ISSN 1798-4769
Journal of Language Teaching and Research, Vol. 5, No. 3, pp. 536-543, May 2014

doi:10.4304/jltr.5.3.536-543

An Experimental Study Testifying Syntactic Move*

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***Abstract*—Some experimental studies have been done to testify the existence of syntactic move. The present paper first illuminates two such experiments and analyzes their problems. By avoiding the same problems, the present paper designates its own experiment by means of E-prime, aiming at testifying the possible existence of syntactic move.**

***Index Terms*—syntactic move, experimental studies, behavioral studies, E-prime**

I. Introduction

Traditional T-G grammar represented by Chomsky constantly focuses its attention on move phenomenon. But now, many scholars challenge that there exists such a syntactic operation as move and they suggest the move operation be cancelled (Brody, 1995; Zhao, 2001, 2002). Some theoretical studies and neurolinguistic experiments have been conducted, aiming at canceling move (Yang, 2002). As matter of fact, among not very much experimental work done concerning the syntactic operation of move, there are still two classical ones which tried to testify the possible existence of move. These two experiments provide two classical paradigms for the experiments of the same kind and can give the present study some insights into the design of the experiment. However, the experiments are not perfectly designed and after a careful examination, some problems can be found. Thus, when a new experiment is designed, the same problems will be effectively avoided after scrutinizing these problems. Basing on this examination work, the present paper designates its own experiment by means of E-prime, aiming at testifying the possible existence of syntactic move.

II. Two Classical Experiments and the Problems

A behavioral study conducted by Lee Osterhout and David A Swinney (1993) mainly focuses on the temporal course of the comprehension of English passive sentences and the ultimate purpose of this study is to see whether so called syntactic operation move is involved in this course of comprehending English passive sentences. The study chooses sixty undergraduates as the subjects and both English active and passive sentences as the language material. And the experiment is cross-model since the subjects are required to read sentences and meanwhile listen to words. The premise for the experiment is: According to T-G grammar, for English passive sentences, the syntactic operation move is involved. If this is true, in these sentences, when the syntactic element is moved from its original position, a trace will remain at that position. The study presumes that at this trace position if a word semantically related to the moved element is inserted, the trace will cause a priming effect which assists subjects to more quickly respond to this newly inserted word, compared with that of active sentences. If this is not true, the priming effect can not be detected. For the convenience of illustration, a particular pair of sentences is listed here.

1. The dentist from the new medical center in town invited the actress to go to the party.
2. The dentist from the new medical center in town was invited i by the actress to go to the party.

The first sentence is in active voice and the second is in passive voice and theoretically speaking, there exists a trace after the matrix verb invited in the second sentence, and thus an italicized i is used to indicate this trace. The study presents the two sentences to the subjects through headphones and for both of the two sentences, after the matrix verb invited is presented, a visual target of a word (For example, in this sample sentence group, tooth may be used as a visual target.) semantically related to the subject NP (a moved out element supposed by T-G) is presented to the subjects to ask them to decide whether there is some connection between the word they have seen and the subject NP they have heard. The aim of doing this is to see whether there is priming effect at the trace position and in turn to testify whether there exists move operation.

The result of the experiment is for the associate group (That is, the target word is semantically related to the subject or the moved out element.), the average response time for active sentences is 631 msec and for passive sentences is 614 msec. According to the analyses of the research team, less time cost to respond to the passive sentence indicates that there is a trace leading to the prime effect which assists the connection judge. On the contrary, for the control group (That is, the target word has no semantic connection with the subject of sentence or the moved out element), the average

* The present research is supported by the Humanity and Social Sciences Research Fund for the Youth from Ministry of Education of China (Grant No. 13YJC740144).

response time for active sentence is 635 msec and for passive sentence is 643 msec. According to the research team, this indicates: for the semantically unrelated targets, there exists no such priming effect even though there is a trace here. When the same procedures are repeated but the target words are not given immediately after the matrix verb but with 500 msec and 1000 msec delay, the same result is achieved. The research team assumes that this further proves that there is a trace at the position after the matrix verb and this in turn testifies the involvement of move operation since trace is closely related to move.

It is thought that the behavioral study conducted by Lee Osterhout and David A Swinney may have the following two problems:

1) The theoretical premise for the study is that there exists a trace after the matrix verb in a passive sentence since the object of the sentence is moved from that original position. The trace may lead to priming effect which in turn assists the subjects to judge the semantic relation. This premise is problematic since in T-G grammar, trace is only theoretical supposition for the convenience of discussing some possible syntactic relation. As Chomsky defines in his Derivation by Phase, all traces are inaccessible to real syntactic operations like move and merge. This in turn indicates that all traces are inaccessible to language computation and have nothing to do with the real mental activities of language. As a matter of fact, a trace has neither phonetic content nor syntactic features of itself. The reason why trace still remains in T-G theoretical framework is it may indicate the position the moved out element has occupied and indicate syntactic relation. In a word, in T-G grammar, trace is mainly for theoretical construction. For some experts like Brody, trace as a syntactic concept is totally abandoned since in his radically minimalism, a syntactic element with phonetic content and syntactic feature instead of a trace remains at the original position and once that element merges at a new position , the element located at the original position will be discarded. As a result, neurologically speaking, to discuss trace is meaningless since once a syntactic element is moved out from its original position it has to be stored and processed at its new position. In this sense, trace itself has no psychological reality and thus will not participate in syntactic operation in real sense. The researchers can not expect a concept only for the purpose of theoretical construction to cause priming effect. The quicker response to do the connection judge in passive sentences may attribute to better memorization or storage of the conveyed information because the complexity of the passive structure increases the burden of mental activity which in turn makes the language computational system more actively involved in processing the information.

2) As has been observed in the study, the control experiment uses the target words which have no semantic relation with the subject of the sentence. According to the common sense, since in passive sentences traces always exist and traces can help the subjects to decide whether they are semantically related, in control group, the response time ought to be shorter for passive sentences. The experiment yet gives opposite results. And for the 500msec and 1000 msec delay, once again, the common sense seems to indicate that since a period of time has elapsed and the priming effect ought to be mitigated, there will be no evident difference as far as the response time is concerned for both the active and passive sentences. The result of the experiment however supports the opposite. All this evidence suggests that the presumption that traces elicit priming effect is not convincing.

Another experiment concerning the syntactic operation of move is done by Samuel Featherston (2000) by using the ERP method. In this experiment, two types of German sentences are chosen as the material. Syntactically speaking, one type is syntactically called control structure sentence and the other is called raising structure sentence. The English equivalents for the two structures can be found as well. The two sample sentences in German are listed here (The second sentence of each group is English word-by-word translation and the third is an English version).

Subject Control sentence

[Der Sheriff]i hoffte [als die Witwe plötzlich in das Zimmerkam] [IP PROi[NP den Täter] endlich verurteilen zu können]

[the sheriff]i hoped [as the widow suddenly into the room came] [IP PROi [NP the offender] at last sentence to can] (= The sheriff hoped, as the widow suddenly came into the room, to be able to sentence the offender at last.)

Subject Raising sentence

[Der Sheriff]i schien [als die Witwe plötzlich in das Zimmer kam] [IP ti [NP den Täter] endlich verurteilen zu können]

[the sheriff]i seemed [as the widow suddenly came into the room] [IP ti [NP the offender] at last sentence to be able to] (= The sheriff seemed, as the widow suddenly came into the room, to be able to sentence the offender at last.)

In T-G grammar, the sentence like The sheriff hoped to be able to sentence the offender at last. is one with subject control structure because it is supposed that after the matrix verb hope there is a empty category PRO and this PRO is controlled by the subject of the sentence. And the sentence like The sheriff seemed to be able to sentence the offender at last. is one with subject raising structure because the subject of the sentence is originally located at the position after the matrix verb and then is moved from its original position to its present position. The experiment is designed to see the difference of the brain potential immediately after the matrix verb during the process of representing the sentence word after word on the screen. And if there is a difference, the possible explanation is the difference might be caused by the involvement of more complicated syntactic operation (in this case move) when no difference of surface structure can be found. The reason German control and raising structures are chosen is as what can be observed from the German, for the infinitive structure after the matrix verb, the German is in inverted order, quite different from that of English

(Bourdages, 1992). This makes the object of the infinitive structure at a position closer to the matrix verb and only in this order can the difference of the brain potential be more easily detected.

The result of the experiment is just as expected; the raising structure elicits stronger P600 than that of control structure. The analyses given by the research team are as follows: P600 is a brain potential element indicating the complexity of the syntactic processing. The fact that raising structure elicits a stronger P600 suggests the processing of the raising structure is more complex than that of control structure. Under the circumstance that the surface structures of the two are quite similar to each other (almost the same except the matrix verb), the most probable explanation for the difference of the brain potential is the syntactic operation of move is involved.

Then a problem naturally occurs. A stronger P600 may not necessarily indicate the complexity of syntactic processing. It is also an indicator of the integration difficulty of the syntactic elements. And in Samuel Feather's study, integration difficulty can be adopted to better illustrate why the raising structure elicits a stronger P600. Before this, the structural difference between English control and raising structures and German equivalents will be discussed. In English, for verbs like want which can be used in control structure, an accusative NP is usually expected to follow as can be seen in the sentence like He wants me to do the job. For the verbs like seem which can be used in raising structure, a nominative NP is usually expected to follow, as can be seen in the sentence like It seems he wants to do the job..In the German equivalents of the control and raising structure, the infinitive is in inverted order which means the object of the infinitive structure is put at the very beginning. Thus it seems as if the object of the infinitive was immediately after the matrix verb. This will cause an integration difficulty for the successful understanding of raising structure. As mentioned above, after the matrix verb like seem people usually expect a nominative NP while the object of infinitive is in accusative case and by chance it is seemingly located right after the matrix verb. The integration difficulty arises. This may better explain a stronger P600 for raising structure.

Since there exists this or that kind of problem for the two classical paradigms in testifying the existence of move, the present research intends to design a new behavioral experiment to avoid the problems of the two experiments mentioned above. In order to achieve this goal, several preliminary considerations are highly necessary.

III. Pre-consideration of Method and Material for Present Experiment

Up till now, the methods for the study of mental process of language activity can be classified into two broad categories: One is the behavioral study, which mainly adopts the E-prime program to measure the response time and accuracy rate. The advantage of this method is it is easy and simple to operate. The disadvantage of the method is it is behavioral; consequently it can only indirectly reveal the mental activity involved in language processing. The other is the neurological study and under this category two specific methods can be used to examine the mental activity. The ERP method has its advantage in examining the real time process of the mental activity for its high sensitivity to the brain potential change within a very short period of time calculated by msec. The fMRI method has its advantage in depicting the special brain areas involved in mental activities.

As far as the present research task is concerned, it is going to be testified whether the syntactic operation of move exists and essentially, this is to examine the real time process of language computation. Since fMRI is mainly for the purpose of studying the brain areas concerning the mental activities, the E-prime or ERP method might be better choices for the present study. However, there exists difficulty in using ERP method and the difficulty largely lies in the following two aspects: 1) Up till now the brain potential elements neurological experiments have got like N400, P600 are the results of semantic or syntactic mismatch or anomalies. It is hard to represent every detail of the real time process of language computation by using the ERP method. It is true for merge case and the same for move case. 2) Though P600 is an index which can indicate the complexity of the language processing and in turn indicate the possible existence of move, this index can also be used to indicate the syntactic integration difficulty.

For the above consideration, E-prime method is adopted to measure the response time and accuracy rate. Though for this method, the long response time and low accuracy rate in understanding sentences possibly involving move may also be interpreted from the perspective of integration difficulty, this factor can be mitigated to the least when the subjects are presented the structure with clearly indicated special syntactic features.

Materials are key factor to the success of the study. For the present study, Chinese material will be better since Chinese students as subjects are more easily chosen. This plan is finally abandoned for1) One of the important interfering factors for the response time and accuracy rate is the subjects' familiarity with the language material. For the native speakers of Chinese, the Chinese language is the language of their daily use. So for most of the language materials possibly used by the present study, they are quite familiar because of high frequency of use. Then the most probable consequence by adopting Chinese is: even though there exists such operation of move in the process, the difference can not be easily detected. 2) Disagreement exists concerning Chinese structures where move is possibly involved, for example, the Chinese passive structures (Huang, 2003). Other examples including sentence like *Wangmian Si le (PERF) Fuqin* (The English equivalent will be *Wangmian died his father*).For T-G scholars like Jie Xu (2001), this is a typical structure of move. The possessive NP *Wangmian* is moved from its original position to the very beginning of the sentence. But for some Chinese scholars (Xu, 1956), *Wangmian* here serves as the topic of the sentence.

IV. Experiment

A. Subjects

Thirty English-major students participate in the experiments. All subjects are native speakers of Chinese. All of them have passed the English major test band four exams. They are non-native speakers of English, which can ensure that their English is not so good as to process the sample sentences without any difficulty but at the same time they may not have so much difficulty in understanding these sentences and thus respond to the sentences too slowly or make too many mistakes in judging the statements. And all of them are from the foreign languages and cultures institute of Nanjing Normal University. All of them have corrected-to-normal visions and are right-handed. Before the experiment, they will be cautiously instructed to ensure that all of them know the procedures of the experiment. And after the experiment, all of them will be paid.

B. Language Materials and Design

Fifty sentence pairs are constructed, with each pair composed of two sentences with the same length (See Appendix). And both of the two sentences follow the pattern that NP followed by a simple relative subordinate clause and then followed by the verb and the complement. In each sentence, both the NP in the main clause and in the relative clause represented distinct occupation (e.g., doctor) or title (e.g., king) for the consideration of convenience and unity.

In each pair of the sentences, the only difference between the two is for one of them, the relative pronoun which refers to the NP in the main clause is the subject of the relative clause and is in the nominative case while for the other, the relative pronoun referring to the NP in the main clause is the object of the relative clause and is in the accusative case. (For convenience, subject relative clause will be abbreviated as SR and object relative clause abbreviated as OR) For example

1. The doctor who loved the nurse has a heart attack.
2. The doctor whom the nurse loved has a heart attack.

So the two relative clauses have different logical structures.

The reason why these materials are chosen is it is hypothesized that in the second sentence there might exist the syntactic operation of move, that is, the move of the object of that relative clause from its original position to its now position. And this hypothesized structure with move is different from other possible moves like English passivization.

It is well known that in English passivization, though the object of the sentence can be hypothesized as moving from its original position to subject position, there is still a be verb involved in. In a passivized structure, be verb and the subject have established a seemingly predicative structure. Thus if the English sentence is shown to the subjects, it might well be processed as predicative structure of active sentence. This will greatly reduce the possible effect primed by move. On the contrary, in this sample sentence there is no such be verb.

The reason for the use of accusative whom instead of nominative who is, supposing slower response and lower accuracy are detected for the object relative clause, one might challenge that the object relative clause violates the syntactic expectation and that might be a better excuse for slower response and lower accuracy. The accusative whom clearly indicates that it is used as the object and it will be followed by special syntactic structure. By this means, the integration difficulty effect might be greatly reduced.

C. Procedures

The subjects are required to sit in a quiet room and watch the computer screen. At the beginning of the experiment, the screen will exhibit a brief introduction to the experiment through which subjects may have a general knowledge of sentences they are going to read and what tasks they are required to do. The introduction will be exhibited for 20 seconds, long enough for the subjects to have a good understanding.

After this introduction, the sample sentence will be shown on the screen segment by segment. The exhibiting pattern is at first the subject of the main clause will be exhibited. If the subject understands the meaning, he may press the button of "enter" on the keyboard of the computer. If the subject responds to that too slowly, beyond 2 seconds, the data will be discarded. Then the next segment of the sentence, the relative clause will be exhibited. The subject may press that button again if he understands the meaning of that relative clause. However, if the subject responds to that relative clause too slowly, beyond 5 seconds, the data will be discarded. Finally the remaining segment of the main clause will be exhibited. The subject may press button to continue. The time allowed is 3 seconds. Then a statement concerning the logical relation between subject and object of the relative clause will be exhibited. For example, for the sentence The doctor who loves the nurse has a heart attack.., we have a statement The doctor loves the nurse. If this statement matches the logical relation of the relative clause, the subject may press the A button. If it does not match that relationship of the relative clause, he may press the L button. And if the statement is responded too slowly, beyond 3 seconds, that data will be discarded. The subject relative clause and the object relative clause in each pair will be exhibited randomly. The true statement and the false statement will be arranged in a random way as well. All the subjects are told before the experiment that they should read the sentences segment by segment. When they understand that segment, they may press the button to continue. They must not read the whole sentence before they respond to the statement.

The useful data for the experiment mainly include: the response time to each segment of the subject relative clause (abbreviated as SRT1 for the subject segment; SRT2 for the relative clause segment; SRT3 for the remaining segment of the main clause); the response time to the statement concerning the subject-relative clause (SRT4); the accuracy rate concerning the subject-relative clause (SAR); the response time to each segment of the object relative clause(ORT1 ORT2 ORT3); the response time to the statement concerning the object-relative clause(ORT4); the accuracy rate concerning the object relative clause(OAR).

After all the subjects have finished all the fifty pairs of sentences, comparison will be done between SRT1 and ORT1, SRT2 and ORT2, SRT3 and ORT3, SRT4and ORT4, SAR and OAR separately.

D. Results

Prior to data analysis, missing data points, erroneous responses, and response times greater than 3 standard deviations from a subject's mean response time are treated as errors and thus discarded. These procedures eliminate less than 10% of the data. Planned comparison tests are performed to compare response times and accuracy rates.

As shown in Table1, the average response time for the first part of the subject relative clause is 877.96 (calculated by msec and the followings are the same) while for the object relative clause is 908.53. It means subjects responds to the first part of the subject relative clause as fast as the first part of the object relative clause.

TABLE 1
MEANS AND STD. DEVIATIONS FOR SRT1 ORT1

Sentence Type	N	Mean	Std. Deviation
SRT 1	1359	877.96	646.607
ORT 1	1354	908.53	681.51

Note: SRT 1 stands for response time to the first part of the subject relative sentence; ORT 1 stands for response time to the first part of the object relative clause.

An independent samples t-test was run to find out whether the difference was statistically significant. As demonstrated in Table 2, at the significant difference level of 0.05, the sig. value is 0.49 (p=0.49>0.05), which suggests these two are not statistically different. Therefore, the results indicate there exists no difference between response times to the first part.

TABLE2
INDEPENDENT SAMPLES T-TEST FOR SRT1 ORT1

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
	Equal variances assumed	2.365	.124	-.683	1258	.495	20.039
	Equal variances not assumed			-.683	1212.612	.495	20.039

As shown in Table 3, the average response time for the second part of the subject relative clause is 877.96 while for the object relative clause is 908.53. It means subjects responded to the first part of the subject relative clause as fast as the first part of the object relative clause.

TABLE3
MEANS AND STD. DEVIATIONS FOR SRT2 ORT2

Sentence Type	N	Mean	Std. Deviation
SRT 2	1359	2748.68	2262.56
ORT 2	1354	3517.33	2722.74

Note: SRT 2 stands for response time to the second part of the subject relative sentence; ORT 2 stands for response time to the second part of the object relative clause.

An independent samples t-test was run to find out whether the difference was statistically significant. As demonstrated in Table 4, at the significant difference level of 0.05, the sig. value is 0.03 (p=0.03<0.05), which suggests these two are statistically different. Therefore, the results indicate there exists evident difference between response times to the second part.

TABLE 4
INDEPENDENT SAMPLES T-TEST FOR SRT2 ORT2

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
	Equal variances assumed	.026	.021	.621	1258	.035	87.58413
	Equal variances not assumed			.621	1193.711	.035	87.58413

As shown in Table 5, the average response time for the third part of the subject relative clause is 1955.73 while for the object relative clause is 1942.24. It means subjects responded to the third part of the subject relative clause as fast as the third part of the object relative clause.

TABLE 5
MEANS AND STD. DEVIATIONS FOR SRT3 ORT3

Sentence Type	N	Mean	Std. Deviation
SRT 3	1359	1955.73	2086.86
ORT 3	1354	1942.24	2304.18

Note: SRT 3 stands for response time to the third part of the subject relative sentence; ORT 1 stands for response time to the third part of the object relative clause.

An independent samples t-test was run to find out whether the difference was statistically significant. As demonstrated in Table 6, at the significant difference level of 0.05, the sig. value is 0.265 (p=0.265>0.05), which suggests these two are not statistically different. Therefore, the results indicate there exists no difference between response time to the third part.

TABLE6
INDEPENDENT SAMPLES T-TEST FOR SRT3 ORT3

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
	Equal variances assumed	3.921	.871	1.114	1258	.265	141.70794
	Equal variances not assumed			1.114	1198.861	.265	141.70794

As shown in Table 7, the average response time for the statement concerning the subject relative clause is 1765.76 while for that concerning the object relative clause is 1785.82. It means subjects responded to the statement concerning the subject relative clause as fast as the statement concerning the object relative clause.

TABLE 7
MEANS AND STD. DEVIATIONS FOR SRT4 ORT4

Sentence Type	N	Mean	Std. Deviation
SRT 4	1359	1765.76	767.43
ORT4	1354	1785.82	800.84

Note: SRT 4 stands for response time to the statement concerning the subject relative sentence; ORT 4 stands for response time to the statement concerning the object relative clause.

An independent samples t-test was run to find out whether the difference was statistically significant. As demonstrated in Table 8, at the significant difference level of 0.05, the sig. value is 0.416 (p=0.416>0.05), which suggests these two are not statistically different. Therefore, the results indicate there exists no difference between response times to the statements.

TABLE8
INDEPENDENT SAMPLES T-TEST FOR SRT4 ORT

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
	Equal variances assumed	.661	.416	-.135	1258	.892	-6.7778
	Equal variances not assumed			-.135	1257.076	.892	-6.7778

As shown in Table 9, the accuracy rate for the statement concerning the subject relative clause is 0.83 while for that concerning the object relative clause is 0.79. It indicates no significant difference.

TABLE 9
SAR AND OAR

Sentence Type	N
SAR	0.83246
OAR	0.79324

Note: SAR stands for accuracy rate of the statement concerning the subject relative sentence; OAR stands for accuracy rate of the statement concerning the object relative clause.

E. Discussion and Conclusion

The average values of SRT1 and ORT1, SRT3and ORT3 show no significant difference since the first segments and the third segments of the subject and object relative clauses are the same. Consequently, in the real-time comprehension process, they cost almost equal amount of time.

The average values of SRT2 and ORT2 show significant difference. This indicates that the understanding of the object relative clause costs more time than that of the subject relative clause. And this in turn shows that in real-time comprehension process, to understand the object relative clause is more difficult than to understand the subject relative clause.

The possible and usual interpretations to this understanding difficulty are the following two:

The first is the integration difficulty caused by syntactic mismatch. For example:

1. The doctor who loved the nurse has a heart attack.

2. The doctor whom the nurse loved has a heart attack.

For the first subject relative clause, the relative pronoun who is immediately followed by a matrix verb and this is in accordance with the normal predicate structure. Consequently, this will not cause the syntactic mismatch. While for the second object relative clause, the relative pronoun whom is immediately followed by an NP and this shows no similarity to the normal syntactic anticipation. And this will cause syntactic mismatch and increase the integration difficulty.

But the present study does not think the integration difficulty will be the major cause for the understanding difficulty of the object relative clause for the following consideration: First, the accusative whom is used, which is an evident indicator that the sentence pattern will not be the normal predicative structure. Second, since whom and NP are next to each other, though at the very beginning of the experiment, the NP following whom might cause integration difficulty, this effect will greatly mitigate once the subjects are familiar with the sentence pattern.

The second interpretation will be move. Since in the object relative clause, the object whom is moved from the original position to the present position, when the subjects are required to capture the logical structure of that relative clause, they have to spend more time in properly understanding those object relative clauses involving move since move is a more complicated syntactic operation. And the understanding difficulty caused by move might not be mitigated by repetition of the same experimental procedure since it is deeply rooted in one's minds.

There is no evident difference between SRT4 and ORT4 but some difference between SAR and OAR. This indicates that when the subjects overcome the comprehension difficulty in understanding the object relative clause, this will not cause further difficulty in making judgment concerning the statement. However, the understanding difficulty will cause somewhat more understanding mistakes in judging the logical structure of the object relative clause and this will in turn influence the accuracy rate of that type of clause.

As a conclusion, the evident difference and mild difference between SRT4 and ORT4, SAR and OAR has something to do with move, which in turn indicates that move possibly exists.

The behavioral experiment done by the present study proves that move might exist in language computation.

APPENDIX. SAMPLE SENTENCES USED IN THE EXPERIMENT AND RELATED STATEMENTS

In order to save place, 10 of the 50 groups of sample sentences used in the experiment and related statements are listed here.

1.The doctor who loved the nurse has a heart attack.
Q: The nurse was loved by the doctor. √
The doctor whom the nurse loved has a heart attack...
Q: The doctor was loved by the nurse. √
2.The president who visited the queen gives a new order.
Q: The queen was visited by the president. √
The president whom the queen visited gives a new order.
Q: The president was visited by the queen. √
3.The professor who disliked the dean majored in chemistry.
Q: The dean was disliked by the professor. √
The professor whom the dean disliked majored in chemistry.
Q: The professor was disliked by the dean. √
4.The Chairman who threatened the public is from China.
Q: The Chairman was threatened by the public. ×
The Chairman whom the public threatened is from China.
Q: The public was threatened by the Chairman. ×
5.The policeman who watched the thief is severely hurt.
Q: The policeman was watched by the thief. ×
The policeman whom the thief watched is severely hurt.
Q: The thief was watched by the policeman. ×
6.The poet who murdered the painter is arrested.
Q: The poet was murdered by the painter. ×

The poet whom the painter murdered is arrested.
Q: The poet was murdered by the painter. √
7.The author who helped the readers becomes more popular.
Q: The author was helped by the readers. ×
The author whom the readers helped becomes more popular.
Q: The readers were helped by the author. ×
8.The football player who scolded the coach made a serious mistake.
Q: The coach was scolded by the football player. √
The football player whom the coach scolded made a serious mistake.
Q: The coach was scolded by the football player. √
9.The accountant who knew the actor works in a big company.
Q: The actor was known by the accountant. √
The accountant whom the actor knew works in a big company.
Q: The accountant was known by the actor. √
10.The artist who saw the anchor returns from Chicago.
Q: The artist was seen by the anchor. ×
The artist whom the anchor saw returns from Chicago.
Q: The artist was seen by the anchor. √

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