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ABSTRACT

One of the important cognitive strategies individuals use when learning is to organize many bits of information into integrated patterns called chunks. To investigate the process of chunking spatial information, 32 college students integrated two cognitive maps either before or after an interfering task. The combined spatial layout formed either a symmetric or asymmetric configuration. The accuracy of movement between points in the spatial layouts significantly increased only when symmetric representations were constructed before the interference. Speed-accuracy tradeoffs during the integration of the spatial layouts and during the performance of the tests could not account for the increased accuracy. The results suggest that the facilitating effect of chunking requires not only the generation of an integrated representation, but also an additional abstraction derived from the integration representation. (Author/JAC)

Chunking Cognitive Maps:
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and Its Effect on Interference

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One of the important cognitive strategies which people use when learning is to organize many bits of information into integrated patterns called chunks (Miller, 1956). Futhermore, when the information has to be recalled, the number of chunks rather than the number of information bits is one determining factor in the accuracy of performances. One prominent situation used by researchers to investigate chunking has been the game of chess. Chase and Simon (1973) have shown that chess masters can remember the location of 16 or more chess pieces by organizing them into meaningful groups or chunks. In contrast, a novice chess player lacks the skill to identify the meaningful relationships between a group of chess pieces and their positions. The novice can not organize the large number of pieces into a few chunks and consequently forgets the relevant information. The chess experiments are excellent illustrations of the chunking process but they do not permit the specification of how chunking initially occurs.

In the present experiment, the subjects had some knowledge of two separate spatial layouts that are actually components of a larger terrain. The experimenter then gave subjects new

information that could be used to spatially relate the two paths. Using this procedure, Hanley and Levine (1980) have demonstrated that adults can cognitively integrate the two separate layouts into a single cognitive map of the entire layout by showing that subjects can accurately move along inferred routes between the two paths.

Let us assume that chunking is the organization of two separate representations into one. If this is the case, when cognitive integration occurs before some interfering task, one rather than two representations has to be held in memory while the subject attends to the interfering material. If two paths are more difficult to recall than one, subjects who integrate two paths before an interfering task should remember more path information than subjects who fail to integrate the two paths. Since movements are more <u>likely</u> to be correct when more path information is recalled, as Hanley and Levine (1980) have shown, the movements should be more accurate when the two learned paths are integrated into a single representation before the interference.

<u>Method</u>

<u>Subjects</u> Thirty-two undergraduates from the State University of New York at Stony Brook participated in the experiment.

<u>Stimuli</u> As shown in Figure 1, the component paths were two three point paths. One component was labelled with letters, A-B-C, and the other with numbers, 1-2-3. Ten sets of paths were drawn so that one point of each path component was coincident (c.f. Figure 1). The configuration of the total path, that is, the two

components combined, was either symmetric or asymmetric. The configuration in this example is symm·tric. Five pairs of paths were symmetric and five were asymmetric. The ten sets of paths paths were used for ten problems.

Insert Figure 1 about here.

<u>Procedure</u> Each subject received all ten problems. In each problem, the experimenter traced the blindfolded subject's right index finger over each of the two component paths six times, announcing each point. The subjects then received one of two conditions. After learning the two component paths, half of the subjects, which we will refer to as the Integration-First group, were instructed that each path had a point in common. For example, "Point A is in the same location as point 3" (cf. Figure 1). After combining the two paths as best they could, they had to say "Ready" aloud. These subjects then received the interference task. During the interference task, the subjects, while blindfolded, traced their fingers around a raised ellipse four times and then estimate how close the ellipse was to a circle using a magnitude estimation procedure. After they estimated the roundness of six different ellipses, the subjects were tested on the integrated configuration. A pen was placed in the subject's hand and subsequently placed at one of the points. That point was announced and the subject was asked to draw a line directly, "as the crow flies", to the announced target point. This movement constituted a test; there were two tests on each configuration. The first test was always a between path

movement, that is going from one point on one path to another point on the other path. Moving from point C to point 2 is an example of a between movement. The second test was always a within path movement, moving from point 1 to point 3 or from point A to point C.

The other sixteen subjects, refered to as the Integration-Last group, learned the two paths, received the same interference task and were then told the intergration points and tested. To control for possible kinesthetic cues that might contain pertinent spatial information, the lettered and numbered paths were traced either to the subject's left or right and the test movements were performed on the configuration itself, directly in front of the subject (c.f. Figure 1). The angular deviation between the subject's drawn path and the correct path was measured for each movement. Also, the subject's reaction times to integrate the paths (thinking reaction reaction time) and to perform the test movement (drawing reaction time) were measured. To review, the two main independent variables were (a) whether the integration of the path components occured before vs. after an interfering task (b) whether the integrated configuration was symmetric or asymmetric.

Results

Figure 2 shows the mean angle errors of test movements on symmetric and asymmetric paths performed by Integration-First group and the Integration-Last group. The Integration-First group performed more accurately than the Integration-Last group only when the integrated configuration was symmetric. Subjects

who integrated the two paths into a symmetric representation before interference performed more accurately than subjects who integrated the same symmetric paths after the interference and then tested on the same movement. As shown in Figure 2, the Integration-First group performed both the within and between movements more accurately. These differences did not occur when asymmetric paths were integrated. The Integration-First group performed both the within and between movements with the same degree of accuracy as the Integration-Last group on the asymmetric configurations. The significant symmetry by time of integration interaction corresponded to this pattern of differences ($F(1,30) = 6.39$, $p < .05$).

Insert Figure 2 about here.

The improvement in angle error of the Integration-First subjects for symmetric paths could be due to a speed-accuracy tradeoff in responding. If this was the case, one would expect a significant symmetry by time of integration interaction for the drawing reaction time. The mean drawing reaction times of tests on the symmetric and asymmetric paths were 13.6 and 13.3 seconds for the Integration-First groups and 9.8 and 9.4 seconds for the Integration-Last groups ($F(1,30) < 1.0$, $p > .05$ for the interaction). A speed-accuracy tradeoff during the initial integration of the paths could also explain the observed pattern of angle errors. Symmetric paths could have been combined by the Integration-First group at a different rate than the other conditions. The mean thinking reaction times of tests on the

symmetric and asymmetric paths were 14.9 and 17.2 seconds for the Integration-First groups and 9.4 and 10.1 seconds for the Integration-Last groups ($F(1,30) = 1.39$, $p > .05$ for the interaction).

Discussion

The improvement in movement accuracy shown by the subjects in the Integration-First group suggests that two conditions are needed for the facilitating effects of chunking to occur. First, the subject has to generate an integrated representation. The two separate components had to be integrated into a single representation before the interference. Secondly, the symmetric quality of the integrated representation had to be abstracted. Two component paths from a symmetric configuration have the same lengths of the corresponding path segments and the same corresponding angle but simply having the redundancy in the spatial information could not produced the effect. The Integration-Last group learned the same symmetric or spatially redundant paths as the Integration-First groups but the Integration-Last did not improve in their performances on the symmetric paths. The symmetric quality could be new semantic relationships that can only be derived from the integrated representation. That is, the symmetric configuration becomes more meaningful. The addition of semantic relationships to a subjects knowledge of a layout and not the replacement of the spatial information by semantic information results in redundant coding of the combined path. An increased ability to recall the paths which resulted in the improved accuracy of performances

could be due to the different but redundant codings. When the presented spatial information is organized into an integrated representaion, which contains both spatial and non-spatial relationships, the integrated representation is a chunk. Consequently, the presented information is more resistant to interference.

References

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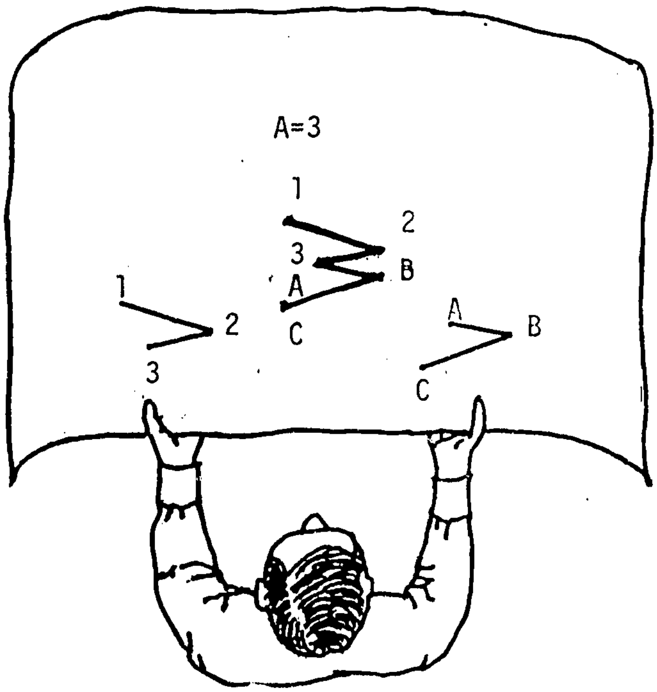

Figure 1. An example of the experimental situation depicting the tracing position of the two separate paths and the testing position of the integrated path.

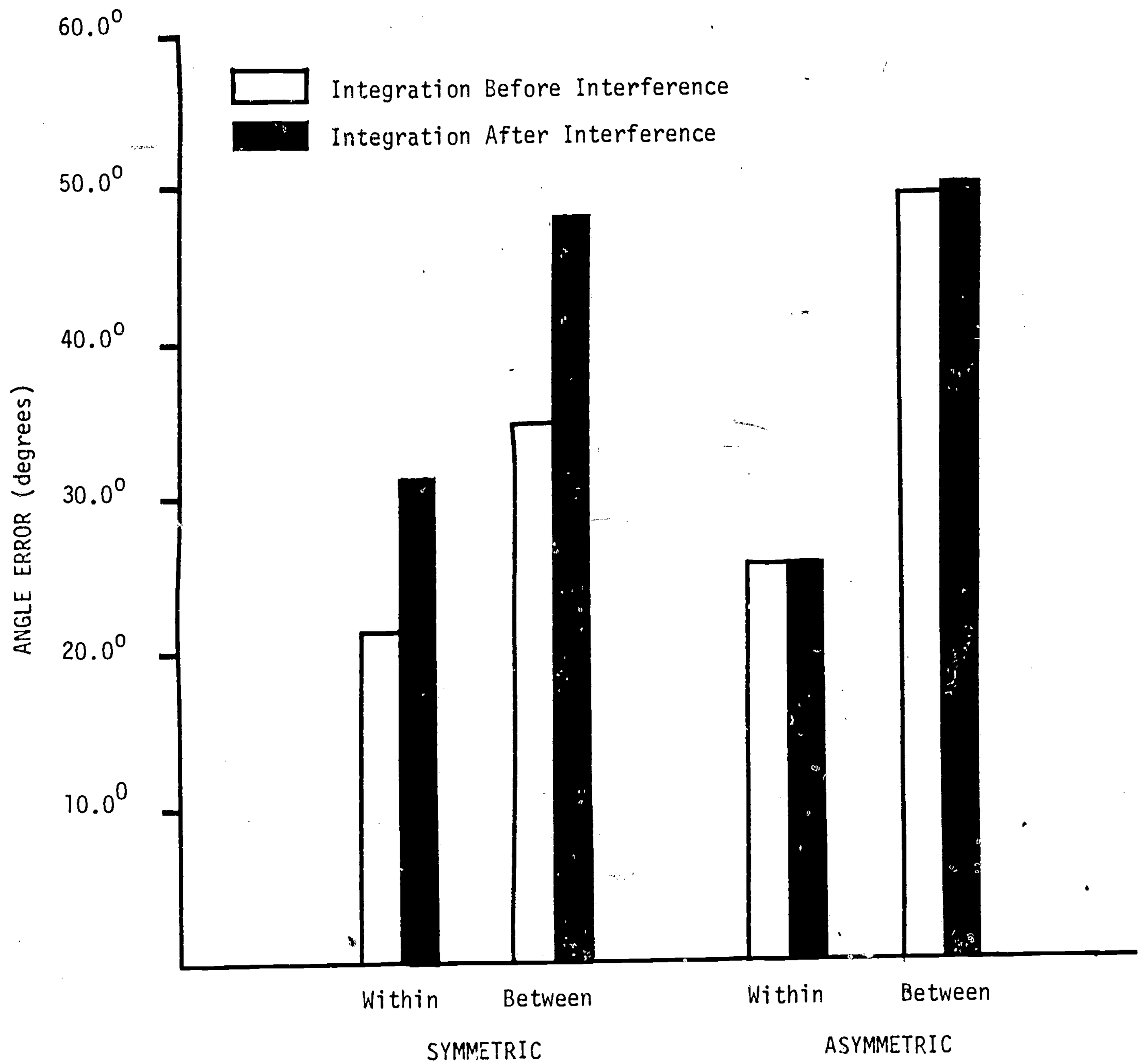

Figure 2. The mean angle error of within and between test movements on symmetric and asymmetric paths performed by subjects who integrated the paths before interference and those who integrated the paths after interference.