Deaf Readers' Lack of Implicit-Prosody Effects

Mari Kobayashi

Edson T. Miyamoto
(etm@lingua.tsukuba.ac.jp)

Kaori Sato

University of Tsukuba
College of Japanese Language and Culture
Tsukuba, Ibaraki 305-8572 Japan

Abstract

According to the implicit prosody hypothesis, prosodic contours usually associated with spoken utterances are implicitly imposed on sentences read in silence, thereby affecting the interpretation of ambiguous constructions (Fodor 2002). Some of the strongest evidence supporting this hypothesis manipulated the prosodic length of segments (Hirose 2003). However, such manipulations also increase the number of characters in the critical words, thus the results may not reflect the influence of prosodic factors but rather how perceptual mechanisms and working memory handle written words with larger number of characters. If so, such results should be replicable even with readers who have low ability in handling phonological information. We report experimental results suggesting that deaf readers are not sensitive to such length manipulations. This is compatible with the assumption that prosodic contours, and not some other type of length measure, are at stake, therefore providing further support for the implicit prosody hypothesis.

Key words: sentence comprehension, deaf, implicit prosody, Japanese, clause boundary, ambiguity

Introduction

According to the *implicit prosody hypothesis* (IPH), prosodic contours usually associated with spoken utterances are implicitly imposed on sentences read in silence, thereby affecting the interpretation of ambiguous constructions (Fodor, 2002). The effects of such implicit prosodic contours have been explored recently both in formal syntax as well as in the language processing literature. A number of empirical results have been reported on implicit prosody effects, but many of them have not addressed alternative explanations. The most common type of manipulation increases the length of constituents in order to show that longer phrases are more likely to modify the farther of two potential attachment sites (see Fodor, 2002, for a summary of the relevant studies).

One of the strongest sets of results providing support for the IPH has used ambiguous relative clause constructions in Japanese (Hirose, 2003; see also Hirose & Kakei, 1998). However, as in other similar studies, the manipulation used leads to unavoidable side-effects such as longer words and phrases measured in number of characters, and not just longer in terms of prosodic length as was intended. This is a problem because it allows for the possibility that it is not implicit prosody that is driving the effect. Instead, perceptual processes for longer written words or the way that working memory handles longer phrases could be the crucial factor.

Ideally, one would like to compare how silent reading is conducted with and without implicit prosody, but this is not easily achieved (but see Miyamoto, Nakamura & Takahashi, 2004, Experiment 2; Slowiaczek & Clifton, 1980, on the possibility of eliminating inner speech during reading through simultaneous articulation of nonsense syllables).

We report the results of a fragment completion study with deaf readers of Japanese, which indicate that they are not sensitive to the manipulations used by Hirose (2003). Therefore, the results support the proposal that the effects are related to prosodic contours rather than working memory or perception, under the assumption that deaf readers are less likely to be affected by implicit prosodic contours during silent reading.

Ambiguous relative clauses in Japanese

Japanese is a head-final language with subject-object-verb order. There are no overt markers to indicate the beginning of embedded clauses, therefore words in the embedded clause are commonly taken to be part of the matrix clause (but see Venditti, in press, for prosodic cues in speech). For example, readers usually interpret the fragment in (1) as a single clause ('Morishita truly trusted the medicine', where *Morishita* is a proper name).[1]

(1)	Morishita-ga	shinyaku-o	kokorokara	shinyooshita
	PN-nom	medicine-acc	truly	trusted

However, when a noun such as *yuujintachi-ni* 'friends-dat' is read after 'trusted', it is clear that this verb is part of a relative clause modifying the noun (relative clauses in Japanese precede the noun they modify) and readers have to decide where the beginning of the relative clause is likely to be. The two most common alternatives are the *late opening* interpretation, in which the relative clause starts after the direct object, and the *early opening* interpretation, in which the relative clause starts at the direct object 'medicine-acc' as schematically represented in (2a, b) (Mazuka & Itoh, 1995; see Hirose, 2003,

[1] The nominative case marker (nom) is usually used for subjects, the accusative marker (acc) for direct objects and the dative marker (dat) for indirect objects.

on the early versus late opening labels; also Inoue, 1990; Miyamoto, 2002, for related experimental results).

(2) a. Late opening
Morishita-ga shinyaku-o $[_{RC}$ kokorokara ...
PN-nom medicine-acc truly

b. Early opening
Morishita-ga $[_{RC}$ shinyaku-o kokorokara ...
PN-nom medicine-acc truly

If the late opening interpretation is chosen, the direct object (the accusative marked 'shinyaku') is to the left of the embedded clause boundary, therefore it belongs to the matrix clause together with the matrix subject ('Morishita'). In this case, the matrix verb at the end of the sentence must be a predicate that can take the direct object as an argument. The dative marked 'friends' is also attached to the matrix verb, therefore ditransitive predicates such as *susumeru* 'recommend' would be a natural continuation (as in 'Morishita$_i$ recommended the medicine to the friends that (he$_i$) really trusts').

If an early opening interpretation is chosen, the direct object is part of the relative clause, therefore only the dative-marked NP 'friends' has to attach to the matrix predicate, therefore a verb such as *au* 'meet' is a grammatical continuation (as in 'Morishita met the friends that really trust the medicine').

Prosodic contours in speech

During oral communication, prosodic contours (such as pauses and word-end lengthening) produced by speakers can help listeners choose between early and late opening interpretations (Sakamoto, Muraoka & Matsuura, 2005; also Venditti, in press, for a summary of prosodic contours in the processing of sentences in Japanese).

Furthermore, Experiment 3 in Hirose (2003) provides evidence that the length of the matrix subject in fragments such as (1) affects the prosodic contours produced by speakers. When an accented noun such as 'Morishita' is used, the subject spans one minor phrase and it becomes part of a major phrase together with an accented noun such as the direct object 'medicine' in (3a). In contrast, with two accented nouns (e.g., the conjoined proper names *Morishita-to Hosokawa* 'Morishita and Hosokawa'), the subject alone constitutes a major phrase as shown in (3b).

The inclusion of the extra accented noun does not change the nature of the syntactic ambiguity. That is, the left edge of the relative clause remains ambiguous and both alternatives in (2) are still possible when 'Morishita' is replaced by 'Morishita and Hosokawa'.

Nevertheless, the prosodic markings often accompanying major phrase boundaries can bias listeners interpretations as they are preferentially aligned with the beginning of the embedded clause. Thus, the major phrase boundary immediately after the conjoined names in (3b) favors the adoption of the early-opening interpretation in (2b); whereas the major phrase boundary after the direct object in (3a) is preferentially aligned with the beginning of the relative clause boundary as in the late opening interpretation in (2a).

Implicit prosody and relative clauses

In Experiment 1 in Hirose (2003), native Japanese speakers read fragments as in (3a, b) in silence, and were asked to complete them into full sentences. The fragments containing conjoined names were more likely to be completed with early opening interpretations than single-name fragments (Hirose, 2003, who also reports similar results when the conjoined names were replaced with a family name followed by a first name, therefore without increasing the number of discourse entities).

These results suggest that a change in the prosodic length of the matrix subject affects the way how readers interpret relative clauses even when the fragments are not overtly articulated.

This type of completion questionnaire task is commonly used in the sentence processing literature to investigate the types of interpretations that are likely to be pursued after a given fragment (see Hirose, 2003, Experiments 4 and 5, for reading time data confirming the questionnaire findings).

One could argue that plausibility factors (how likely is it that 'Morishita really trusts his friends' compared to 'Morishita's friends really trust the medicine'?) or preferences in gap position within the relative clause (gaps in subject position are preferred over gaps in object position in Japanese; e.g., Miyamoto & Nakamura, 2003) could affect the preference for early opening versus late opening. However, such differences are orthogonal to the subject-length manipulation and are equally likely to affect the interpretations of fragments with a single name as well as fragments with conjoined names, therefore they do not constitute a problem in this case.

In sum, although the syntactic ambiguity in (2a, b) remains the same, the prosodic length of the matrix subject affects the favored interpretation even when read in silence, thus providing support for the IPH.

However, it is conceivable that the number of characters, rather than the prosodic length of the matrix subjects, influenced the way the relative clauses were interpreted and a number of alternative explanations would be possible. For example, at least since the 1970s (e.g., Frazier & Fodor, 1978) there have been proposals that the perceptual span during reading may affect how phrases are associated together. Another possibility is the way working memory may handle longer strings of letters as they are concatenated into more complex chunks, which in turn may define phrasal boundaries.

If non-phonological aspects of the input strings are responsible for the effects reported by Hirose (2003), it should be possible to replicate them even with participants who are less likely to be generate implicit prosodic contours.

Experiment

Under the assumption that deaf readers are less likely to produce prosodic contours during silent reading, a completion questionnaire experiment was conducted with deaf Japanese readers.

(3) a. Single-name matrix subject ('Morishita')

Morisita-ga	sinyaku-o		kokorokara	sinyoosita	yuujintati-ni
PN-nom	medicine-acc		truly	trusted	friends-dat
[MinP	MinP	$]_{MajP}$			

b. Conjoined-names matrix subject ('Hosokawa and Morishita')

Hosokawa-to	Morisita-ga		sinyaku-o	kokorokara	sinyoosita	yuujintati-ni
PN-and	PN-nom		medicine-acc	truly	trusted	friends-dat
[MinP	MinP	$]_{MajP}$				

c. 森下が新薬を心から信用した友人達に ____________________

Method

Participants Forty-one deaf students at the Tsukuba University of Technology were paid to take part in the experiment. One of the requirements for entrance in this university is that the candidate is unable to hear sounds below 60 dB or unable to carry out conversations even with the use of hearing aids (there is a different set of requirements for blind candidates). In the case of the participants, hearing levels for the right ear were between 65 and 140 dB ($M = 104$), and between 77 and 140 dB for the left ear ($M = 105.7$). Thirty participants were deaf since birth, four since the age of 1 year, another four since the age of 2 years, and two others since the ages of 3 and 4 years. At the time of the experiment, their ages ranged from 18 to 27 years ($M = 20.1$). Because of the diverse educational backgrounds, age in which Japanese Sign Language (JSL) acquisition started varied considerably (one participant since birth, two at 3 years, seven between 6 and 10 years, six between 12 and 14, seven at 15 years, seventeen between 16 and 23 years, and one never learned JSL). Twenty-two participants reported to use one of the dialects of the Kanto (Tokyo and surroundings) or the Kansai (Kyoto or Osaka) areas.

As control group, 56 hearing students at Kobe Shoin Women's University, volunteered to take part in the experiment. Their age range was between 18 and 23 years ($M = 19.7$) and 45 of them reported to be users of one of the dialects of the Kansai area (Kobe, Kyoto or Osaka).

Materials Eight pairs of fragments (from Hirose, 2003) like the ones shown in (3a, b) were used. The fragments included up to the head of the relative clause ('friends'), which was always followed by the dative marker *ni*. Each pair of sentences was exactly the same except that in the single-name condition, the fragment included a matrix subject with a single name (or a profession) as in (3a), while in the conjoined-names condition, the matrix subject contained two conjoined names (or two professions) as in (3b).

Assuming that deaf readers are less likely to produce prosodic contours when reading in silence, they should not be affected by the length manipulations in (3a, b) if those are prosodic in nature. However, if the manipulations affect a non-phonological process during sentence comprehension, then deaf readers should show biases similar to those reported by Hirose (2003), namely matrix subjects that contain two conjoined names should lead to more completions with the early opening interpretation than matrix subjects that contain only one single name.

Procedure The eight pairs of test sentences were distributed into two lists according to a Latin Square design, and filler items were added to each list. Each of the two resulting lists were ordered pseudo-randomly so that at least one filler intervened between two test items. Each participant saw one list and was instructed to complete each fragment into a sentence using a pen. Fragments were presented in Japanese fonts followed by a straight line as in (3c) (which corresponds to (3a)).

For the control group, 44 fillers were included in each list. However, because the procedure took longer than expected (around 30 minutes), the number of fillers was decreased to 28 for the deaf participants in order to avoid long sessions. With 36 items (8 test items and 28 fillers), the deaf participants completed the questionnaire in around 30 minutes. Although the number of fillers was smaller, their variety was kept the same for the two groups, with some fragments requiring one predicate while others requiring two predicates to yield complete sentences.

Each questionnaire was preceded by a consent form, a profile (requesting information such as age and major at the university attended) and instructions.

For the deaf participants, the profile also requested self-assessments of their Japanese (e.g., grammar, pronunciation) and JSL. The completion questionnaire was followed by a *kanji* (Chinese origin characters used in written Japanese) test. Because the critical manipulations in (3a, b) require the proper names and professions in the matrix subject to be read correctly, the kanji test included those words intermixed with 16 unrelated kanji words, and participants were requested to write their readings in *kana* (syllabic characters). Although some of the answers were not the most standard for the names used (proper names can have virtually any reading), they fell within the uses in current Japanese, and most important for our purposes, the readings were compatible with the prosodic manipulations described earlier.

Analysis Completions obtained for the eight test items were classified according to their grammaticality. Ungrammatical completions were not analyzed further.

Following Hirose (2003), grammatical completions were analyzed as being of the early opening or the late opening type depending on the matrix clause produced by participants. For example, completions with a matrix verb that cannot take an accusative NP as argument were analyzed as early opening because in this case the direct object 'medicine-acc' in (3a, b) cannot be part of the matrix clause. In contrast, completions with a matrix verb that requires an accusative NP as an argument were analyzed as being of the late opening type if that argument position was not saturated by another accusative NP appearing in the completion.

Analyses of variances (ANOVA) on participant means (F_1) and on item means (F_2) were conducted with the percentages of grammatical completions and with the percentages of early opening completions. Participant group (control or deaf participants) was entered in the analyses as a between-participants factor, and matrix-subject type (single-name or conjoined names) as a within-participants factor.

Arcsine corrected analyses were also conducted and revealed trends similar to the ones obtained for the analyses on the raw percentages reported.

Results

In terms of percentage of grammatical completions, there was no interaction between group (control × deaf) and type of matrix subject (single name × conjoined names; both Fs < 0.5). The main effect of matrix-subject type was not reliable either (Fs < 0.2). There was, however, a main effect of group as the control group produced more grammatical completions (single name: 96%; conjoined names: 97.3%) than the deaf participants (single name: 88.4%; conjoined names: 89%; $F_1(1{,}95) = 13.2$, $P < 0.001$; $F_2(1{,}7) = 7.61$, $P < 0.05$). This is compatible with earlier reports that the deaf tend to have an imperfect command of Japanese (Matsui, Watanabe, Sato & Hosoya, 2006, and references therein).

For the grammatical completions, the percentage of early openings did not differ between the two groups (deaf: 74.7%; control: 72.5%; Fs < 1). This overall preference for early opening (where 50% would be chance) is compatible with earlier literature (Mazuka & Itoh, 1995; also Miyamoto, 2002, for experimental results) and indicates that the deaf participants are not interpreting the construction in a way completely different from the hearing participants. Detailed results are reported in the following sections and in Table 1.

Types of completions for the control group In the control group (column A in Table 1), the conjoined-names condition led to more early-opening completions than the single-name condition according to the participant analysis ($F_1(1{,}55) = 7.57$, $P < 0.01$; $F_2(1{,}7) = 4.12$, $P = 0.082$). Restricting the analysis to the 45 participants in the control group who claimed to use dialects of the Kansai area, the conjoined-names condition led to more early opening completions (76.8%) than the single-name condition (66.7%) in the participant analysis ($F_1(1{,}44) = 5.34$, $P < 0.05$; $F_2(1{,}7) = 4.25$, $P = 0.078$). These results replicate previous findings (Hirose, 2003) according to which the conjoined-names condition tend to lead to more early opening interpretations. The weak results in the analysis by items is probably due to the small number of items used (in Hirose, 2003, 12 items or more were used in each experiment).

The results with the speakers of Kansai dialects suggest that the effect is not restricted to speakers of Kanto dialects (as the ones in Hirose, 2003). This is unsurprising given that the Kanto accent is adopted as standard Japanese, is widely used in spoken media and is likely to be enforced when students read aloud in school (see Sakamoto, Muraoka & Matsuura, 2005, who report that speakers of the Hakata dialect are sensitive to Kanto prosodic cues when they hear sentences similar to (3a)).

Types of completions for the deaf participants For the deaf participants (column B in Table 1), the conjoined-names condition led to numerically fewer early opening interpretations (71.7%) than the single-name condition (77.6%) but the difference was not statistically reliable ($F_1(1{,}40) = 1.1$, $P = 0.301$; $F_2(1{,}7) = 1.09$, $P = 0.332$). In the analysis including group (control × deaf; i.e., A × B in Table 1) and matrix-subject type (conjoined names × single name), an interaction is observed in the participant analysis ($F_1(1{,}95) = 6.2$, $P < 0.05$; $F_2(1{,}7) = 3.84$, $P = 0.091$). A similar interaction was detected when the deaf participants were restricted to the 22 users of Kansai or Kanto dialects ($F_1(1{,}76) = 11.02$, $P < 0.005$; $F_2(1{,}7) = 9.41$, $P < 0.05$). The latter analysis was conducted because the influence that the various dialects may have is uncertain, and right now it is only clear that the prosodic manipulation works for speakers of Kanto (Hirose, 2003) and Kansai (the control group) dialects.

We also conducted analyses with a more strict cutoff with the 29 deaf participants who claimed to have hearing levels equal or above 100 dB for each ear (right ear $M = 110.72$ dB, left ear $M = 108.83$ dB). In this case as well (column G in Table 1), the conjoined-names condition led to fewer early opening completions (70.4%) than the single-name condition (81.3%) but the difference was only marginal in the participant analysis ($F_1(1{,}28) = 3.47$, $P = 0.073$) and not reliable in the item analysis ($F_2(1{,}7) = 1.87$, $P = 0.214$). However, this group of participants and the control group (G × A) interacted with the type of matrix-subject in the fragments according to both types of analyses ($F_1(1{,}83) = 10.05$, $P < 0.005$; $F_2(1{,}7) = 6.74$, $P < 0.05$).

The results indicate that deaf readers (and the ones with hearing levels equal or above 100 dB in particular) behave differently from hearing readers with respect to the the matrix-subject manipulation. This difference can be readily understood if one assumes that the deaf participants are less likely to be sensitive to prosodic manipulations. If some non-phonological feature had been responsible for the effect, the same result should have been observed with the deaf participants. That this is not the case provides further evidence for the IPH.

There is, however, the possibility that deaf readers imperfect knowledge of the grammar of Japanese (Matsui, Watanabe, Sato & Hosoya, 2006, and references therein) may have had some influence on the results. The syntactic constructions investigated are complex, involve relative clauses and, more crucially, require reanalysis in order to correct an initial misparse of the sentence as a simple clause. However, this is unlikely given that the

Table 1: Percentage of early-opening completions for the control group (column A) and for the deaf participants (B to G). Deaf participants were classified as high skill or low skill according their self-assessments of their pronunciation skills (C and D) and grammar knowledge (E and F) of Japanese.

	Control	Deaf participants					
		All	Pronunciation		Grammar		>100dB
			Low	High	Low	High	
Group	A	B	C	D	E	F	G
Number of participants	56	41	23	18	18	23	29
(I) Conjoined-names	77.7	71.7	69.6	74.5	68.1	74.6	70.4
(II) Single-name	67.4	77.6	84.1	69.4	74.1	80.4	81.3
Difference: (I) - (II)	10.3	-5.9	-14.5	5.1	-6.0	-5.8	-10.9

number of ungrammatical completions produced by deaf participants, although reliably larger than for the control group, was small (an average of less than one incorrect completion per participant). Analyses based on the deaf participants' self-assessments of their knowledge of Japanese grammar are reported in the following section and tend to confirm this claim.

Self-assessment scores In the profile form, deaf participants were asked to assess their knowledge of Japanese grammar and their skill in pronouncing Japanese aloud on a scale from 0 (poor) to 7 (perfect). This type of self-rating is commonly used in the assessment of participants' linguistic knowledge and is considered to be one of the best measures available in the bilingual literature (e.g., Fishman & Cooper, 1969).

Participants who rated themselves from 5 to 7 were classified as high skill for each individual category (grammar or pronunciation), and participants who rated themselves from 0 to 4 were classified as low skill. In terms of grammar, there were 23 high-skilled participants and 18 low-skilled. For pronunciation, there were 18 high-skilled and 23 low-skilled. There were 13 participants who rated themselves as low skilled in both grammar and pronunciation, another 13 were high skilled in both categories, 10 were high skilled in grammar but low skilled in pronunciation, whereas the reverse pattern included the remaining five participants.

The percentages of early-opening completions for each subgroup in each category are shown on columns C to F in Table 1. For the grammar-based breakdown, the difference between the conjoined-names and single-name completions (last row on the table) are similar for the low-skill (-6.0, column E) and high-skill (-5.8, column F) participants, and this is reflected in the lack of interaction between the two skill groups (E × F) and matrix-subject type (conjoined names × single name; Fs < 0.3). When each skill group is compared to the control group (column A), a tendency for interaction between group and matrix-subject type is observed in each case (A × E: $F_1(1{,}72) = 3.35$, $P = 0.072$; $F_2(1{,}7) = 4.3$, $P = 0.077$; A × F: $F_1(1{,}77) = 5.41$, $P < 0.05$; $F_2(1{,}7) = 1.8$, $P = 0.22$). In other words, knowledge of Japanese grammar does not seem to have affected the completions produced by the deaf participants.

In contrast, when we consider pronunciation, the high-skilled participants (column D) show more early opening interpretations with conjoined-names than with single-name subjects (a 5.1% difference) similar to the control participants, whereas the low-skilled participants show the reverse tendency (-15.5%), although the interaction is only marginal in the participant analysis ($F_1(1{,}39) = 3.15$, $P = 0.084$) and not reliable in the item analysis ($F_2(1{,}7) = 1.31$, $P = 0.29$). When compared to the control group, the differences become more evident. There is no interaction between the control and the high-skilled participants (A × D) and matrix-subject type (Fs < 1), whereas the equivalent interaction is reliable with the low-skilled participants (A × C: $F_1(1{,}77) = 11.76$, $P < 0.005$; $F_2(1{,}7) = 9.63$, $P < 0.05$).

In sum, while the classification according to grammar knowledge does not have any detectable effect, different levels of pronunciation skills reveal differences in the types of completions produced. Hence, these results reinforce the possibility that the manipulations conducted are having an effect at the phonological level. Clearly, the results in this section should be interpreted with caution given that several of the statistical results are suggestive at best and they are based on self-assessment scores. But the trends are encouraging and are compatible with our claims.

The difference between the conjoined-names condition and the single-name condition for the deaf participants was consistently negative (last line of Table 1 for columns B to G, except for column D) indicating a larger number of early-opening interpretations for the single-name condition, although none of the pairwise comparisons was statistically reliable. At the moment we do not have an explanation for such a possible bias and future work should investigate it further. It is unlikely that interference from JSL caused the effect as analyses considering age of JSL acquisition as well as self-assessed JSL ability did not detect any differences across groups.

General discussion

The present results suggest that deaf readers, especially the ones that are most likely to have problems handling phonological information (i.e., the participants that can only hear sounds above 100 dB, on column G of Table 1; or the ones with low self-assessed pronunciation skills, on column C), are less likely to be affected by the length of the matrix subject when compared to the control group. This result underscores the phonological nature of the effect, and thus provides new support for the implicit prosody hypothesis by raising the likelihood that implicit prosodic contours are affecting the way ambiguous sentences are read by hearing participants.

However, a version of the alternative explanation based on working memory factors may still be sustainable. It is possible that the way the *phonological loop* (Baddeley, 1992) handles longer-sounding phrases or how it converts written input into phonological representations may influence phrasal-boundary analysis (which in turn could affect prosodic contours rather than the other way around as assumed in the IPH). It is not clear at this point how to differentiate between a purely prosody-base explanation from the possible effects of the phonological loop. But the present results contribute in determining more firmly that the phenomenon considered is phonological in nature, thus at least restricting the kinds of explanations that can be entertained.

It is not our intention to claim that deaf readers generate no phonological representation when they read. At least for those who are highly skilled in pronouncing Japanese, there does seem to be a tendency for prosody to affect sentence comprehension (column D of Table 1) in a way similar to the control group. Even for the other deaf participants who show the opposite tendency, it is possible that prosodic structures are being created but that these readers are unable to use this type of information in order to disambiguate the input.

A final caveat is in order in relation to grammatical knowledge. We have claimed based on self-assessments of grammatical knowledge that the deaf readers' less than perfect command of Japanese language is not an issue here. This should not be taken to mean that grammatical knowledge is not important in the processing of the relative clause constructions investigated. On the contrary, grammatical knowledge is crucial in understanding the experimental sentences as they involve complex structures that lead to longer reading times even for hearing participants with full command of the language (Inoue, 1990; Miyamoto, 2002; and references therein). It just seems that for the particular deaf participants in our study, their overall grammatical knowledge is high enough not to interfere with our results (this is probably because students at this university are likely to be relatively successful academically as this is the only tertiary school for the deaf in Japan).

Acknowledgments

The authors would like to thank Yuki Hirose for providing the items used in her experiments, Yoko Iguchi for help running the experiment with the control participants, Marie Watanabe for helpful discussions, and professor Miyoko Hosoya for help recruiting the participants at the Tsukuba University of Technology.

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