Private Speech in the Classroom: Effects of Number Facts Training in a Private Speech Internalization Perspective

Snorre A. Ostad
University of Oslo, Oslo Norway

Abstract ¹
The overall purpose of the present study was to test whether an (50 weeks) intervention program, modelled as training in accordance with the developmental course of private speech (from audible private speech to silent inner speech), itself would add positively to the development of mathematical competence. The sample comprised two comparable groups of 82 third-grade children. One followed the intervention program, the other a traditional teaching program. The result indicated successful influence of the intervention program reflected in more internalized private speech and more internalized task-specific strategy use. Given the results of the study, classroom teachers should be encouraged to utilize private speech internalization as a valuable and potentially powerful tool for efficiently retrieving number fact information.

Key-words: private speech, private speech internalization, strategy use, number facts learning, multiplication learning

Private speech

Vygotsky (1934/1986) hypothesized that the phenomenon of private speech (self-talk used by children in various situations that is not addressed to others) reflects children’s potential for self-direction to plan, guide, and monitor their goal-directed activity. In short, from the Vygotskian developmental perspective children’s private speech comes to be used by the children as an important intrapsychological tool for regulating thought and behaviour (Berk & Winsler, 1995; Winsler & Naglieri, 2003).

In terms of the developmental course for private speech, referred in the present study to the private speech internalization perspective, researchers have shown an overall ontogenetic pattern of children’s overt private speech being replaced by partially internalized whispers and inaudible muttering, and silent inner speech or covert verbal thoughts, as children progress through elementary school (Berk, 1992; Winsler & Naglieri, 2003).

Linkage to mathematical competence

Several models have been proposed concerning the representation of mathematical knowledge (e.g., Butterworth, 1999; Cohen & Dehaene, 2000). Thus, the use of input through the auditory channel to form connections between the phonological features of numbers has been discussed as an approach to learning number facts (Robinson, Menchetti, & Torgesen, 2002; Ostad & Sorensen, 2007). Underlying this approach is the belief that arithmetic facts are stored in a sound-based, or phonological, form. Along this avenue, there are several variants of phonological storage hypothesis (e.g., Cohen & Dehaene, 2000; McCloskey, 1992).

A further dispute relates the extent to which the phonetic and semantic memory systems might contribute to children’s basic fact proficiency in mathematics (Hecht, Torgesen, Wagner, & Rashotte, 2001; Geary, Hamson, & Hoard, 2000). At present, it seems generally accepted that phonological-processing skills may play a part in acquisition of number facts (Bull & Johnston, 1997). Thus, when presented with a simple arithmetic problem (e.g., “6 x 2 = “) the child may retrieve a phonologically based answer code from long-term memory (Geary et al., 2000; Ostad, 2000). Alternatively, the child may use a backup strategy (e.g., counting fingers) in which the phonological system is engaged when phonological name codes are used to count (Hecht et al., 2001; Ostad, 1998).

It is well established that many children who struggle in reading have poor phonological processing skills (Torgesen, 1999, Robinson et al., 2002). A considerable body of evidence indicates that private speech differences are critical indicators of children’s basic fact proficiency as well (e.g., Hecht et al., 2001; Robinson et al., 2002). Thus, phonological processing deficits are quite commonly found among children with difficulties in mathematics, and retrieval deficits are suggested to relate to difficulties in activation of phonetic representation (Geary, Hamson, & Hoard, 2000).

Moreover, further evidence for a hypothesized link between children’s private speech and mathematical competence was supported by a recent published cross-sectional study (Ostad & Sorensen, 2007). In summary, this study demonstrated a grade-determined shift among children without difficulties in mathematics (1) away from the less-to the more internalized private speech, and (2) from the less-to the more internalized strategy-use. In contrast, the private speech and strategy-use internalization by children with difficulties in mathematics seemed to converge at earlier developmental levels. Actually, these results revealed reasons to assume that arithmetic facts are stored and retrieved from memory phonologically as a function of the children’s level of private speech internalization, from audible to private speech in silence.

**The present study**

Although most of the investigators cited earlier in this paper have anchored their research from the Vygotskyian developmental perspective, no
published study have investigated effect(s) of *stimulating private speech internalization*, that is, teaching programs that are conducted to strengthen children’s conscious awareness of their own private speech, the various roles private speech plays in the learning process, and how learners can benefit from and utilize it in the private speech internalization perspective. This limitation in the private speech literature is surprising given that Vygotsky (1934/1986) suggested long ago that children’s developing awareness of their own self-talk might be important for private speech to move into its most mature, useful, and self-regulatory forms. Thus, referring to research showing that children’s conscious awareness positively predicts both strategy use and effectiveness (e.g., Winsler & Naglieri, 2003) private speech researchers have called for investigator-initiated intervention studies carried out in natural classroom settings (Robinson et al., 2002; Ostad & Sorensen, 2007).

The present study was addressed the above mentioned limitation, and contribute to the private speech literature by providing much needed data about effects from intervention programs which were designed systematically to use children’s private speech as a resource to facilitate learning.

Furthermore, the study addressed conceptual discrepancies in the private speech literature (Berk, 1992; Girbau, 2000; Winsler & Naglieri, 2003) by introducing two different developmental dimensions in the study of private speech and its role for mathematical competence: (1) private speech internalization, (i.e., the intrapsychological perspective) which refers to the movement through the developmentally typical chain of increasing sophisticated private speech categories, with private speech in silence as “top level”, and, (2) strategy use internalization, (i.e., the task-specific behavioural perspective) which refers to the movement through the developmentally typical chain of increasingly sophisticated task-specific strategy categories, with retrieval strategies as “top level”.

In general, the present study intended to add our knowledge about the role of private speech by examining its contributions to the development of mathematical competence.

More specifically, the issue was whether an (50 weeks) intervention program modeled in a private speech internalization perspective (from audible to inaudible private speech) itself would enable children to learn basic mathematical facts more readily, that is, contribute to more internalized private speech and task-specific strategy-use (Ostad & Sorensen, 2007). The present study was designed to address these issues by taking the point of departure in single-digit multiplication learning arranged in natural classroom settings.

**Method**

*Design:* The research had a quasi-experimental design. It consisted of two comparable groups: One group, the C-group, (the compare group) followed the official plan for introduction to single-digit multiplication in Norway. The I-
group (the intervention group) included in the same timetable as the C-group a teaching component developed with input and learning activities specific related to the auditory channel, and conducted in the private speech internalization perspective.

Two separate laboratory observations were performed for each child, one focusing on children’s private speech during the process of solving single-digit multiplication facts, and one on children’s strategy use for solving the same problems (14 problems).

**Overview of the intervention program**

Pre-training for the I-group teachers: The teachers were offered a pre-training program (about 20 hours). This program included (a) *lessons* in private speech internalization (theories, earlier research studies, possible role of inner speech in mathematics learning based on the phonological storing hypothesis, etc.) and (b) *discussions* concerning how a practical private speech internalization teaching programs should look if the aims were to make the children conscious of their private speech and stimulate them make use of their private speech as an explicit component in their own mathematics learning.

The actual application:

1. **Introduction to multiplication (week 1 - week 3):** According to the official plan.

2. **Introduction to private speech (week 4 - week 6):** Included partly teacher instruction and partly pupil activities. In particular, the aim for the teacher instruction during these weeks was to make the children familiar with (a) the notion of private speech, (b) the various roles private speech plays, and (c) how they can benefit from and utilize it during their own learning process.

   *The pupil activities* were modeled in the private speech internalization perspective, that is, in accordance with the developmental course for private speech: from audible to inaudible private speech (Ostad & Sorensen, 2007; Winsler & Naglieri, 2003).

   More specifically, the program included classroom activities as singing well known songs, counting the number sequences as 1-5, and reading poems with end rhyme using *high, low, and whispering voice*. As a last step, *the children were urged to make use of the corresponding inner speech*. The teacher underlined the importance of distinct articulation at each step from the high audible to the inaudible private speech.

3. **Introduction to multiplication tables (week 7 - week 24, and week 33 - week 50):** The single-digit multiplication combinations were introduced starting from the $1 \times n$, $2 \times n$, $3 \times n$... tables. The children had to find the right answer to each of the combinations, and subsequently *reiterate the problem and it’s answer with high, low, whispering voice, and finally with their inner speech*.

   On the whole, the private-speech internalization component in these weeks represented *only a supplement* to the official mathematics teaching plan. As a
rough estimate, about 10 minutes of each lesson in mathematics was devoted to learning the single-digit multiplication combinations through activating children’s private speech within the private speech internalization perspective, that is, from using audible to using inaudible private speech.

Collection of the data

Observational categories of private speech: In the categorization system applied in the present study, various viewpoints from earlier research were integrated (Berk, 1992; Girbau, 2002; Kohlberg, Yaeger, & Hjertholm, 1968; Ostad & Sorensen, 2007; Winsler & Naglieri, 2003). To this end, the categorization units of private speech were defined in relation to private speech internalization and included: (1) audible, (2) inaudible and (3) in silence, respectively.

More specifically, the first category (high, normal or low) was audible, i.e. made intelligible to a listener, and could be transcribed. The second category was inaudible, but observable by face-to-face observation, and accordingly, unintelligible to a very near listener. This category refers to externalized private speech that is not loud enough to attribute any semantic content to verbalization including inaudible muttering and also made evident by lip and tongue movements (Berk, 1992; Girbau, 2002). It seems to be widely accepted that private speech according to this classification unit represents an external manifestation of inner speech (Fuson, 1979; Kolberg et al., 1968). Furthermore, studies have determined that private speech can take place (in silence) as a fully covert, silent, inner speech without any external verbal production or lip/tongue movements (Girbau, 2002; Ostad & Sorensen, 2007; Vygotsky, 1934/1987; Winsler & Naglieri, 2003; Winsler, Feder, Way, & Manfra, 2006). In view of the considerations alluded to above, answers given, with no evidence of visible whispers, inaudible lip movements or muttering observed by the experimenter, were coded in the third mentioned category, that is, in silence.

Observational categories of strategy use: The present study was based on the categories system used by Hecht (1999) and further developed by (Mabbot & Bisanz, 2003). The following multiplication strategies were identified: (a) repeated addition, which involved adding an operand the number of times indicated by the other operand, for example, $2 \times 3 = 2 + 2 + 2$; (b) number series, which involved using a memorized string to produce the answer, for example, solving $2 \times 7$ by counting $2, 4, 6, 8, 10, 12, 14$; (c) rules, which involves algorithms unique to problems with a 0 or a 9 as operand. ‘The 0 rule’: Numbers multiplied with 0 are always equal to 0. ‘The nine-rule’, for example for $4 \times 9$, the child would extend 10 fingers and identify the fourth finger. He or she would then count the number of fingers before the fourth finger and state this value as the tens number (3), and count the number of fingers after the fourth finger and state this value as the ones number (6); (d) decomposition, which involved the use of known arithmetic facts to derive solutions. For
example, for the problem $6 \times 7$, a child might report ‘I know that that $6 \times 6 = 36$, and so 6 more would be 42’; (e) direct retrieval, which refers to strategies based on recalled number facts. Children ‘simply state the answer following presentation the problem’ (Siegler, 1987, p. 83). For example, children claimed that they remember the answer, ‘just knew it’, or solved the problem ‘from memory’ and there was no evidence of overt calculations. The procedure for strategy use observation was almost identical to that used by Siegler.

The frequencies of responses on each of the categories based on ‘recipes’, that is, repeated addition, number series and rules, were relatively low. Therefore, in accordance with earlier research studies (Ostad & Sorensen, 2007) the responses of these categories were gathered under an umbrella category, coded as backup strategies. Thus, ordered in relation to strategy use internalization (Siegler, 1987, Ostad, 2000), the present study took the point of departure in three main strategy categories. These included: (1) backup strategies (points a, b and c in the above described overview), (2) decomposition (point d) and (3) direct retrieval (point e).

The reliability of the collection format: Two master degree students who had received extensive training in the research procedure developed for the study, coded, independent of each other, private speech and strategy use responses based on 20 random chosen number single-digit multiplication problems. The quantified inter-coder reliability (i.e. Kappa coefficient 0.96 for the private speech variable and 0.93 for the strategy use variable) indicated very good rater agreement.

Results and discussion

Patterns of private speech differences: To examine whether the I-group and the C-group children performed differently on private speech, multivariate analyses of variance were performed. There was a significant main effect of the teaching program, $[F(3, 156) = 3.768, p < 0.05]$, a non-significant achievement level main effect, $[F(6, 312) = 0.968, p > 0.05]$, and a non-significant teaching program category by achievement level interaction, $[F(6, 312) = 0.445, p > 0.05]$. In addition, independent samples tests (t-tests for equality of means) were performed to determine whether possible private speech differences of the I-group and the C-group could be identified within anyone of the three achievement levels. Tests of between-subject effects did not indicate significant audible private speech differences at any the achievement levels, $[t_{LL}(54) = 0.045, p > 0.05$; $t_{ML}(56) = 0.783, p > 0.05$; $t_{HL}(48) = 1.314, p > 0.05]$. Here there were no significant inaudible private speech differences at the lowest and at the medium achievement levels, $[t_{LL}(54) = 2.133, p > 0.05$; but significant differences at the highest achievement level, $[t_{HL}(48) = 2.231, p < 0.05]$. Finally, the tests indicated non-significant silence private speech differences at the lowest and medium achievement levels, $[t_{LL}(54) = 1.829, p > 0.05; t_{ML}(56) =$
1.057, p > 0.05) and significant differences at the highest achievement level, [t_{HL}(48) = 2.602, p < 0.05].

As a whole, the result of the study indicated that the two teaching programs had developed significant different patterns of private speech use. More precisely, the I-group children seemed to have moved significantly more markedly away from less internalized to toward more internalized private speech, (i.e., from the inaudible to the in silence category). An earlier study has demonstrated that the private speech internalization among the mathematically less able children seems to converge at earlier developmental levels reflected in inaudible private speech (Ostad & Sorensen, 2007). Accordingly, there were reasons for expecting that the I-program would influence relatively more successfully children belonging to the lowest performance level. Unexpectedly, therefore, the analyses of the private speech differences based on the children’s achievement levels showed that the most striking differences between I- group and C-group children seemed to be related to the highest achievement level.

**Patterns of strategy use differences:** To examine whether the I-group and the C-group children performed differently on strategy categories, multivariate analyses of variance were performed. There was a significant main effect for teaching program, [F(3, 156) = 14.190 p < 0.01)]. Furthermore, the multivariate tests indicated a significant achievement level main effect, [F(6, 312) = 2.976, p < 0.01)] and a non-significant teaching program by achievement interaction, [F(6, 312) = 0.592, p > 0.05)].

In addition, independent samples tests (t-tests for equality of means) were performed to determine whether possible strategy differences of the I-group and the C-group could be identified within anyone of the three achievement levels. The results indicated significant backup strategy differences in each of the achievement levels, [t_{LL}(54) = 2.619, p < 0.05; t_{ML}(56) = 4.207, p < 0.01; t_{HL}(48) = 4.207, p < 0.01]. Furthermore, the tests indicated non-significant decomposition strategy differences in each of the achievement levels, [t_{LL}(54) = 0.418, p > 0.05; t_{ML}(56) = 1.322, p > 0.05; t_{HL}(48) = 0.777, p > 0.05] and significant direct retrieval strategy differences in each of the achievement levels, [t_{LL}(54) = 3.407, p < 0.01; t_{ML}(56) = 2.968, p < 0.01; t_{HL}(48) = 4.306, p < 0.01].

As a whole, the two teaching programs seemed to develop significant different patterns of strategy use. More specifically, the children that followed the I-program used direct retrieval strategies significantly more frequent than the children that followed the C-program, clearly at the expense of backup strategies. This was also the result from comparing the children’s strategy use at all (three) achievement levels included in the research design.

In theory, the efficiency of phonological memory system may influence children’s ability to retrieve simple arithmetic answers from long-term memory (Torgesen, 1999). However, there is evidence from the results of the present study that a high level of private speech internalization might underlie
successful establishment of fact retrieval. Thus, consistent with the private speech literature, the results of the present study seems to argue for the position, as some investigators have assumed (e.g., Harris, 1986; Ostad & Sorensen, 2007) that children’s mathematical competence might be a function of efficiency in the production of task-relevant private speech. Consistent with this suggestion, a considerable body of evidence indicates that arithmetic facts are stored and retrieved from memory, phonologically, as a function of the children’s level of private speech internalization.

In terms of the implications for educational practice, the current study raises several possibilities. In general, the major importance of the present study seems to be anchored to the data indicating that a teaching program designed to stimulate private speech internalization might successfully influence the children’s mathematical competence, reflected in more internalized private speech and more internalized strategy use. This may seem to be a relatively obvious implication of this study.

Given that the results are valid, classroom teachers should be encouraged to allow their students to utilize their private speech in a private speech internalization perspective. Furthermore, consistent with suggestions developed from earlier private speech investigations (Ostad & Sorensen, 2007; Winsler & Naglieri, 2003) the various roles private speech plays should be a critical objective in the teacher preparation programs. Based on the results of the present study, it seems reasonable to look toward children’s levels of private speech internalization as an indicator of the extent to which their instructional efforts have been appropriated.

References


