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Research Article

Information Updating in Working Memory: Its Effect on Teacher Efficacy

Jun Tao

Department of Psychology, Harbin University, 109 Zhongxing Avenue, Nangang, Harbin 150086, China

Correspondence should be addressed to Jun Tao, tjkevin@hrbu.edu.cn

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Teacher efficacy has a great impact on effective teaching and has been studied in various perspectives. The updating information ability in working memory is always related with many capabilities of cognition. An experiment of N-back task and a questionnaire of teacher efficacy were conducted in this study to test the effect of the ability of information updating in working memory on the teacher efficacy. A significant difference was found in the reaction time between high teacher efficacy group and low teacher efficacy group. The results showed that teachers who scored higher in the teacher efficacy scale tended to react faster than those who scored lower based on the same accuracy. And the updating information ability could serve as a predictor of teacher efficacy.

1. Introduction

The concept of teacher efficacy was proposed by RAND Corporation in the year of 1976 [1], referred to the confidence that teachers hold about their individual and collective capability to influence student learning and was considered to be the key motivation beliefs influencing teachers' professional behaviors and student learning [2]. While Tschannen-Moran et al. (1998) believed that teacher efficacy was the teacher's belief in one's capability to organize and execute courses of action required to successfully accomplish a specific teaching task in particular context [3].

Teacher efficacy is believed to play an important role in teaching situation. Previous researches show that teacher efficacy has great impact on both teaching behavior [4–7] and the student achievements [6–9]. Statistically significant relation was found between professor self-efficacy in enthusiasm, breadth and teaching effectiveness regarding enthusiasm and breadth, respectively [10]. The teacher efficacy effects on teaching situation in various ways. Tschannen-Moran and Hoy proposed the constructs of teacher efficacy were efficacy in student engagement, efficacy in instructional strategies, and efficacy in classroom management [11]. These three components serve as the mediator for a teacher to influence the student, in which the inner cognitive process decides the proper behaviors that would be taken based on the inputting information from the teaching environment.

Researchers are also interested in the sources of teacher efficacy from which they can predict the level of a teacher's efficacy. Bandura [12] postulated four sources of teacher efficacy: mastery experiences, physiological and emotional cues, vicarious experiences, and social persuasion. Actually, these four sources do not influence the level of teacher efficacy directly according to Tschannen-Moran et al. [3]. The sources of efficacy information are analyzed and evaluated under the control of a cognitive process. Tschannen-Moran et al. [3] believed that cognitive process played an important role in the creation of efficacy beliefs. It is the cognitive process that determines how the sources of information will be weighed and how they influence the analysis of the teaching task and the assessment of personal teaching competence. The interaction of task analysis and competence, in turn, shapes teacher efficacy. They have introduced a model to illustrate how central cognitive process interacts with other sources of teacher efficacy.

As illustrated in Figure 1, the cognitive process has a close relationship with teacher efficacy and influences the teaching performance both directly and indirectly by raising cognitive effort which would arouse more resources needed for better cognition. Many evidences show that working memory plays

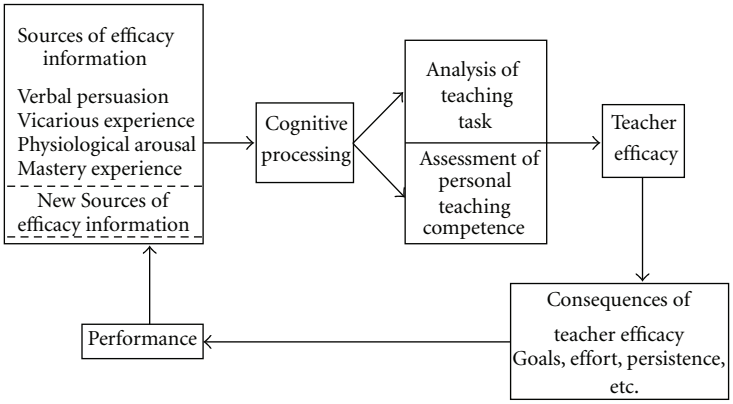

Figure 1: The cyclical nature of teacher efficacy [3].

a very important role for individuals to perform in an effective way, because it influences the cognitive process [12], such as perception [13], attention [14], reasoning [15], and decision making [16] which are necessary for teachers to perform in the teaching situation. The teaching situation is changing all the time, and it is important for a teacher to perceive the information from the environment and to react in a proper way. Thus, the teacher efficacy is regarded as an outcome of the cognitive process which is based on the inner information processing between the perception and reaction. The teaching information is processed and updated with the changing of teaching situation and then interacts with teacher efficacy together to influence the teaching behavior and the students achievement. Obviously, an ability of information updating is needed to deal with the changing information at a high speed of central executive process which is the core component of working memory.

Working memory is more like a processor rather than a storage in which information is temporarily stored and maintained in performance of complex cognitive processing [17]. Baddeley and Hitch suggested working memory was comprised of three components: a phonological loop, a visuospatial sketch pad, and the central executive [18]. The phonological loop is known as "articulatory loop" in Baddeley's early model of working memory and now is regarded as a relatively modular system comprising a brief store together with means of maintaining information by vocal or subvocal rehearsal. The visuospatial sketch pad keeps the visual and spatial information in a relatively short time in memory for further processing. Baddeley regarded the central executive as the most important component of working memory. He was criticized for saying nothing about it in his early research and suggested that the central executive needed to be able to focus on attention, to divide attention between two important targets or stimulus streams, and involved in tasks switching [19].

The working memory construct is a strong predictor of general fluid intelligence and a weaker predictor of domain-specific reasoning, and the reverse is true for the short-term memory construct. The findings support a domain-general view of working memory capacity, in which executive-attention processes drive the broad predictive utility of working memory span measures, and domain-specific storage and rehearsal processes relate more strongly to domain-specific aspects of complex cognition [20].

Previous studies show that the updating abilities are closely linked with performance on both verbal and visuospatial working memory span tasks [21]. Working memory updating is the ability to maintain accurate representations of information changing over time, and it has been successfully used in individual differences research to predict higher cognitive abilities [22]. Working memory updating and working memory capacity may make independent contributions in predicting higher mental abilities.

The teacher efficacy maybe has a close relation with the cognitive process. It is influenced by the information processing ability in which the ability of updating would help individuals to perceive the environment and react to it in a proper way. The updating information ability in working memory was selected as a predictor to test its impaction on teacher efficacy in this study. An experiment of N-back working memory task and a questionnaire of teacher efficacy were used in this study in order to test the effect that the information updating ability had on the teacher efficacy. The subjects were supposed to score higher for the teacher efficacy scale if they performed faster in the N-back working memory task.

2. Method

2.1. Subjects. 30 teachers from Harbin University were involved in this study via an instant message group. 3 teachers quitted at the beginning of the experiment, and 2 teachers gave up during the experiment. The rest 25 teachers (6 males and 19 females) composed the valid participants in this study. Their average age was 35.56 (SD = 6.92) and 11 (SD = 8.66) years of average teaching years.

The hypothesis of this study is to test whether the low and high teacher efficacy subjects also differ in their updating information ability. Therefore, data for a total of 25 subjects

were divided into three groups according a traditional way that 27% of the top scores and the 27% of low scores composed the higher group and lower group, respectively. The high teacher efficacy group in this study is defined as the subjects who rank the top 7 that scored from Teachers' Sense of Efficacy Scales with a mean score of 168.43 (SD = 5.62). The low teacher efficacy group is defined as the last 7 subjects whose scores are ranked the bottom 7 with a mean score of 123.71 (SD = 14.02). The rest 11 subjects are defined as the middle group of teacher efficacy with a mean score of 152.91 (SD = 7.35). ANOVA analysis shows that there is a significant difference between these three groups ($F = 41.96$, $P < 0.01$) (see Table 2), and the Tukey HSD test shows the differences between each group are also significant with mean differences of -29.19 ($P < 0.01$), -44.71 ($P < 0.01$), and -15.52 ($P < 0.01$) by low-middle, low-high, and middle-high comparison, respectively. No sex differences were found in teacher efficacy, reaction time, and accuracy in this study.

2.2. Procedure. There were two stages in this study. Subjects were asked to operate an N-back working memory task in the first stage. In the N-back task paradigm, subjects are asked to monitor the identity of a series of stimuli and to indicate whether the currently presented stimulus is the same as the one presented in N trials previously. For example, subjects would compare the current stimulus with the previous stimulus in 1-back task and compare with the stimulus appeared before the previous one in 2-back task. As N-back task requires online monitoring, updating, and manipulation of remembered information and is therefore assumed to place great demands on a number of key processes within working memory [23]. In this study, the experiment of N-back task aimed to identify how well the subjects would perform in dealing with the updating information. As the new stimuli come into their working memory and caused the old stimuli to be expelled from working memory, the central executive of cognitive process must maintain at least N+1 items at a time and make comparisons between the old and new stimuli till the decision is made and responded.

In the second stage of the study, subjects were asked to complete a Teachers' Sense of Efficacy Scale (long form) after they finished the N-back task. The scale (TSES) was developed by Tschannen-Moran and Woolfolk Hoy and was translated into simplified Chinese by an English-Chinese translation expert. The reliability of this scale is 0.94 of alpha in Tschannen-Moran's original research [11] and 0.885 of Cronbach's Alpha with reliability analysis in this study.

All the subjects were invited individually to the Cognitive Psychology Laboratory of the Psychological Department of Harbin University where they took the N-back task experiment and finished the scales.

2.3. Experiment Design and Material. The experimental program of N-back task was produced with E-prime 2.0 and presented by a HP notebook. Sixteen simplified Chinese words were selected to be the items subjects need to remember and identify in the experiment.

The 2-back task was used in this study in which participants were asked to respond to the words they saw on the screen and to judge whether the word was the same or not with the one he/she saw two words before (see Figure 2). Participants were instructed to press "F" button if he/she judges this word was the same as the one two trails previously and press "J" button if the judgment is not the same. Before the formal experiment, there was a practice phase in which subject should be familiar with the progress and required 90% accuracy to be the criterion to go to the formal experiment. Subjects received feedback of being right or wrong when they responded to the current stimulus in the practice phase but no feedback in the formal experiment phase. There is no time restriction for subjects, and the stimulus disappears as the subjects respond to it before the next stimulus appears on the screen. Data were collected and analyzed by using SPSS 13.0.

Table 1: The general analysis of teacher efficacy, reaction time, and accuracy.

	N	Mean	Std. deviation	Std. error
Teacher efficacy				
Low	7	123.71	14.02	5.30
Middle	11	152.91	7.35	2.22
High	7	168.43	5.62	2.13
Total	19	149.08	19.57	3.91
Reaction time				
Low	7	2094.32	840.47	317.67
Middle	11	1521.72	426.73	128.66
High	7	1277.96	273.90	103.53
Total	19	1613.80	612.66	122.53
Accuracy				
Low	7	94.44	4.08	1.54
Middle	11	92.04	3.31	0.99
High	7	95.07	1.24	0.47
Total	19	93.56	3.33	0.67

3. Result

3.1. The General Analysis of Reaction Time and Accuracy. The reaction time and accuracy are the most important measures in this task. The general reaction time and accuracy for all subjects are 1613.80 (SD = 612.66) ms (millisecond) and 93.56 (SD = 3.33) percent, respectively. The reaction time of the low teacher efficacy group is 2094.32 ms (SD = 840.47) and 1277.96 ms (SD = 273.90) for the high teacher efficacy group. The reaction time of middle group is 1521.72 ms (SD = 426.73). The mean accuracy of the low teacher efficacy group is 94.44% and 95.07% of the high teacher efficacy group which are much better than the middle teacher efficacy group of the 92.04% accuracy (see Table 1). There is strong tendency that the reaction time reduces as the teacher efficacy increases.

Table 2: The ANOVA analysis for teacher efficacy, reaction time, and accuracy.

	Sum of squares	df	Mean square	F	Sig.
Teacher efficacy					
Between groups	7285.79	2	3642.90	41.96*	0.000
Within groups	1910.05	22	86.82		
Total	9195.84	24			
Reaction Time					
Between Groups	2499088.14	2	1249544.07	4.22*	0.028
Within groups	6509432.26	22	295883.29		
Total	9008520.40	24			
Accuracy					
Between groups	46.91	2	23.45	2.36	0.118
Within groups	218.61	22	9.94		
Total	265.52	24			

* $P < 0.05$.

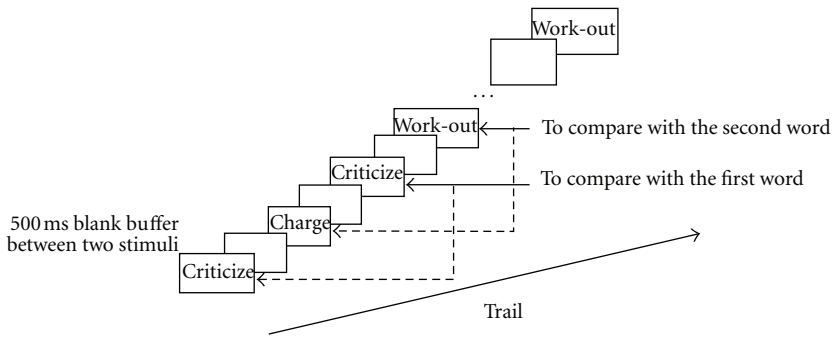

Figure 2: The procedure of 2-back task experiment.

3.2. The ANOVA Analysis for Teacher Efficacy, Reaction Time, and Accuracy. The one way ANOVA analysis was conducted to examine the relationship between teacher efficacy and updating ability in working memory. The results show that there is a significant difference of reaction time between groups ($F = 4.22$, $P < 0.05$). But no significant difference is found in accuracy among three groups ($F = 2.36$, $P > 0.05$) (see Table 2).

Further analysis by Tukeys HSD found that there was a significant difference in reaction time between the low teacher efficacy group and high teacher efficacy group (the mean difference is 816.36, $P < 0.05$), but no significant difference was found in accuracy between these two groups.

3.3. Correlation of Teacher Efficacy, Reaction Time, and Accuracy. Significant negative correlation was found between teacher efficacy and reaction time ($r = -0.491$, $P < 0.05$), but no significant correlation was found between the teacher efficacy and accuracy ($r = -0.203$, $P > 0.05$) while the reaction time and accuracy are correlated in the positive way but still not significant ($r = 0.361$, $P > 0.05$). The subjects tend to perform faster but with more mistakes in the N-back task if they have higher score from the Teachers' Sense of Efficacy Scale.

4. General Discussion

This study investigated the effect of updating information in working memory on teacher efficacy at levels of reaction time and accuracy. The hypothesis was tested that higher teacher efficacy need more cognitive effort which stated that the working memory updating made independent contributions in predicting higher mental abilities which consisted the ability of teacher efficacy sources from an evaluation of the inputting information. Although previous research established a clear relationship between teacher efficacy and cognitive process, few studies have investigated the details of how cognitive process interacted with teacher efficacy. This study hypothesized that the updating information ability had effect on the performance of teacher efficacy when reaction time of high teacher efficacy group was faster than low teacher efficacy group.

Results in the experiment and the scale supported the hypothesis of better updating information lead to higher teacher efficacy (see Figure 3). The mean of three groups of reaction time had a significant difference with the analysis of ANOVA and differed significantly between high teacher efficacy group and low teacher efficacy group with Tukeys HSD test. The high group and low group revealed nearly identical accuracy for N-back task but faster reaction time

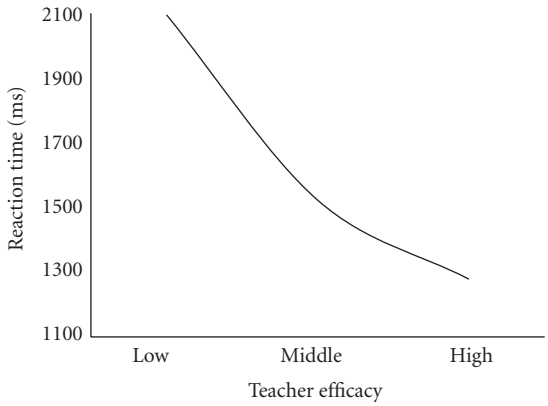

Figure 3: The relationship between updating information and teacher efficacy.

with increasing teacher efficacy. And negative correlation was also found between reaction time and teacher efficacy serving as evidence that the ability of updating information in working memory does affect the teacher efficacy.

The teacher efficacy was constructed by three components which would be mediators of cognition effect on teacher efficacy. The efficacy of student engagement depended on the ability to motivate students by the proper behavior [24] that was generated on the basis of the interaction of new and old information. The efficacy of instructional strategy needs effective expression that could be predicted by the updating information ability of working memory proposed by Morris and Jones who found that the updating memory affects the performance independently of the effects of irrelevant speech and suppression [25].

Walczyk et al. proposed that individuals with higher levels of self-efficacy may be more resourceful in the allocation and adaptations of alternative strategies compared to those individuals with lower levels of self-efficacy and thus solve problems with greater accuracy and efficiency [26]. The resources of cognition are limited. The allocation strategy would be an alternative explanation for the results of this study.

Serving as one of the sources of teacher efficacy, the high speed of updating information leads to a higher teacher efficacy. Due to the fact that teaching situation is changing all the time, the high-speed response to the teaching situation is necessary for a teacher to perform in a proper way during their instruction, classroom management, and interactions with students. Teachers are required to integrate and evaluate the current information that comes from the environment in order to adjust their behavior that is suitable for the teaching situation. This is done with the working memory—especially the central executive. Besides the storage of information, working memory is a functional component that is in charge of the information processing. There will be a more effective information processing ability if the inputting information from the teaching situation is processed at a higher speed. Teachers with high speed information updating ability will adjust their teaching behavior rapidly with the changing outer environment, and therefore they will have higher teacher efficacy.

Finally, the level of teacher efficacy was measured by the scale, and subjects completed it based on their beliefs about teaching episodes. As were identified artificially by the scores of the subjects responded in the scale, the three groups of low, middle, and high teacher efficacy did not mean their sense of efficacy is low or high absolutely but relatively within the sample of this study.

Appendix

Materials Used in the Experiment

鼓励 (encourage) 赞扬 (commend) 批评 (criticize) 提问 (ask questions) 解答 (answer questions) 备课 (prepare lessons) 激励 (motivate) 授课 (instruction) 缴费 (charging) 计算 (calculate) 购物 (shopping) 健身 (work-out) 聊天 (chat) 旅游 (travel) 促销 (promote) 印刷 (print).

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