Annals of Behavioral Neuroscience**The Impact of Dialogic Learning on Students' Attention and Academic Achievement**

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Abstract

This study is a mixed method design which employed both quantitative and qualitative methods in order to investigate the impact of dialogic learning on students' attention and academic achievement. Data were collected using several instruments, including: the Attention Network Test; academic performance tests and semi-structured interviews. Results of Analysis of Covariance (ANCOVA) indicated that there is a statistically significant difference between the mean scores of students of the experimental and control groups on the executive control in favor of the experimental group after controlling the IQ score and pre-test scores. Further, there is a statistically significant difference between the mean scores of student of the experimental and control groups on the academic achievement tests (except of mathematics) in favor of the experimental group. The qualitative data also supported the quantitative findings. Therefore, dialogic teaching has significantly greater and more positive changes on some aspects of attention and academic performance.

Keywords: Attention, Attention training, Dialogue, Dialogic learning

Introduction

Educators have long known the critical significance of attention in the learning process and memory storage. They constantly have looked for innovative strategies to stimulate and maintain students' attention. Research into exploring the neural bases of attention has expanded significantly in recent years and provided increasing evidence supporting the critical role that attention plays in cognitive, social and emotional development of humans [1-3]. According to these studies, human attention is a multifaceted complex construct involving multiple components. It can be broadly defined as the

mental ability to select stimuli, responses, memories, and thoughts that are behaviorally relevant among a host of others that are behaviorally irrelevant [4].

The recent studies have indicated that, there are three distinct neuronal circuits that are involved in the basic functions related to attention [1-3,5]. From this model, alerting is referred to the process of achieving and maintaining a state of high sensitivity to incoming stimuli. Orienting is referred to the process of selectively focusing on information from sensory inputs. And, executive network is referred to the ability to regulating

and resolving conflict among thoughts, feelings, and responses [1,3,6].

The exploration of attention networks has attracted interest from researchers to examine the physical and functional connections between these networks. Based on the findings of these studies, the alerting network is assumed to involve the locus coeruleus, right frontal cortex, right parietal cortex and modulated by norepinephrine. Orienting is supposed to be associated with parts of frontal eye fields, superior parietal lobe, temporal parietal junction, superior colliculus, pulvinar and modulated by acetylcholine. The executive control network is thought to involve the anterior cingulate, anterior insula, frontal cortex, striatum and modulated by dopamine and serotonin [2,3,6,7]. The recent neuroimaging studies have indicated that, the three attentional systems are anatomically separable and functionally independence [8].

Researchers have considered the development of the functional organization of these networks across the lifespan and shown important changes in control systems over age, up to adulthood [9-11]. Based on these studies, alerting efficiency is much higher in children up to 9 years with no significant change across age. The efficiency of the alerting network significantly reduces by age 10 and for adults [10]. The orienting network regulates attention during infancy and early childhood [12]. This network seems to be relatively stable up to 10 years with no significant change across age [10]. The executive attention begin to dominate the regulation of thought and emotion after about age three years and continues to develop throughout childhood, but may stabilize at near-adult levels of performance by about eight years of age [10].

There is also increasing evidence on the connection between attention and effortful control [13,14]. Effortful control refers to the ability to inhibit, activate or sustain a response, which includes the capacity to inhibit a dominant response in order to perform a subdominant response [15]. For instance, Simonds et al. [14] reported the positive relationships between attention control and emotional regulation. The development of attention networks related to self-regulation abilities allows children to control their thought, emotion, and behavior [16]. Congruent with these findings, using Reaction time (RT) and event-related potential (ERP) measures, Racer et al. [17] examined the relationships between psychopathic symptoms and three major attention networks (alerting,

orienting, and executive attention) among a community sample of youth. They found an association between psychopathic symptoms and reduced attentional alerting. They relate these deficiencies in attentional alerting to abnormal noradrenergic functioning, which may have cascading effects on higher order cognitive and affective processing.

Whereas there is evidence exploring the heritability origins of attentional networks [18], a rapidly growing body of work is exploring the significant role of experience in shaping these networks [10,19]. There are accordingly strong individual differences in the efficiency of each attention network due to specific genetic variations in conjunction with specific experience variations during development [9]. Therefore, some studies have focused to understand how specific training may influence and improve the efficiency of attention networks and effortful control.

In the recent decades, several studies have reported positive effects of attention training on improvement of executive attention in children with attention disorders [20-22]. For instance; it has shown that early interventions based on attention games can improve attention performance of preschool children with attention deficit hyperactivity/ impulsivity disorder [22]. In addition, a growing body of studies has persuaded to investigate the effects of attention training on executive attention in normal children [23-25]. Interestingly, these studies have demonstrated the role of training on executive attention on improved structural and functional changes in the connectivity between the coordinated brain areas which occur through expansion of axons and their myelination. For instance, Rueda et al. [23] have investigated the efficacy of executive attention in 4- and 6-year-old children who received 5 days of attention training using computerized exercises. Compared to a control group, the trained children showed some improvement on executive attention and intelligence measures. The event-related potentials also revealed changes in the pattern of brain activations. After training, the 4-year-olds showed a pattern similar to the untrained 6-year-olds, and the trained 6-year-olds showed a more adult-like neural response. Also, Rueda et al. [24] recently examined the function of brain circuitry involved in executive attention of 5 years old children who performed ten sessions of computerized training of attention. The study demonstrated that trained children activate the executive attention network faster and more efficiently than untrained children, an effect that was still observed two months after without further training. In

addition, Tang et al. [26] investigated the mechanisms of white matter changes induced by Integrated Body Mind Training (IBMT). They revealed changes in axonal density after two weeks of training and changes in myelination changes after 4 weeks of training. The changes in axonal density were correlated with improved mood and affect in some areas. They also found that reaction time in the attention network test and specifically the executive network was improved more by IBMT training in comparison to a control group.

These findings support the potential benefit of attention training in promoting children's attention regulation [15,24]. All of these data support providing systematic opportunities to promote children's attention regulation skills through and by school curriculum [23,24]. However, it has not yet investigated how attention training can be embedded and integrated into the school curriculum. It may be realized by recruiting the potential of existing teaching strategies that teachers have long known and used in their practice. The Socratic dialogue is one of those well-known strategies that thought to have clear and consistent positive effects on students' attention and is widely practicable in all classrooms.

The Socratic dialogue is an appropriate technique to learning and thinking which enable students to make sense of their world using provocative questions. There is substantial quantitative and qualitative evidence suggesting the positive effects of Socratic dialogue on students' learning and memory in educational contexts [27]. For example, it has demonstrated that even in early years of life, using dialogic reading technique has clear and consistent positive effects on children's vocabulary knowledge [28,29]. Most recently, Goldin et al. [30] presented 58 participants a contemporary version of Socratic dialog based on a lesson of geometry that Socrates gave to Meno's slave. This lesson included 50 questions requiring simple additions or multiplications. At the end of the lesson the slave discovered the solution by himself. The results showed that participants remarkably made those trajectories, pattern of errors and corrects that Meno's slave made.

Given previous evidence on the relations between Socratic dialogue and student's learning, it would seem highly promising to explore the potential advantages of this strategy in school-related abilities. On the basis of this line, the main objective of the present study was to explore the impact of dialogic teaching on students' attention ability and academic achievement.

It was specifically focused to investigate the effects of Socratic dialogue on behavioral performance linked to attention networks and educational performance linked to academic achievement. The results of this study will provide some insight and offer ways to gain and keep student attention in the classroom and improve their academic success. This experience also will provide a practical framework for future researchers who are interested to produce a kind of knowledge that is scientifically valid and educationally relevant.

Research design

This study is a mixed method design which employed both quantitative and qualitative methods. The experimental design with control group was used for comparing the process of changes in students' attention at the three networks of attention. A phenomenological research also employed to describe the live experiences of students with the dialogic learning strategy.

The preliminary participants were 28 (12 year-old) male students at a public primary school in Tehran, Iran who randomly divided into two groups. The sample was homogenous with respect to grade, age, gender, ethnicity, the sources of academic achievement and Wechsler Intelligence Scale for Children. They also reported no history of neurological or cognition impairment.

Two groups were taught for 4-month period with or without Socratic dialogue during 4 teaching sessions lasting about 45 minutes. Finally, 3 participants were withdrawn from the research and 25 students participated in the post tests of attention and academic achievement. Data from 1 student (from experimental group) has been excluded from the final analysis due to an insufficient number of acceptable trials on pre- and post-tests. Thus, the final participant sample consisted of 24 sixth grade students (12 experimental and 12 controls). Students and their parents were informed about the research aims and procedure and they were asked to give informed consent letter.

The Instruments

The Attention Network Test (ANT) was used for evaluating the efficiency of students' attention [2,10] in result of recruiting Socratic dialogue technique comparing with a control group. This test has been designed based on research on brain mechanisms of attention in children and adults. The ANT measures the efficiency of three independent neuronal networks for alerting, orienting, and executive control in conflict resolution [2].

Researchers have provided evidence on the reliability of ANT and indicated the independence of the functions of each networks [8].

Three trained investigators administered the testing protocol. Participants were instructed to press the left or right button of the keyboard, according to which direction the central arrow was pointing. They were told to keep their eyes on the fixation point during the presentations and to concentrate on the central arrow that can either point in the same (congruent) direction or in the opposite (incongruent) direction. Cues presented prior to the target provide information on where or when the target is occurred [19].

Each participant was tested for 1 hour approximately, including time for task instruction and breaks between tasks. Target stimuli consisted of five horizontally arranged arrows or lines presented above or below the fixation cross. By left or right button press, subjects had to indicate the direction of the central arrow irrespective of flanking conditions that were either lines (neutral), congruent flankers, or incongruent flankers. Target stimuli represented a total visual angle of 3.08 on the x axis and 0.40 on the y axis. The congruent, incongruent and neutral trials occurred in equal proportions. Under each condition (congruent, incongruent or neutral), half were pointing to the left and half to the right.

To occupy the alerting and orienting processes, a fixation cross was visible in the center of the screen during the whole experiment. Cue stimuli appeared above or below the fixation cross (spatial cue condition), above and below the center (double cue condition), in the center (center cue condition), or were not present (no cue condition). All cues occurred in the same proportions. Cues were displayed with a visual angle of 0.27 on the x axis and 0.27 on the y axis.

The experiment consisted of 384 trials in 4 blocks of 96. Reaction time and accuracy were calculated for all conditions and averaged separately. Analysis of data was restricted to trials with response times (RTs) longer than 350 ms and less than 1500 ms (with reference to target onset). Attention network effects were calculated as reaction time (RT) differences of the following task conditions: alerting=RT no cue – RT double cue; orienting=RT center cue – RT spatial cue; executive control=RT incongruent – RT congruent.

Academic Achievement Test also designed with

close collaboration with teachers and administrated to measure students' academic performance in the all main courses including Social Studies, Language Skills, Basic Sciences, and Mathematics.

Semi-Structured Interviews were conducted by the principal investigator for understanding participants' thought and their views about dialogic learning method after 4 months exposing with this method of learning and teaching. Interviews were held with teacher and 9 students after the dialogic learning period.

The Persian Form of Wechsler Intelligence Scale for Children (WISC-IV) was administrated to measure general intelligence [31]. The test scores recorded to statically control the potential influence of IQ on the dependent variables.

Procedure

All participants carried out the first assessment sessions of ANT in a quiet room at the Cognitive Neuroscience Lab, Institute for Cognitive Studies. During these sessions children were administered a set of other tasks including IQ and Academic Achievement Tests. The last sessions were also allocated to assess students' attention abilities and academic achievement by re-conducting the pretest tasks. In addition, semi-structured interviews administrated with experimental teacher and students during post-tests.

Following the completion of the first sessions, students of one class were randomly selected as experimental and students from the other class as control group. The dialogic condition considered as the experimental condition and the non-dialogic condition as the control condition. Participants in the two groups attended the same school. Also, they did not differ in age, grade, gender or parental educational level.

The experimental teacher followed five days (4 hour per day) training at the school. The training included information about the rationale and significant of the study, the principles which needed to design unit plans and the procedures required to apply during class sessions. In collaboration with teacher, a dialogic based lesson design was designed by the first author and intensively reviewed by the co-authors. After several revisions, the final version was edited based on the comments of three educators with expertise in dialogic learning. The final designed lesson plans ultimately implemented in classroom in the process as follows:

Asking the related questions for inactivating students' prior knowledge;

Allowing wait time and listening to the students' responses;

Assessing students' responses and following up the new lesson with a series of new questions;

Asking subsequent questions and stimulating group discussion allowing students to reveal their real understanding of the concepts being explored;

Summing up the results of group discussion and asking new questions for reflection at home.

Taken together, in the dialogic lesson series, each concept was introduced by a short introduction by teacher. Students then had the opportunity to engage and discuss about. The students provided with opportunities to communicate and cooperate with each other. They analyzed the concepts and arguments, and then formulated their own opinion, working in pairs or quartets. Much of the time teaching was focused on three general categories of spontaneous or unplanned questioning, exploratory questioning, and focused questioning [32]. In the non-dialogic condition the assignments included the same information, but the input content was presented mostly by teacher as structured in the textbooks. They worked individually according to the usual teaching method in schools.

Results

The goal of this study was to test whether dialogic learning enhances students' attention networks and academic achievement. An analysis of covariance (ANCOVA) was conducted to compare students' performance in attention abilities and academic achievement in dialogic and non-dialogic conditions. The effects of general intelligence and pre-test scores (covariate variables) were adjusted (Table 1).

The results indicated that students' performance in executive attention was significantly higher in the dialogic learning than to non-dialogic learning after adjusting for IQ [$p=0.049$]. There were no significant differences between students' attention in the dialogic and non-dialogic learning conditions in the alerting, orienting, overall error, and overall RT.

The results of academic performance data indicated

that the differences in the two groups were statistically significant in Social studies [$p=0.029$], Language Skills [$p=0.049$], Basic Sciences [$p=0.040$], and Total Academic Achievement [$p=0.01$] in favor of experimental group. However, the two groups were not significantly different with regard to Math performance after correcting for IQ and pre-test scores (Table1).

Discussion

The results of this study indicated that the scores for executive control network were significantly different between dialogic and non-dialogic conditions after correcting for baseline performance. The two groups were not statistically different with regard to alerting, orienting, overall RTs, and overall errors. It was also demonstrated that students' academic achievement (exception of math) more improved in dialogic learning condition than non-dialogic condition.

The qualitative data also supported the quantitative findings. The results of interviews with teacher and students supported the positive impacts of the dialogic learning on improvement their knowledge, attitudes and skills. Students stated that they were satisfied with the dialogic learning process and its positive impacts on their learning. According to students, discussions and questions had been effective on the focusing their attention and producing new ideas. As one student stated:

"It helped us to see details and developed the ability to look from different angles and solve problems."

The students also expressed how they experienced changes in their social behavior and communication with others as the result of exposing to dialogic teaching strategy. For example, one student stated:

"This method (Dialogic teaching) taught me look from the different points of view and accept negative criticism".

According to the teacher, using dialogue has made her teaching more effective. She included dialogic learning as an innovative strategy in producing observable improvements in students' academic success, including increased attentiveness, stimulating imagination and creativity and appropriate relationships with others. She also stressed that dialogic learning is useful for teaching all subjects. The teacher stated that dialogic learning is effective in eliciting students' attention and making active and dynamic discussions.

Table 1: Summary of ANCOA results (after controlling IQ and pre-test scores).

		Mean						P	EF
		Mean Experimental			Control				
Task	Score	Pre	Post	Post-Pre	Pre	Post	Post- Pre		
ANT	Alerting	45.75	28.312	-17.437	41.166	33.833	-7.333	0.48	0.025
	Orienting	73.583	87.75	-4.666	81.916	76.083	-5.833	0.36	0.042
	Executive control	104.5	612.25	-39.583	104.91	458.83	-14.833	0.049*	0.18
	Overall RT	519.58	422.66	-96.916	510.66	412.08	-98.583	0.861	0.002
	Overall Error	0.044	0.016	-0.028	0.046	0.023	-0.023	0.278	0.058
AP	Total. AP	30.89	58.09	16.562	28.45	52.72	6.92	.000**	0.547
	Social Studies	17.66	26.37	5.408	17.93	24.19	2.928	0.029*	0.216
	Language	5.2	11.82	4.27	4.27	110.56	2.408	0.049*	0.18
	Basic Science	4.4	10.71	5.02	3.25	9.69	0.75	0.040*	0.195
	Math	3.53	9.18	1.666	3.33	8.26	0.75	0.272	0.6

*p < 0.05; **p < 0.01

The following citations provide examples:

"I found a great deal of interest in dialogic teaching. It improved my way of teaching."

"I now know why children love to formulate and ask questions to learn and think. It makes learning a very enjoyable practice."

"It was the first time experienced such a practice, but it is very easy to manage the classroom using dialogue."

When interviewed about the main concerns related to applying dialogic method, the teacher emphasized on the extra time and energy that required for dialogic teaching. She noted:

"While dialogue seems to be a familiar method for all teachers, it takes more time to implement than lecture-based teaching and thus it is so difficult to cover all syllabuses and materials which anticipated to be presented for one semester".

Therefore, dialogic teaching has significantly greater and more positive changes on some aspects of attention and academic performance. The result of the present study is consistent with previous research in relation to the impact of training on attention efficacy. For instance, the positive effects of attention training on the executive attention network [24]; the effects of short-term meditation training on the efficiency of executive attention and self-regulation [33]; the impact of integrative body-
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mind training on the pattern of white matter changes in the brain network related to self-regulation [26].

The innovative aspect of this study however is related to illuminating the potential of dialogic learning in improving attention as well as academic performance. The better performance of students with dialogic method compared to non-dialogic method is likely to be the consequence of effective questioning embodied in dialogue which demands greater attention from the student [34]. It allows the teacher to determine students' levels of understanding and encourage them to reflectively explore complex concepts and build meaningful knowledge. This may also be related to the impact of questioning on shifting students' attention into focus on learning situation and then facilitate their learning and memory. As Posner and Peterson [5] pointed, shifting attention from one point to another is not a simple task but it requires a three step process of disengagement, movement and engagement. In the dialogic learning contexts, attention shifts managed by the process of continuous questioning and allowing learners sufficient time and space.

It seems that improved interactions between students and teacher in dialogic learning environments encourage student to demonstrate greater sense of competence and increased intrinsic motivation for their own learning. This is related to effortful control ability- an outcome of the development of executive attention, including the ability to inhibit adominant response in order to activate a subdominant response, to plan, and to detect errors [13].

Conclusion

One of the serious concerns of today teachers is finding ways to gain and keep student attention focused on the learning process. The findings presented above clearly document the primary role of the dialogic learning in lessening such concerns. Teachers are able to invoke productive attention through effective questioning that can be asked of the whole class, small groups, or individuals. The questioning aspect of dialogic learning has established it as one of the most striking demonstrations of universality across time and cultures which persists more than 24 centuries after its conception [30].

To conclude, the positive effects of dialogic teaching on children's attention and academic skills provide evidence for the usefulness of evidence based teaching practices on improvement of domain-general skills and school-related expectations as well. This study however, was tested over a relatively short time period (4 month) and within just one grade (6th grade). A longer study might have produced more reliable results. The Socratic dialog recruited in this study is just one renowned way of teaching among a verity of dialogic strategies. Additional research hence is needed to explore the effects of different kinds of dialogue on students' attention and their academic performance. It is also needed to investigate the neural wiring of inter-conversation between students and teacher during dialogue. As Battro [35] stated, this pedagogical trick to change the focus of the learner's attention is often used in our teaching practice and could perhaps be studied in an experimental setting involving brain-imaging equipment with both teacher and student. Researchers however must be consider that some children have greater connectivity and activations in brain areas related to attention than others and are thus better able to exercise the various functions of attention.

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