the position interaction (PI) task, participants were presented with the lower half of a 9" x 9" matrix in which the rows and columns were labeled with the names of the baseball positions. The participants were asked to fill in each block of the matrix with the number indicating what percentage of the time the two players interacted on defensive plays. A 9-point scale was used where 9 equalled between 88% to 100% of the time, 8 equalled between 77% to 88% of the time, 7 equalled between 66% to 77% of the time, etc. Approximately 20 minutes were given to complete the task.

The position similarity (PS) ratings were performed approximately one week later. Participants were again presented with the lower half of the 9" x 9" matrix, with two new random orders of position names employed along the rows and two new random orders occurring along the columns. One-half of the participants received each new random order. They were asked to fill in each block of the matrix using a 9-point number scale, with the numbers indicating the degree of similarity, 9 denoting as similar as possible, 5 as no more similar than dissimilar, and 1 as dissimilar as possible. The remaining numbers denoted intervening, ordered judgments. Approximately 20 minutes were given to complete the task.

Results: Experiment 1

Figures 1A and 1B present the three-dimensional solution for the HK individuals in the PI task. [Figure 1A presents a plot of the first (horizontal) and second (vertical) dimensions of the solution, while Figure 1B presents a plot of the first (horizontal) and third (vertical) dimensions.] The MDS procedure employed was Carroll and Chang's (1970) INDSCAL.

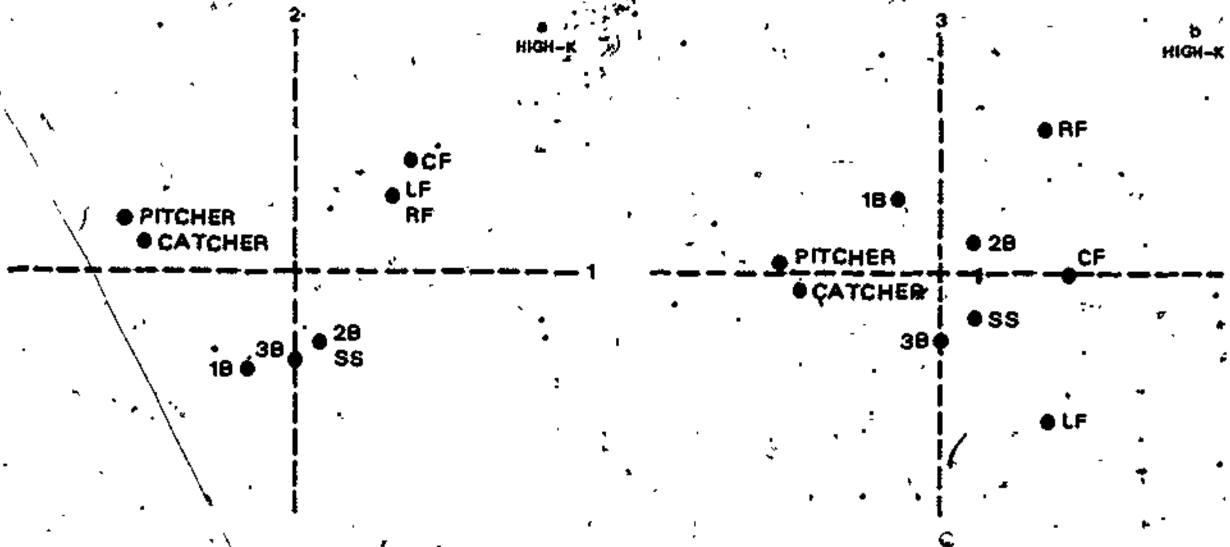

Figure 1. MDS solution of the PI task for the HK group.

Two aspects of the data should be noted, the nature of the dimensions and the nature of the clusters. Realizing that naming dimensions is a subjective exercise, we termed the first dimension as functional distance along a line from home plate to center field. The second dimension was taken to depict functional distance from the interaction of the infielders, and the third dimension was regarded as baseball field symmetry. Figure # also indicates that there was a distinct clustering of pitcher-catcher, the infield positions, and the outfield positions. Finally, one cannot help but be struck by Figure 1B with respect to its close approximation of actual baseball positions, with the exception of the location of the pitcher. However, in a baseball game the pitcher interacts more with the catcher than with the infielders and the pitcher is related functionally more to home plate than the catcher, thus making the pitcher's location on the horizontal axis quite reasonable. With respect to the variance explained, the three-dimensional solution explained 72%. (The variance explained by the one-dimensional and two-dimensional solutions was 40% and 57%, respectively.)

Figure 2A and 2B present the three-dimensional solution of the PI task for the LK group. As with the HK subjects, the first dimension appears to be a functional distance along home plate to center field dimension, although the ordering of positions along the dimension is less clear than in the HK data. The second dimension represents a symmetry dimension, while the third dimension represents a functional distance from infield dimension. The variance accounted for by the three-dimensional solution for LK data was 46%. (The one-dimensional solution accounted for 23% and the two-dimensional solution accounted for 36%.)

Comparison of the HK and LK solutions thus indicates that the judgments of the HK subjects are more consistent than the LK judgments, that the HK data cluster more appropriately with respect to the three basic position groupings, pitcher-catcher, infielders, and

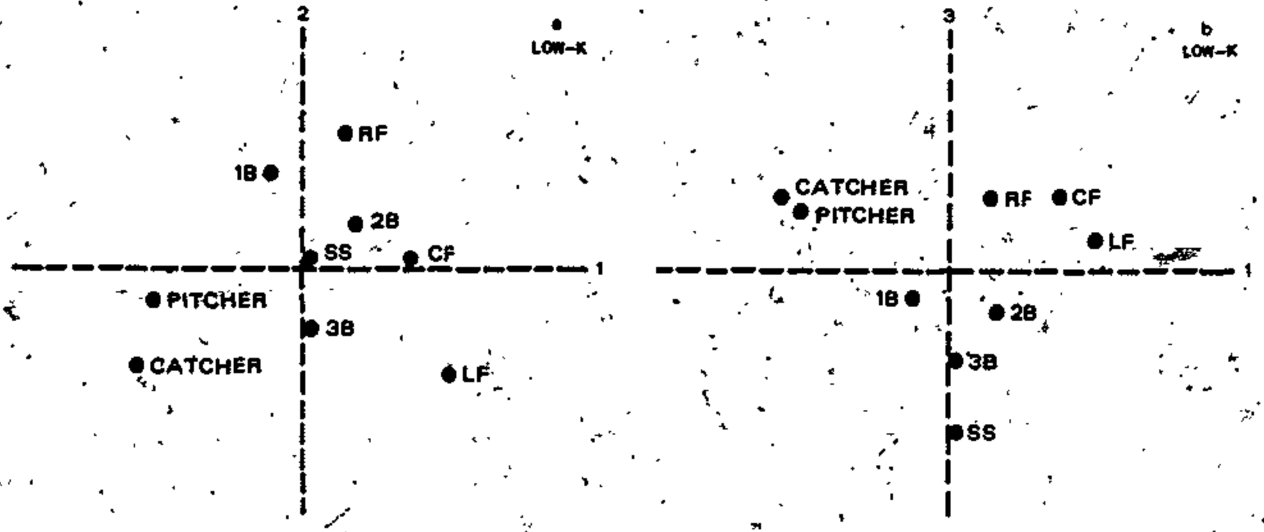

Figure 2. MDS solution of the PI task for the LK group.

outfielders, and that while the first dimension of the HK and LK spaces is quite similar, the second and third dimensions are reversed for the two groups.

It is possible to test the relations of the HK and LK dimensions by correlating the coordinate values of the positions along a particular dimension of the HK space with the coordinate values of the corresponding positions along a dimension of the LK space. By correlating the coordinates of each dimension with each other dimension, one obtains the matrix found in the upper left of Table 1. These correlations show that a substantial relationship exists for the first dimension of the HK and the LK space, and substantial correlations are also shown that indicate that the second and third dimensions are reversed in the HK and LK spaces.

Table 1
Intercorrelation Matrix of Experiment 1

		Position Interaction Dimension HK					Position Similarity Dimension HK		
		1	2	3			1	2	3
LK	1	.96**	.18	.24	LK	1	.93**	.04	.08
	2	.27	.14	.87**		2	.29	.97**	.03
	3	.09	.84**	.27		3	.19	.07	.91**

		PI and PS Correlations HK PI					PI and PS Correlations LK PI		
		1	2	3			1	2	3
PS	1	.59	.90**	.00	PS	1	.47	.00	.49
	2	.84**	.32	-.04		2	.89**	.37	.29
	3	.03	14	.02		3	.06	.29	.25

**Sig. at .01 level ($r = .798$, $df = 7$)

An advantage of the INDSCAL procedure is that it permits a single analysis to be conducted that treats the experimental subjects as objects in multidimensional space. This analysis produces a plot in which each subject is represented as a point in multidimensional space, with each point weighted according to how that particular subject responded with respect to the dimensions of the object space. The advantage of this procedure is that the two groups of individuals, in this case the HK and LK subjects, are plotted individually according to their weighted judgments, and it is possible to perform a discriminant analysis on the coordinate values of the points in order to determine whether the two groups of points (subjects) differ significantly from each other. Such an analysis was conducted, with the result: $\underline{F}$ (3,41) = 15.86, $\underline{p}$ < .001, indicating the the judgments of the HK and LK individuals were indeed significantly different from each other. This result is of interest because it suggests that although the dimensional structure of the HK and LK space was similar, the two groups of subjects were quite different in terms of their weighting of these dimensions in making their judgments.

Figures 3 and 4, respectively, present the MDS scaling results for the PS ratings for the HK and LK subjects. The three dimensions of both sets of data may be interpreted respectively as an infield-outfield dimension, the functional distance from the home plate dimension, and a thrower-recipient dimension. The variance explained for the HK data was 88% for the three-dimensional solution. (The variance explained for the one- and two-dimensional solutions was 54% and 80%, respectively.) For the LK data, the variance explained was 67% for the three-dimensional solution. (The percent explained for the one- and two-dimensional solutions was, respectively, 36% and 57%.) The intercorrelation matrix of these data, shown in the upper right of Table 1, indicates a substantial agreement of dimensions between the two groups. Nevertheless, a discriminant analysis performed on the subject spaces again revealed that the HK and LK populations yielded significantly different results, $\underline{F}$ (3,41) = 9.77, $\underline{p}$ < .01.

The bottom two matrices of Table 1 present the correlations between the instructional conditions for the HK and LK individuals. These

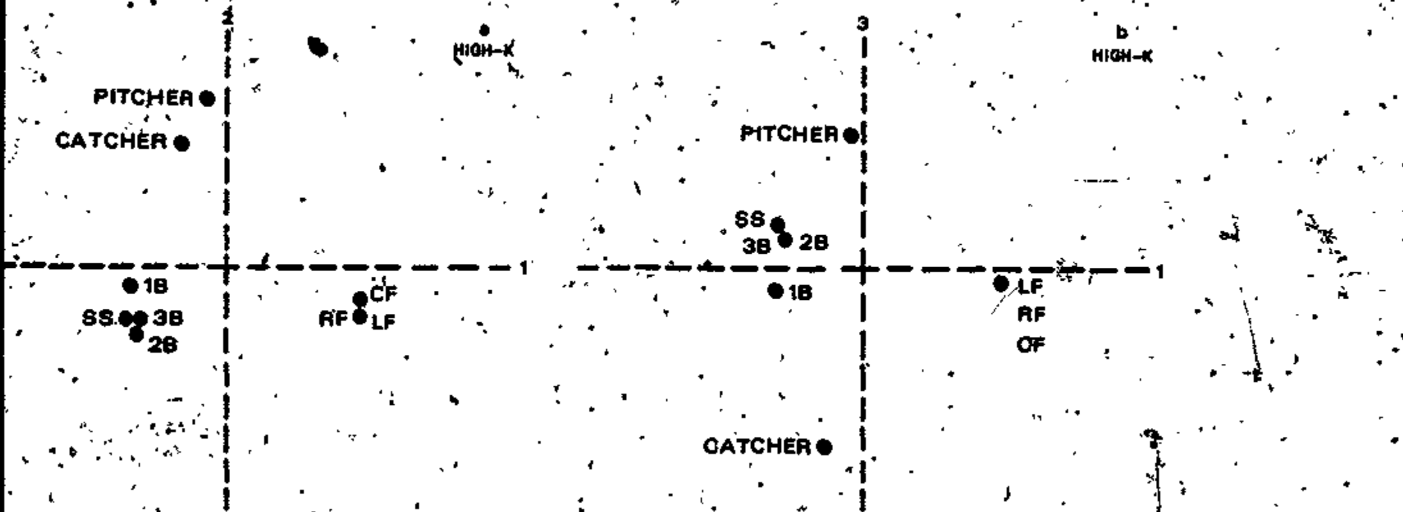

Figure 3. MDS solution of the PS task for the HK group.

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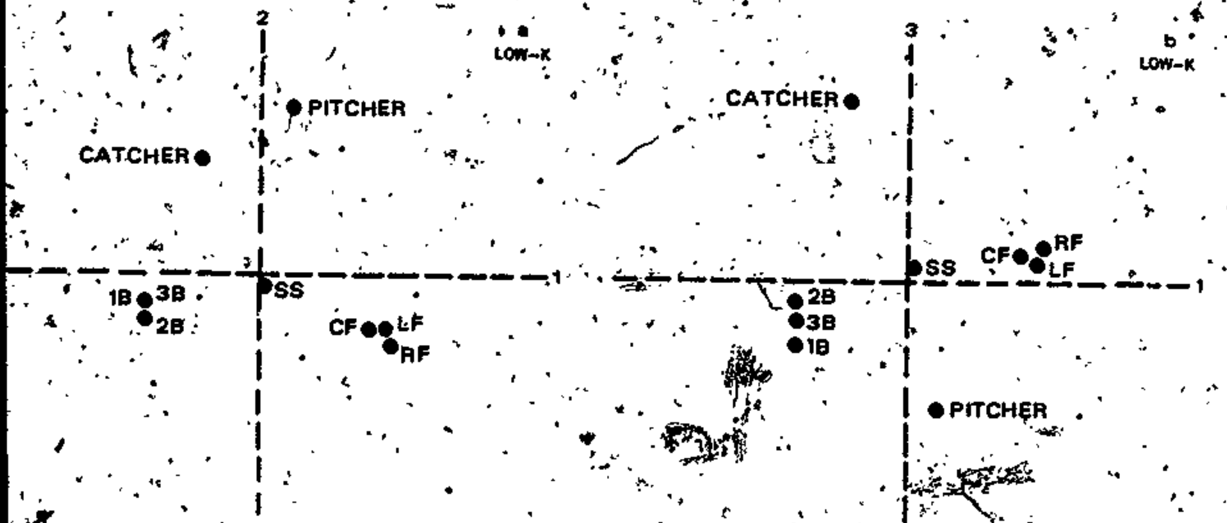

Figure 4: MDS solution of the PS task for the LK group.

matrices provide a comparison of the obtained dimensions across the two sets of instructions. For the HK individuals, the first and second dimensions are essentially equivalent, but they are reversed for the two instructional conditions. The third dimension was different, however, for the two tasks. For the LK subjects, the first dimension of the PI task, functional distance from home plate to center field, correlates significantly with the second dimension of the PS task, but no other substantial correlations were obtained. The correlational data of the two rating procedures thus indicate that across the two instructional conditions, the dimensional structure of the HK subjects was more consistent.

Discussion: Experiment 1

The results indicated that judgments of HK individuals were more consistent than those of LK individuals and that the HK solutions did produce more appropriate clustering of positions in terms of what would be expected from a more substantive baseball knowledge. Finally, the correlational data suggested that a more stable structure exists for the HK individuals in that both sets of instructions produced the dimensions of functional distance from home plate and left-right field symmetry, whereas only the former was present in the two solutions for the LK subjects.

Experiments 2 and 2A

One of the hypotheses developed in the introductory section was that the concepts of HK individuals should be more differentiated than the concepts of LK individuals and that this difference should lead to differences of acquisition. Given that stimulus differentiation is a significant component of paired-associate learning (cf. Battig, 1968), we expected that presentation of a paired-associate list consisting of baseball concepts as stimuli would be acquired more readily by HK than by LK individuals, primarily because the stimuli would be more differentiated for the HK individuals. As it happens, a baseball lineup is essentially a list of nine paired associates. so we therefore presented lineups, using fictitious names. There were four experimental conditions in Experiment 2 and two in Experiment 2A. The rationale for these conditions is described in the next section.

Method

Subjects. Forty-eight subjects were selected from Population 1.

Design and procedure. The four experimental conditions were Name recall, Name-Cue recall, Position-Cue recall, and Pair recall, with each subject serving in all conditions. There was a 15-second delay between conditions. The Name recall condition was always the first task, and the presentation order of the other three conditions was counterbalanced via a 3" x 3" Latin square. In the Name recall condition, the stimulus list contained nine surnames (not the names of known players), and since these names essentially formed a 9-unit free recall list with contents not related to baseball, the list served as a control and we expected no differences in performance between HK and LK individuals.

Each of the stimulus lists of the other three conditions contained nine surnames that were paired respectively with player positions. e.g., RETOS-SHORTSTOP. The positions were ordered so that adjacent positions were drawn from the different playing units of pitcher-catcher, infield, and outfield. The lineup also was not typical. e.g., the pitcher was not last. (The "designated hitter" was not used.)

The recall sheets for the Name recall and Pair recall conditions were blank. The subjects were instructed to recall the names (or pairs) in any order. The recall sheet for the Name-Cue condition provided the list of nine names, with the names presented in a different order than that presented on the study phase of the trial. The recall sheet for the Position-Cue recall condition presented the positions as cues, also in a different order than that employed in the study phase of the trial. According to our hypothesis, HK recall was expected to be superior to LK recall for the Position-Cue condition, but the difference was not necessarily expected for Name-Cue recall. This is because the different position concepts of the HK and LK individuals were expected to provide more highly differentiated stimuli for the HK individuals; whereas fictitious names were not expected to provide such an advantage for HK individuals. For the Pair recall task, we expected the HK individuals to recall more pairs because they would consider each pair as a unit more than LK individuals.

A total of 36 surnames was divided into four lists of equal length. Each of the four surname lists appeared equally often in the Name recall condition, and the surname lists were counterbalanced across the remaining three conditions via use of a Greco-Latin square.

In the Name recall condition, subjects were told they would be given one minute to memorize a list of nine names. Instructions for the three other conditions specified memorizing nine name-position pairs in the allotted minute. After the study period, subjects were given the appropriate recall sheet and informed that they had one minute for recall.

In Experiment 2A, 48 subjects were selected from Population 2. Only the Name recall and Pair recall conditions were employed and, in this case, the subjects were instructed to recall the items or pairs, respectively, in the order in which they were presented. The two conditions were counterbalanced in terms of order of presentation.

Results: Experiments 2 and 2A

Table 2 presents the mean correctly recalled items in each condition. The lack of a significant difference in HK and LK performance in the Name recall condition, $F < 1$, indicates that the groups were essentially equivalent in a straightforward recall task that did not involve baseball-related concepts.

Table 2

Summary of Results of Experiments 2 and 2A

EXPERIMENT 2				
Knowledge Condition	Name Recall	Position-Cue Recall	Name-Cue Recall	Pair Recall
HIGH	7.50	4.83	6.13	4.42
LOW	7.38	2.95	4.71	3.58
	N.S.	Sig. (.01)	N.S.	N.S.

EXPERIMENT 2A		
Knowledge Condition	Name Recall	Pair Recall
HIGH	7.50	3.75
LOW	7.38	2.21
	N.S.	Sig. (.025)

The HK group recalled significantly more names than the LK group in the Position-Cue task, $F(1, 24) = 9.88$, $p < .01$, $MSE = 4.27$, a result supporting our hypothesis. While we argue that the reason for this finding is that the stimulus items were more differentiated for the HK individual and that new information may be mapped onto more highly differentiated concept structures, we do not claim to know the complete basis of the differentiation. Indeed, sometime after the whole series of experiments was completed, the subjects were asked about their strategies in the experiment, and the HK subjects reported the use of position-related imagery as well as the use of elaboration-type procedures such as thinking of what a Shortstop does and trying to relate the name presented with Shortstop to the particular action. They also reported studying the pairs as units. On the other hand, a number of LK subjects reported viewing the names and positions as separate lists that had to be linked, and they reported trying to rehearse the terms. These reports are consistent with our interpretation.

Mean recall in the Name-Cue task was greater for the HK than the LK individuals, although the difference did not reach significance, $F(1, 24) = 3.71$, $p > .05$, $MSE = 6.50$. Our interpretation of this result is that the name did not provide a more discriminable cue for the HK than the LK subjects, but instead the nonsignificant advantage found in the HK subjects occurred because the responses (positions) were more available in the Underwood, Runquist, and Schulz (1959) sense of response learning.

In the Pair recall task, analysis revealed that although HK performance was superior to the LK performance, $F(1, 24) = 1.74$, $p > .05$, $MSE = 4.79$, the difference was not significant. Although we expected the HK subjects to recall more pairs than the LK subjects because they would be able to unitize each pair, we felt that one reason why a significant difference was not found was possibly because the recall was not ordered. (The typical baseball lineup is, of course, an ordered structure.) We tested this hypothesis in Experiment 2A and found that although the ordered Name recall task revealed no significant difference between the HK and LK groups, $F(1, 24) < 1$, HK recall was significantly greater than LK recall for the ordered Pair recall task, $F(1, 24) = 6.81$, $p < .025$, $MSE = 4.19$.

Discussion: Experiments 2 and 2A

The results of the Position-Cue condition support the notion that baseball-related concepts are more differentiated by the HK individuals than by the LK individuals. The results also indicate that ordered Pair recall, which is the traditional lineup format of baseball, provides an advantage for the HK individuals, a result supporting the previously stated idea that HK individuals should be better able to use context in order to recall sequential information. However, since the mean of ordered Pair recall for the HK group (3.75) is considerably less than the single item Name recall mean (7.54), it is clear that for the HK individuals the "pair units" are more complex than the individual name units.

Experiment 3

One of the ideas suggested in the introductory section was that the HK individual has a better knowledge of SAS sequences than the LK individual. This notion leads to the hypothesis that if a given situation is presented, the HK person should be able to generate more events that could follow that situation and that the events generated, would be more appropriate with respect to the subsequent situations. These notions were tested in Experiment 3 by presenting a series of six situations and asking HK and LK individuals what would be likely to occur next in each situation. Three of the situations employed were "open" and three were "closed," where "open" refers to situations that provided for a wider range of predictions and "closed" refers to situations in which the anticipated outcomes were expected to be more specific.

Method

Subjects. There were 44 individuals from Population 2 who served in Experiment 3.

Materials and design. A three-sentence description was written for six different game situations. For example: "The Pirates trail the Brewers 1-0 in the bottom of the eighth. With nobody out, the Pirates have two fast runners on first and second base. Their left-handed hitting shortstop comes to bat." Descriptions varied with respect to the number of situational constraints (the inning, the score, etc.), which reduced the number of plausible outcomes. "Open" situations had 0-2 constraints, while "closed" situations like the one above had 3-5 constraints.

Procedure. All individuals recieved a booklet containing descriptions of the same six game situations. Situations 1, 4, and 5 were "open," while 2, 3, and 6 were "closed." Participants were asked to read each situational description and write as many possible outcomes (things that could happen on the next play) as they could think of--up to a maximum of 15. They were specifically instructed to generate different outcomes and were told not to state a narrative continuation. Everyone was given 20 minutes to complete the task.

Results: Experiment 3

Scoring. Each outcome was placed in one of five categories: H--high probability, appropriate; L--low probability, appropriate; M--marginally appropriate; N--not appropriate; and C--a narrative chain following one of the above response types. Two investigators scored 12 of the 44 protocols and had an interrater reliability coefficient of .91. The data were analyzed in two different ways with respect to chaining responses: (a) counting each link in a narrative chain as one "C" response, or (b) counting each chain as one "C" response. The two analyses produced identical effects of significance, so only the results of the second method are reported.

Mean responses. The HK individuals generated more outcomes per item (7.19) than LK subjects (4.66), $F(1,42) = 5.70$, $p < .05$, $MSE = 24.73$, and more outcomes were generated for "open" (6.30) than "closed" (5.55) situations, $F(1,42) = 9.62$, $p < .01$, $MSE = 1.26$. Although HK individuals appeared to differentiate "open" from "closed" situations (7.74, $SD = 4.63$ versus 6.64, $SD = 4.06$) more than LK subjects (4.86, $SD = 3.79$ versus 4.52, $SD = 3.69$), the interaction was not significant, $F(1,42) = 2.31$, $p > .05$, $MSE = 1.26$.

Response category. Of those responses that were generated, the mean (untransformed) percentage of responses per category for the HK and LK groups is shown in Table 3. As the data clearly indicate, HK individuals produced a greater percentage of appropriate, high probability outcomes than LK individuals, $F(1, 42) = 7.25$, $p < .01$, $MSE = 732.38$. A greater percentage of high probability responses were given in "open" situations (79.9%) than in "closed" situations (74.9%), $F(1, 42) = 10.10$, $p < .01$, $MSE = 54.60$. The interaction was not significant, $F < 1$. Despite the failure to obtain a significant interaction, however, the analyses supported the hypothesis that HK individuals would generate more outcomes, but also more plausible ones.

Table 3
Percent of Responses of Various Types
(Experiment 3)

Knowledge Condition	Appropriate High Probability	Appropriate Low Probability	Marginally Appropriate	Not Appropriate	Chaining
High	85.13	2.91	1.42	1.67	8.86
Low	69.60	3.53	2.25	7.55	17.07

Specific responses and their commonality. The responses given to Situation 2, which were quoted in the Materials section, were placed into 34 categories, corresponding to specific plays (e.g., single, bunt, pitchout) mentioned in the responses of the HK individuals. (The HK group was used as a "baseline" for deriving categories since it was assumed that they were familiar with more types of plays than the LK group.) A final category ("other") was created for low-frequency responses of LK individuals that did not appear frequently in HK protocols. Approximately 19% of LK responses fell in this category.

These tabulations revealed several interesting phenomena. First, LK responses represented only about one-half (16 of 34) of the categories represented by the HK group. Second, despite the greater variety of responses among the HK individuals, there was a high degree of commonality on responses of strategic, goal-related plays. For example, among the HK responses, there were 18 double steals, 15 bunts, 7 drag bunts, and 10 hit-and-run plays. The corresponding LK frequences were 1, 8, 0, and 0. Finally, 45.0% of HK responses represented plays designed to advance runners (bunt, hit-and-run) or defensive plays to prevent such advances (pitchout, pickoff), while only 12.5% of LK responses fell into these categories. The LK responses tended to be of a general nature, such as "the batter made an out."

Discussion: Experiment 3

The results of the present experiment are in strong agreement with the rationale of the introductory section, for they indicate that given a particular baseball situation, HK individuals are able to state a greater number of possible subsequent events than LK individuals, and a greater proportion of these events are appropriate and related to the game's goal structure. In addition, the HK individuals, while giving about twice as many different types of responses than the LK individuals, nevertheless show relatively substantial aggreement concerning particular strategic plays.

Experiment 4

In this experiment, we studied the recall of sequential information in a modified memory-span paradigm. Based upon the rationale presented in the introduction, we hypothesized that if a scenario of meaningful baseball material is presented, the HK individuals should be able to recall the information more readily than the LK individuals. However, if the baseball information is scrambled, in the sense of not following the normal account of baseball episodes, HK performance should deteriorate whereas LK performance should remain the same. Finally, if information is presented that is not related to baseball, there should be no difference in performance of HK and LK individuals. To test the above notions, we used two within-subject variables, length of scenario and the nature of the information within the scenario.

Method

Subjects. Forty-two subjects from Population 1 participated in this experiment.

Design and procedure. The ordered baseball passages consisted of brief scenarios of baseball events as one would find them in an account of a baseball game. In the scrambled baseball passages, baseball scenarios were again presented, but the sentence presentation order within each scenario was random. The third condition consisted of accounts of visual scenes of everyday events, such as a person crossing a street. Passage length was 1, 3, 5, 7, or 9 sentences, with an average sentence length of 7.18 words per sentence, SD = 1.66.

Each subject received two passages of each length in each of the three conditions. Thus, each person received 30 presentations, i.e., 5 lengths x 3 types x 2 passages per condition. The order of presentation consisted of presenting one passage of each length in a random order within each block of five presentations. The three types and two passages of each type were varied randomly over the trial blocks.

The passages were presented on audiotape and the instructions stated that the subjects were to listen to each passage and that they would be asked to recall the passage information immediately after its presentation. The time allotted for recall was 10 seconds for each sentence in the passage, i.e., 10 seconds for a one-sentence passage, 30 seconds for a three-sentence passage, etc. The recall was written.

Results: Experiment 4

Percent correct recall. The data were scored in terms of gist-unit recall, with each sentence broken down into three components that essentially were the subject, verb, and object. These scores were then converted to percentages.[4] The two findings of greatest interest are shown in Figures 5 and 6. Figure 5 presents the data for the significant interaction of Passage Type x Knowledge, F (2,80) = 24.31, $p < .001$, $MSE = .115$. The HK group demonstrated significantly greater recall for normally ordered baseball information, F (1,80) = 53.17, $p < .001$, $MSE = .115$, as well as for scrambled baseball information, F (1,80) = 14.94, $p < .01$, $MSE = .115$. For visual scenes, LK subjects performed better, F (1,80) = 5.93, $p < .05$, $MSE = .115$. Figure 6 presents data of the significant interaction of Passage Type x Length x Knowledge, F (8,320) = 4.21, $p < .001$, $MSE = .047$. As shown, the HK group yielded superior recall at all sentence lengths for the normal sentence order.

Percent consecutive recall. Because we were interested in whether recall was more ordered for the HK individuals, the data were tabulated as follows. Starting with the first sentence of each scenario, the number of consecutive sentences (from which at least one gist unit was recalled) was tabulated for each participant for each condition. This number was then divided by the total number of sentences from which at least one gist unit was recalled by the individual in that condition. Thus, the score effectively gives the percent ordered recall of the total amount recalled. The one-sentence experimental condition was deleted from this analysis as was the scrambled presentation

[4] In all analyses presented in this paper involving percentages, the percents presented were calculated directly from the data and the analyses were performed on the arc sin transformed percentages, unless otherwise noted.

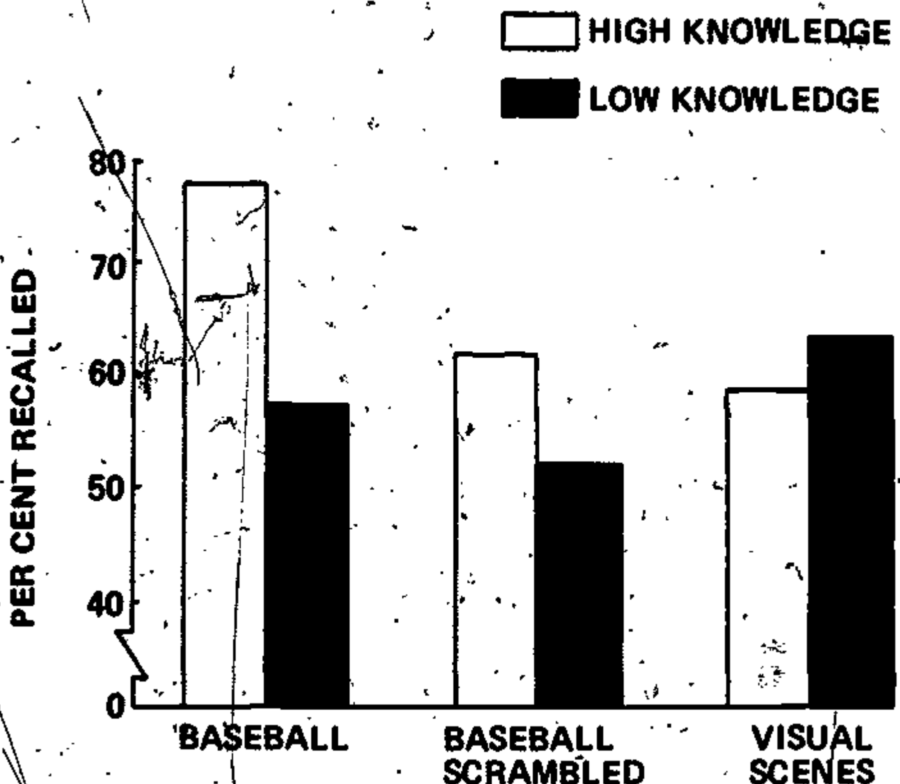

Figure 5. Percent correct recall for HK and LK individuals for the three types of verbal material (Experiment 4).

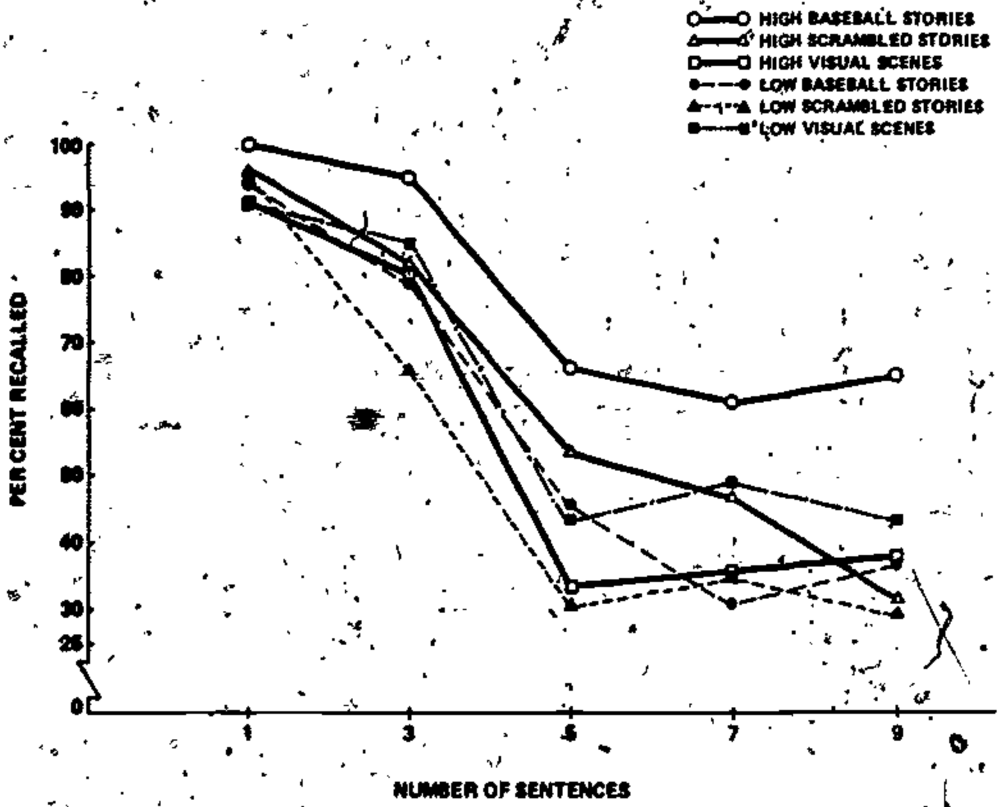

Figure 6. Percent correct recall as a function of length with knowledge group and type of material as parameters.

condition. The latter was omitted because of ambiguity in what should be considered ordered recall for the scrambled sentences.

Table 4 presents the mean percent consecutive recall for the significant Knowledge x Passage Type interaction, $\underline{F}$ (1,40) = 7.14, $\underline{p}$ < .05, MSE = .154. The results indicate that percent consecutive recall was greater for the HK group than for the LK group, but there was little difference in percent consecutive recall for the visual scene data between the two groups.

Table 4

Percent Consecutively Recalled Sentences

Verbal Material	Knowledge Condition	
	HK	LK
Baseball-Normal	74.4	55.0
Visual Scene	57.8	54.8

Table 5 presents the means for the significant Length x Knowledge interaction, $\underline{F}$ (3,120) = 4.78, $\underline{p}$ < .01, $\underline{MSE}$ = .106. The data indicate that although performance at the length of three was similar for the two groups, there were differences at longer lengths. There was convergence at the length of nine. The Knowledge x Type x Length interaction was not significant, $\underline{F}$ (3,120) = 1.52, $\underline{p}$ > .05, $\underline{MSE}$ = .093.

Table 5

Percent Consecutively Recalled Sentences

Condition	Length 3	5	7	9
Baseball-Normal	89.3	62.3	50.3	57.1
Visual Scene	91.7	50.3	47.7	35.6
HK	91.0	64.7	60.7	48.0
LK	89.9	47.9	37.3	44.7

Discussion: Experiment 4.

The data of Experiment 4 support the notion that performance of HK individuals is superior to that of LK individuals on an immediate memory task, with the result obtained only for baseball information, and especially for normally sequenced baseball information. With respect to why the HK subjects tended to recall scrambled baseball information better than LK subjects, one possibility is that there may have been sufficient cues in the scrambled material that enabled the HK individual to relate adjacent sentences by providing meaningful relationships for the information of the adjacent sentences.

Since intuitively it may be expected that the HK individuals could recall sentence sequences longer than nine sentences, the finding of a decrease in consecutive sentence recall at the length of nine sentences for HK individuals raises an interesting question. One possible reason for this finding is that at a given length an excessive memory load develops (which probably would vary with specific contents), and the HK individuals may effectively try to recode the information into a more abstract structure. Such recoding would be expected to take place by retaining only the most salient (with respect to the game's goal structure) aspects of the previously stated information and disregarding other information from the earlier sentences. A second possibility is that at the time of output there is considerable output interference taking place so that the individual may not be able to retain the most recently presented material (cf. Tulving & Arbuckle, 1966). The present data do not provide for selection of either of these alternatives or of some other explanation (such as implicitly weighting input information for importance and forgetting according to importance), but they do suggest the question of how information recalled immediately may be selectively retained over longer intervals.

Taken as a whole, however, the results of the present experiment provide strong support that, based upon the structural mapping notion. HK individuals are able to recall sequences of baseball-related information better than LK individuals.

Experiment 5

The rationale of the introductory section indicated that ordered baseball information should be better recalled by HK than by LK individuals because differences in the knowledge of the HK and LK individuals enable the HK person to map input information more readily only his/her memory structure. Moreover, it was hypothesized that if baseball information involving standard game sequences were presented to the HK individual, and s/he subsequently tried to recall this information via a procedure in which some of the information is used for cueing purposes, the recall of the HK individual should be greater than that of the LK individual because the former would have understood more readily how the input information is related. In other words, if A-B-C is a presented sequence of three sentences of ordered baseball information, and at recall A and B are presented, the HK individual should be better able to recall C because s/he has processed A-B-C as an integrated unit. The LK individual, however, not having encoded A-B-C as a unit, because of not being able to relate A, B, and C, will be helped less than the HK individual by the cueing procedure.

Following the above notation and defining C as the target sentence, subjects were presented with A-B-C, B-C, or C. Subsequently, they first were asked to recall the target sentences and then were presented with A-B or B, respectively, for the A-B-C and B-C conditions. We could then assess whether cueing with the context sentences would produce relatively greater improvement over non-cued recall for the HK individuals than for the LK persons. Finally, a recognition test was given.

Method

Subjects. The 36 subjects participating in this experiment were drawn from Population 1.

Design and procedure. A total of 24 three-sentence stories was constructed. The last sentence in each story was the target sentence, and it always appeared in capital letters. Eight of the target sentences were presented without any context sentences, eight target sentences were preceded by only the second sentence of the story (one context sentence), and eight target sentences were presented with the initial two sentences of the story (two context sentences). There were three counterbalanced arrangements of the sentences so that each of the 24 target sentences appeared equally often in the zero-, one-, and two-sentence conditions. The three context conditions were presented in a blocked random order such that the entire nth instance of zero-, one-, and two-sentence context conditions were presented before the $n + 1$ instance. The order of the three context sentence conditions was randomized in each block.

Participants were tested in group sessions. Each person was given a materials booklet with numbered pages and informed that stories of various lengths appeared on each page. The instructions specified that while the entire story was to be read, particular attention should be given to the sentences in capital letters because testing would subsequently take place on those sentences. Reading time was controlled by a tape that instructed participants to turn the booklet pages. Presentation time was at a rate of eight seconds/sentence. Thus, target sentences presented alone were given 8 seconds, one-cue stories were given 16 seconds, and two-cue stories were presented for 24 seconds. After each individual had read all 24 stories, a letter cancellation task was given for three minutes.

With respect to testing procedure, the first task was a free recall task in which the individuals were given 10 minutes to recall as many target sentences as they could. Next, the appropriate subjects received two sheets of paper containing eight one-sentence cues and eight two-sentence cues that were identical to those context sentences they had seen previously. They were given a total of 10 minutes to recall the 16 corresponding targets, being instructed to write them down after the appropriate context sentence(s).

After the cued recall task, each individual was given a sheet containing 24 pairs of sentences and s/he was asked to check the number of each pair that had previously been presented as a target sentence. The distractor sentences were baseball-content sentences of the same length as the target sentence. While phonetically similar to the target sentences, the distractors differed in meaning. For example, one target sentence was: Batting slumps tend to be long for good and poor hitters alike. The corresponding distractor sentence was: Batting slumps tend to belong to the category of events that no hitter likes.

Responses in the non-cued recall tasks were scored on a three-point scale for each sentence. One point each was given for each of three gist units, which roughly corresponded to subject, verb, and object construction.

Results: Experiment 5

Free recall. Figure 7 presents the recall probability for the HK and LK groups for the three context conditions. Although the HK individuals exhibited much better performance than the LK individuals, $F(1, 30) = 10.17$, $p < .01$, $MSE = 2.22$, the most interesting result is the significant interaction of Knowledge x Number of Context Sentences, $F(2, 10) = 9.92$, $p < .001$, $MSE = .148$. As shown, LK mean recall of target sentences decreased as a function of number of context sentences at input, whereas HK recall increased with number of input context sentences. In other words, having the context sentences

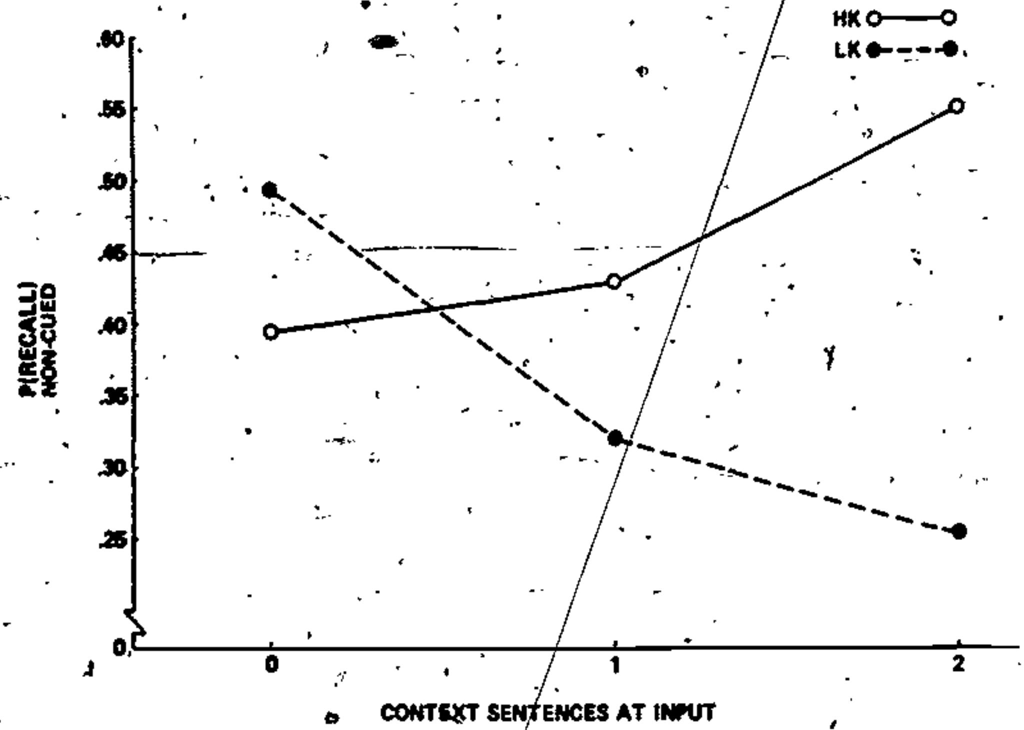

Figure 7. Probability of non-cued recall as a function of numbers of context sentences at input for the HK and LK conditions (Experiment 5).

present at input aided the HK subjects in generating the target sentences at recall even though the context sentences were not present at recall, whereas the presence of the context sentences at input reduced recall effectiveness for the LK subjects. Finally, for zero context sentences at input, free recall performance did not differ significantly for the HK and LK groups, $\underline{F}$ (1,60) = 1.42, $\underline{p}$ > .05, $\underline{MSE}$ = 1.92.

One interpretation of why the presence of context sentences at input facilitates target sentence recall is that the HK individual may generate a context sentence at recall, and, because the context sentence(s) and the target sentence are encoded as a unit, the subject is able to generate the target sentence from the context sentence(s) s/he recalled. Moreover, such an effect would be expected to increase with an increasing number of context sentences, a result that was obtained. We, of course, do not not know the specific recall probability of a context sentence and the probability that a recalled context sentence could evoke the target sentence, but our interpretation (i.e., that for HK subjects the context sentence(s) and related target sentence are encoded as a unit) suggests that the latter probability is reasonably substantial.

One interpretation of the LK uncued recall data is that processing the context and target sentences at input consists of a tendency to store the sentences as discrete units. The information load, therefore, is greater with contextual sentences, and, since the LK individual is not as able as the HK person to encode the sentences as a unit, recall is affected detrimentally with the increasing information present at input. Thus, for LK individuals, there is a possibility that at recall some context sentences may have been generated, but this did not tend to lead to successful target recall.

Finally, the failure to obtain a significant difference between the HK and LK groups with no context sentences at input, coupled with the facilitative effects of context with HK individuals, suggests that HK persons not only use context more effectively than the LK individuals, but perhaps even more importantly, the HK individuals require context to produce recall superior to that of the LK individuals. In other words, the advantage in recall for HK individuals rests upon their knowledge of inter-sentence relations, a result consistent with the formulations presented earlier.

Cued recall. Analyses performed on the cued recall data were aimed at determining whether the HK individuals were helped more by cueing than the LK individuals. The analyses yielded an affirmative answer. The measure employed was the (untransformed) percentage of targets for which cued recall was greater than free recall (percent of 16 target sentences for which more gist units were recalled in cued recall than in free recall). The HK group showed a significantly greater increase in recall with cueing (54.0%) than the LK group (29.4%), F (1,30) = 37.23, $p < .001$, MSE = 484.58. The data then were separated into two categories, when free recall was greater than zero and when it was zero, i.e., no part of a target sentence was recalled. As one would expect, cueing produced a greater effect when nothing about a sentence had been recalled in free recall, F (1,30) = 94.45, $p < .001$, MSE = 681.48 (62.9% versus 20.6%), and the interaction of Knowledge and the none-versus-some-recall variables is significant, F (1,30) = 4.34, $p < .05$, MSE = 681.48. Specifically, both the LK and HK groups showed greater facilitation with cueing when no information was recalled, but the facilitation was less in the LK group, 12.8% to 46.0%, than in the HK group, 28.4% to 79.7%. Thus, the analyses indicated that the HK individuals were able to make more effective use of the context sentences when they served as cues, as originally hypothesized.

Recognition. The recognition data yielded essentially no difference in performance between the HK and LK groups. The mean number of targets recognized (of 24) was 23.5 for the HK group and 23.0 for the LK group. Although there are problems of interpretation for such ceiling effects, two reasons may nevertheless be suggested for this result. One is that the distractors were not sufficiently similar to the target sentences to obtain a significant number of incorrect responses. On the other hand, the possibility does exist that the HK and LK individuals may perform at approximately equivalent levels on baseball-related recognition tasks, in which case the knowledge differences obtained in the retrieval tasks would be taken to reflect access to stored information and not storage of the information.

Discussion: Experiment 5

The primary result of Experiment 5 was the demonstration of strong context effects in both uncued and cued recall for the HK individuals. Perhaps the most significant result is that contextual information presented at input not only led to superior recall when the context sentences were presented as cues, but the presence of contextual information at input enabled the HK individuals to generate more target sentences in the free recall phase of the experiment. This result was interpreted as indicating that the HK individuals were able to generate the target sentences because they were able to relate the sentence sequence to their memory structure and encode the sentence sequence as a unit. On the other hand, for the LK individuals the context and target sentences at input were essentially discrete, and increasing the number of sentences at input effectively increased the memory load for these subjects.

Experiments 6 and 6A

The previous experiments demonstrated that HK performance was superior to LK in a number of task situations. In Experiments 6 and 6A, we were interested in whether the superiority of the HK subjects in recall performance would persist in a more naturalistic setting. We presented a play-by-play account of an inning of a hypothetical baseball game and subsequently asked a number of questions related to the account. Based upon the previous findings, we expected to find superior recall for the HK individuals, and our greater interest was in the effect upon performance of particular variables that were manipulated within the play-by-play account.

Two types of material were presented in the play-by-play account, termed baseball information and color information. As an example, our play-by-play account began with the announcers introducing themselves, the teams were then mentioned in the usual manner, and the National Anthem was announced. The singer was introduced, and the National Anthem was played. A subsequent "color" question was, "Who sang the National Anthem?" Other color material included what a player did in the off-season, who threw out the first ball, etc.

A second variable was frequency or repetition of information. From the total set of statements in the account, particular statements were made one, two, or four times for both color and baseball material. We were interested in determining whether frequency would be of greater importance to LK individuals than to HK individuals. The basis for this hypothesis was that since we assume that HK individuals will acquire play-by-play by a structural mapping process, frequency may have relatively little effect, at least for baseball-related (as opposed to color) information. However, because the memory structure of the LK individuals is considered to be less developed and provide less opportunity for structural mapping, frequency may have a relatively greater effect than for HK individuals.

A third variable was the nature of the questions, whether factual or inferential. The nature of the inferential questions is described more fully in the Method section, as are the differences of Experiments 6 and 6A. We expected that HK individuals would be more likely to make appropriate inferences than LK individuals.

Finally, we conducted a delayed recall test in Experiment 6A in order to determine whether HK individuals were superior not only in the immediate recall of baseball-related information, but also in the delayed recall of such information, given that it was correct at immediate recall.

Method

Subjects. Forty-two individuals from Population 1 served in Experiment 6 and 42 individuals from Population 2 in Experiment 6A.

Procedures and materials. The subjects listened to a 45-minute, audiotape-recorded play-by-play of a fictional baseball game between two fictional minor league teams, the Duquesne Dukes and the Fox Chapel Chargers.

A cued recall procedure was employed in which a question was asked that contained information from one part of a sentence, and the individual was asked to recall the information that had occurred in the other part of the sentence. For example, during the play-by-play account with the Chargers in the field, the baseball statement "Steve Farlow played centerfield for the Chargers" was made. An example of a color statement is that Agnes Miller sang the National Anthem. Later, the following questions were asked, "What position did Steve Farlow play?", and "Who sang the National Anthem?"

The frequency variable represented the number of times a factual statement was mentioned in different sentences, 1, 2, or 4. For example, that Steve Farlow played centerfield was mentioned in four sentences, while Agnes Miller's singing of the National Anthem was only mentioned in one.

No attempt was made to counterbalance particular statements and their frequency of occurrence. Also, the spacing of repetitions was not systematic. There was a slight tendency for repeated baseball statements to be more spaced than color statements due to our interest in making the play-by-play account authenic. No repetitions occurred in adjacent sentences, however.

The play-by-play account was recorded on a cassette tape recorder. Instructions on the beginning of the tape asked individuals to listen carefully to the play-by-play account and prepare to answer questions about it. The individuals, run in groups, were not permitted to take notes.

After completion of the broadcast, taped instructions told the individuals to prepare for questioning. Each person was given a blank sheet of paper. The voice on the tape called out the number of each question, read the question, and gave the individuals 30 seconds to answer before announcing the next question. There were five baseball and five color questions at each frequency. Participants were asked to write down the number of each question and to answer it during the prescribed period. The questions were presented in blocked random order so that n questions of each frequency content combination were asked prior to asking the n + 1 questions from any category.

After the initial set of 30 questions was presented, the individuals were asked to answer 20 questions involving inferences. These questions were also read at 30-second intervals on the tape. The inference questions reconstructed some event in the broadcast and asked the subject how and why it came to occur. Ten inference questions were on baseball content and 10 were on color content.

In Experiment 6A, Experiment 6 was replicated with four changes. First, the play-by-play account was modified by changing a few names, making a few statements more specific, and changing two questions. Second, one-half of the individuals in Experiment 6A heard a scrambled version of the game, which was formed by breaking the play-by-play account into blocks of 6-10 sentences and then randomly reordering the blocks as well as randomly rearranging sentences within the blocks. Third, in addition to the immediate test, a second test consisting of the same questions was given approximately one week later. The questions were presented in a different order. This was an important addition because it enabled us to determine not only whether immediate recall was better for HK than for LK individuals, but it also provided for determining whether forgetting was less for LK or perhaps equivalent for both HK and LK individuals. Finally, no inference questions were asked in Experiment 6A.

Results: Experiment 6 and 6A

The results were highly consistent for the two experiments with respect to the common variables. Since Experiment 6A was more refined, the results presented are those of Experiment 6A except where indicated.

HK versus LK. As expected, the percent correct recall for the HK group (44.3%) was significantly greater than for the LK group (27.3%), F (1, 36) = 27.01, p < .001, MSE = 1.16.

Baseball versus color contents. The percent correct recall was significantly better for color contents (47.2%) than for baseball (24.5%), F (1, 36) = 49.17, p < .001, MSE = .92. The interaction of knowledge and type of content was not significant, F (1, 36) = 1.69. (HK: baseball - 34.4%, color - 54.3%; LK: baseball - 14.6%, color - 40.0%.)

Frequency. There was a significant effect of frequency, F (2, 72) = 51.11, p < .001, MSE = -.63, with the mean recall of 1, 2, and 4 event frequencies = 22.4%, 28.5%, and 46.9%, respectively. Frequency did not interact with Knowledge, F (2, 72) = 2.12, p > .05, nor was the Knowledge x Frequency x Color interaction significant, F (2, 72) = 1.13.

Normal versus scrambled information. There was no difference in recall for normal and scrambled information, F (1, 36) = 1.75, p > .05, nor did this variable interact with Knowledge, F (1, 36) = 1.91, p > .05.

Immediate versus delayed recall. We now consider one of the most important questions asked by this study, namely, whether HK individuals not only acquire information better, but remember it better under conditions of delayed recall. The overall analysis of variance performed on the percent correct response data revealed that as expected, immediate recall performance was superior to delayed recall, F (1, 36) = 49.17, p < .01, MSE = .92. The Knowledge x Retention Interval interaction was not significant, F (1, 36) = 2.74, p > .05, MSE = .92, nor was the Baseball versus Color contents x Knowledge x Retention Interval interaction, F < 1. However, these analyses were on the overall recall data and thus did not yield a measure of correct delayed recall, given correct immediate recall.

Figure 8 presents a tree diagram that provides the probability of immediate recall and the probability of delayed recall, given that a particular item was correct in immediate recall. The data are broken down into the baseball and color contents. The data analyzed were the percent correct responses in delayed recall, given that the item was correct in immediate recall. This analysis revealed that the HK group yielded better delayed recall than the LK group, F (1, 36) = 13.40, p < .01, MSE = 1.72. Furthermore, although the conditional probability of recall of color information was greater than that of baseball information, F (1, 36) = 88.08, p < .01, MSE = 1.07, the interaction of knowledge group and type of contents was significant, F (1, 36) = 10.73, p < .01, MSE = 1.07, with the HK group showing relatively better delayed recall than the LK group for the baseball-related information as compared with the color information.

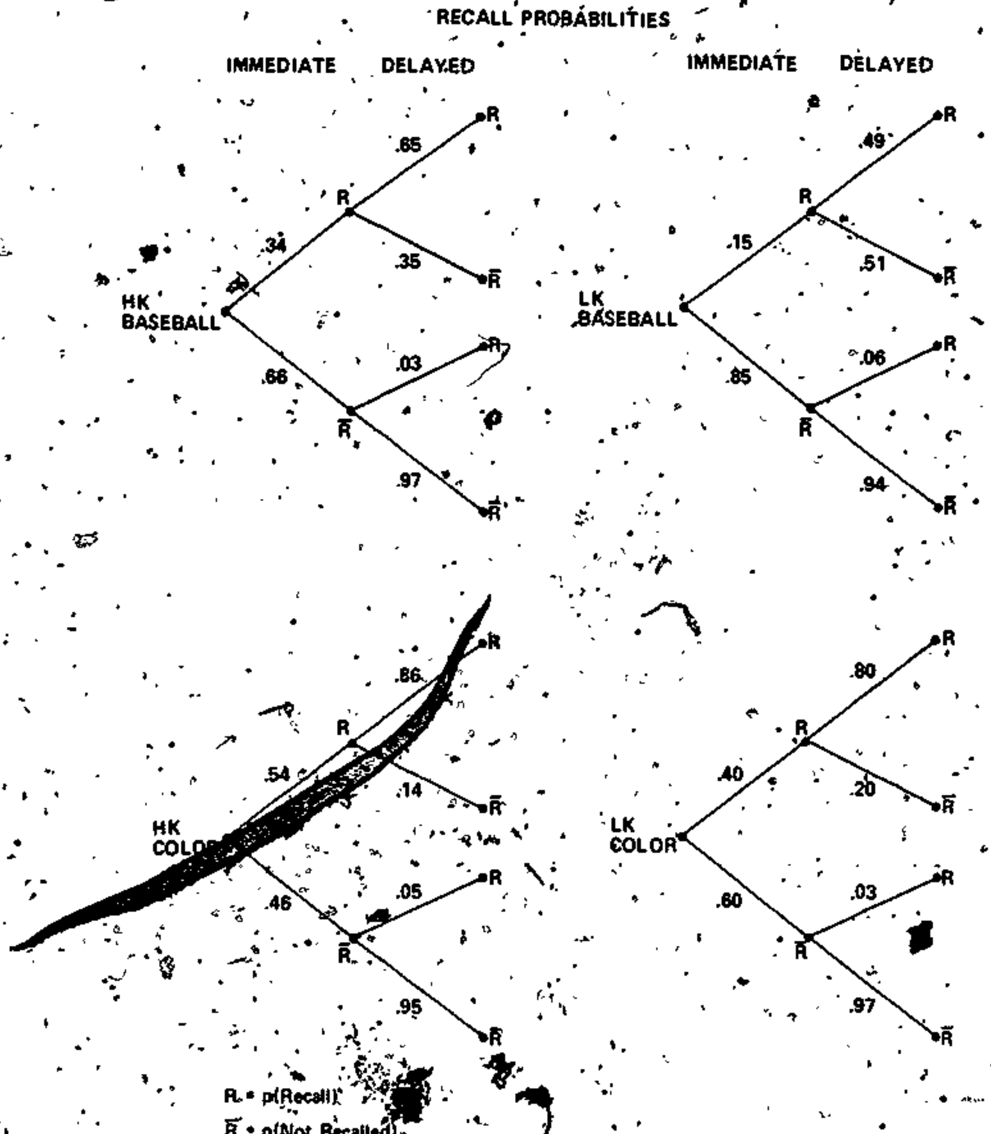

Figure 8 Tree diagrams of immediate and delayed recall conditions for the HK and LK groups and color and baseball information (Experiment 8A).

Finally, the more frequently information was presented, the better the delayed recall, $F(2, 72) = 5.59$, $p < .01$, $MSE = 1.24$. This finding is worth noting because it indicates that frequency had an effect upon delayed recall for items of all frequencies that were recalled correctly in immediate recall. The Knowledge x Frequency interaction and Knowledge x Frequency x Baseball versus Color interaction were both nonsignificant, $F < 1$.

<u>Inferential Information (Experiment 6)</u>

The percent of correctly recalled answers for inferential questions was 85.5% for the HK individuals and 56.1% for the LK individuals. Since the information for all inferential statements that were tested had only a frequency of one, an arc sin transformed analysis was performed that compared the frequency of one recall data for non-inferential questions and inferential recall data. This analysis revealed that inferential questions yielded greater correct recall (71.0%) than factual questions (36.1%), $F(1, 40) = 235.21$, $p < .01$, $MSE = .039$. The percent recall was Factual, HK = 44.5, LK = 27.6; Inference, HK = 85.8, LK = 56.1. Thus, the advantage of HK condition is slightly better for inferential questions.

Analysis also revealed that although percent recall for the HK group was approximately equal for baseball (66.1%) and color information (64.2%), the LK group was substantially better with respect to color information (Baseball: 35.0%, Color: 48.7%). This interaction was significant, $F(1, 40) = 9.34$, $p < .01$, $MSE = .067$. These two factors, Knowledge and Contents, however, did not interact significantly with Question-Type, $F < 1$.

In interpreting these data, it should be noted that the nature of the inferential information did not provide for determining whether correct answers were due to prior knowledge, i.e., knowledge of the individual before hearing the play-by-play account or due to making inferences solely based upon information of the play-by-play description.

Discussion: Experiments 6 and 6A

The results of Experiment 6 and 6A provided answers to a number of questions. First of all, the HK group showed better immediate recall than the LK group, and the HK group also showed better delayed recall with the data conditionalized on correct immediate recall. Moreover, the delayed recall effect was greater for baseball information. These results indicate that HK individuals thus have greater access to long-term information, a result we attribute to the greater ability of the HK subjects to relate information to their memory structure in the manner outlined in the introduction.

The relatively high level of color information recall warrants comment. Color information was not really neutral "control" information since some of it contained information about the players, etc., even though the information was not germane to the game. We had thought of using commercials as control information, but opted for this type of information, feeling that it more accurately simulated play-by-play accounts. We would attribute the relatively high level of recall of color information to the uniqueness or novelty of such information in the baseball context.

While the frequency variable significantly influenced performance, there was little differential effect of frequency upon HK and LK performance. Similarly, the scrambled versus normal order had little effect in this study. In one sense, these two negative results are important, for in comparing HK and LK groups, it sometimes is almost as important to determine where differences do not exist as it is to determine where they do exist. With respect to the lack of effects of scrambling the information, the testing procedure of the present experiment may have mitigated against obtaining such an effect. Experiments 6 and 6A involved asking specific questions, with the question and answer both derived from one sentence, and for within-sentence information, scrambling may have little effect. In Experiment 4, however, in which an effect of scrambling was obtained, recall was of the information of consecutive sentences.

General Discussion

The present results provided an affirmative answer to the first question of the introductory section, that of whether HK individuals actually acquire new domain-related information more readily than LK individuals. Moreover, the findings of Experiment 6A indicated ~~that not only did the HK individuals acquire baseball-related informa-~~ tion more readily, but once acquired, they retained it better than LK individuals. Furthermore, in demonstrating such differences between HK and LK individuals, the present research extends our knowledge of expert and novice performance differences. With the possible exception of Reitman (1976) and of Loftus and Loftus (1974), previous research on differences in the expert and novice focused primarily upon processing differences of perceptual processing (e.g., Chase & Simon, 1973a) and not upon information acquisition. It is of more than passing interest to note that the present paper may be viewed as an extension of the previous work because the mechanisms proposed in the present paper to account for the HK and LK acquisition differences are based upon perceptual processing concepts.

Considering the second question of the introduction, that of the processes underlying the acquisition differences, the present formulation attributes such acquisition differences to a relatively straightforward principle termed structural mapping. Basically, this principle asserts that the HK individual acquires domain-related information more readily than the LK individual because the more highly developed memory structure of the HK individual enables him/her to "provide more meaning" to the particular input information. The view thus assumes that we tend to acquire what we understand, and the HK individual understands more because his/her knowledge of concepts, higher-ordered structures, situations, SAS sequences, and strategies is much greater than that of the LK individual.

The results of the present experiments present a type of converging evidence for the above position. The findings of Experiment 1 support the notion that there are differences in the nature of baseball concepts in the HK and LK individuals. While the experiment only involved study of a limited set of baseball-related concepts, the data nevertheless indicated that the conceptual relations (as measured by MDS procedures) are different for HK and LK individuals and that HK individuals are in greater agreement among themselves regarding conceptual relations than the LK individuals. These findings are in agreement with the result showing that as a person learns the material of a given subject matter area, one's organization of the material more closely approximates that of the expert (Shavelson, 1972).

The results of Experiment 2 supported the idea that domain-related concepts are more differentiated in HK than in LK individuals, while the results of Experiment 3 supported the idea that HK individuals should have a more extensive and more appropriate (in terms of goal structure) knowledge of SAS sequences. An issue raised in Experiment 3 is that since the rather loosely defined "Open" and "Closed" variable yielded significant effects, a factor that may be important to acquisition is the extent to which a given input restricts the possible range of subsequent events. Indeed, a question for future consideration involves how HK acquisition can be influenced by the HK individual's greater knowledge of what comes next in any situation. Does, for example, an HK person remember an unexpected or an expected event better? One could argue the case either way, i.e., easier mapping versus a type of novelty effect.

The results of Experiments 4, 5, and 6 point to what perhaps is the strongest effect obtained in the series of experiments: The HK individuals are able to utilize context much more than the LK individuals. Within the present framework, this result is attributed to the fact that because HK individuals have a more developed knowledge of SAS sequences, they are more readily able to map the sequential information onto their memory structure. Of particular note is the result of Experiment 5 which indicates that one reason why HK recall is generally superior to LK recall is because the HK individual is able to use the context at input to generate subsequent recall. This result has two implications of note. First, it suggests that more knowledgeable individuals have better "memories," at least in part, because they are better able to generate responses by using other information they know for cueing purposes. Second, the results at least raise the question of the extent to which individuals, and HK individuals in particular, furnish their own context at input implicitly by bringing to bear something they know to the input situation. Obviously, it is difficult to demonstrate such implicit occurrence of information.

Taken as a whole, the experiments provide evidence for the formulation presented earlier, and although at this stage of development the framework is, of necessity, quite general, the experimental findings nevertheless are supportive of the framework and, in particular, the results underscore the importance of one's knowledge of conceptual relations in acquiring domain-related information.

The present formulation bears an interesting relation to the depths-of-processing concept (e.g., Craik & Lockhart, 1972). Not only could one argue that HK individuals process information more deeply than LK individuals, but one could also use the present formulation to help provide an interpretation of "depth." In particular, the HK individual may be presumed to process input information at a greater "depth" because the information is processed in terms of a more highly differentiated memory structure (cf. Lockhart, Craik, & Jacoby, 1976). Moreover, this interpretation relates "depth" to differences of semantic processing in HK and LK individuals and not to instructional conditions such as instructions to process semantically or phonologically.

The present formulation also helps to provide for the development of schema theory (cf. Anderson, Spiro, & Montague, 1977). In particular, while the principle of structural mapping may be viewed as mapping information onto a schema, the more important consideration is that the occurrence of schema instantiation or activation according to the present view is taken to be a perceptual matching process in which the parameters of the input information are fitted to existing schema. Moreover, this view has the interesting implication that since the schema are assumed to be more highly differentiated in the HK than in the LK individual, the HK individual may often need more parameters to identify a particular schema than the LK individual. In other words, to "understand" input information, the HK individuals often need to process more facets of that information than the LK individual; the LK individual is able to "understand" information at his/her level, having relatively few facets of the information available.

With respect to the third question posed in the introduction, that of the relation of the present work to acquisition and transfer theory, the present findings have a number of implications. First, this research suggests that, in a more than trivial sense, one cannot separate the process of acquisition and the process of transfer. This point has been made before (e.g., Ferguson, 1954, 1956; Voss, Note 1), but the present results underscore quite clearly that the amount and type of information an individual acquires in a given knowledge domain is a function of what s/he already has learned, and that, by definition, is transfer. Furthermore, since the HK and LK individuals tended to perform similarly with materials that were not baseball-related, the difference in

HK and LK acquisition may be attributed to the differences in the knowledge of domain-related information and not to differences in "intelligence" or some other factor.

A question raised by the present findings is, of course, to what extent knowledge of one domain facilitates the acquisition of information in another domain. While the present research did not address this issue, the answer offered by the present framework is that transfer will occur to the extent that the memory structure developed in one domain contains conceptual relations employed in the second domain. But perhaps even more important, the present formulation suggests that the more one knows in one knowledge domain, i.e., the more highly developed and differentiated the knowledge structure, the more likely it is that input information from another domain may be mapped onto the existing memory structure and thus facilitate acquisition. In other words, transfer from a given domain to a new domain is more likely to occur when one's knowledge of the given domain is quite substantial.

An instructional implication of the present work is that the learning process for a given subject-matter domain should develop an understanding of the basic concepts and relationships of the given subject-matter domain. While this assertion may appear to be obvious, it carries with it implications that are important. In particular, it suggests that if a person is able to recall facts in a given subject-matter domain, s/he may not necessarily have the knowledge structure important for acquiring new domain-related information. Instead, the individual may be much like the LK individuals of Experiment 5, able to recall a number of specific propositions, but having trouble in recall when they were unable to relate the information contained in a number of consecutive propositions. Thus, implication for instruction is rather clear--for individuals to acquire new domain-related information, it is important that the basic concepts be understood and that higher-ordered structures be developed that indicate how concepts are grouped and interrelated. Parenthetically, one may note that multiple-choice tests, unless carefully constructed, tend to produce acquisition habits that are in opposition to this conclusion.

Another issue requiring consideration is the extent to which the present framework and findings generalize to other domains of knowledge. While this question is clearly empirical, we would argue that the present work is reasonably representati[illegible]ost domains of knowledge have conceptual structures not unlike that postulated for baseball; there are basic concepts, there are relations among concepts, there often are components to the higher-ordered concepts, and conceptual structures are related in a temporal-like manner, e.g., "If, then" statements are probably common in almost all domains of knowledge. Thus, in political science, for example, the more knowledgeable person would be expected to have a somewhat different concept of an election than the less knowledgeable person. Moreover, recent research being conducted on specific knowledge domains, e.g., geometry (Greeno, 1976) and physics (Larkin & Reif, 1976; Shavelson, 1972), emphasizes relational structures in a manner similar to the present formulation. Thus, while baseball no doubt has its share of unique characteristics, as does any other domain, we would suggest that the present formulation is nevertheless applicable to other knowledge domains and that the findings reported in the present paper could also be obtained in analogous experiments conducted in such domains.

We want to acknowledge the fact that the present paper, for the most part, involved the problem of the acquisition of domain-related information, and the framework developed referred to postulated differences in the HK and LK individuals as such differences may influence acquisition. Except for a few comments on acquisition and transfer, we did not deal with the problem of how domain-related memory structures develop in the first place, nor did we deal with how the LK person may become an HK person, and we did not consider what the most effective ways of training may be that would enable the LK individual to become an HK individual. These issues are clearly quite important and require future attention.

Finally, we want to indicate that our HK participants were high-knowledge in the sense of knowledge of the game; they were not necessarily high-knowledge in the sense of participation. This form of high knowledge thus differs from the Chase and Simon (1973a, 1973b) and Reitman (1973) descriptions of high knowledge in that the latter were knowledgeable with respect to participation and, in all likelihood, with respect to knowledge of the game.

Reference Note

1. Voss, J. F. Cognition and instruction. Toward a cognitive theory of learning. Paper presented at NATO Conference, Amsterdam, June 15, 1977.

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