Teaching Sign Language to Hearing Children as a Possible Factor in Cognitive Enhancement

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We describe an educational experience designed to teach Italian Sign Language (LIS) to a group of hearing children. The hypothesis underlying this experience was that learning a visual-gestural language such as LIS may improve children's attentional abilities, visual discrimination, and spatial memory. To examine this hypothesis, we conducted two studies. The first involved an educational experience lasting two years with a group of hearing children attending a Sign Language class from first to second grade. The Raven PM 47 TEST was administered at the beginning and at the end of each school year to children attending the LIS classes and to a control group of children enrolled in the same school but not exposed to LIS. The second study involved an educational experience in first grade. The Raven PM 47 and Corsi's block-tapping tests were administered at the beginning and at the end of the school year to the children attending the LIS classes, to children enrolled in the same school but attending an English class, and to children not exposed to a second language. We found that in both studies the LIS group performed better than the other groups. These results suggest that learning a sign language may lead to a cognitive advancement in hearing children.

Sign languages used by deaf people employ sophisticated ways of representing space. Do signers develop other, nonlinguistic, visual-spatial abilities as a result of this linguistic feature? Bellugi and her colleagues studied visual-spatial cognition in deaf signers, comparing their performance to that of hearing, nonsigning children on a battery of visual-spatial tests (Bellugi, O'Grady, Lillo-Martin, O'Grady, van Hoek, & Corina, 1990). In tests of spatial construction, spatial organization, and facial recognition, deaf signing children were markedly ahead of the hearing nonsigning children and far in advance of their chronological norms. Similar results were reported by Chovan, Waldron, and Rose (1988), indicating that deaf middle school and high school students had faster responses in visual cognition tasks than their hearing peers.

To clarify the relation between familial deafness and intelligence, Zweibel (1987) examined the intellectual abilities of 243 children, each with familial deafness. The Snijders-Oomen Nonverbal Intelligence Test (SON) and the Goodenough-Harris Human Figure Drawing Test were administered both to deaf children with deaf parents or deaf siblings (suggesting genetic deafness) and to deaf children with hearing parents and hearing siblings. Zweibel found that, in both tests, deaf children with deaf parents scored significantly higher than deaf children with hearing parents but deaf siblings, according to scores on the SON and Figure Drawing tests. Furthermore, the latter group did not differ from deaf children with all-hearing families (nongenetic deafness). The main conclusion of the study was that genetic background makes no difference in intelligence. Zweibel suggested that these results were best interpreted in terms of manual communica-

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tion use in the home, which increased the ability of deaf children to absorb messages and stimuli, thus leading to subsequent enhancement in cognitive development.

Finally, a recent study by Parasnis, Samar, Bettger, and Sathe (1996) compared deaf nonsigning children with hearing controls on five tests that measured visual spatial skills. Deaf and hearing children did not differ in their performance, suggesting that exposure to sign language and not to deafness itself determines differences in visual spatial skills.

Few studies have focused on the use of sign language by normally developing hearing children. In most cases sign language has been used with hearing children exhibiting particular pathologies such as Down syndrome, (Acosta, 1981) or autism (Konstantareas, 1984; see Bonvillian & Miller, 1995, for a recent review of Sign Communication Training with mentally retarded children). Research in this area has shown that the use of signs improves the communicative skills of these children.

A limited number of studies have been carried out in situations where bilingualism comes naturally in a family context: hearing children of deaf parents who acquire sign language together with spoken language. Often bilingual children show very rapid language development in both languages (Capirci, Montanari, & Volterra, in press; Griffith, 1985; Orlansky & Bonvillian, 1985; Prinz & Prinz, 1981).

In particular, a study by Daniels (1993) shows that bilingual-bimodal children achieve higher scores on the Peabody Picture Vocabulary Test (PPVT), suggesting that knowledge of American Sign Language (ASL) has a positive effect on the acquisition of English by hearing children.

Only one study (Daniels, 1994) reports a pilot project of teaching sign language to hearing children of hearing parents in a school context. Daniels demonstrated that preschoolers who learned sign language showed a greater understanding of English vocabulary. At the end of the year, the children attending ASL lessons achieved significantly higher scores in the PPVT vocabulary comprehension test than their peers who did not take part in the project. The teaching method employed was basically bimodal, supplying the corresponding sign for each word. Additional brief phrases in which the two modes were separated and presented as two different languages were introduced only when the children had acquired a basic ASL vocabulary.

The aim of this article is to evaluate the effects of sign language instruction in hearing children. Specifically, we hypothesize that hearing children's experience with sign language in the early school years may enhance performance in the domain of nonverbal cognitive skills such as visual perception, visual discrimination, and spatial memory. Two studies are reported here. The first study describes an educational experience lasting two years with a group of hearing children attending a sign language class in first and second grade matched to a group of hearing children not exposed to sign language. All of the children were given the Raven PM 47 test that measured visual-spatial skills at four time points. This study investigated whether the performance of children who were exposed to sign language was different from the performance of hearing children not exposed to sign language on this test of visual-spatial cognition.

The second study describes a similar educational experience of teaching sign language to hearing children attending the first grade. The children attending the sign language class were matched to two control groups: (1) hearing children enrolled in the same school but exposed to an English course; and (2) hearing children not exposed to any foreign language. All children were given the same test as in the first study and a Corsi's block-tapping test that measured spatial memory at two time points. The second study investigated whether the performance of children exposed to sign language was different from the performance of children exposed to English and to children not exposed to any foreign language on tests of visual-spatial cognition and spatial memory.

Study 1: Method

Subjects. Twenty-eight children from two first-year elementary school classes participated in a longitudinal two-year study. Half of the children attended a course in Italian Sign Language (LIS group), while the other half had no such experience (control group). The afternoon program in sign language was voluntary. All children in the class were given a choice of activities: music, gymnastics, or sign language. Half the children (14) chose to participate in the sign language program. The remaining 14 participated in music or gymnastics programs. The two groups came from families living in the same neighborhood and of the same low–middle-class background, and with the exception of Sign Language class, they were enrolled in the same school program. All children (28) are from monolingual Italian-speaking families and they had no experience with deaf culture or sign language. At the beginning of the course, the mean age of the children in the LIS group was 6.6 years, and the mean age of the children in the control group was 6.5 years.

Procedure. The LIS course was held in the afternoon, one hour a week (for seven months in the first year and for eight months in the second year) on the school premises by a deaf teacher whose first language was sign language. All of the lessons were video-recorded and transcribed by an experimenter. Children in the LIS group also worked for an hour each week with a hearing teacher who had knowledge of LIS.

The educational experience is based on the following methodological principles: (1) presenting LIS through a native signer interacting with the children exclusively in this language; (2) offering children the opportunity to experiment with LIS in familiar contexts; (3) never translating from one language to another, only stimulating children to capture analogies; (4) improving the development of comprehension skills, especially in the first stage; and (5) letting children spontaneously develop their production skills.

The LIS program lessons developed in the two years of the course are outlined in Table 1.

At the beginning and end of each of these two academic years, all of the children in our sample were given the Raven PM 47 Test (Raven, 1949). This test measures visual perception and level of mental development. It consists of a series (36 color pictures) of increasingly difficult matrixes, each with one piece missing. The subject must select the correct piece to complete the matrix from six alternatives. For each trial, a single stimulus picture is presented above the six response-choice pictures. The subject's task is to point to the one picture that fits in the stimulus picture. There is no time limit for responding. The correct solution for each problem requires logical nonverbal reasoning. Children's responses were scored by totaling the number of correct responses.

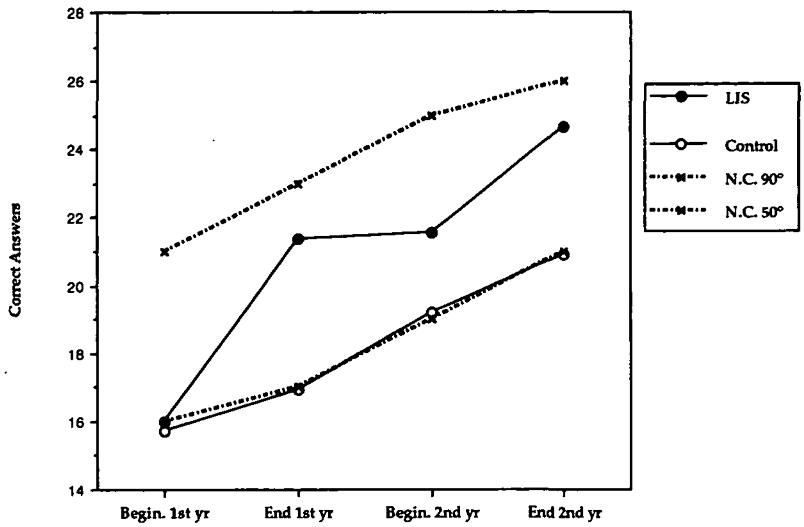
Table 1 Course outlines

Outlines	Description
1-year course	
Name signs	
Fingerspelling	letters and syllables
Geometric blocks	triangles, squares, circles, rectangles
Number	from 1 to 10
Geometrical figure	
Colors	primary
Animals	
Family members	father, mother, brother, and sister
Meals	objects and dishes
Narration	comprehension of short fairy tales and real life events
Pretended play	individually and as a group
2-year course	
Fingerspelling	first and last name
Number	to 30
Colors	complementary, light, and dark
Family	all members, e.g., grandmother, uncle, cousin
Geometrical drawing	two or more figures spatially located
Months and days	
Picture story	"The Balloon"
Pretend play	e.g., "The doctor and the patient"
Fairy tales playing	as a group

Results

As shown in Figure 1, the two groups attained very similar scores in the first test, but considerable differences had already emerged by the end of the first and the second years, with the children attending the LIS course showing evident gains. While the line for the children who did not attend the course rises fairly steadily, the graph for the LIS group shows no such stability, reaching maximus corresponding to the two end-of-course tests and a stationary state during the summer break.

In Figure 1 two dotted lines represent the 50th and 90th percentile scores per age obtained by normative values of a sample of French children (Bourdier, 1964).



N.C. 90° = Normative Control 90° percentile scores
N.C. 50° = Normative Control 50° percentile scores

Figure 1 RAVEN PM 47. Mean scores in the four trials for the two groups.

Table 2 Raven PM 47, mean scores and standard deviations for the two groups for each year

Group	Beginning 1st yr	End 1st yr	*p*	Beginning 2nd yr	End 2nd yr	*p*
LIS	16.0 (3.5)	21.4 (3.8)	.003*	21.6 (4.0)	24.6 (4.3)	.01**
Control	15.7 (3.0)	16.9 (4.6)	NS	19.2 (5.0)	20.9 (5.8)	NS

*Highly significant.

**Significant.

These norms were developed from 784 children from different cities in France. In Figure 1 we present four time points for the following ages: 6.6; 7.0; 7.6; 8.0. As is evident, the control children's performance on the Raven test fell within the 50th percentile score of the French sample across all of the time points. Children who attended the LIS course were initially in the 50th percentile, like the control group, but their mean performance was close to the 90th percentile at the end of both years of the LIS course.

We calculated the mean scores attained by the LIS group and by the Control group at both administrations of the Raven PM 47 (Table 2). To determine whether the two groups differed in performance from the beginning of the first year to the end of the second year, a 2 × 4 analysis of variance (ANOVA) was conducted, with Group (LIS course and no course) as the between-subjects factor and Trials (time point) as the within-subjects factor. The dependent variable was the raw score of correct responses. This analysis yielded significant Group, $F(1, 26) = 4.179$, $MSE = 48.71$, $p < .05$, and Trials, $F(3, 78) = 26.886$, $MSE = 8.67$, $p < .0001$, effects, and the Group × Trials interaction approached significance, $F(3, 78) = 2.68$, $MSE = 8.67$, $p = .053$. The main effect for Group reflected higher performance at test for the LIS group, and the main effect for Trials reflected increasing scores across trials for both LIS and control subjects.

We also examined differences between the two groups for individual trials. Group *t* tests showed no significant group differences in performance on the first trial ($t(26) = .233$, *ns*), as expected since our intention was to have similar groups. On the second trial, LIS group's performance was significantly better than that of the control group ($t\ (26) = 2.76$, $p < .01$). On the third trial there was a trend toward better performance in the LIS group ($t(26) = 1.38, p = .09$). However, this may be due to the fact that the control group caught up between the end of the first year LIS course and the beginning of the second year LIS course (about 4–5 months). Finally, on the fourth trial, at the end of the second year, performance was again significantly different in the expected direction ($t(26) = 1.94, p < .05$).

These results indicate that exposure and participation in a sign language program enhances nonverbal cognitive development. The data also show that the control group caught up to some extent over the summer vacation, while the experimental group shows a performance plateau. This plateau suggests that the accelerated growth in nonverbal cognition was strictly related to the sign langage course.

Study 2: Method

The results of the first study led us to conduct a second experiment to determine whether the acquisition of LIS or the exposure to a second language enhances visual discrimination and recognition of spatial relations. To address this possibility, we added as control a group of children attending an English course as second language. In addition, in order to explore whether sign language per se has specific effects on children's ability to process and memorize visual stimuli trhough space, we included an additional task that tapped short-term spatial memory.

Subjects. The 49 first-grade children who participated in this study came from three classes in the same school. All 20 children from one class attended a course in LIS, the 20 children of the other class attended a course in English language, and the remaining 9 children had no second language exposure. The three groups came from families living in the same neighborhood and of the same low–middle-class background. With the exception of Sign or English Language class, they were enrolled in the same school program. All children (49) are of monolingual Italian-speaking families and they had no experience with deaf culture or sign language.

Procedure. The LIS course lasted five months during the first grade with the same procedure as Study 1. The English course was held in the afternoon two hours a week. Before the beginning and soon after the last lesson of the course, all the children in our sample were given two tests: the Raven PM 47 Test (Raven, 1949), as in Study 1, and the Corsi's block-tapping test to examine visual and spatial memory (Corsi, 1972; for Italian data see Orsini, Grossi, Capitani, Laiacona, Papagno, & Vallar, 1987).

In the Corsi test, nine identical small white cubes (4 × 4 × 4 cm) are arranged irregularly on a small wooden board (26 × 32 cm). The sides of cubes facing the examiner are numbered from 1 to 9. The examiner taps a certain number of blocks (digits) in a particular sequence, and the subject is required to tap out the same pattern immediately afterwards. The test begins with a sequence of two units and then increasingly long sequences are presented; each time a maximum of five equal unit sequences is tapped out. In the present article, we used the procedure suggested by Orsini (1994) and Orsini, Maggiore, and Rotondaro (1996) with the variation that the test was administered with sequences of from 2 to 5 digits (for a total of 20 items). The child's score is the number of items correctly reproduced.

Results

Data from individual subjects on each of the two tests were analyzed to determine whether group differences existed in performance at the beginning and the end of the academic year.

Raven PM 47

Figure 2 and Table 3 show the mean scores obtained by the three groups of children at the beginning (first trial) and at the end (second trial) of the school year. It can be seen that on the first trial, the three groups performed similarly, with no difference among means. On the second trial, all groups showed an increase in their Raven's score, with children attending the LIS course showing a clear gain. The 50th and 90th percentile per age obtained from normative data available on

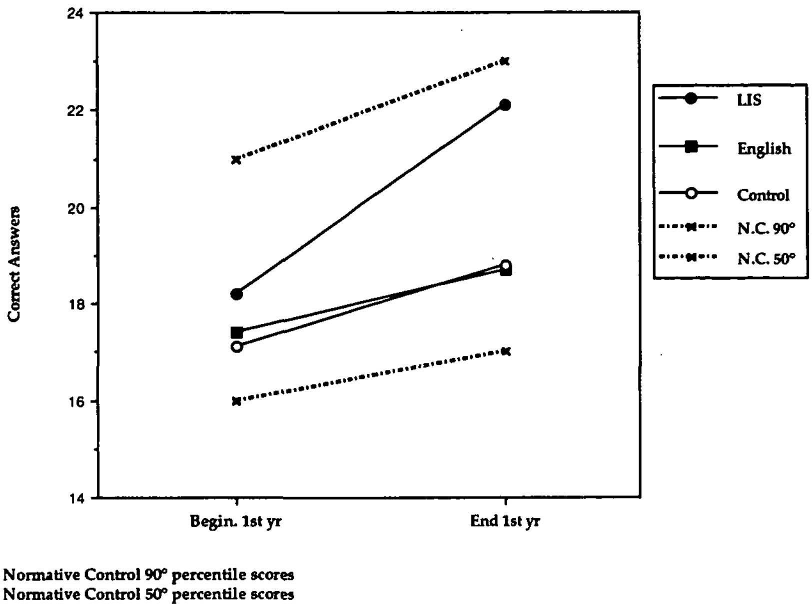


Figure 2 RAVEN PM 47. Mean scores in the two trials for the three groups.

Table 3 Raven PM 47, mean scores and standard deviations for the three groups

Group	Beginning 1st yr	End 1st yr	*p*
LIS	18.3 (5.3)	22.2 (5.2)	.001**
English	17.5 (4.1)	18.8 (3.8)	NS
Control	17.1 (3.4)	18.9 (2.9)	NS

**Highly significant.

this test on French children are also shown in Figure 2 (Bourdier, 1964).

As it is apparent in the figure, performance on the Raven PM 47 by children enrolled in the English course and by the control children was close to the 50th percentile score in both observations. Children who attended the LIS course performed similarly to the other children on the first trial. The same children at the end of the course performed better, approaching the 90th percentile of the French sample.

A simple effects analysis was carried out on the data from the first trial to determine whether significant differences existed among the groups (LIS course, English course, and no course). This analysis revealed no significant difference, $F(2, 46) < 1$, *ns*. In contrast, on the second trial, there was a significant difference among the groups, $F(2, 46) = 3.4$, $p < .05$. Pairwise comparisons carried out on the second trial revealed significant differences between the LIS group vs. the English and the control group, $F(1, 46) = 13.33$, $p < .01$, and no difference between the English group and the control group, $F(1, 46) < 1$, *ns*.

Corsi's Block-Tapping Test

The data in Figure 3 and Table 4 show that children who attended the LIS course and control children were equivalent on the first trial, with no difference among means. Performance in both groups increased on the second trial, with children who attended the LIS course showing again a clear gain. Children who attended the English course showed no such enhancement, but equal performance across the two trials.

A 3 × 2 ANOVA was carried out with Group (LIS course, English course, and no course) as the between-subjects factor and with Trials (beginning vs. end of course) as the within-subjects factor. The dependent variable was the number of correct responses. The analysis yielded a significant main effect and a Group × Trial interaction that approached significance, $F(2, 46) = 2.66$, $MSE = 4.51$, $p = .08$. The main effect for Trials, $F(1, 46) = 8.13$, $MSE = 4.51$, $p < .01$, indicated a higher performance at the end of academic year. A simple effects analysis indicated that this interaction

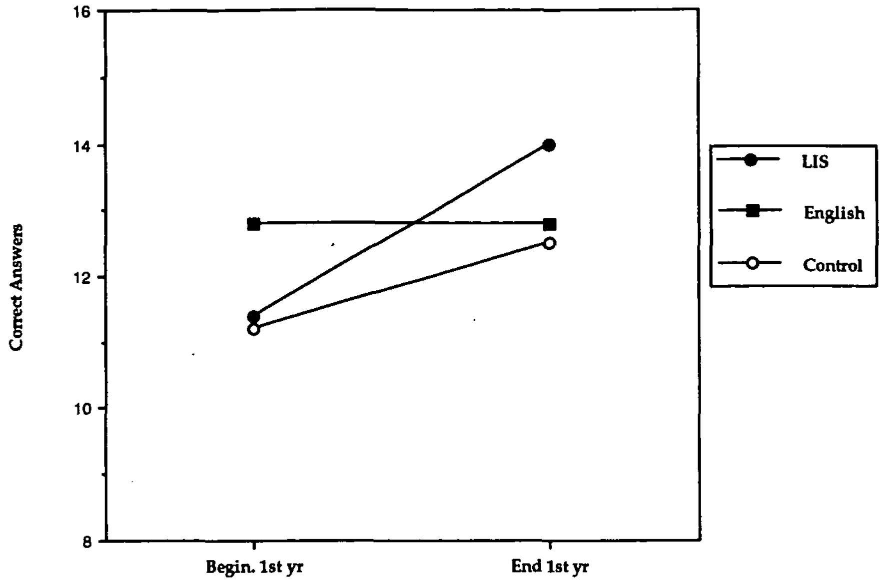


Figure 3 CORSI SPAN. Mean scores in the two trials for the three groups.

Table 4 Corsi span, mean scores and standard deviations for the three groups

Group	Beginning 1st yr	End 1st yr	*p*
LIS	11.5 (3.8)	14.1 (3.4)	.001**
English	12.8 (3.7)	12.8 (3.1)	NS
Control	11.2 (1.8)	12.6 (3.5)	NS

**Highly significant.

was solely due to an increase in the performance of children who attended the LIS course, $F(1, 46) = 14.99$, $MSE = 4.51$, $p < .001$.

Conclusion

The results of the educational experience reported here show that hearing children who learn sign language as a second language in the early school years improve more rapidly on tests of visual-spatial cognition and spatial memory than their schoolmates not attending a sign language course.

Our findings are consistent with previous studies reported on signing (Bellugi et al., 1990; Zweibel, 1987) and nonsigning (Parasnis et al., 1996) deaf children. Specifically, our results support the position that it is exposure to a visuo-gestural language per se that is responsible for enhanced visual-spatial abilities.

In our first study, the finding that hearing children attending the LIS course performed better relative to control children and in advance of their chronological norms on the Raven PM 47 is consistent with the idea that experience with sign language enhances nonverbal cognitive skills such as visual and perceptual discrimination and recognition of spatial relations (Emmorey, Kosslyn, & Bellugi, 1993). Attendance of the LIS course appears to promote faster development in nonverbal cognition: children learning LIS reach the level achieved by their schoolmates not attending the LIS course almost one year earlier.

In the second study, we examined whether the acquisition of LIS or the exposure to a second language enhances visual discrimination and memory of spatial relations. We found that children who attended the LIS course showed enhanced performance on the Raven PM 47 compared to controls, that is, to children attending an English course and to chronological norms. Similar findings were obtained on the Corsi's block-tapping test.

In summary, these results suggest that exposure to sign language among hearing children may be an important factor in the enhancement of visual-spatial cognition.

In the present article our focus was on cognitive improvement as a consequence of sign language teaching. While the data concerning sign language acquisition by the same group of children are reported elsewhere (Capirci, Cattani, Rossini, & Volterra, 1997), we would briefly like to mention here only the major goals achieved through this educational experience in the linguistic domain.

Hearing children attending the LIS course showed an increasing interest in sign as an alternative to spoken communication, reached a basic competence in LIS, and displayed a new, spontaneous sensitivity towards the culture and communicative modes of someone differing from them: they always communicated with their deaf teacher through the appropriate visual-gestural modality rather than in speech.

These findings suggest that it would be extremely useful to offer sign language as a second language to hearing children for linguistic as well as cognitive reasons.

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