Effect of Different Presentation Orders on Processing Time and Time Estimation of Verbal Working Memory

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Abstract – **This research explored the effect of different presentation orders on processing time and time estimation, from the perspective of verbal working memory dual-task mode task. 108 participants took part in memorizing order or disorder French word, it showed that the presentation order significantly shortens the processing time and estimation time, thus it proved that the orderly presentation can enhance the work efficiency compared with the disorderly presentation. This research highlights the impact of presentation upon the verbal working memory, which had important theoretical and practical implications.**

Keywords – **Order, Disorder, Processing time, Time estimation**

I. INTRODUCTION

As the computer revolution and smart phone era arrive, a large amount of information sweeps over the life of everyone like a storm, how to rapidly and effectively process all sorts of information and enhance the efficiency of time management for people has increasingly become a hot issue. Since ancient China, there had been a lot of phrases such as orderly talk, apple-pie order, progression and so on which explain the efficiency and habits. In Sun Tzu in the Art of War which created a lot of war legends, it mentions that through systematic analysis if you can associate the elements, subject to orderly sorting and selection strategies, you can manage to keep your own army in order and make your adversary's a chaos [1]. But currently in psychological evidence study, there still lacks direct research reference. This paper tries to discuss the impact of different sequence presentation impact upon the processing time and time estimation from the psychological perspective, and thus to reach the conclusion that the scientificalness of progressive thinking, which is also the scientific charm of the ancient Chinese philosophy.

II. LITERATURE REVIEW

A. Concept of order

"Order" means a condition of regular and proper arrangement or sequential arrangement. It extends to the action of distinguishing and sorting by sequence. The sequence can be orderly and disorder. Orderly means the objects and the intrinsic factors of them have regular connections or motions. Disorder means the chaos and disorderly connections and motions or transformations. In psychological area, Ebbinghaus believes the chaining is the most ancient method to study sequence, which stimulates the theoretical development [2]. The sequence effect should mean the phenomena where the stimulant presentation sequence impacts humankind judgment. In 1994, Keane and so on proved the existence of sequence effect through the property—mapping issue [3].

B. Sequence-related theory

The main theories of sequence study both at home and abroad include chaining theory, ordinal theory and position theory. In chaining theory, one far item is connected by the intermediate item which is connected by the relations formed with the previous items [4]. The chaining theory stresses the impact of clues in chaining process on the sequence. Among the orderly array, there is a clue to connect all the elements; it thus saves the processing time. In the sequencing theory, the items have an interior sequence in the array; the item is retrieved according to the queued sequence [5]. Suppose the orderly presentation is connected with the original interior sequence in the array, the more the items are connected in the array, the more they facilitate the cognitive processing. The position theory believes that the item positions are connected, the items are stored by connections of their positions, and the items are retrieved by their position. Conrad raised the "Box model", the "Box" means the set program (or mode), the item is stored in the" Box", and retrieved via the" Box". [6]. Suppose, for the items that are presented in certain order, the distance between the items are shorter than the disorderly ones, which leads to shorter processing time. The start- end model, SEM, is acknowledged by the psychology world as the relatively systematic and comprehensive model that can explain how the sequence is formed, SEM stresses the queued position and coding based on the start and finish points, through recall of position codes, it provides each response with clues [7]. The orderly presentation brings about the orderly coding, which makes the clue clearer and thus saves the processing time.

C. The relevant research of time processing and time estimation regarding verbal working memory

Cognitive psychology defines the working memory, short for WM, as the memory system of limited power that temporarily processes and stores the information [8]. Human conducts verbal understanding, reading, operation and reasoning and so on cognitive activities via the system, the verbal working memory is very important for working memory.

Subjective time measurement is one indispensable dimension for human to define the surrounding world. In our daily life, our physiologic rhythm, the periodical change of space environment, calendar, clock and so on all provide information for our psychological time estimation. Therefore, we have the ability to estimate the event completion time. Hecht put forth in 2000 that humankind uses the perceptions and arithmetic skills to estimate event finish time [9]. Stephken k.Reed and Bob hoffman raised the proportion capacity strategy, time inference strategy, time filling strategy and psychology simulation strategy for time estimation [10]. We hereby conclude that the factors that impact the time estimation are mainly cognitive processing speed, quantity of estimated objects, situation variables, and psychological simulation accuracy.

The actual processing time of working task directly reflects the processing speed of human, which is shown in the individual speed for multiple different cognitive operations; it is not only the important indicator for measuring the mental ability, but also the important indicator for measuring the individual mental development level [11]. In 1997, Keane and so on once again proved that different presentation sequence have impact on analogical reasoning through the study of mapping issue and triangular love affair issue [3]. The analogical reasoning ability and fluid intelligence level are highly related, in many intelligence scales, the design adopts analogical reasoning. In 1997, analogical reasoning is adopted during the study of Parbhakaran regarding Raven Intelligence Test which uses fMRI technologies [12]. Salthouse also pointed out that the general reaction time factor (cognitive speed) is related with the fluid intelligence [13]. Based on the above, different presentation order has impact on the analogical reasoning, the analogical reasoning impacts the fluid intelligence display level thus impacts the processing speed.

D.   The relevant research of different sequence presentation on processing time

Among the psychology studies both home and abroad, Elke Van der Meer and so on discovered that compared with the disorder and neutral words, the readers take shorter time to memorize the orderly words [14]. Mandler discovered that compared with the disorderly sentence, the orderly sentence needs shorter time to read [15]. He Xianyou and so on concluded that humankind process the orderly events by priority based on their study of verbal understanding [16]. Currently, there is no study pointing to the theory or model of different sequence presentation impact on the time processing and time estimation.

Based on the above, we reached the conclusion that the orderly presentation puts the items among more connections, which increases the processing speed, and at the same time it brings the distance among items closer, which gives the feeling of less information to process and the estimated object total even less, The assumption: the orderly presentation method consumes shorter processing time and estimated time than the disorder mode. To widely discuss the objective presentation impact, we introduce subjective emotions as the impact factor. As emotions are automatically processed, it won't cause too much subjective processing, thus the interference of introduced variable is reduced. In comparison, the negative stimulation attracts more attention and further level processing, which may extend the estimation time and processing speed, but with less impact than that of orderly presentation. We speculate that with all emotions present, the orderly presentation is better than the disorder presentation.

III. METHODS

A. Approach

Rammsayer and Ulrich adopt the double task approach of memory search and time comparison, they place requirement on the tested English letters and judge the time taken to memorize the letters. They found the number of English letters will not impact the time estimation. Based on this we infer that when using the English words as the tested object, the English words and their quantity will cause less deviation for the estimated time and processing time. To avoid the any deviation brought about by the previous learning experience, we use French words. Taken into account the possible impact of the emotion variable and word property on the test results, we divide into neutral, positive and negative three groups of words. To underline the orderliness, we stress from the word property (such as noun, verb), word length, and initials sequence.

B. Design

The first part of the study is word memorization task by categories and alphabetical order, which uses inter-group design, the independent variable is sequence (orderly vs. disorderly), as the dependent variable are time estimation and the actual memory time. Use the accuracy rate of the memory as the screening criteria (The accuracy needs to reach 80% above).

The second part is emotion word memorization task, In a 2 (orderly vs. disorderly) ×2 (positive word vs. negative word) design, the dependent variable are time estimation and the actual memory time, Use the accuracy rate of the memory as the screening criteria (The accuracy needs to reach 100%).

C. Participants

108 participants(65 females) took part in our study, (age 20-30: 69, age 30-40: 39; education background: below undergraduate: 5, undergraduate: 92, masters: 11). They are all right, and their vision or corrected visual acuity are normal. They never participated in similar research before. They were randomly assigned to orderly group(50 samples) or disorderly group(58 samples).

D. Measures

This study adopts PHP computer development language, database MySQL, Jquery front end webpage processing techniques to compile the test procedure, all use 14 inch monitor to display. Before the task starts, the participants are placed in a quiet environment as much as possible, quiet and earnest, they would complete the task without interruptions. At the same time, the participants are notified to estimate the time and memorize tasks etc., which they should complete as fast and accurate as they can. The procedure adopts self-report method for the estimated time; the other time (Task completion whole total time, the actual memorization time of participants) and the accuracy rate of memorization are calculated by the computer with precision of 0.01 second.

E. Materials and procedure

The first part of the study selects 10 groups of French words and the Chinese meanings thereof as the test materials, which have two categories: one is 5 fruit nouns (the Chinese is 2-character long), the length is 6 letters; the other is 5 verbs (the Chinese is 1-character long), with length of 5 letters. Initials of two categories are selected alphabetically. They are presented by categories, also by the initials in alphabetical order. The disorderly category is 10 groups of words of random arrangement. Both groups all present by their words and the relevant meanings, and meanings precede the words, first conduct the memory time estimation and input the estimated time in the answer box, and the unit is minute. Then preset the same sequence panel once again, start timing and click the memorization end key to stop the timing. Then confirm by matching the words and their meanings, and confirm the effect by the accuracy, and use it as the filter criteria.

The test procedure of the second part is completely the same with the first part, the test material selects 4 groups of positive emotion French word (clair, joyeux, heureux, vaillant) and 4 groups of negative emotion French words (peine, triste, dauleur conconne). Both groups of French words have words of the same length. Under the orderly scenario, the French words are sorted from short to long and their initials alphabetically.

IV. RESULTS

Table 1 shows the statistic results and different test results of the time estimation and the actual time under the orderly and disorderly modes. In the neutral word memorization estimated time, the estimated time greater than 1800s data is excluded, and at the same time data with accuracy rate above 80% are screened out, eventually, the valid data of the orderly group is 36 with effective rate of 72%, while the disorderly group is 40 with effective rate of 69%. In the actual time for neutral words, the data of actual memory time less than 5s is deleted, eventually the valid data of the orderly group is 36 with effective rate of 72%, while the disorderly group is 36 with effective rate of 62%. Through the independent samples t test, we can learn, the neutral word memory time estimation of the orderly group ($M = 435$, $SD = 368.58$) is shorter than that of the disorderly group ($M = 564$, $SD = 312.15$; $t(74) = -1.65$, $p=0.05$). The actual memory time of orderly group for neutral word ($M = 31.02$, $SD = 26.04$) is shorter than that of the disorderly group ($M = 105.45$, $SD = 105.15$; $t(70) = -4.12$ $p < 0.001$).

TABLE I
DIFFERENCE ANALYSIS OF VERB ESTIMATED MEMORY TIME AND PROCESSING TIME UNDER ORDERLY AND DISORDER PRESENTATION SEQUENCE

Dependent variable	Independent variables	N	Mean (s)	t	p
Neutral memory estimates available	Order	36	435.00	-1.65	0.05
	Disorder	40	564.00		
Neutral memory actually available	Order	36	31.02	-4.12	<0.001
	Disorder	36	105.45		
Positive memory estimates available	Order	40	172.50	-1.71	0.045
	Disorder	48	260.63		
Positive memory actually available	Order	40	9.98	-2.15	0.035
	Disorder	48	16.39		
Negative memory estimates available	Order	31	160.65	0.84	0.20
	Disorder	37	138.65		
Negative memory actually available	Order	31	20.27	1.60	0.06
	Disorder	37	12.55		

In the two tasks for positive word memorization and negative word memorization, with data of estimated time greater than 900s, and un-estimated data deleted, eventually the valid data of the orderly memorization group for positive words is 40, with effective rate of 80%, while 48 and 82% for that of the disorderly. The valid data of orderly group for negative word memorization is 31, with effective rate of 62%, while 37and 63% for that of the disorderly.. The time estimation of orderly group for positive works ($M = 172.5$, $SD = 163.15$) is shorter than that of the disorderly group ($M = 260.63$, $SD = 289.68$;($t(86) = -1.71$, $p = 0.045$); The time estimation of orderly group for positive words ($M = 9.98$, $SD = 10.32$) is shorter than that of disorderly group ($M =16.39$, $SD = 17.29$;$t(86) = -2.15$, $p=0.035$. There was no different effects between the time estimation of orderly group

for negative words (*M*=160.65, *SD* = 132.71) and that of the disorderly (*M* = 138.65, *SD* = 81.04; t(66) = 0.84, p = 0.20); the actual processing time of orderly group for negative words (*M* = 20.27, *SD* = 22.76) is shorter than that of the disorderly (*M* = 12.55, *SD* = 17.08;*t*(66) = 1.60, *p*= 0.06).

From the paired samples t test, we can learn the memorization estimation of the neutral word group (*M* = 497.50, *SD*= 349.05) is longer than the actual memory time (*M* = 68.24, *SD* = 84.79; *t*(71)=10.48 *p*<0.001); the memorization estimation for positive words (*M* = 220.57, *SD* = 243.34) is longer than the actual memory time (*M* = 13.47, *SD* = 14.82; *t*(87) 8.11, *p*<0.001); while the memorization estimation for negative words (*M* = 148.68, *SD* = 107.41) is longer than the actual memory time *M* = 16.07, *SD* 20.09; *t*(67) = 10.48, *p*<0.001). Based on the above, there is obvious over-estimation for word memorization task.

V. DISCUSSIONS

A. Results discussion

Based on the research results, we found that the orderly presentation method has shorter time estimation and processing time regarding verbal memorization tasks. This is consistent with the research results of Elke Van der Meer, Mandler and so on. In the research results of this paper, the orderly presentation is more difficult to process compared with the disorder presentation method in resource sharing model in the work memory capacity model, which leads to longer processing time, and the conclusion is consistent [17],but it is not verified that this model may result in worse memory effect. The disorderly presentation may lead to more conversions among items, which results in higher forgetting rate, and impact the memorization results. This verifies the conclusion that the possible forgetting time of the item in the task-switching model impacts the working memory. [18]. The disorderly presentation may result in occupancy of more processing resource to process the sequence issue among the items. This agrees with the explanation in the time - based resource - sharing model TBRS, which stresses the limited processing resources. At the same time, it proves that different presentation sequence may impact the analogical reasoning, thus impact the fluid intelligence processing level, and the processing speed further. This paper also proves the study of time estimation by Burt and so on people, the time tends to be overly estimated for the participants regarding short time task from 30 seconds to 4 minutes. But it does not prove that the over-estimation is related to the complexity degree of task and the previous experience [19].

The memorial difficulty may also impact the perception and judgment, according to the memorization study of Rammsayer, the accuracy rate is 80% and 50% around [20], this also becomes the screening reference in test a. In the second part of the study, the orderly

sequence impact of the negative word group is not obvious; this may be due to the fact that the participants immediately started the negative word group task when they just completed the positive word group. According to the anchoring effect study of Tversky and Kahneman, the participants will generate an anchoring value for the similar task before they complete the previous task, which makes the time estimation closer the actual processing value. Therefore the estimated value has large deviation, and thus impacts the time difference brought by the presentation modes [21]

B. Theoretical and practical implications

The orderly presentation method can bring a higher work efficiency, which proves the scientific direction significance of Chinese progression thought. We for the first time use the word memorization method to discuss the orderly and disorderly difference, using the estimated time (Subjective psychological characteristics) and processing time (Objective psychological characteristics) as study variables, thus the impact of sequence upon the efficiency is obtained. The cross study approach that crosses multiple areas also expands the ways of study for chaining theory and so on. Furthermore, we also prove the proper division of the time interval related to the over-estimation phenomena of time estimation theory. At the same time, it discusses the interaction of sequence on the analogical reasoning, fluid intelligence level and processing speed, thus it is concluded that the orderly sequence increases the efficiency intrinsically.

The conclusion of this paper can be widely used in practice, it can be used in HR performance management, where the orderly establishment of working plans can promote information processing efficiency thus increase work efficiency, it can also be used in project management, where it serves as the reference for proper project sequence. This conclusion can also be used as the method to accelerate verbal memorization, and provide theoretical support for developing the kids into an orderly habit.

C. Limitations and future directions

This study also has limitations. It does not verify that the longer processing time results in worse memory recollection results in the resource sharing model and task switching model and so on study. The previous and current test results may contradict, they need to be measured separately. Not too many limits are placed on the participants age; the fluid intelligence is highly related to the participants age, so the age difference may impact the test results.

In the future, figure processing, letters, meaningless syllables, paragraph and statement and so on test materials can be used to discuss the impact of different presentation method on the efficiency. The mediating variables can also be introduced, such as different interpretation level etc., to discuss the different sequence presentation impact on the working memory.

Furthermore, we can also discuss how to achieve orderly presentation without sufficient required information. The sequence and laws are diverse, among them which factors exert the leading role regarding the verbal working memory.

VI. CONCLUSION

Through the study of difference of time processing and time estimation regarding verbal working memory under different presentation sequence, the progression method is verified for being capable of increasing work efficiency, the following conclusions are obtained: (1) In the verbal memory working task, there is obvious over-estimation phenomena. (2) Among the memory tasks for neutral, positive and negative word, the orderly presentation method has shorter time estimation and time processing compared with that of the disorderly presentation method.

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REFERENCES

[1] X. M. Fan, "The 'order' in Sun Tzu on the Art of War", *Social sciences review*, vol. 24, no. 2, pp. 137-138, Feb. 2009.

[2] P. N. Johnson-Laird, *Cognitive neuroscience*, Shanghai Foreign Language Education Press, 1998, pp. 683–695.

[3] M. T. Keane, "What makes an analogy difficult? The effects of order and causal structure on analogical mapping", *Journal of Experimental Psychology* , 1997, vol. 23, no.4, pp. 946-967.

[4] E. W. Farmer, J. V. F. Berman, Y. L. Fletcher, "Evidence for a visuo-spatial scratch-pad in working memory." *The Quarterly Journal of Experimental Psychology*, 1986, vol. 38, no.4, pp. 675–688.

[5] K. J. Gilhooly, R. H. Logie, N. E. Wetherick ,V. Wynn, "Working memory and strategies in syllogistic reasoning tasks. " *Memory and Cognition,* 1993, vol. 21, no.1, pp. 115-124.

[6] A. Vandieredonck and G. D. Vought "Working memory and language." *Lawrence Erlbaum Associates LTD*, 1993, pp. 206-211.

[7] P. A. Carpenter, M. A. Just , P. Shell,"What one intelligence test measures: A Theoretical account of the processing in the Roven. Progressive Matrices Test." *Psychological Review* , vol. 97, no. 3, pp. 404-431, Mar.1990.

[8] A. D. Baddeley and G. J. Hitch , "Recent and once in learning and motivation." *Working memory* .In: G A Bouer (Ed) , New York: Academic Press.1974, pp. 47-90.

[9] H Z Yin and X T Huang "Time estimation methodology dilemma.", *Journal of Inner Mongolia Normal University (Philosophy & Social Science)* vol. 32, no.3, pp. 106-109, Jun.2003.

[10] S. Kreed and B. Hoffman "Use of temporal and spatial information in estimating event completion time." *Memory and Cognitio,* 2004 , vol. 32, no.2, pp.271-282.

[11] M. Minsky, "The Society of Mind." *New York:* Simon and Schuster, in press.1988, pp. 7-15.

[12] V. Prabhakaran , A. L. Jennifer, J. E. Smith, et al, "Neural substractcs of fluid reasoning an fMRI study of neocortical activation during performance of the Ravcn's Progvessive level. " *Brain and Cognition.*1994, vol. 24, no.4, pp. 244-258.

[13] T. A. Salthouse, "Speed mediation of adult age differences in cognition." *Developmental Psychology*, 1993, vol.29, no.4 , pp. 722-738.

[14] E. V. D. Meer, R. Beyer , B. Heinze , "Isolde Badel Temporal Order Relations in Language Comprehension" *Journal of Experimental Psychology: Learning, Memory. and Cognition*, vol. 28, no. 4, 2002, pp. 770-779.

[15] J. M. Mandler, "On the comprehension of temporal order", *Language and Cognitive Processes*, vol. 1 no. 4, 1986. pp. 309-320.

[16] X Y He, L M Liang, X Y Zeng,, "Effects of Temporal Order Relations on Language Comprehension", *Psychological Science.* vol. 28, no. 1, 2005, pp.80-84

[17] M. Daneman and P. A. Carpenter, "Individual difference in working memory and reading." „*Journal of Experimental Child Psychology*, vol. 33, no.3,1980, pp.86-404.

[18] J. N. Towse , G. j. Hitch and U. Hutton, "A revalution of working memory capacity in children." *Journal of Memory and language*, vol. 39, no. 1, 1998. pp. 195-217

[19] C. D. B. Burt and S. Kemp, "Construction of activity duration and time management potential. " *Applied Cognitive Psychology,* vol.8, no. 2, 1994 , pp. 155–168,

[20] T. Rammsayer and R. Ulrich, "No evidence for qualitative differences in the processing of short and long temporal intervals." *Acta Psychologica*, 2005, vol. 120, no.2, pp. 141-171.

[21] A. Tversky and D. Kahneman , "Judgment under uncertainly: Heuristics and biases. " *Science,* 185: pp. 1124-1131