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An Analysis of the Momentum Effect by Students' Characteristics and the Modes of Representation Patterns

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ABSTRACT

The purpose of this study was to find the effect of these variables on the duration of the momentum effect. To examine the momentum effect for gravitational field concepts, an intensive time series design was used. We collected data every day except Sundays and holidays for 50 days; 5 days for baseline, 30 days for intervention, and 15 days for the follow up

We adopted cognitive levels and styles as students characteristics and two item characteristics(quantity versus quality, and word versus picture) as the item representation patterns.

In this study, the momentum effect was influenced by students characteristics and item representation patterns.

The results showed that two variables, cognitive style and quantity/quality, were the most influential factors for the duration of momentum effect. Field independent students showed a longer duration than field dependent students did. In addition, students showed a longer duration in quality items than in quantity items. However, students cognitive levels (formal or preformal) and word/picture presentations seemed to have relatively weak effect on the duration of the momentum effect.

Key words: momentum effect, cognitive level, cognitive style, intensive time series design

I . Introduction

The so called "momentum effect" was named by Mayer and Kozlow (1980) for the phenomenon of class performance increase for several days after the end of instruction. The

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evidences supporting momentum effect have been repeatedly observed (Mayer & Rojas, 1982; Farnsworth & Mayer, 1984; Kwon, 1984; Kwon & Mayer, 1985) and believed it to be rather a genuine phenomenon than any artifact occurred by testing of other influence.

Kwon and Mayer (1985) developed a new method to identify and estimate the duration (days of a post-intervention increase) of the momentum effect. They used a segmented regression analysis method and estimated the duration by putting dummy variables. Their statistical method gave good visual presentations of the momentum effect.

Up to present, the studies on the momentum effect had been concentrated on the identification of the effect rather than on seeking the factors affecting the momentum effect. However, Kwon (1984) in his doctoral study reinterpreted the former studies on the momentum effect (Mayer & Rojas, 1982; Farnsworth & Mayer, 1984; Kwon, 1984) by students' cognitive tendency levels and the abstractness of testing concepts. He found the duration of the momentum effect was influenced by the cognitive levels and the characteristics of testing items. Kwon's identification of the related factors might provided a significant rational for the genuine nature of the momentum effect. Kwon tried to explain the momentum effect in terms of existing psychological and instructional theories and proposed several theories as the candidates for the explanation of the momentum effect. They are consolidation theory supporting spacing effect, reminiscence theory (Ballard, 1913), constructive theory of memory (Bartlett, 1932), Piagetian idea of cognitive equilibration, generative learning (Wittrock, 1980), and dual coding theory (Paivio, 1973). Examining the candidate theories, we could identify several variables which might affect momentum effect. One group of variables would be content variables and the other subject variables. The abstractness and types of testing items, the areas of learning content might be the candidates for the content variables. Cognitive level, learning style and affective characteristics might be the candidates for the subject variables.

This study was further extension of the previous researches on momentum effect. In this study we have attempted to find further factors affecting momentum effect and their effects on the duration of momentum effect. By reviewing the previous studies, we chose Piagetian cognitive level and cognitive style as subject variables and item representation patterns as content variables. The purpose of this study was to find the effect of these variables on the duration of momentum effect

Ⅱ. Methods and procedures

1. Data collecting schedule

To examine the momentum effect for gravitational field concepts, an intensive time series design (Mayor & Pezarro, 1980; Kwon & Mayor, 1985) was used. The intensive time series

design was defined as a time series experimental design to measure a class or group performance in a daily basis. The design has a long history and has been used in the area of economics, social studies, and physical science. However, the application of time series design in an educational situation has been rare and has relatively short history. The interrupted time series design was initially proposed by Campbell and Stanley (1966) as a means of assessing a treatment effect in an educational or social process.

We collected data every day except sundays and holidays for 50 days; days for baseline, 30 days for intervention, and 15 days for the follow up. During the intervention, students were taught on the gravitational field. The overall testing schedules are illustrated in the following table field.

Table 1. Data collecting schedule

Test of subject characteristics		Test of achievement		
		Base line	Intervention	Follow-up
GA	GI	O_1 O_2 O_3 O_4 O_5	I_1O_6 I_2O_7...$I_{30}O_{35}$	O_{36} O_{37} O_{38} ...O_{49} O_{50}

GA: cognitive level test, GI: mean cognitive style test, O: item card test, I: instruction.

2. Experimental design

The purpose of this study was to find the effect of student characteristics and test item representation patterns on the momentum effect. For students characteristics, we measured students cognitive levels and students cognitive styles. The cognitive levels were measured by GALT (Group Assessment of Logical Thinking) developed by Roadranka and his fellows (1983) and translated by the research group in Korea National University of Education.

Even though GALT was consisted of 24 item in the complete form. Roadranka showed that the short version of GALT with 12 items was also enough to test cognitive levels significant. It was proved that reliability of GALT using 24 item is 0.85 and mean difficulty was 0.40. The cognitive styles were measured by GEFT (Group Embedded Figure Test) developed by Distefano (1969).

Cognitive styles had been measured by Rod Frame Test traditionally. However, recently developed a paper pencil test named as GEFT. The correlation between GEFT and RFT was 0.65. In this study GEFT was consisted of part 1 and part 2. Part 1 and part 2 of GEFT were consisted of 16 items respectively. And the correlation between GEFT and Rod Frame Test was 0.65.

For item representations, we chose two different aspects; one was the item characteristics

categorized as quantity versus quality, the other was those categorized as word versus picture. By the comparison of these two aspects, four different kinds of items could be developed; word and quantity, word and quality, picture and quantity, picture and quality.

Figure 2 shows the structure of the variables adopted in this study

3. Item pools

The total item pool consisted of four different sub-item pools. The item variables adopted in the study were divided into two categories; quality versus quantity and word versus picture. Therefore, four different item types was possible; word and quantity, word and quality, picture and quantity, picture and quality. Each type of items consisted of 50 items since the data collection was designed to continue for 50 days. Therefore the total item pool consisted of 200 items with four different sub-item pools.

Table 2. The number of items by the representations of item variables

	Word	Picture	Total
Quantity	50	50	100
Quality	50	50	100
Total	100	100	200

4. Subjects

Subjects in this study were also divided into four groups; word and quantity, word and quality, picture and quantity, picture and quality. Each group of students was consisted of 50 making total 200 students. Each subject received one item from the respective sub-item pool on each day of the study. No two students were to receive the same item on the same day in each group. No student was to receive an item for a second time until the entire item pool was exhausted. In this manner, the daily testing took less than five minutes.

The subjects were separated into two different cognitive tendency groups ; formal level group and preformal level group and two different cognitive style groups ; field dependent group and field independent group based on the result of the test of GALT and GEFT. The students scored higher than mean value in GALT test were categorized as formal level group and the other students were categorized as preformal level group. The students scored higher than mean value in GEFT test were categorized into field independent group and the other students were categorized into field dependent group. The results of GALT and GEFT are shown in table 3 and table 4.

Table 3. Result of GALT

Cognitive level	Mean	SD	N
Formal level	8.61	0.96	184
Preformal level	4.10	1.56	216
Total	6.17	2.61	400

Table 4. Result of GEFT

Cognitive style	Mean	SD	N
Field independent	15.45	4.28	178
Field dependent	5.61	2.63	222
Total	9.99	6.00	400

5. Determination of the durations of the momentum effect

In the beginning of the studies on the momentum effect, to locate a transition point in a learning curve, they used separate regression analyses for the baseline, intervention, and the follow-up. However, as indicated by Kwon and Mayer (1985), this technique did not adequately represent the actual learning curve because of the presence of discontinuity between the two regression lines at the intersection of the intervention and follow-up period. On the contrary, the segmented straight line regression technique seems to be appropriate, since student learning was represented as changing continuously from the intervention to follow-up period. Here we used the method of Kwon and Mayor (1985) study to locate the transition point.

The approximately parabolic curve in the Figure 1 shows how the sums of square error for the segmented regression line varies when different transition points were tried. The sum of square error was minimum at DAY 47. Therefore, DAY 47 was regarded as the best estimation of transition point for the given data.

Results

1. Analysis of data

The profiles of daily group scores collected in this study were plotted in Figure2. The

daily fluctuations appeared in this study were very small compared to previous studies (Rojas, 1982; Farnsworth, 1984; Kwon and Mayor, 1985; Kwon, 1984). This stability of daily profile data need to be explained.

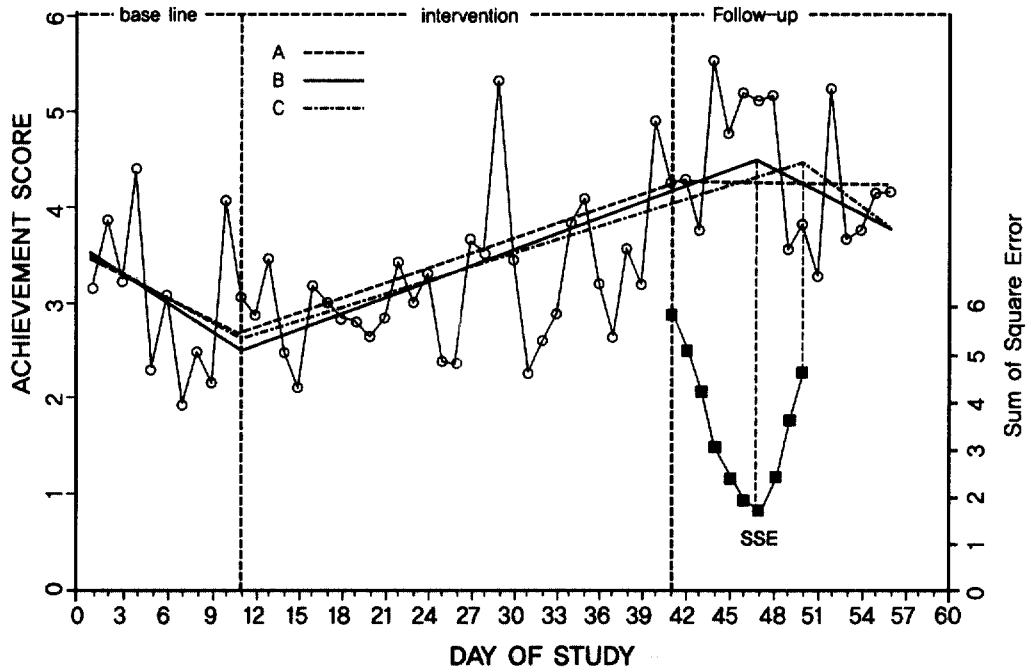

Fig. 1. The estimation of the transition point comparing sum of square errors (Kwon & Mayor, 1985).

The item pool used in this study was characteristically different from the previous studies. In this study the item pool with 50 items were given to 50 students for 50 days. This means the same item set was given to each subject group everyday from the baseline to follow-up periods, even though no two students were given the same item in a day and no one student was given the same item for 50 days. In the previous studies, they selected items randomly everyday, therefore the items varied used form day to day. Therefore, the difficulty of item set for each day was not uniform even though they adjusted the difficulty by producing product scores. This might be one of the reason for the stability of daily data. The low fluctuation made the results more statistically significant.

Figure 3 shows the daily profile of data for four different sub-item pools. However, this picture does not well discriminate the difference in slopes and durations of the momentum effect. Therefore, we plotted the regression lines only to compare the sample slopes and durations of the momentum effect. The sample results are shown in Figure 4.

more statistically significant.

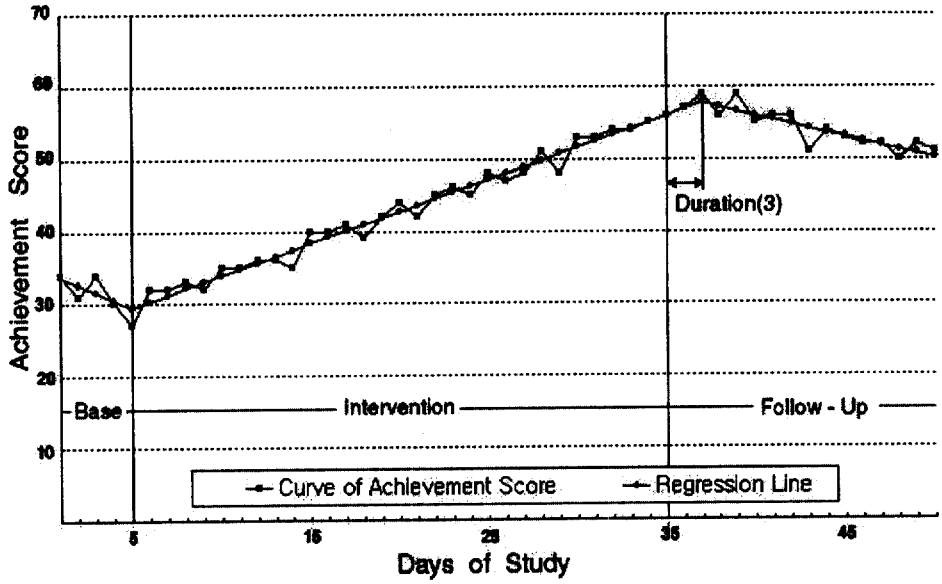

Fig. 2. The profile of daily group scores and segmented regression for word and quantity item.

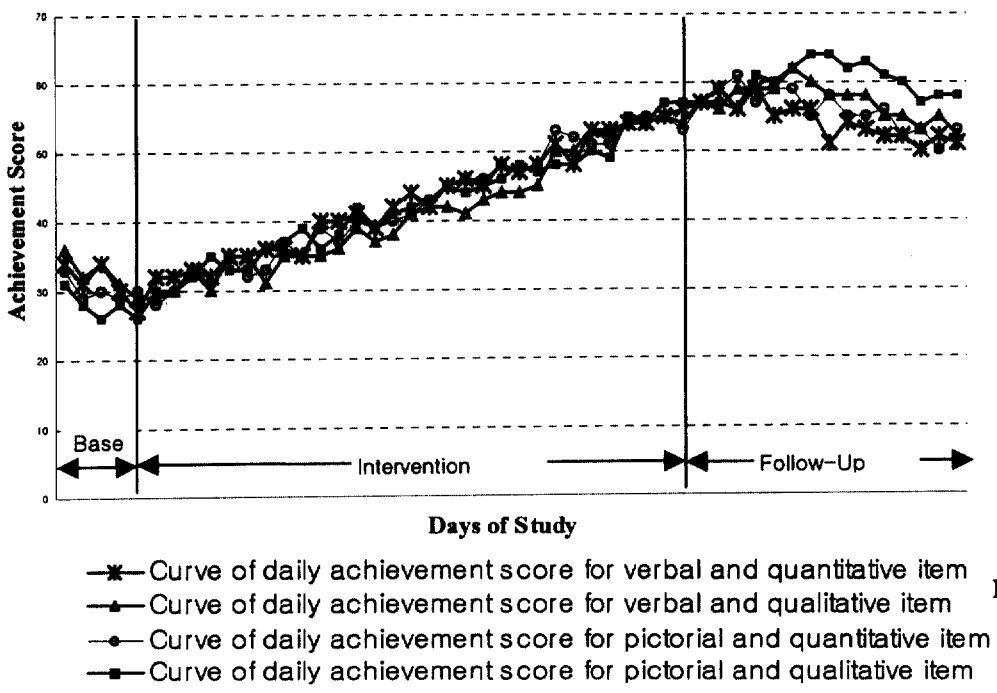

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Fig. 3. The profile of daily group scores for four items

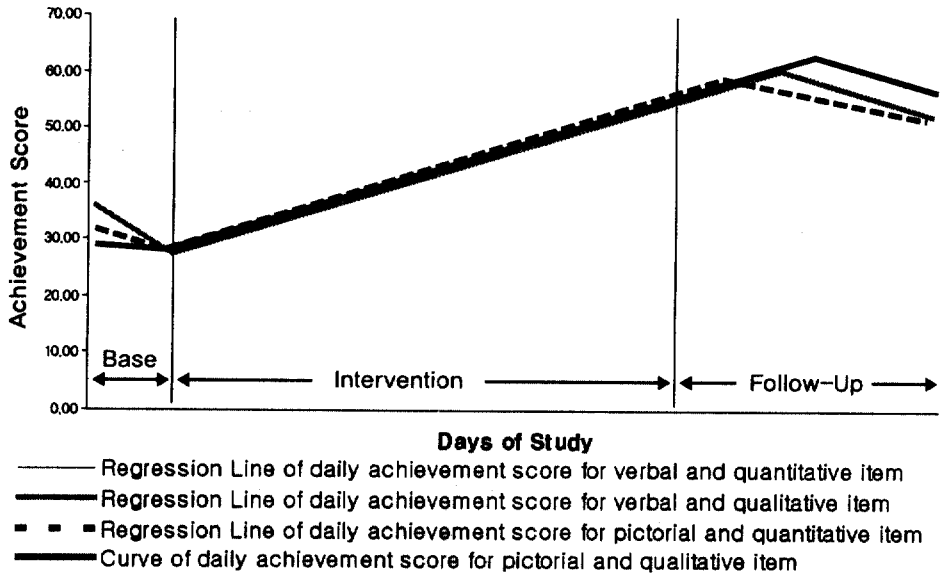

Fig 4. The segmented regression line of daily group scores for four item representation patterns

2. Main effect of cognitive characteristics and item representation patterns

Table 5 is the summary table of durations of momentum effect and slopes of the daily profile by students characteristics and item variables.

Even though students were not taught on the target concepts in the base line, achievement scores were decreased steadily. This result was consistent with previous studies (Rojas, 1982; Farnsworth, 1984; Kwon & Mayor, 1985; Kwon, 1984). The tiresomeness of students by daily repetition of tests might be one of the reasons for the decrease of learning curve in base line. Another candidate explanation of the result might be found in some psychological base such that recall and recollection of science concepts were interfered by similar concepts in daily repetition test. However, we were not going to go further on this matter in this study.

The slopes in the intervention period were slightly changed from variable to variable. However, the differences were not significantly large. The slopes of learning curves after transition points were negative and showed considerable differences. In case of duration, they ranged from 3 days to nine days in the 15 days follow up period. We will discuss the difference in detail later.

Effects of cognitive characteristics. The duration for field independent style showed the longest among the four cognitive characteristics. While the duration for field dependent style showed the shortest among the four cognitive characteristics. The duration difference (four experimental days) of momentum effect between dependent and independent was larger than duration difference (one days) of momentum effect between formal cognitive level and preformal level. This seems to mean that cognitive style would be more important factor for duration of momentum effect than cognitive level would. However, a different interpretation might also be possible; traditional grouping of cognitive levels was to categorize the students into formal level and concrete level based on the result of GALT. But we categorized the students into formal level that scored higher than the mean and preformal level that scored lower than the mean. We adopted this method since the subjects employed in our study were greatly skewed to formal cognitive level with very small number of concrete level. Therefore most of the students were on formal level by Piagetian classification scheme and this uniformity of cognitive level made the result statistically insignificant.

(1) Effects of the cognitive levels : The duration (six days) for formal level showed longer than for preformal level (five days) . This might be interpreted as that the students on formal level would learn the concepts and reorganize those meaningfully but the students on preformal level wouldnt learn the concepts and reorganize meaningfully. The Durations of momentum effect were considered as the reorganization period of the new information. Therefore, formal cognitive level students need longer duration than preformal level students.

(2) Effects of the cognitive styles : The duration (eight experimental days) for field independent style showed longer than that field dependent style (days). This might be interpreted as that the students of field independent style would learn the concepts by their own method and reorganize those meaningfully but students in field dependent style wouldnt learn the concepts and wouldnt reorganize meaningfully. Therefore, the durations of momentum effect were periods of reorganization.

Effects of representation patterns. Duration for qualitative representation showed the longest among the four representations. While duration for quantitative representation showed the shortest. Duration differences (four days) of momentum effect between quantity and quality representation were larger than duration differences (two days) of momentum effect between word and picture representation.

(1) Effects of quantitative/qualitative representation patterns : The duration (eight experimental days) for qualitative representation pattern showed longer than for qualitative representation pattern (four experimental days). Learning a quantitative content might he regarded as simpler than learning a qualitative content. This means mental

reorganization of a qualitative contents needs longer time, therefore, the qualitative items showed longer duration than the quantitative items did.

(2) Effects of Word/Picture Representation Patterns : The duration (seven experimental days) for picture representation pattern showed longer than for verbal representation pattern (five experimental days). This result can also be interpreted in similar lines of thinking as in quality versus quality case. Since verbal representation is simple and specific, while pictorial representation conveys lots of meaning, students might read a longer time for the reorganization of the learned information.

Table 5. The effects of item representations and cognitive characteristics

Item representation and cognitive characteristics		Duration	Slope of the learning curve		
			Base	Intervention	Follow-up*
Level					
	Formal	6	-0.95	0.89	-0.44
	Preformal	5	-1.09	0.92	-0.74
Style					
	Dependent	3	-1.15	0.93	-0.53
	Independent	8	-1.00	0.92	-0.83
Item representation patterns					
Quantity/quality					
	Quantity	4	-0.95	0.90	-0.67
	Quality	8	-1.15	0.91	-0.85
Word/Picture					
	Word	5	-1.58	0.89	-0.66
	Picture	7	-0.45	0.91	-0.75
Total		5	-1.05	0.92	-0.54

* After transition point in follow-up period

The slopes of the regression lines in baseline as well as in intervention was not difference significantly in all item representation patterns and cognitive characteristics. Whereas the slope of the regression line during follow-up period for the formal level showed the least decrease ratio among the four cognitive characteristics. This seems to mean that cognitive level was more important factor of decrease ratio in follow-up period.

Interactive Effects in cognitive characteristics and in item representation patterns. In the previous section, we examined the independent variables separately. However, it is necessary to examine the interactive effect between two variables such as interaction between cognitive level and cognitive style, and interaction between a quality/quantity and word/picture variables.

3. Students characteristics

Table 6 shows a strong interaction effect between cognitive level and cognitive style. For field dependent students, formal as well as preformal level students showed short and similar durations; three days for formal group and 4 days for preformal group. However, for field independent students, the formal group showed significantly longer duration (11days) than the preformal group did (8days).

The Table 6 shows the matrix of duration of momentum effect for cognitive characteristics. The field independent style showed twice longer duration of the field dependent style. The difference of duration (two experimental days) between formal and preformal level was smaller relatively than that between independent style and dependent pattern (four experimental days). This meant that cognitive style variables were more important independent variables of momentum effect than cognitive level. But it (two experimental days) was significant.

Table 6. Momentum effects to cognitive characteristics

Cognitive characteristics	Formal	Preformal	Total
Dependent	3 (100)	4 (100)	3 (200)
Independent	11 (100)	8 (100)	8 (200)
Total	6 (200)	5 (200)	5 (400)

Note: Number of responses in parentheses.

The table 7 is the matrix of durations of momentum effect by representation patterns. The quality representation showed twice duration of quantity representation. The difference of duration (two experimental days) between word and picture representation was relatively smaller than that between quantity and quality pattern (four experimental days). This meant that quantity/quality variables were more important independent variables of momentum effect than word/picture. But the difference of duration (two experimental days) between word and picture representation was also significant output of momentum effect.

Table 7. Duration of momentum effects by representation patterns of science concepts

Representation patterns of science concepts	Word	Picture	Total
Quantity	3 (100)	4 (100)	4 (200)
Quality	7 (100)	9 (100)	8 (200)
Total	5 (200)	7 (200)	5 (400)

Ⅲ. Conclusion

In this article, we have argued that the momentum effect was influenced by students characteristics and item representation patterns. We adopted cognitive levels and styles as students characteristics and two item characteristics (quantity versus quality, and word versus picture) as the item representation patterns.

The result showed that the two variables, cognitive style and quantity/quality, were the most influential factors for the durations of momentum effect. Field independent students showed longer durations than field dependent students did. In addition to this, students showed longer durations in quality items than in quantity item. However, students cognitive levels (formal or preformal) and word/picture presentations seemed to be relatively week effect on the durations of the momentum effect.

In the case of students cognitive levels, the students employed in this study were not classified clearly into concrete and formal cognitive levels. The two cognitive level groups were classified by the scores of GALT, assigning higher half to formal group and lower half to preformal group. Therefore, preformal does not mean concrete. This ambiguity might be one of the reasons for the small difference in the durations.

At the beginning of the study, we had expected the word/picture representations would show very strong effect on the duration of momentum effect. Even though picture representation showed a longer duration than word representation, the difference was small (two days).

This study strongly suggests that the momentum effect should be a genuine effect that had its origin in the human cognitive processes. The study also suggested that memory or learning should not be considered as a copy of the original task, but an active internal construction and reconstruction processes of once encoded information.

This means that identification of independent variables affecting the momentum effect would contribute in understanding humane cognitive processes and in teaching scientific concepts.

This study did not suggest sufficient explanations of the results. To find a reliable theory to explain the momentum effect and the role of subject and task variables on the momentum effect, more elaborated experimental designs should be developed and tested.

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