Educational Implications of Private Speech for Children's Problem-solving Abilities

Jiatong Liu[1, *]

[1]Department of Psychology, University of California, Davis, 95616, United States

*Corresponding author: jttliu@ucdavis.edu

Abstract. This paper analyzes the educational implications of using private speech and discusses whether the instruction and guidance of private speech should be a practical teaching strategy for teachers at school and help students master more skills on how to solve multifaceted tasks. It is crucial to comprehend the definition and characteristics of private speech from the perspective of Piaget's and Vygotsky's theories. According to the development trajectory of private speech, the frequency of using it varies with age, tasks, and literacy levels. This utterance is most prevalent from the age of 2 to 6 and declines when children enter elementary school; people are most likely to use private speech while doing tasks of medium difficulty level; adults who received more formal education and have higher literacy levels employ internalized private speech more frequently than those with lower literacy level. Additionally, private speech positively influences children's executive functioning as well as task performance. Together, these benefits suggest that it is promising to apply scaffolding as a pedagogical method to encourage students to use private speech so that teachers can evaluate students' competence scope. It is also important to construct supportive adult-children interactions for those with Attention-deficit/hyperactivity disorder (ADHD) and autistic spectrum disorders (ASD) to make more private speech with a purpose of improving executive functioning. Future studies about using private should focus more on classroom settings and examine the feasibility of encouraging students to use private speech while solving problems.

Keywords: Private speech; Educational implications; Executive functioning.

1. Introduction

There is a common phenomenon that children like to talk to themselves aloud when they are solving mathematical or reasoning problems. This is called private speech, and this type of utterance usually occurs between 2 and 7 years old but gradually fades as children grow older [1]. Private speech, different from social speech, is conducted from children's own perspective instead of addressing others' needs. In Jean Piaget's opinion, private speech is a cognitive inadequacy and a transition to social speech. It doesn't serve any immediate purpose for children's formation of thoughts because it is more likely to be a manifestation of children's egocentrism [1]. Instead, in Les Vygotsky's view, private speech has many cognitive functions, and it won't disappear but becomes internalized as children grow up [2].

Fernyhough and Fradley [3] found that children who use task-relevant private speech have better performance on completing tasks of intermediate difficulty level. Additionally, children's executive functioning largely improves with the use of private speech [4]. In specific aspects of executive functioning, working memory and inhibitory control can be positively influenced by private speech [5, 6]. However, few studies have assessed the influence of private speech in school settings and teachers' interventions on private speech, and few teachers guide students to use private speech as assistance to solve problems at school. Educators may overlook the benefits of private speech during children's cognitive development.

As a universal phenomenon and a typical characteristic of preschool children's cognitive development, it is necessary to consider the educational implications of private speech. The objective of this paper is to determine whether the instruction and guidance of private speech can be an effective pedagogical tool to assist children upgrade problem-solving capabilities. This paper defines private speech in the view of both Piaget and Vygotsky, but the paper is mainly based on Vygotsky's theory which emphasizes the significance of private speech on the needs of thoughts in problem-solving [2].

To further evaluate the functions and benefits of private speech, the paper assesses its effects on task performance, executive functioning (i.e., working memory and inhibitory control), as well as the development trajectory of private speech from different levels (i.e., age, task-specific, literacy). Finally, the paper determines the educational implications of private speech, including the effects of scaffolding, suggestions on task difficulty and students' competence scope, and interventions for children with special needs.

2. Overview of Private Speech

2.1 Definition and Characteristics

Private speech, a type of self-directed speech, is spoken to oneself with the purpose of communication, self-guidance, and self-regulation of various behaviors [1, 2]. Children from 2 to 7 years old usually talk to themselves about their thoughts when they do daily activities [1]. This kind of verbalization is not intended for listening to the needs of others. There are some characteristics that can distinguish private speech from social speech, such the communication with others. While using private speech, children don't make lasting eye contact with someone else, and their actions don't incorporate others [7]. The content of private speech also focuses on their own thoughts and behaviors rather than the same theme as someone else's previous utterances, and children won't think from others' perspectives [7].

2.2 Theoretical Overview

The theoretical foundations of private speech can be found in the theories of Les Vygotsky and Jean Piaget, two contemporary psychologists who have made significant contributions to the study of cognitive psychology. Both of them agreed on the phenomenon of private speech, but they hold different views on the role of private speech during a child's cognitive development.

2.2.1 Piaget

In Piaget's book "The Language and Thought of the Child" [1], he labeled the circumstance that children talk to themselves in the absence of any signs of understanding others' utterances as "egocentric speech". He conceived it as young children's inability to differentiate their own perspective from that of others, which is a fundamental cognitive inadequacy of young children [1]. It does not produce any representation and is not directly involved in the formation of thoughts [1]. Children usually use egocentric speech until they go to elementary school, about the age of 7, and it gradually wanes as they develop social speech [1].

2.2.2 Vygotsky

Vygotsky agreed with Piaget's observations that the use of private speech declines as children reach the age of seven. However, he took issue with Piaget's theory on "egocentric speech" which is a cognitive immaturity. Instead, based on Vygotsky [2], the decline of using private speech represents the process of internalization: external private speech gradually becomes "inner speech" [2]. Private speech also has many cognitive functions such as planning, self-guiding, problem-solving, and helping children concentrate on tasks [2]. Overall, private speech serves a personal purpose that goes along with the child's behaviors and is connected to the cognitive processes of planning, sequencing, and solving problems [2].

3. Influence of Private Speech

3.1 Executive Functioning

Executive functioning is the capability to store information in people's working memory, in order to prevent rapid and unconscious responses to stimulation as well as to allow people to flexibly shift the focus of their mental frames [8]. These cognitive skills lay a solid foundation for academic

performance, problem-solving skills, emotional regulation, and limiting impulsive behaviors. Dimensional Change Card Sort (DCCS) test, which is a common task to measure executive functioning, requires children to switch between card sorting rules [4]. By controlling their age, gender, verbal abilities, and fluid reasoning, children who used partially internalized private speech more frequently were more likely to correctly switch between sorting rules and pass the toughest phase of the task [4]. In addition, children's executive functioning ameliorated if they used more task-relevant externalized private speech. Furthermore, a critical leap occurring during the development of executive functioning at the age between 3 and 6 may also result from the application of private speech [4]. Most research mainly focuses on the aspects of working memory and inhibitory control, so the effects of private speech on working memory and inhibitory control will be discussed below.

3.1.1 Working memory

Private speech serves the functions of concentration and memorizing key information, thus upgrading working memory capacity. Working memory is the system that is responsible for active attention, information collection, maintenance, storage, and processing [9]. According to Baddeley [5], working memory creates ephemeral storage for challenging tasks including learning, comprehension, and reasoning. The phonological loop, which represents speech perception and production, is an important system in Baddeley and Hitch's three-component model of working memory [5]. Therefore, it is reasonable to infer that private speech can be a strategy that helps children improve their working memory. By making utterances about the information children obtain from the task and probably repeating it several times, they are more likely to focus on the task and intend to store more information in their minds [7]. Therefore, it becomes easier to increase their working memory capacity and recall information, which is conducive to the ability to solve problems.

3.1.2 Inhibitory control

Inhibitory control represents the ability to exert inhibition on one's behaviors or thoughts, reject interference, and choose the action which is more appropriate at that moment instead [10]. Researchers found that task-directed speech enhances children's awareness of their activities and helps them employ inhibitory control over their thoughts and behaviors [6]. In their study, children were required to match the color of the cards to win some Smartie candy, and the wrong colors constituted interference for these children. To succeed in the task, they had to show their inhibitory control by resisting the wrong cards and picking the correct ones. During this experiment, children who were encouraged to label the color of the cards obtained better scores during the task, thus usually demonstrating better performance on inhibitory control than those who were not encouraged to do so [6]. Although the study didn't directly measure the use of private speech, it illustrated the impact of task-relevant speech on children's inhibitory control. To conclude, if children can speak out their thoughts, they will exhibit better inhibitory control and improve their executive functioning.

3.2 Task Performance

The frequency of using task-relevant private speech is positively associated with the performance on medium difficulty level tasks. Fernyhough and Fradley [3] have conducted research on the association between children's use of private speech and task performance. In their study, 46 children who are from 5 to 6 years old were asked to complete Tower of London tasks which were classified with different levels of difficulty, and researchers evaluated their performance by measuring how much time they need to finish each task. In their experiment, the task-relevant private speech was characterized as self-guiding comments, self-answered questions, task-relevant affect expressions, and overtly delineating own behaviors. They found that for the medium level of difficulty, children who frequently applied task-relevant private speech were more likely to finish the task in a shorter time period. So they showed better task performance than those who didn't use private speech. However, in the simplest and most difficult tasks, private speech didn't show striking assistance to the task performance [3].

3.3 Developmental Trajectory

It is important to consider whether there is a certain developmental trajectory for the usage of private speech. Studies indicate that the developmental trajectory of private speech manifests at several levels, including age, specific tasks, and literacy level. This infers that the utilization of private speech is not only determined by biological factors but also by experiences in various situations. Understanding the developmental trajectory can provide insightful implications for educators to determine when and how they can interfere with children's use of private speech.

3.3.1 Age level

Both Vygotsky [2] and Piaget [1] observed that the frequency of private speech peaks during preschool ages from 2 to 6, and it becomes less common during elementary school ages. Vygotsky [2] has demonstrated the pattern that children's private speech turns out to be more internalized as they grow older. Overt private speech is gradually substituted by inner speech such as muttering and whispering [2]. Adults also utilize private speech while solving problems, but their pattern for using private speech fits more in the task-specific level and literacy level.

3.3.2 Task-specific level

Children are willing to speak out to themselves while the task is neither too hard nor too simple, so there is a quadratic relationship between the frequency of private speech usage and task difficulty [3]. Therefore, children are more likely to use private speech during a task with an intermediate complexity level [3]. Generally, from a task-specific level, overt private speech seems to be the most frequent when people are new to the challenging task and then gradually declines as they master the task over time through repeated practice [11].

3.3.3 Literacy level

Adults who have higher literacy level apply internalized private speech more frequently than those who are less literate. In the study conducted by Alarcón-Rubio et al. [11], 126 adults were divided into three literacy levels: low, intermediate, and advanced. Their private speech utterances were characterized by two systems: externalized and partially internalized private speech. The result indicated that adults in the advanced-literacy group, those who received more formal education, were less likely to utter externalized private speech, and their private speech was more internalized than that used by adults who were in low-literacy and intermediate-literacy groups [12]. Accordingly, the study implies that education plays a role in the use of private speech, and interventions can exert effects on it even after preschool age.

4. Educational Implications of Private Speech

Since private speech has a large variety of benefits, educators should not disregard its significance at school. By daily observations, teachers show an inclination to quiet children during class. Teachers are accustomed to inhibiting students from making any utterances during class. They typically believe that talking while solving problems indicates being inattentive to the knowledge they are learning about. However, encouraging private speech by utilizing appropriate methods during classes has several advantages that are helpful to boost teaching quality and foster students to make progress.

4.1 Effect of Scaffolding on Private Speech and Problem-solving Abilities

Scaffolding instruction is a pedagogical practice that originates from Vygotsky's sociocultural theory. In scaffolding instruction, the more knowledgeable person scaffolds the learner so that the learner is able to complete the task with help and finally accomplish it independently [13]. The finding that launching a verbal scaffolding instructional program can improve young children's performance in solving problems in the classroom context is supported by the study conducted by White and Manning [14]. Their study demonstrates that with specific verbal scaffolding instructions about how to talk to themselves during problem-solving tasks, students are able to use more private speech that

is relevant to the task as well as to perform better in the analogical reasoning assessment. During the classes, teachers, as the more knowledgeable person, can give students some cues or model scripts to motivate them to talk to themselves about their own ideas. As students are able to apply private speech more spontaneously, teachers can relatively decrease the number of cues and instructions, which will be a gradual process of learning. The final goal of the scaffolding method is to prompt students to use private speech without reminders from teachers when solving diversified problems. As a consequence, scaffolding constitutes an effective method for teachers to guide students to speak to themselves about the thoughts relevant to the task so that they are capable to hone better problem-solving skills and achieve academic success at school.

4.2 Task Difficulty and Competence Scope

The quadratic relationship between the use of private speech and task difficulty shows that children don't utter private speech frequently when the task is too simple or too difficult [3]. Instead, they talk to themselves most frequently when the task is at a medium difficulty level. When students become garrulous, it doesn't necessarily mean that they are not paying attention to the teachers and knowledge, but they are energetically engaging in the class and actively thinking about the problems. Therefore, the appearance or the lack of private speech might give the instructors hints that can be utilized to confirm if the activities or assignments are appropriate for students' competence level, and teachers can flexibly adjust the difficulty level to adapt to the capabilities of students. As a result, in an effort to design more appropriate course content, it is necessary for teachers to attend to the frequency of children's use of private speech instead of restraining this behavior. Besides, differentiating task-relevant private speech from irrelevant ones is a rudimentary and essential skill for every teacher. Only if teachers are able to recognize students' private speech, they can apply this method to efficiently assess students' competence scope. As a result, training on private speech recognition also becomes indispensable among teachers.

4.3 Intervention on Children with Special Needs

Attention-deficit/hyperactivity disorder (ADHD) and autistic spectrum disorders (ASD) are disorders that involve deficits in the brain areas of self-regulation and executive functioning [15] [16]. Children with these disorders usually have trouble with shifting attention, planning, and cognitive flexibility during problem-solving tasks [15, 16]. Since self-talk, as a form of language, is a common practice most children utilize for the foregoing functions, paying attention to the extent to which children with ADHD and ASD talk to themselves and whether their self-talk serves any function is indispensable[16]. In general, these children still use private speech during tasks and activities, and such speech indeed helps normalize their performance and improve their executive functioning [17]. Therefore, to foster their executive functioning and self-regulation abilities, teacher don't need to instruct them on how to talk to themselves with detailed speech scripts [17]. It is also Important to note that parent-child conflicts and parental disturbance would appear more often in these families. For example, children's complicated situations can cause anxiety among their family members and entail more quarrels among them. Also, some families may suffer from poverty because of long-time medical treatments. Due to their special conditions, these children receive less support and are more likely to have negative controls during social interactions with adults. Consequently, the intervention for these children should be focused on establishing healthy adult-children interactions. It is necessary to place children in a supportive and encouraging scaffolding context where they are provided with more opportunities to utter private speech so that they can improve their executive functioning and succeed in solving problems.

5. Summary

This paper discusses whether the instruction and guidance of private speech is an effective pedagogical practice to assist children to develop their problem-solving abilities. Through reviewing

the previous research, it is reasonable to conclude that teachers should encourage private speech at school due to its certain beneficial effects on children's cognitive development. Based on the literature review, both task performance and the development of executive functioning are positively influenced by the utterance of private speech, which suggests its useful role in children's problem-solving abilities. The review of the development trajectory of private speech gives an overview of how age, task, and literacy impact private speech usage. This implies that education does play a key role in the use of private speech, and it is vital for teachers to take the effect of task difficulty into account and consider how interventions should take place for children of different ages. Verbal scaffolding instruction on private speech is a feasible pedagogical strategy to help students have better task performance and accomplish more achievements in solving all kinds of problems. By paying attention to students' frequency of private speech utterances, teachers are able to have a basic understanding of their competence scope so that they can flexibly adjust the difficulty level of their course contents, thus maximizing teaching efficiency. Furthermore, for students with ASD and ADHD, private speech is also helpful in solving problems. Given the special situations of these children, rather than giving them detailed words and scripts, encouraging private speech in healthy adult-children interaction settings is more practical to enhance their executive functioning and help them succeed in more tasks. However, it is important to notice that more studies should be conducted in real classrooms at school to evaluate the feasibility of instructions on private speech, and schools should launch more teacher training on how to provide scaffolding in order to motivate students to utter private speech during class. This paper provides a reference for related follow-up research.

References

[1] Piaget J. The language and thought of the child[M]. Psychology Press, 1959

[2] Vygotsky LS. Thought and language[M]. MIT Press, 1986

[3] Fernyhough C, Fradley E. Private speech on an executive task: Relations with task difficulty and task performance. Cognitive development, 2005, 20(1): 103-120.Ma Kunlong. Short term distributed load forecasting method based on big data. Changsha: Hunan University, 2014.

[4] Alarcón-Rubio D, Sánchez-Medina J A, Prieto-García J R. Executive function and verbal self-regulation in childhood: Developmental linkages between partially internalized private speech and cognitive flexibility. Early Childhood Research Quarterly, 2014, 29(2): 95-105.Fangfang. Research on power load forecasting based on Improved BP neural network. Harbin Institute of Technology, 2011.

[5] Baddeley A. The episodic buffer: a new component of working memory?. Trends in cognitive sciences, 2000, 4(11): 417-423. Ma Kunlong. Short term distributed load forecasting method based on big data. Changsha: Hunan University, 2014.

[6] Müller U, Zelazo P D, Hood S, et al. Interference control in a new rule use task: Age‐related changes, labeling, and attention. Child development, 2004, 75(5): 1594-1609.

[7] Gholami M, Salehi N, Azizi E, et al. Private speech and cognitive development: A review of the two theories. IIOAB Journal, 2016, 7(1): 262-269.SHI Biao, LI Yu Xia, YU Xhua, YAN Wang. Short-term load forecasting based on modified particle swarm optimizer and fuzzy neural network model. Systems Engineering-Theory and Practice, 2010, 30(1): 158-160.

[8] Blair C. Developmental science and executive function. Current directions in psychological science, 2016, 25(1): 3-7.

[9] Cowan N. Working memory maturation: Can we get at the essence of cognitive growth?. Perspectives on Psychological Science, 2016, 11(2): 239-264.

[10] Davidson M C, Amso D, Anderson L C, et al. Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. Neuropsychologia, 2006, 44(11): 2037-2078.

[11] Winsler A, Fernyhough C, McClaren E M, et al. Private speech coding manual. Unpublished manuscript. George Mason University, Fairfax, VA, USA. Available at: http://classweb. gmu. edu/awinsler/Resources/PsCodingManual. pdf, 2005.

[12] Alarcón-Rubio D, Sánchez-Medina J A, Winsler A. Private speech in illiterate adults: Cognitive functions, task difficulty, and literacy. Journal of Adult Development, 2013, 20(2): 100-111.

[13] Van Der Stuyf R R. Scaffolding as a teaching strategy. Adolescent Learning and Development. Section 0500A, 2002.

[14] White C S, Manning B H. The effects of verbal scaffolding instruction on young children's private speech and problem-solving capabilities. Instructional Science, 1994, 22(1): 39-59.

[15] Hill E L. Executive dysfunction in autism. Trends in cognitive sciences, 2004, 8(1): 26-32.

[16] Bronson M B, Bronson M. Self-regulation in early childhood: Nature and nurture[M]. Guilford press, 2001.

[17] Winsler A, Abar B, Feder M A, et al. Private speech and executive functioning among high-functioning children with autistic spectrum disorders. Journal of Autism and Developmental Disorders, 2007, 37(9): 1617-1635.