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Research Article

Production of Korean Idiomatic Utterances Following Left- and Right-Hemisphere Damage: Acoustic Studies

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AQ1 **Purpose:** This study investigates the effects of left- and right-hemisphere damage (LHD and RHD) on the production of idiomatic or literal expressions utilizing acoustic analyses.
Method: Twenty-one native speakers of Korean with LHD or RHD and in a healthy control (HC) group produced 6 ditropically ambiguous (idiomatic or literal) sentences in 2 different speech tasks: elicitation and repetition. Utterances were analyzed using durational and fundamental-frequency (F0) measures. Listeners' goodness ratings (how well each utterance represented its category: idiomatic or literal) were correlated with acoustic measures.
Results: During the elicitation tasks, the LHD group differed significantly from the HC group in durational measures. Significant differences between the RHD and HC groups were seen in F0 measures. However, for the repetition tasks, the LHD and RHD groups produced utterances comparable to the HC group's performance. Using regression analysis, selected F0 cues were found to be significant predictors for goodness ratings by listeners.
Conclusions: Using elicitation, speakers in the LHD group were deficient in producing durational cues, whereas RHD negatively affected the production of F0 cues. Performance differed for elicitation and repetition, indicating a task effect. Listeners' goodness ratings were highly correlated with the production of certain acoustic cues. Both the acoustic and functional hypotheses of hemispheric specialization were supported for idiom production.

Speech is composed of segmental and suprasegmental features. The segmental aspects of speech are related to the characteristics of individual phonemes such as consonants and vowels. The suprasegmental features of speech refer to prosody, which includes pitch, loudness, and duration, and manifests itself acoustically as fundamental frequency (F0), intensity, and a variety of durational parameters (Baum & Pell, 1999; Gussenhoven, 2001; Kent, Weismer, Kent, Vorperian, & Duffy, 1999; Lehiste, 1970, 1972; J. J. Sidtis & Van Lancker Sidtis, 2003).

Prosody plays an important role in communication. Prosody can indicate lexical stress, establish focus, distinguish given and new information, segment grammatical structures, convey emotions and attitudes, and signal personal identity (Baum, Pell, Leonard, & Gordon, 1997; Kreiman & Sidtis, 2011; J. J. Sidtis & Van Lancker Sidtis, 2003). It has also been reported that prosodic features play a significant role in signaling the speaker's intention to convey literal or nonliteral meanings, as in idioms (Ashby, 2006; Lin, 2013), as reported for Swedish (Hallin & Van Lancker Sidtis, in press), American English (Van Lancker, Canter, & Terbeek, 1981), Korean (Yang, Ahn, & Van Lancker Sidtis, 2015), and French (Abdelli-Beruh, Yang, Ahn, & Van Lancker Sidtis, 2007).

Hemispheric Specialization for Prosodic Cues

Considerable research has investigated whether the processing of auditory-acoustic cues associated with speech relies on hemispheric specialization. The term *prosody* is used to refer to the functional, nonsegmental auditory-acoustic cues associated with speech. Functions of prosody are many, encompassing the conveyance of attitudes, emotions, numerous aspects of discourse structure, and levels of grammatical contrast. Studies have addressed the role of the respective cerebral hemispheres in production and comprehension of the prosodic elements of speech. Following neurological impairment, failure to produce and/or comprehend selected prosodic cues of speech can arise from

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several neurobehavioral conditions, including motoric loss of pitch or timing control, abulia (motivational deficit), mood disturbance, or cognitive impairment (J. J. Sidtis & Van Lancker Sidtis, 2003). There is evidence supporting a role of the right hemisphere in the production and comprehension of some prosodic elements, especially pitch (J. J. Sidtis, 1980), as well as in signaling selected linguistic and emotional information (e.g., Baum & Dwivedi, 2003). In contrast, studies have shown that the left hemisphere is important for production and comprehension of identifiable temporal aspects of prosody (Robin, Tranel, & Damasio, 1990; Zatorre & Belin, 2001). In several studies, both hemispheres have been implicated in prosodic processes (e.g., Ross, Shayya, & Rousseau, 2013), although possibly for different reasons (Pell, 2006; Van Lancker & Sidtis, 1992).

Two specific hypotheses proposed to explain hemispheric asymmetry for auditory processing were considered in this study: the functional lateralization hypothesis (Gandour et al., 2003; Van Lancker, 1980) and the acoustic cue-dependent hypothesis (Robin et al., 1990; Van Lancker & Sidtis, 1992). For prosody, the functional lateralization hypothesis holds that acoustic elements of prosody will be relegated to the left or right hemisphere, respectively, depending on whether a linguistic or nonlinguistic function is involved. A number of studies led to this proposal. Using the dichotic listening paradigm, stress on words yielded better left-hemisphere performance, whereas stress patterns alone were better perceived in the right hemisphere (Behrens, 1985). Pitch contrasts in tones of a tone language were processed better in the left hemisphere of native speakers of Thai but not American English (Van Lancker & Fromkin, 1978). In examining persons with brain damage, left-hemisphere damage (LHD) was found to disrupt production and perception of tone contrasts in speakers of tone languages (Gandour & Dardarananda, 1983), findings later supported by results from functional imaging in healthy speakers (Hsieh, Gandour, Wong, & Hutchins, 2001; Klein, Zatorre, Milner, & Zhao, 2001). In probing perception of affective prosody in tone languages, prosody associated with emotion was reportedly lateralized to the right hemisphere (Edmondson, Chan, Seibert, & Ross, 1987). In a similar vein, using emotional prosodies in speakers of English, individuals with right-hemisphere damage (RHD), compared with individuals with LHD, demonstrated poor performance, suggesting right-hemisphere superiority in processing emotional prosody (Blonder, Pettigrew, & Kryscio, 2012; Heilman, Scholes, & Watson, 1975; Ross & Mesulam, 1979; but see also Cancelliere & Kertesz, 1990).

For this study, the functional lateralization hypothesis addressed an alleged superiority of the right hemisphere in modulating pragmatic abilities in language use (Cheang & Pell, 2006; Dronkers, Ludy, & Redfern, 1998; Mackenzie & Brady, 2004; Weed, 2011). A relative paucity in the proportion of formulaic expression in the spontaneous speech of persons with RHD, compared with persons with LHD, has been documented (D. Sidtis, Canterucci, & Katsnelson, 2009; Van Lancker Sidtis & Postman, 2006). Deficits in processing nonliteral expressions have been reported (Van Lancker & Kempler, 1987; Winner & Gardner, 1977). Although controversies and counterexamples have emerged (Giora, Zaidel, Soroker, Batori, & Kasher, 2000; Papagno, Curti, Rizzo, Crippa, & Colombo, 2006; Papagno, Tabossi, Colombo, & Zampetti, 2004), it has been a consistent finding for about three decades that persons with RHD exhibit impairment in measures of pragmatic language, including inference, nonliteral meanings, and social conversational settings (Cutica, Bucciarelli, & Bara, 2006; Joanette, Goulet, Hannequin, & Boeglin, 1990; Kaplan, Brownell, Jacobs, & Gardner, 1990; Martin & McDonald, 2006; Myers, 2005; Wapner, Hamby, & Gardner, 1981).

The acoustic cue-dependent hypothesis posits the possible superiority of each hemisphere for the comprehension and production of specified acoustic cues within speech prosody (Robin et al., 1990; Van Lancker & Sidtis, 1992). That is, in this view, the left hemisphere is biased for the comprehension and production of temporal cues, and the right hemisphere is biased for the comprehension and production of pitch information (Pell, 1999; Robin et al., 1990; Shah, Baum, & Dwivedi, 2006; J. J. Sidtis, 1980; Van Lancker & Sidtis, 1992; Zatorre, 1997). Performance on a given stimulus will depend on the relative roles of temporal versus pitch information carried by the stimulus. Acoustic analyses of speech prosody produced by individuals with LHD and RHD have yielded consistent results showing impaired control of temporal parameters in individuals with LHD (Baum & Pell, 1997; Gandour & Baum, 2001; Grela, 1999; Ouellette & Baum, 1994; Seddoh, 2004, 2008; Shah et al., 2006; Schirmer, Alter, Kotz, & Friederici, 2001; Van Lancker Sidtis, Kempler, Jackson, & Metter, 2010; Walker, Joseph, & Goodman, 2009) but relatively preserved ability to control durational (and other prosodic) cues in individuals with RHD (Baum & Pell, 1997; Schirmer et al., 2001; Walker, Pelletier, & Reif, 2004). Investigations of the control of F0 in individuals with LHD have yielded mixed results (Baum et al., 2001; Cooper, Soares, Nicol, Michelow, & Goloskie, 1984; Danly & Shapiro, 1982; Gandour & Baum, 2001; Ouellette & Baum, 1994; Schirmer et al., 2001; Walker et al., 2009). For this study, speech productions of idioms and their literal counterparts were acoustically analyzed to determine the relative contribution of the cerebral hemispheres to the integrity of F0 and durational cues.

Speech Task: Effects on Speech Characteristics

The differential effect on phonation and articulation of speech tasks, such as spontaneous speech, reading, or repetition, has been reported (Andrews, Howie, Dozsa, & Guitar, 1982; Hébert, Racette, Gagnon, & Peretz, 2003; Kempler & Van Lancker, 2002; Ludlow & Loucks, 2003; Van Lancker Sidtis, Pachana, Cummings, & Sidtis, 2006). Measures of voice and fluency, as well as of intelligibility, have been reported to vary with spontaneous speech as compared with repetition in disordered speech (Van Lancker Sidtis, Rogers, Godier, Tagliati, & Sidtis, 2010). Task-dependent differences in speech production have suggested that speech task may be an important factor in speech performance. Restricting studies to samples derived from only one kind of task—for example, repetition—may not yield results that can be generalized to typical language use. Although studies of task effects on motor speech disorders have become plentiful, only a few investigations have been conducted regarding the differential effects of speech tasks in individuals with speech-language disorders due to cerebrovascular accidents.

It is well known that repetition and spontaneous speech can be relatively differentially affected or preserved in aphasic disturbance (Goodglass & Kaplan, 1972), leading to differential diagnosis, for example, of conduction versus transcortical aphasia. Further, repetition competence can emerge in different forms. In one study, an individual with aphasia who, by diagnostic criteria, suffered a reduced ability to repeat on command was observed to successfully use repetition in conversation (Oelschlaeger & Damico, 1998). It was our goal to exactly equate and acoustically measure speech samples obtained from repetition and elicitation for idioms and their literal counterparts across persons with LHD and a diagnosis of mild aphasia and those with RHD, as compared with matched speakers in a healthy control (HC) group. Thus, in gathering and analyzing speech samples, this study included two different speech tasks: elicitation and repetition. These tasks differ in terms of speech planning and control. *Elicited speech*, which is defined in our study as the free production of sentences given contextually biased linguistic contexts, is meant to simulate spontaneous speech as closely as possible, requiring the initiation of speech planning and control. *Repeated speech* is the repetition of the same sentences presented and modeled by the examiner. This design enabled a direct comparison of these two tasks using the same sentences.

Goals of the Study and Hypotheses

The study investigated the extent to which literally produced utterances compared with idiomatically produced utterances in a matched ditropic pair are successfully differentiated in production by persons with unilateral brain damage. The main question of this study was whether distinctive neural circuitry is involved in the production of different auditory-acoustic cues for these two different types of utterances. Acoustic analyses of prosodic attributes for different types of sentences produced by individuals with and without brain damage were conducted, with samples acquired in two different speech tasks: elicitation and repetition.

On the basis of the cue-dependent hypothesis, individuals with LHD are expected to have difficulty controlling temporal cues, whereas individuals with RHD are expected to have difficulty with the control of F0. On the basis of the functional lateralization hypothesis, because of background studies showing that RHD is associated with pragmatic deficits, individuals with RHD may be at a selective disadvantage in producing idiomatic utterances that are distinguishable from their literal counterparts.

Method

Data Acquisition

Speakers

Twenty-one native speakers of Korean participated: seven individuals with RHD, seven with LHD, and seven age- and education-matched individuals in the HC group. Demographic and clinical attributes of all speakers are presented in Tables 1 and 2. The speakers ranged in age from 56 to 72 years and in education from 9 to 18 years. Study speakers were right-handed native speakers of Korean, born and educated in South Korea. Healthy speakers had no history of speech-language disorders, or any major medical, other neurological, or psychiatric conditions. T1 T2

Individuals with brain damage had all sustained a single unilateral lesion due to cerebrovascular accident at least 6 months prior to testing. Confirmation of the lesion site for each speaker was obtained from a computed-tomography scan or magnetic resonance imaging (see Tables 1 and 2).

All study speakers with LHD and aphasia were administered the Korean version of the Western Aphasia Battery (K-WAB; Kim & Na, 2001) to determine their language abilities. The K-WAB was also administered to individuals with RHD and to the HC group to confirm that they did not exhibit any language impairment. The severity of the aphasia, as determined by the Aphasia Quotient of the K-WAB, was mild to moderate for individuals with LHD, and individuals with RHD did not show any impairment in language. Individuals with RHD completed the Korean version of the Mini Inventory of Right Brain Injury (K-MIRBI) to detect the presence of neurocognitive deficits associated with RHD. AQ2 For the subtests of the K-MIRBI related to the production of emotional prosody and proverb comprehension, the mean scores of individuals with RHD were, respectively, 1.86 and 2 (out of 2). These scores indicated that individuals with RHD did not reveal abnormal performance on the two subtests. Further, during speech-language evaluations by a trained speech-language pathologist, no speaker was observed to present with dysprosodic speech, aprosodia, conduction aphasia, or transcortical aphasia. The K-MIRBI was not administered to individuals with LHD, because the results can be invalid due to difficulties in speech and language. All speakers with brain damage met the inclusion criteria (mild–moderate aphasia) by scoring an Aphasia Quotient of 50 or above on the K-WAB. None of the individuals with brain damage exhibited any significant motor speech disorders affecting the speech musculature, such as dysarthria

Table 1. Information about speakers in the HC group.

Age (years)	Gender	Education (years)	K-WAB (AQ)
56–71	3 women, 4 men	12–18	98–100

Note. K-WAB (AQ) = Aphasia Quotient on the Korean version of the Western Aphasia Battery. HC = healthy control.

AQ3 **Table 2.** Information about speakers with unilateral cerebral lesions.

Speaker	Age (years)	Gender	Education (years)	Time postonset (years;months)	Lesion site	K-WAB (AQ)	K-MIRBI
LHD							
1	56	F	16	0;11	Frontal	70.6	
2	61	M	12	1;1	Temporoparietal	87.2	
3	67	M	16	5;6	Frontoparietal	63.2	
4	63	F	12	1;9	Frontoparietal	90.2	
5	59	F	16	4;6	Temporoparietal	78.3	
6	68	M	16	3;0	Parietal	82.4	
7	65	M	18	0;8	Frontal	64.8	
Average	62.71		15.14	2;7		76.67	
RHD							
1	63	F	16	1;4	Temporal	98	18.
2	57	F	18	2;5	Frontal	99.0	28.
3	72	M	12	1;7	Temporoparietal	94.5	32.
4	67	M	12	3;2	Frontotemporal-parietal	96.8	30.
5	64	M	12	3;2	Temporoparietal	100.0	27.
6	59	M	16	2;2	Frontal	95.4	22.
7	66	M	16	0;9	Frontoparietal	98.5	31.
Average	64		14.57	1;9		97.46	26.86

Note. K-WAB (AQ) = Aphasia Quotient on the Korean version of the Western Aphasia Battery (scores out of 100); K-MIRBI = Korean version of the Mini Inventory of Right Brain Injury (scores out of 43); LHD = left-hemisphere damage; RHD = right-hemisphere damage.

or apraxia, according to the evaluation by the speech-language pathologist.

Stimuli

Six Korean ditropic sentence pairs were utilized. The sentences were initially selected from a published list of idiomatic expressions derived from ratings of familiarity, meaningfulness, and literal plausibility (Libben & Titone, 2008). Twenty native speakers of Korean then rated 20 idiomatic phrases using those parameters. The results were used to select the six ditropic-idiomatic sentences that obtained the highest ratings. All study sentences have a subject–verb–object structure. All stimuli are provided in the Appendix.

Procedure

Using these stimuli, target utterances were provided by speakers in the three study groups (RHD, LHD, and HC) using two different tasks: elicitation and repetition. Task instructions were given in that order to rule out the possible effect of prerecorded modeled utterances on the production of elicited utterances. The recordings were conducted in a quiet environment using a head-worn microphone maintaining a constant mouth-to-microphone distance of 2 in. Microphone position and recording gain settings were the same across all groups of speakers. Speakers first reviewed a written master list of the target sentences to familiarize themselves with the study material. For the elicitation task, speakers were instructed to produce spoken target utterances in response to a verbal and written situational context provided by the experimenter. Modeled utterances were not provided for the elicitation task. Using cards, social and verbal (linguistic) contexts in the form of possible scenarios were given in order to help the speakers to generate the target utterances with the intended meanings. For the ambiguous sentence "그사람이입을다물었어 (*He closed his mouth*)," one linguistic context (*During the police investigation, he did not say anything*) referenced the idiomatic interpretation (*He kept silent*). The other linguistic context (*After the oral surgery, he could not open his mouth*) referenced the literal interpretation (*He had his mouth closed*). Linguistic contexts for each target utterance used during the elicitation task are provided in the Appendix. Speakers were provided with cards written with the target sentences, their intended interpretations labeled as either *idiomatic* or *literal,* and the respective linguistic context for the idiomatic or literal interpretation. Before speakers produced the target utterances, the cards containing the written target sentences and their intended interpretations were taken away, in order to encourage speakers to produce the sentences in a natural manner. Familiarity with the stimuli and understanding of their meanings were confirmed by speakers' producing the target utterances. Speakers produced the target sentence first in its idiomatic interpretation and then in its literal interpretation (always in this order to minimize confusion). Speakers were allowed to revisit the master list of target utterances whenever they needed to. Twelve utterances were elicited (six with the idiomatic interpretation and six with the literal interpretation) per speaker.

The same sentences used in the elicitation task were used in the repetition task. Each utterance corresponding to the intended category (literal or idiomatic) was prerecorded by a native speaker trained to produce the utterances in a natural manner. For the repetition task, all speakers were asked to listen to the recording and repeat the recorded sentences as closely as possible. Speakers were informed of the intended meaning of each utterance before producing their response.

Acoustic Measurements

The stimuli were analyzed with the Praat software (Version 4.6.34; Boersma & Weenink, 2007). Acoustic parameters were selected for differentiating idiomatic from literal counterparts on the basis of previous studies (Van Lancker et al., 1981). Durational measures included overall sentence duration, variability of syllable duration, final-syllable duration, and percentage of pause duration in the whole sentence. In order to calculate variability of syllable duration, the duration of each syllable in the utterance was measured; variability of syllable duration was represented by the standard deviation. With respect to F0 measurements, the mean F0, standard deviation of F0 (*SD* F0), and F0 declination were computed. To allow for gender differences in F0, the raw F0 of literal utterances was subtracted from the raw F0 of idiomatic utterances, and then the number was divided by the raw F0 of literal utterances. Coefficients of F0 variation were calculated to measure *SD* F0. In order to compute F0 declination, percentages of F0 changes at the ends of sentences were measured to calculate the F0 changes between the last two syllables in the idiomatic as compared with the literal utterances.

Goodness-Rating Task

Forty native speakers of Korean were recruited to judge the goodness of each stimulus. The listeners were between 25 and 40 years old; ranged in education from 9 to 18 years; and were free of hearing deficits, speech-language disorders, and major medical, neurological, and psychological conditions. Listeners were instructed to rate each item individually on a scale of 1 (*very poor*) to 5 (*good*) on presentation of the stimulus item. For this task, each listener was informed, before the presentation of each stimulus, whether the given utterance was spoken with an intended idiomatic or literal meaning. Two groups of listeners listened to 216 test utterances, separated into blocks so that no utterance was heard in both the literal and idiomatic version by any single listener.

Statistical Analysis

Repeated measures analyses of variance (ANOVAs) were conducted to determine the difference between groups (LHD, RHD, HC) and, within each group, between sentence types (idiomatic vs. literal). Dependent variables were durational and F0 measurements. Separate ANOVAs were carried out for each dependent variable. Independent and pairwise *t* tests were conducted as post hoc analyses to further examine between-groups and within-group comparisons and to compare between tasks (elicitation vs. repetition). Effect size (partial eta squared) is also reported for each analysis.

To examine the relationship between the acoustic features and native listeners' goodness ratings, a stepwise multiple linear regression procedure was conducted. Correlation coefficients were calculated to further analyze the relationship between individual acoustic features and goodness ratings.

Results

Elicitation Task

Durational Measurements

Syllable-duration variation, final-syllable duration, and percentage of pause duration were selected for reporting here. Typical examples of variability of syllable duration and final-syllable duration within a sentence produced by a speaker from each study group are presented in Figure 1. AQ4 F1

Variability of syllable duration. For stimuli obtained from the elicitation task, a repeated measures ANOVA revealed significant main effects in the syllable-duration measure of group, $F(2, 123) = 7.39$, $p = .001$, $\eta_p^2 = .11$; sentence type, $F(1, 123) = 41.83$, $p < .001$, $\eta_p^2 = .25$; and a Group × Sentence Type interaction, $F(2, 123) = 10.75$, $p < .001$, $\eta_p^2 = .15$.

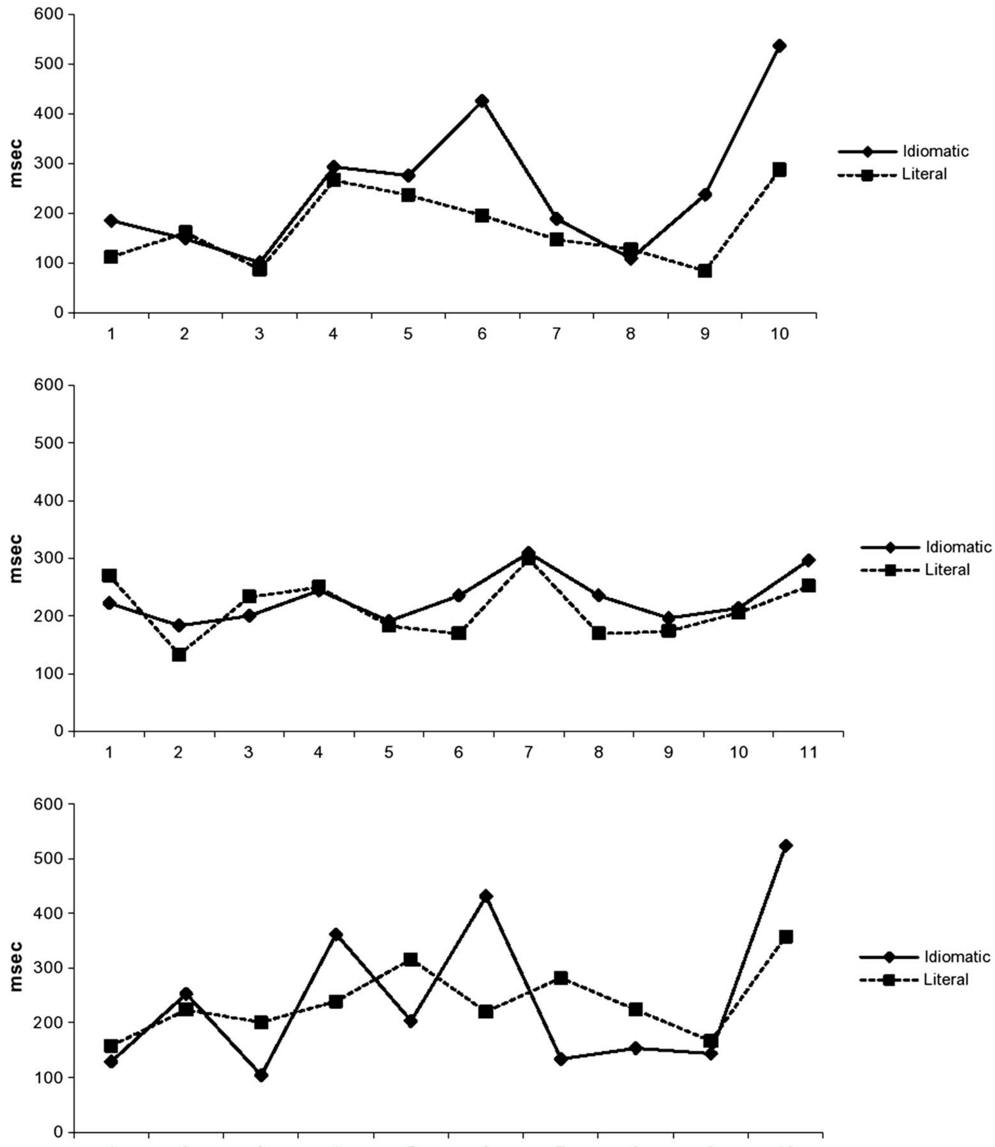
In comparing syllable-duration variation between idiomatic and literal utterances obtained by elicitation, sentence-type differences revealed greater variation in idiomatic utterances. Further analysis of the Group × Sentence Type interaction revealed that only the RHD group, $t(42) = 8.16$, $p < .001$, and HC group, $t(41) = 13.78$, $p < .001$, produced idiomatic utterances with greater variation in syllable duration compared with literal utterances; the LHD group did not show such differences.

Final-syllable duration. Continuing with results for the elicitation task, a repeated measures ANOVA revealed significant main effects of group, $F(2, 123) = 26.21$, $p < .001$, $\eta_p^2 = .30$; sentence type, $F(1, 123) = 99.73$, $p < .001$, $\eta_p^2 = .45$; and a Group × Sentence Type interaction, $F(2, 123) = 15.07$, $p < .001$, $\eta_p^2 = .20$—suggesting a main role of the final syllable in these studies.

Comparing groups, final-syllable durations in idiomatic utterances were significantly longer for the RHD group, $t(82) = 22.76$, $p < .001$, and HC group, $t(82) = 50.50$, $p < .001$, compared with the LHD group. The three groups did not differ from each other in terms of the final-syllable duration of literal utterances. Further analysis of the Group × Sentence Type interaction demonstrated significant differences in final-syllable duration between idiomatic and literal utterances in the RHD group, $t(41) = 9.12$, $p < .001$, and HC group, $t(41) = 12.65$, $p < .001$, but not the LHD group. These results reflect better preserved temporal information in the RHD compared with the LHD group.

Percentage of pause duration. A repeated measures ANOVA revealed significant main effects of group, $F(2, 123) = 11.16$, $p < .001$, $\eta_p^2 = .15$, and sentence type, $F(1, 123) = 38.39$, $p < .001$, $\eta_p^2 = .24$. However, there was no Group × Sentence Type interaction. Post hoc analyses of group differences revealed that the LHD group did not show any significant difference in pause duration between the two sentence types. In contrast, the percentage of pause duration was greater for literal utterances in the RHD group, $t(41) = -4.557$, $p < .001$, and HC group, $t(41) = -9.492$, $p < .001$ (see Figure 4). It appears that F4

Figure 1. Typical examples of variability of syllable duration and final-syllable duration within a sentence produced by a speaker of each group (top: right-hemisphere damage, middle: left-hemisphere damage, bottom: healthy control).



speakers in the RHD group may have used pausing to discriminate between utterance types, as did those in the HC group.

Summary: Durational measurements of elicited utterances. Durational measurements of elicited utterances revealed that sentence types spoken with contrasting idiomatic or literal meanings differed in duration measures, and these differences varied across groups. There were no significant differences between idiomatic and literal utterances in speakers in the LHD group with respect to three durational measures (syllable-duration variation, final-syllable duration, and percentage of pause duration) during the elicitation task. The HC and RHD groups produced literal utterances with longer sentence durations and greater percentages of pause duration compared with idiomatic utterances. They also produced idiomatic utterances with greater syllable-duration variation and final-syllable duration compared with literal utterances. Overall, for the elicitation task, speakers in the LHD group made less use of durational cues to differentiate the two types of meanings. However, speakers in the RHD group produced idiomatic and literal utterances comparable to those of the HC group in terms of durational measures.

F0 Measures

The results for F0 variation and sentence-final F0 change are reported here; typical examples as produced by a speaker from each group are presented in Figure 5. F5

Figure 2. Means and standard errors for variability of syllable duration for the utterances produced by the three groups on the elicitation task. Idiomatic utterances are represented by the filled bars. Literal utterances are represented by the open bars. LHD = left-hemisphere damage; RHD = right-hemisphere damage; HC = healthy control.

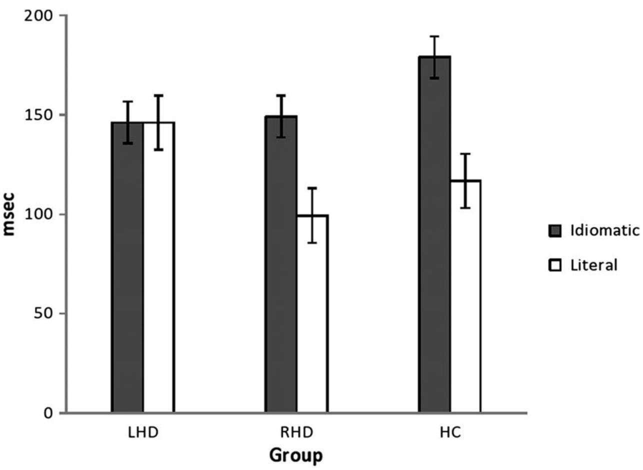
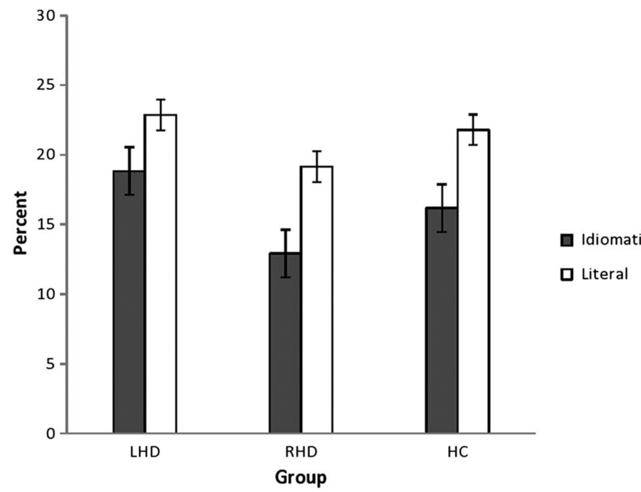


Figure 4. Means and standard errors for percentages of pause duration to overall sentence duration for the utterances produced by the three groups on the elicitation task. Idiomatic utterances are represented by the filled bars. Literal utterances are represented by the open bars. LHD = left-hemisphere damage; RHD = right-hemisphere damage; HC = healthy control.



F0 variation. When F0 variation measures were compared for elicited stimuli, a repeated measures ANOVA yielded significant main effects of group, $F(2, 123) = 33.52$, $p < .001$, $\eta_p^2 = .35$; sentence type, $F(1, 123) = 103.22$, $p < .001$, $\eta_p^2 = .46$; and a Group × Sentence Type interaction, $F(2, 123) = 16.50$, $p < .001$, $\eta_p^2 = .21$.

Group comparisons revealed that the responses elicited from the RHD group differed significantly from those obtained from the other groups in terms of F0 variation for both idiomatic and literal utterances. Speakers in the RHD group produced idiomatic utterances with less variation compared with those in the LHD group, $t(82) = 1.92$, $p < .001$, and HC group, $t(82) = 1.06$, $p < .001$. Literal utterances elicited from speakers in the RHD group were also produced with less variation than those from speakers in the LHD group, $t(82) = 0.79$, $p = .11$, and HC group, $t(82) = 0.15$, $p < .001$. Further analysis of the Group × Sentence Type interaction revealed that idiomatic utterances were produced with greater variation in F0 compared with literal counterparts in the LHD group, $t(41) = 6.02$, $p < .001$, and HC group, $t(41) = 11.07$, $p < .001$, whereas such differences were not shown in the RHD group. The LHD and HC groups showed similar patterns with respect to F0 variation between the two types of utterance. These results suggest that production of pitch contrasts was less successful in the RHD group.

F0 change at the ends of sentences. Measures of F0 on sentence-final syllables in elicited utterances were compared, because these have been revealed to be potent cues to differentiating utterance meanings (Yang et al., 2015). A repeated measures ANOVA yielded significant main effects of group, $F(2, 123) = 92.90$, $p < .001$, $\eta_p^2 = .65$; sentence type, $F(1, 123) = 60.26$, $p < .001$, $\eta_p^2 = .37$; and a Group × Sentence Type interaction, $F(2, 123) = 14.76$, $p < .001$, $\eta_p^2 = .23$—indicating that the F0 of final syllables contrasted sentence types differently in the three groups.

Post hoc analyses of the Group × Sentence Type interaction revealed, for elicited utterances, significantly greater F0 change in the last two syllables of idiomatic utterances compared with literal counterparts for both the LHD group, $t(30) = 4.46$, $p < .001$, and HC group, $t(41) = 8.52$, $p < .001$. However, the RHD group did not show such differences in final F0 change, as shown in Figure 7. F7

Figure 3. Means and standard errors for percentages of final-syllable duration to overall sentence duration for the utterances produced by the three groups on the elicitation task. Idiomatic utterances are represented by the filled bars. Literal utterances are represented by the open bars. LHD = left-hemisphere damage; RHD = right-hemisphere damage; HC = healthy control.

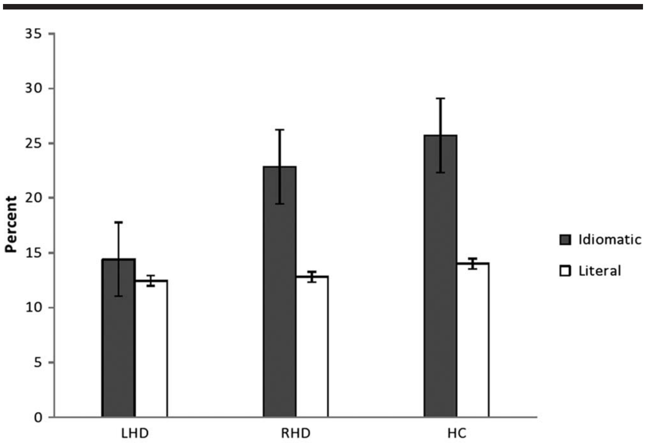
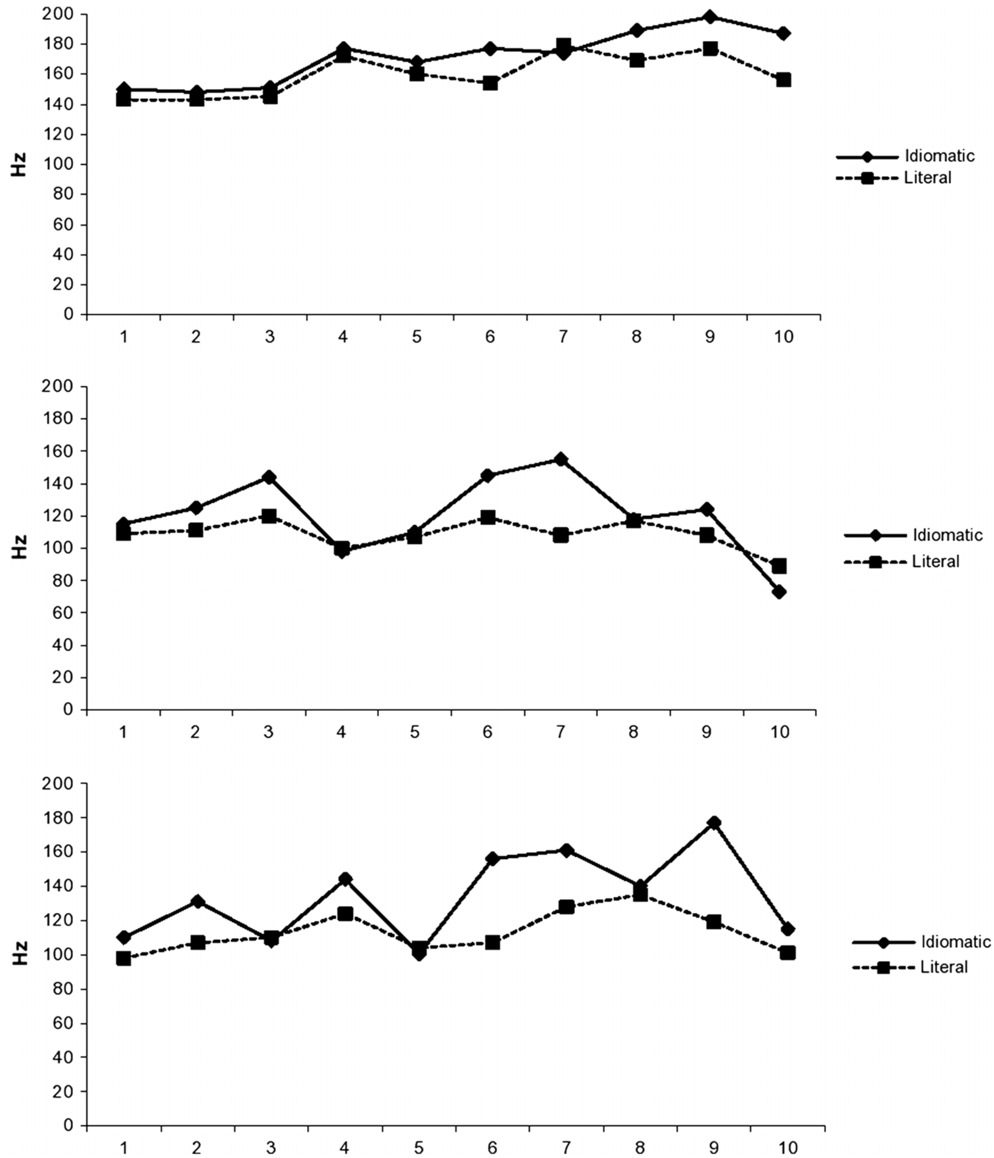


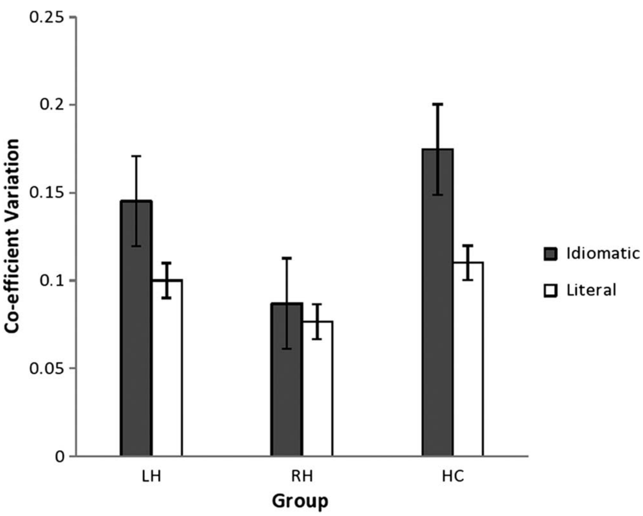
Figure 5. Typical examples of F0 variation and final F0 change within a sentence produced by a speaker of each group (top: right-hemisphere damage, middle: left-hemisphere damage, bottom: healthy control).



The LHD group differed significantly from the HC group in mean final F0 measures of idiomatic utterances. However, the LHD and HC groups showed similar patterns in percentage of change in F0 between the two sentence types. As can be seen in Figure 7, the RHD group did not manifest this pattern in F0 contrast. Again, the RHD group revealed insufficient use of pitch contrasts in this measure compared with other groups.

Summary: F0 measurements of elicited utterances. F0 measures of utterances elicited from speakers in all three groups showed that idiomatic and literal utterances produced by the HC group differed significantly with respect
AQ5 to overall F0, F0 variation, and sentence-final F0 change. For the HC group, idiomatic utterances had higher overall F0, greater F0 variation, and greater F0 change in final syllables compared with literal utterances. Unlike the HC group, speakers with brain damage did not show differences between the two types of sentences with respect to overall F0. However, differences in F0 variation were seen: Speakers in the LHD group produced idiomatic utterances with greater F0 variation and greater F0 change in sentence-final position compared with literal utterances. They produced idiomatic utterances comparable to those of the HC group with respect to F0 variation and final F0 change. However, speakers in the RHD group did not show such differences. It can be inferred that speakers in the RHD group showed a reduced tendency to use F0 cues to differentiate between idiomatic and literal utterances.

Figure 6. Means and standard errors for F0 variation for the utterances produced by the three groups on the elicitation task. Idiomatic utterances are represented by the filled bars. Literal utterances are represented by the open bars. LH = left hemisphere; RH = right hemisphere; HC = healthy control.



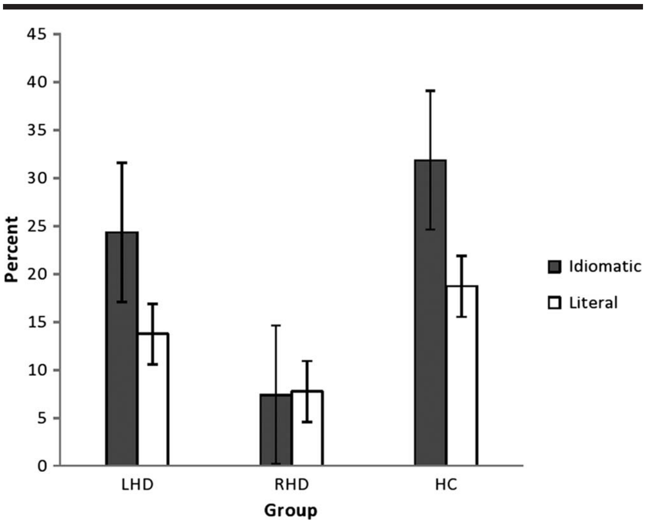
Repetition Task

The repetition task differed from the elicitation task in that an audio-recorded model was provided for repetition by the speakers. Therefore, productions by speakers were evaluated in comparison to measures taken for the modeled utterances.

During the repetition task, all three groups of speakers showed similar patterns to differentiate between idiomatic and literal utterances with respect to all durational measures, likely due to the influence of modeled utterances. Statistical procedures did not yield differences between groups on duration or F0 measures; speakers with brain damage produced the two different types of utterances with durational measures comparable to those of the HC group. For speakers overall, literal utterances were produced with longer sentence duration, longer final syllables, and longer pauses compared with idiomatic utterances. Idiomatic utterances were produced with greater syllable-duration variation and longer final-syllable duration than their literal counterparts.

With respect to F0 measurements during the repetition task, all groups of speakers showed similar patterns: Idiomatic utterances were produced with high overall F0, greater F0 variation, and greater final F0 change compared with literal counterparts. Speakers with brain damage showed comparable performance to those in the HC group in producing F0 cues for idiomatic and literal utterances during the repetition task. These results reflect the effect of speech task on speech performance, and also indicate that F0 and duration cues were available and appropriate when a model was provided. These results indicate that the deficiencies in producing prosodic contrasts in the elicited stimuli may arise from "higher order" programming contingencies and are not the result of peripheral motor deficits.

Figure 7. Means and standard errors for final F0 change for the utterances produced by the three groups on the elicitation task. Idiomatic utterances are represented by the filled bars. Literal utterances are represented by the open bars. LHD = left-hemisphere damage; RHD = right-hemisphere damage; HC = healthy control.



Relationship Between Goodness Ratings and Acoustic Features of Elicited Utterances

The results from acoustic analyses were further analyzed by examining the relationship between acoustic features and native listeners' goodness ratings of elicited utterances produced by speakers in the three study groups (RHD, LHD, HC) combined. Multiple linear regression revealed that final F0 change, final-syllable duration, F0 variation, and overall sentence duration are significant predictors for goodness ratings of idiomatic utterances in the elicitation tasks, $R^2 = .641$, $F(3, 111) = 66.02$, $p < .001$. AQ6 Further analyses were conducted for each acoustic feature. Significantly strong correlations were found for elicited idiomatic utterances between goodness ratings and final F0 change, $r = .75$, $p < .001$, and between ratings and F0 variation, $r = .65$, $p < .001$. Examination was also conducted for each group of speakers separately. Whereas final F0 change was the significant predictor of idiomatic utterances for the RHD group, $R^2 = .32$, $F(1, 35) = 16.11$, $p < .001$, final-syllable duration and overall sentence duration were the significant predictors of idiomatic utterances for the LHD group, $R^2 = .42$, $F(2, 33) = 12.15$, $p < .001$. For the HC group, both final F0 change and final-syllable duration were significant predictors of idiomatic utterances, $R^2 = .3$, $F(2, 39) = 8.44$, $p = 0.001$.

For literal utterances elicited from all three groups of speakers (RHD, LHD, HC), utterance-final F0 change and F0 variation were significant predictors, $R^2 = .48$, $F(3, 107) = 10.83$, $p < .001$. Further correlation analysis revealed that the F0 difference between idiomatic and literal utterances was moderately correlated with the goodness ratings of elicited literal utterances, $r = .31$, $p < .001$. Individual group analysis for elicited literal sentences revealed that final F0 change and overall F0 were significant predictors of literal utterances for the RHD group, $R^2 = .38$, $F(2, 32) = 9.87$, $p < .001$, whereas F0 variation and final F0 change serve as significant predictors of literal utterances for the LHD group, $R^2 = .12$, $F(1, 32) = 4.40$, $p = .44$, and the HC group, $R^2 = .16$, $F(1, 40) = 7.40$, $p = .1$.

Statistical analyses on the relationship between acoustic features and native listeners' goodness ratings suggested that some acoustic cues are highly related with the goodness ratings, serving as significant predictors for elicited utterances. Overall, final F0 change and F0 variation were found to be significant predictors for goodness ratings.

Discussion

The purpose of this study was to investigate acoustically the differential contributions of the intact left hemisphere and right hemisphere in persons with hemispheric damage in producing prosodic features used to differentiate idiomatic from literal meanings of ambiguous sentences. One main question addressed the ability of the speakers with LHD and RHD to utilize different acoustic cues to differentiate idiomatic from literal utterances. The other questions addressed the differential effect of speech task on performance.

The acoustic analyses of utterances produced by the HC group in both elicitation and repetition tasks suggest that idiomatic and literal meanings of ditropic sentences are signaled by contrasting, quantifiable acoustic cues in Korean. Healthy native speakers of Korean (HC group) consistently utilized acoustic cues to signal the intended meanings (idiomatic vs. literal) of ditropic sentences; durational cues (syllable-duration variation, final-syllable duration, pause duration) and F0 cues (F0 variation, final F0 change) were seen to contrastively represent idiomatic versus literal meanings of ambiguous utterances. Idiomatic utterances were produced with greater syllable-duration variation and longer final-syllable duration compared with literal utterances. The results of acoustic analyses are consistent with previous findings (Abdelli-Beruh et al., 2007; Van Lancker et al., 1981; Yang et al., 2015) in that idiomatic and literal utterances are characterized by specific prosodic contours.

A major finding of this study is that damage to different parts of the brain differentially affected the production of prosodic cues. Acoustic analyses of elicited utterances revealed that, overall, LHD negatively affected the production of durational cues and RHD negatively affected the production of F0 cues, which is consistent with previous studies showing impaired control of temporal parameters (Baum et al., 2001; Baum & Pell, 1997; Robin et al., 1990; Schirmer et al., 2001; Seddoh, 2004, 2008; Shah et al., 2006; J. J. Sidtis, 1980; Van Lancker & Sidtis, 1992) and intact ability to control F0 cues in LHD (Ouellette & Baum, 1994; Zatorre, 1997; Zatorre & Belin, 2001).

During the elicitation task, speakers with LHD significantly differed from those in the HC group in duration measures. Speakers with LHD failed to modulate durational cues to signal the contrast between idiomatic and literal utterances. Speakers with LHD also exhibited impairment in controlling final-syllable duration, which is compatible with previous research suggesting that individuals with LHD show reduced sentence-final lengthening compared with other participant groups (Baum et al., 1997, 2001; Baum & Boyczuk, 1999; Bélanger, Baum, & Titone, 2009; Danly & Shapiro, 1985; Van Lancker Sidtis et al., 2010). AQ7 AQ8 Significant differences between speakers with RHD and those in the HC group were seen in measures of F0 during the elicitation task. Speakers with RHD showed relatively preserved ability to control duration cues, which is consistent with previous findings (Baum & Pell, 1997; Schirmer et al., 2001; Walker et al., 2004). These findings are compatible with the acoustic cue-dependent hypothesis (Robin et al., 1990; J. J. Sidtis, 1980; Van Lancker & Sidtis, 1992).

The findings of this study reveal that individuals with brain damage showed performance differences between two speech tasks (elicitation vs. repetition). They approximated the performance of speakers in the HC group for durational and F0 cues in the repetition task, whereas they showed significant differences in producing prosodic cues compared with the HC group in the elicitation task. These task-dependent differences provide evidence that phonatory and articulatory parameters of speech may be affected by different speech conditions (Canter & Van Lancker, 1985; Duffy, 1995; Kempler & Van Lancker, 2002; Kent et al., 1999; Schalling & Hartelius, 2004; Van Lancker Sidtis et al., 2010). A fundamental reason for the discrepancy on the basis of speech task may involve the availability of external or internal visual or timing models guiding a motor act (Freeman, Cody, & Schady, 1993; Georgiou et al., 1993). For spontaneous speech production, speakers generate a novel action plan and execute and monitor the action using internal models. In repetition, an external model is provided, reducing the burden of planning, execution, and monitoring for the speaker (Max, Guenther, Gracco, Ghosh, & Wallace, 2004).

Further studies might examine abilities to produce contrasts in idiomatic and literal utterances in association with diagnostic categories in aphasia. A previous report by McCarthy and Warrington (1984) described differential performance in repetition, depending on aphasic diagnosis, in association with high or low semantic content. In a related finding, an individual diagnosed with transcortical sensory aphasia spontaneously produced and repeated formulaic expressions fluently despite a severe semantic disability. Other explorations would do well to compare study groups with and without focal subcortical damage, probing prosodic as well as idiomatic competences (Karow, Marquardt, & Marshall, 2001; D. Sidtis et al., 2009; Van Lancker Sidtis et al., 2006; Van Lancker Sidtis, 2012).

Acoustic analyses combined with the results from goodness ratings by listeners suggest that combined durational and frequency measurements were linked to the identification and goodness ratings in elicited modes. It was revealed that final F0 change and F0 variation were the most important predictors for the goodness ratings of sentences.

Findings of this study implicate both left and right hemispheres in the production of idiomatic utterances. All speakers with brain damage exhibited impairment in the production of prosodic cues associated with idiomatic sentences during the elicitation task when compared with speakers in the HC group. As measured by acoustic analysis of elicited sentences, speakers with LHD exhibited a diminution of durational cues and relied primarily on final F0 changes to signal the contrast between idiomatic and literal utterances. In contrast, speakers with RHD showed difficulty modulating F0 cues and depended mainly on temporal cues to discriminate between two different types of languages (idiomatic vs. literal) during the elicitation task. However, it is striking to note that speakers with brain damage revealed relatively intact competence at idiomatic and literal utterance production when given a model in a repetition task.

These results suggest that both left and right hemispheres are involved in idiom production and that damage to either hemisphere can impair this ability in spontaneous speech but less so in repetition. The present findings point to specific F0 and durational parameters that are utilized for signaling idiomatic versus literal utterances and implicate left-hemisphere superiority for the control of temporal cues and right-hemisphere modulation of F0 cues in speech production.

The deficit in producing typical elicited idiomatic utterances in speakers with RHD is all the more compelling because RHD is not typically associated with speech
AQ9 or language disorder. In a companion study (Yang & Van Lancker Sidtis, 2015), it has been reported that in an identification task (labeling utterances as *literal* or *idiomatic*), healthy listeners perform worse on utterances produced by speakers with RHD than by speakers with LHD or in an HC group. A right-hemisphere specialization for pragmatic communication, including processing of nonliteral expressions, is also supported by our findings. Both the acoustic and functional hypotheses of hemispheric specialization remain viable explanations for these results.

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References

Abdelli-Beruh, N., Yang, S., Ahn, J., & Van Lancker Sidtis, D.
AQ10 (2007, November). *Acoustic cues differentiating idiomatic from literal expressions across languages*. Presented at the Annual Convention of the American Speech-Language-Hearing Association, Boston, MA.

Andrews, G., Howie, P. M., Dozsa, M., & Guitar, B. E. (1982). Stuttering: Speech pattern characteristics under fluency-inducing conditions. *Journal of Speech and Hearing Research, 25,* 208–216.

Ashby, M. (2006). Prosody and idioms in English. *Journal of Pragmatics, 38,* 1580–1597.

Baum, S. R., & Boyczuk, J. P. (1999). Speech timing subsequent to brain damage: Effects of utterance length and complexity. *Brain and Language, 67,* 30–45.

Baum, S. R., & Dwivedi, V. D. (2003). Sensitivity to prosodic structure in left- and right-hemisphere-damaged individuals. *Brain and Language, 87,* 278–289.

Baum, S. R., & Pell, M. D. (1997). Production of affective and linguistic prosody by brain-damaged patients. *Aphasiology, 11,* 177–198.

Baum, S. R., & Pell, M. D. (1999). The neural bases of prosody: Insights from lesion studies and neuroimaging. *Aphasiology, 13,* 581–608.

Baum, S. R., Pell, M. D., Leonard, C. L., & Gordon, J. K. (1997). The ability of right- and left-hemisphere-damaged individuals to produce and interpret prosodic cues marking phrasal boundaries. *Language and Speech, 40,* 313–330.

Baum, S. R., Pell, M. D., Leonard, C. L., & Gordon, J. K. (2001). Using prosody to resolve temporary syntactic ambiguities in speech production: Acoustic data on brain-damaged speakers. *Clinical Linguistics & Phonetics, 15,* 441–456.

Behrens, S. J. (1985). The perception of stress and lateralization of prosody. *Brain and Language, 26,* 332–348.

Bélanger, N., Baum, S. R., & Titone, D. (2009). Use of prosodic cues in the production of idiomatic and literal sentences by individuals with right- and left-hemisphere damage. *Brain and Language, 110,* 38–42.

Blonder, L. X., Pettigrew, L. C., & Kryscio, R. J. (2012). Emotion recognition and marital satisfaction in stroke. *Journal of Clinical and Experimental Neuropsychology, 34,* 634–642.

Boersma, P., & Weenink, D. (2007). Praat: Doing phonetics by computer (Version 4.6.34) [Computer software]. Retrieved from http://www.URL.com AQ11

Cancelliere, A. E. B., & Kertesz, A. (1990). Lesion localization in acquired deficits of emotional expression and comprehension. *Brain and Cognition, 13,* 133–147.

Canter, G. J., & Van Lancker, D. R. (1985). Disturbances of the temporal organization of speech following bilateral thalamic surgery in a patient with Parkinson's disease. *Journal of Communication Disorders, 18,* 329–349.

Cheang, H. S., & Pell, M. D. (2006). A study of humour and communicative intention following right hemisphere stroke. *Clinical Linguistics & Phonetics, 20,* 447–462.

Cooper, W. E., Soares, C., Nicol, J., Michelow, D., & Goloskie, S. (1984). Clausal intonation after unilateral brain damage. *Language and Speech, 27,* 17–24.

Cutica, I., Bucciarelli, M., & Bara, B. G. (2006). Neuropragmatics: Extralinguistic pragmatic ability is better preserved in left-hemisphere-damaged patients than in right-hemisphere-damaged patients. *Brain and Language, 98,* 12–25.

Danly, M., & Shapiro, B. (1982). Speech prosody in Broca's aphasia. *Brain and Language, 16,* 171–190.

Dronkers, N. F., Ludy, C. A., & Redfern, B. B. (1998). Pragmatics in the absence of verbal language: Descriptions of a severe aphasic and a language-deprived adult. *Journal of Neurolinguistics, 11,* 179–190.

Duffy, J. R. (1995). *Motor speech disorders: Substrates, differential diagnosis, and management*. St. Louis, MO: Mosby.

Edmondson, J. A., Chan, J.-L., Seibert, G. B., & Ross, E. D. (1987). The effect of right-brain damage on acoustical measures of affective prosody in Taiwanese. *Journal of Phonetics, 15,* 219–233.
Freeman, J. S., Cody, F. W., & Schady, W. (1993). The influence of external timing cues upon the rhythm of voluntary movements in Parkinson's disease. *Journal of Neurology, Neurosurgery, & Psychiatry, 56,* 1078–1084.
Gandour, J., & Baum, S. R. (2001). Production of stress retraction by left- and right-hemisphere-damaged patients. *Brain and Language, 79,* 482–494.
Gandour, J., & Dardarananda, R. (1983). Identification of tonal contrasts in Thai aphasic patients. *Brain and Language, 18,* 98–114.
Gandour, J., Dzemidzic, M., Wong, D., Lowe, M., Tong, Y., Hsieh, L., . . . Lurito, J. (2003). Temporal integration of speech prosody is shaped by language experience: An fMRI study. *Brain and Language, 84,* 318–336.
Georgiou, N., Iansek, R., Bradshaw, J. L., Phillips, J. G., Mattingley, J. B., & Bradshaw, J. A. (1993). An evaluation of the role of internal cues in the pathogenesis of parkinsonian hypokinesia. *Brain, 116,* 1575–1587.
Giora, R., Zaidel, E., Soroker, N., Batori, G., & Kasher, A. (2000). Differential effects of right- and left-hemisphere damage on understanding sarcasm and metaphor. *Metaphor and Symbol, 15,* 63–83.
Goodglass, H., & Kaplan, E. (1972). *The assessment of aphasia and related disorders*. Philadelphia, PA: Lea & Febiger.
Grela, B. (1999). Stress shift in aphasia: A multiple case study. *Aphasiology, 13,* 151–166.
Gussenhoven, C. (2001). Suprasegmentals. In N. J. Smelser & P. B. Baltes (Eds.), *International encyclopedia of the social & behavioral sciences* (pp. 15294–15298). Oxford, England: Pergamon.
AQ12 **Hallin, A. E., & Van Lancker Sidtis, D.** (in press). A closer look at formulaic language: Prosodic characteristics of Swedish proverbs. *Applied Linguistics*. doi:10.1093/applin/amu078
Hébert, S., Racette, A., Gagnon, L., & Peretz, I. (2003). Revisiting the dissociation between singing and speaking in expressive aphasia. *Brain, 126,* 1838–1850.
Heilman, K. M., Scholes, R., & Watson, R. T. (1975). Auditory affective agnosia. Disturbed comprehension of affective speech. *Journal of Neurology, Neurosurgery, & Psychiatry, 38,* 69–72.
Hsieh, L., Gandour, J., Wong, D., & Hutchins, G. D. (2001). Functional heterogeneity of inferior frontal gyrus is shaped by linguistic experience. *Brain and Language, 76,* 227–252.
Joanette, Y., Goulet, P., Hannequin, D., & Boeglin, J. (1990). *Right hemisphere and verbal communication*. New York, NY: Springer-Verlag.
Kaplan, J. A., Brownell, H. H., Jacobs, J. R., & Gardner, H. (1990). The effects of right hemisphere damage on the pragmatic interpretation of conversational remarks. *Brain and Language, 38,* 315–333.
Karow, C. M., Marquardt, T. P., & Marshall, R. C. (2001). Affective processing in left and right hemisphere brain-damaged subjects with and without subcortical involvement. *Aphasiology, 15,* 715–729.
Kempler, D., & Van Lancker, D. (2002). Effect of speech task on intelligibility in dysarthria: A case study of Parkinson's disease. *Brain and Language, 80,* 449–464.
Kent, R. D., Weismer, G., Kent, J. F., Vorperian, H. K., & Duffy, J. R. (1999). Acoustic studies of dysarthric speech: Methods, progress, and potential. *Journal of Communication Disorders, 32,* 141–186.
Kim, H., & Na, D. L. (2001). *Paradise Korean version—the Western Aphasia Battery*. Seoul, South Korea: Paradise Welfare Foundation. AQ13
Klein, D., Zatorre, R. J., Milner, B., & Zhao, V. (2001). A cross-linguistic PET study of tone perception in Mandarin Chinese and English speakers. *NeuroImage, 13,* 646–653.
Kreiman, J., & Sidtis, D. (2011). *Foundations of voice studies: An interdisciplinary approach to voice production and perception*. Boston, MA: Wiley-Blackwell.
Lehiste, I. (1970). *Suprasegmentals*. Cambridge, MA: MIT Press.
Lehiste, I. (1972). The timing of utterances and linguistic boundaries. *The Journal of the Acoustical Society of America, 51,* 2018–2024.
Libben, M. R., & Titone, D. A. (2008). The multidetermined nature of idiom processing. *Memory & Cognition, 36,* 1103–1121.
Lin, P. (2013). The prosody of formulaic expression in the IBM/Lancaster Spoken English Corpus. *International Journal of Corpus Linguistics, 18,* 561–588.
Ludlow, C. L., & Loucks, T. (2003). Stuttering: A dynamic motor control disorder. *Journal of Fluency Disorders, 28,* 273–295.
Mackenzie, C., & Brady, M. (2004). Communication ability in non-right handers following right hemisphere stroke. *Journal of Neurolinguistics, 17,* 301–313.
Martin, I., & McDonald, S. (2006). That can't be right! What causes pragmatic language impairment following right hemisphere damage? *Brain Impairment, 7,* 202–211.
Max, L., Guenther, F. H., Gracco, V. L., Ghosh, S. S., & Wallace, M. E. (2004). Unstable or insufficiently activated internal models and feedback-biased motor control as sources of dysfluency: A theoretical model of stuttering. *Contemporary Issues in Communication Science and Disorders, 31,* 105–122.
McCarthy, R., & Warrington, E. K. (1984). A two-route model of speech production: Evidence from aphasia. *Brain, 107,* 463–485.
Myers, P. (2005). Profiles of communication deficits in patients with right cerebral hemisphere damage: Implications for diagnosis and treatment. *Aphasiology, 19,* 1147–1160.
Oelschlaeger, M., & Damico, J. S. (1998). Spontaneous verbal repetition: A social strategy in aphasic conversation. *Aphasiology, 12,* 971–988.
Ouellette, G. P., & Baum, S. R. (1994). Acoustic analysis of prosodic cues in left- and right-hemisphere-damaged patients. *Aphasiology, 8,* 257–283.
Papagno, C., Curti, R., Rizzo, S., Crippa, F., & Colombo, M. R. (2006). Is the right hemisphere involved in idiom comprehension? A neuropsychological study. *Neuropsychology, 20,* 598–606.
Papagno, C., Tabossi, P., Colombo, M. R., & Zampetti, P. (2004). Idiom comprehension in aphasic patients. *Brain and Language, 89,* 226–234.
Pell, M. D. (1999). Fundamental frequency encoding of linguistic and emotional prosody by right hemisphere-damaged speakers. *Brain and Language, 69,* 161–192.
Pell, M. D. (2006). Cerebral mechanisms for understanding emotional prosody in speech. *Brain and Language, 96,* 221–234.
Robin, D. A., Tranel, D., & Damasio, H. (1990). Auditory perception of temporal and spectral events in patients with focal left and right cerebral lesions. *Brain and Language, 39,* 539–555.
Ross, E. D., & Mesulam, M.-M. (1979). Dominant language functions of the right hemisphere? Prosody and emotional gesturing. *Archives of Neurology, 36,* 144–148.
Ross, E. D., Shayya, L., & Rousseau, J. F. (2013). Prosodic stress: Acoustic, aphasic, aprosodic and neuroanatomic interactions. *Journal of Neurolinguistics, 26,* 526–551.

Schalling, E., & Hartelius, L. (2004). Acoustic analysis of speech tasks performed by three individuals with spinocerebellar ataxia. *Folia Phoniatrica et Logopaedica, 56,* 367–380.

Schirmer, A., Alter, K., Kotz, S.A., & Friederici, A. D. (2001). Lateralization of prosody during language production: A lesion study. *Brain and Language, 76,* 1–17.

Seddoh, S. A. (2004). Prosodic disturbance in aphasia: Speech timing versus intonation production. *Clinical Linguistics & Phonetics, 18,* 17–38.

Seddoh, S. A. (2008). Conceptualisation of deviations in intonation production in aphasia. *Aphasiology, 22,* 1294–1312.

Shah, A. P., Baum, S. R., & Dwivedi, V. D. (2006). Neural substrates of linguistic prosody: Evidence from syntactic disambiguation in the productions of brain-damaged patients. *Brain and Language, 96,* 78–89.

Shapiro, B. E., & Danly, M. (1985). The role of the right hemisphere in the control of speech prosody in propositional and affective contexts. *Brain and Language, 25,* 19–36.

Sidtis, D., Canterucci, G., & Katsnelson, D. (2009). Effects of neurological damage on production of formulaic language. *Clinical Linguistics & Phonetics, 23,* 270–284.

Sidtis, J. J. (1980). On the nature of the cortical function underlying right hemisphere auditory perception. *Neuropsychologia, 18,* 321–330.

Sidtis, J. J., & Van Lancker Sidtis, D. (2003). A neurobehavioral approach to dysprosody. *Seminars in Speech and Language, 24,* 93–105.

Van Lancker, D. (1980). Cerebral lateralization of pitch cues in the linguistic signal. *Papers in Linguistics, 13,* 201–277.

Van Lancker, D., Canter, G. J., & Terbeek, D. (1981). Disambiguation of ditropic sentences: Acoustic and phonetic cues. *Journal of Speech and Hearing Research, 24,* 330–335.

Van Lancker, D., & Fromkin, V. A. (1978). Cerebral dominance for pitch contrasts in tone language speakers and in musically untrained and trained English speakers. *Journal of Phonetics, 6,* 19–23.

Van Lancker, D. R., & Kempler, D. (1987). Comprehension of familiar phrases by left- but not by right-hemisphere damaged patients. *Brain and Language, 32,* 265–277.

Van Lancker, D., & Sidtis, J. J. (1992). The identification of affective-prosodic stimuli by left- and right-hemisphere-damaged subjects: All errors are not created equal. *Journal of Speech and Hearing Research, 35,* 963–970.

Van Lancker Sidtis, D. (2012). Formulaic language and language disorders. *The Annual Review of Applied Linguistics, 32,* 62–80.

Van Lancker Sidtis, D., Kempler, D., Jackson, C., & Metter, E. J. (2010). Prosodic changes in aphasic speech: Timing. *Clinical Linguistics & Phonetics, 24,* 155–167.

Van Lancker Sidtis, D., Pachana, N., Cummings, J. L., & Sidtis, J. J. (2006). Dysprosodic speech following basal ganglia insult: Toward a conceptual framework for the study of the cerebral representation of prosody. *Brain and Language, 97,* 135–153.

Van Lancker Sidtis, D., & Postman, W. A. (2006). Formulaic expressions in spontaneous speech of left- and right-hemisphere-damaged subjects. *Aphasiology, 20,* 411–426.

Van Lancker Sidtis, D., Rogers, T., Godier, V., Tagliati, M., & Sidtis, J. J. (2010). Voice and fluency changes as a function of speech task and deep brain stimulation. *Journal of Speech, Language, and Hearing Research, 53,* 1167–1177.

Walker, J. P., Joseph, L., & Goodman, J. (2009). The production of linguistic prosody in subjects with aphasia. *Clinical Linguistics & Phonetics, 23,* 529–549.

Walker, J. P., Pelletier, R., & Reif, L. (2004). The production of linguistic prosodic structures in subjects with right hemisphere damage. *Clinical Linguistics & Phonetics, 18,* 85–106.

Wapner, W., Hamby, S., & Gardner, H. (1981). The role of the right hemisphere in the apprehension of complex linguistic materials. *Brain and Language, 14,* 15–33.

Weed, E. (2011). What's left to learn about right hemisphere damage and pragmatic impairment? *Aphasiology, 25,* 872–889.

Winner, E., & Gardner, H. (1977). The comprehension of metaphor in brain-damaged patients. *Brain, 100,* 717–729.

Yang, S.-Y., Ahn, J. S., & Van Lancker Sidtis, D. (2015). The perceptual and acoustic characteristics of Korean idiomatic and literal sentences. *Speech, Language, and Hearing, 18,* 166–178.

Yang, S.-Y., & Van Lancker Sidtis, D. (2015). Listeners' identification of matched idiomatic and literal utterances by left- and right-brain damaged speakers. Manuscript submitted for publication.

Zatorre, R. J. (1997). Cerebral correlates of human auditory processing: Perception of speech and musical sounds. In J. Syka (Ed.), *Acoustical signal processing in the central auditory processing system* (pp. 453–468). New York, NY: Plenum Press.

Zatorre, R. J., & Belin, P. (2001). Spectral and temporal processing in human auditory cortex. *Cerebral Cortex, 11,* 946–953.

Appendix

AQ14 Stimuli

Target sentence	Intended meaning	Situational/linguistic context
1. 그 아이는 이를 갈았어.	Idiomatic (The kid ground his teeth in anger.)	그 아이는 자기가 좋아하는 장난감을 잃어버려 화가 몹시났다. (The kid was so angry because he lost his favorite toy.)
	Literal (The kid lost his baby teeth.)	그 아이는 유치가 다 빠졌다. (The kid lost his last baby tooth.)
2. 그 사람이 입을 다물었어.	Idiomatic (He kept silent.)	그 사람은 그 사건에 대해 아무말도 하지 않았다. (During the police investigation, he did not say anything.)
	Literal (He had his mouth closed.)	그 사람은 치과수술 후 입을 벌릴수가 없었다. (After the oral surgery, he could not open his mouth.)
3. 그 사람이 벌집을 건드렸어.	Idiomatic (He caused a big problem.)	그 사람은 상사의 험담을 인터넷에 올렸는데, 그 상사가 그것을 보았다. (He posted his negative comments about his boss on his personal website, which his boss saw.)
	Literal (He stirred up a beehive.)	산에 벌이 많아서 그 사람은 벌집을 만지지 않도록 주의했다. (He tried not to touch a beehive when he did hiking.)
4. 그 사람은 발을 굴렀어.	Idiomatic (He was nervous.)	그 사람은 마지막 차시간에 맞추지 못할까봐 잔뜩 긴장했다. (He was so nervous since he almost missed the train.)
	Literal (He stomped his feet.)	그 사람은 춤추는 기술을 배웠다. (He stomped his feet during dancing.)
5. 그 사람은 무릎을 꿇었어.	Idiomatic (He surrendered.)	그 사람은 할 수 있는것을 다해봤지만 결국엔 포기했다. (He ended up giving up his dream.)
	Literal (He kneeled down.)	그 사람은 아침마다 부모님께 절을 한다. (He always started his day by performing one deep traditional bow to their parents.)
6. 그사람은콩밥을먹었어.	Idiomatic (He served a prison term.)	그 사람은 감옥에 갔다 온적이 있다. (He was charged with bank fraud and went to jail.)
	Literal (He ate bean-mixed rice.)	그 사람은 오늘 아침 콩밥에 미역국을 먹었다. (He had bean-mixed rice and seaweed soup for breakfast.)

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AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES

AQ1: This article has been edited for grammar, APA style, and usage. Please use annotations to make corrections to this PDF. Please limit your corrections to substantive changes that affect meaning. If no change is required in response to a question, please respond "OK as set."

AQ2: Under Speakers, please provide a citation (and corresponding reference) for the K-MIRBI.

AQ3: In Table 2, the averages of ages are given with different numbers of decimal places; please reconcile.

AQ4: Please add in-text callouts for Figures 2, 3, and 6. Also, Figures 1–7 are low resolution and will therefore not be very clear when reproduced. Would it be possible for you to provide figures with a higher resolution?

AQ5: The Summary: F0 Measurements of Elicited Utterances seems to cover overall F0 rather than just for the elicited utterances; please reconcile as appropriate.

AQ6: Just before the Discussion, when correlations are covered, the number of decimal places for given values of R^2 varies; in accordance with journal style, please regularize to the same number of decimal places throughout.

AQ7: In the paragraph in the Discussion beginning "During the elicitation task," there's a citation to Danly & Shapiro 1985. The references list has Danly & Shapiro 1982 and Shapiro & Danly 1985 (and there is no in-text citation for Shapiro & Danly 1985), but no Danly & Shapiro 1985; please reconcile.

AQ8: In the two in-text citations to Van Lancker Sidtis et al. 2010, please distinguish between Van Lancker Sidtis, Kempler, et al. 2010 and Van Lancker Sidtis, Rogers, et al. 2010.

AQ9: The last paragraph has a citation to Yang & Van Lancker Sidtis 2015 that corresponds to the references list's Yang & Van Lancker Sidtis in preparation; please reconcile (updating the reference if possible).

AQ10: In the Abdelli-Beruh et al. 2007 reference, please clarify whether this was a poster or paper presentation.

AQ11: In the Boersma & Weenink 2007 reference, please provide the URL.

AQ12: Is there an update to the "in press" status of the Hallin & Van Lancker Sidtis reference?

AQ13: Please confirm the specifics of the Kim and Na 2001 reference; I'm unable to confirm them. I do see at least one listing that has the authors in the reverse order.

AQ14: Please confirm or replace inserted title for the appendix.

END OF ALL QUERIES