This research contrasted deaf and hearing students’ interpretive knowledge of English sentences containing numeral quantifier phrases and indefinite noun phrases. A multiple-interpretation picture task methodology was used to assess 305 participants’ judgments of the compatibility of sentence meanings with depicted discourse contexts. Participants’ performance was assessed on the basis of hearing level (deaf, hearing) and grade level (middle school, high school, college). The deaf students were predicted to have differential access to specific sentence interpretations in accordance with the relative derivational complexity of the targeted sentence types. Hypotheses based on the pressures of derivational economy on acquisition were largely supported. The results also revealed that the deaf participants tended to overactivate pragmatic processes that yielded principled, though non-target, sentence interpretations. Collectively, the results not only contribute to the understanding of English acquisition under conditions of restricted access to spoken language input, they also suggest that pragmatic factors may play a broad role in influencing, and compromising, deaf students’ reading comprehension and written expression.

The English language challenges confronting deaf students can be attributed to the fact that, for a large majority of deaf learners, their English acquisition is arguably second language (L2) acquisition in the absence of a fully intact spoken first language (L1) (Berent & Kelly, 2008). Factors that contribute to this characterization include the typically delayed onset of English acquisition and severely restricted access to the target language input. As a result, deaf learners’ English acquisition is generally protracted and gradual over the lifespan with highly variable ultimate attainment that rarely reaches the level of hearing native English speakers (Berent, Kelly, & Schueler-Choukairi, in press). Not only does this lesser attainment affect deaf students’ learning, understanding, and use of English language in general, it also affects their learning of specialized academic content that requires mastery of the specific English discourse properties of mathematical, scientific, and technological fields. For example, the intricacies of mathematical discourse along with low English language skill levels have been identified as factors contributing to many deaf students’ difficulties with mathematics in general and, more specifically, with mathematics problem solving, especially word problems (Barham & Bishop, 1991; Kelly, Lang, & Pagliaro, 2003; Kelly, 2008). Although a number of studies have shown that the English language properties of both verbal and written instructions for mathematical problems cause general difficulty for deaf students (Kelly, Lang, Mousely, & Davis, 2003; Kidd & Lamb, 1993; and Kidd, Madsen, & Lamb, 1993; Rudner, 1978), no studies have thoroughly examined deaf students’ understanding of very specific English structures that are central to mathematical discourse. Among these structures are sentences containing English quantifiers, which pervade the discourse of mathematics word problems. The goal of this article is to investigate deaf students’ knowledge...
of English quantifiers, specifically numeral quantifiers, and to examine deaf students’ interpretations of numeral quantifier sentences in comparison with the interpretations of their hearing peers. Isolating and exploring such specific knowledge might uncover subtle reasons for the challenges confronting deaf students in their management of the discourse of specialized academic disciplines.

This study is part of a larger research agenda (Kelly et al., 2004–2006) that focused on deaf students’ mathematical knowledge, including conceptual and procedural knowledge, and English language knowledge required for the successful management of mathematical discourse. That research agenda was motivated by the need to gain a better understanding of the factors that account for the serious challenges that many deaf students face in developing the requisite levels of mathematical knowledge and skills for educational and career success. The results of that research agenda have provided new insights into the challenges confronting deaf students and new direction for developing more effective educational interventions. Results of the Kelly et al. initiative have been reported in Berent, Kelly, Porter, and Fonzi (2008), Berent, Kelly, and Schueler-Choukairi (2009, in press), Blatto-Vallee, Kelly, Gaustad, Porter, and Fonzi (2007), Mitchell, Young, Hochgesang, Bachleda, and Karchmer (2007), and in technical reports and conference presentations.

The data analyzed and reported both in this article and in Berent et al. (2008) were collected during the same administration of a 50-item sentence-picture matching task to participant groups of deaf and hearing students at the middle school, high school, and college levels of education. Whereas Berent et al. analyzed and explained participant performance on the picture task’s universal quantifier (UQ) items, this article analyzes and explains participant performance on the numeral quantifier (NumQ) items. Briefly, this research targeted sentences containing both a numeral (Num) phrase and an indefinite noun phrase (NP), as exemplified in (1a) and (2a) below.

(1) a. Three guys are carrying a box.
   b. Three guys are carrying the box.

(2) a. A mother is bathing three babies.
   b. The mother is bathing three babies.

In sentence (1a), the Num phrase *three guys* appears in subject position, and the indefinite NP *a box* appears in object position. Sentence (2a) reflects the opposite phrasal order, in which the indefinite NP *a mother* appears in subject position and the Num phrase *three babies* appears in object position. These sentence types have special interpretive properties established by the quantifier scope relations that emerge when a quantifier phrase and an indefinite NP co-occur in a sentence. It is specifically the presence of the *indefinite* NP (the noun preceded by the indefinite article *a/an*) that expands such sentences’ interpretive options. When the NP is *definite* (preceded by *the*), as in (1b) and (2b) above, *the box* in (1b) and *the mother* in (2b) must refer to one specific box and one specific mother, respectively, already known to both the speaker (or writer) and the hearer (or reader). The expanded interpretive options of this study’s target sentences such as (1a) and (2a) containing a NumQ phrase and an indefinite NP are discussed in detail in subsequent sections.

Details on both the NumQ task and the participant groups are provided in the Methods section. To set the stage for the description and explanation of participants’ knowledge of NumQ sentences, the following summary of the results of Berent et al. (2008) is provided as relevant background.

**Knowledge of Universal Quantifier Sentences**

*Recognition of ambiguity.* The picture task employed in the UQ research elicits participants’ judgments regarding whether or not each of five pictures in an item set reflects the meaning of that item’s target sentence. These five separate decisions on each “pictorial discourse” allow participants to demonstrate their knowledge of the semantic interpretation of English sentences containing quantifiers and their recognition of the possible ambiguity (multiple interpretations) of specific target sentences or preferences for certain interpretations over others. Sentences (3) and (4) below exemplify the picture task’s UQ sentence types in sentences containing, in these two examples, the UQ *every.* As with the NumQ sentences (1a) and (2a) above, (3) and (4) contain both a quantifier phrase and a singular indefinite NP. In (3), the UQ phrase
Every boy appears in subject position and the indefinite NP a tree in object position, the UQ-NP order. In (4), the indefinite NP a woman appears in subject position and the UQ phrase every flower in object position, the NP-UQ order.

(3) Every boy is climbing a tree.
(4) A woman is smelling every flower.

Collective and distributive interpretations. A fundamental property of UQ sentences is their ability to receive both a collective and a distributive interpretation. Syntactic, semantic, and pragmatic factors guide hearers’ and readers’ probable and preferred interpretations; nevertheless, in English, both interpretations are available options. On the picture task, the collective interpretation of sentence (3) was portrayed in a picture choice in which four boys were all climbing one and the same tree. The distributive depiction showed four boys each climbing a different tree. With respect to the NP-UQ sentence (4), the collective depiction showed one woman smelling a collection of four flowers, whereas the distributive depiction showed four women, each independently smelling a different flower.

Participants’ response patterns were explained in the context of derivational economy. Following principles of the Minimalist Program in linguistic theory (Chomsky, 1995, 2000), the collective derivations are more economical. They involve no covert movement in order to adjust the relationships between the UQs and NPs and derive the necessary interpretation (explained in detail in Berent et al., 2008, and in Berent et al., 2009, in press). Furthermore, their morphologically singular NPs, a tree and a woman, are also singular semantically. That is, in the collective interpretations of (3) and (4), a tree and a woman denote one specific tree (being climbed) and one specific woman (smelling flowers), respectively. These NPs can be interpreted as singleton indefinites (Schwarzschild, 2002) denoting one-member sets. In contrast, in the distributive derivation of (3), when the domain of a tree is restricted within the scope of every boy, it denotes a plural set of trees to which members of the set of boys distribute: a tree is morphologically singular but semantically plural. In Berent et al. (2008), the deaf student groups’ acceptance of fewer distributive interpretations of sentences like (3), relative to the hearing student groups, was attributed to the added derivational complexity of the distributive interpretation. It was argued that the consequences of derivational complexity are more apparent in learner groups whose acquisition of spoken language knowledge has occurred under conditions of restricted access to the input normally available to hearing learners from birth.

The distributive derivation of (4) is even more complex than the other interpretations in that its derivation involves “costly” Quantifier Raising (May, 1977, 1985), which moves every flower from its surface position in (4) to a position to the left of a woman from which it takes scope over a woman. It is only within the scope of the UQ that the domain of a woman can be restricted to a multimember set whose members distribute to all members of the set of flowers. In the Minimalist framework, Quantifier Raising is a last resort operation of the computational system for human language (Chomsky, 1995) that is required at the syntax-semantic interface to derive interpretations that are obtainable in no other way than to violate fundamental economy principles (Reinhart, 2006). In view of the high derivational cost of the distributive interpretation of NP-UQ sentences such as (4), the deaf participants in Berent et al. (2008) accepted very few distributive interpretations of this sentence type, as predicted.

Extra object depictions. Another fundamental issue associated with quantifier sentence interpretation that was explored in Berent et al. (2008) is the so-called “symmetry effect.” The symmetry effect occurs, especially among young children, on picture tasks intended to elicit learners’ knowledge of English UQ sentences. The symmetry effect refers to the rejection of a sentence-picture match when the picture contains an additional, uninvolved member of a set of entities referred to in the sentence. For example, the picture task extra object depiction of UQ-NP sentence (3) above shows four boys each climbing a different tree plus an additional tree not being climbed. Even though that depiction satisfies the truth-value of the sentence Every boy is climbing a tree, young children frequently reject that sentence-picture match. The name of the phenomenon derives from assertions that children’s
distributive interpretations of a sentence like (3) require an exhaustive one-to-one match between members of the agent and object sets with no extraneous entities. Some studies have even argued that, in view of the symmetry effect, young children’s grammars differ fundamentally from adult grammars (e.g., Philip, 1995).

However, in more recent research, the symmetry effect has been observed among older learners, including hearing learners of English as an L2, and even among native speakers (Berent et al., 2009; Brooks & Sekerina, 2005/2006), effectively eliminating the need to propose separate child and adult grammars of UQ knowledge. Therefore, Berent et al. (2008) investigated whether the symmetry effect would be observed among deaf learners and, if so, how this might contribute to an understanding of the phenomenon. Indeed, the results of Berent et al. (2008) revealed that both the deaf and hearing student groups accepted fewer extra object depictions than symmetrical distributive depictions. However, the deaf groups differed significantly from the hearing groups in accepting many fewer extra object depictions than symmetrical depictions. The symmetry effect is analyzed further in the Discussion relative to the results of this article.

Properties of Numeral Quantifier Sentences

**Num-NP sentences.** Like sentences containing UQ phrases and indefinite NPs, sentences containing Num phrases and indefinite NPs have semantic properties that can make multiple interpretations available. For example, a sentence like (1a) above, repeated in (5a) below, in which the Num phrase precedes the indefinite NP—a *Num-NP* sentence—is ambiguous between a collective interpretation, as represented in (5b), and a distributive interpretation, as represented in (5c).

(5) a. Three guys are carrying a box.
   b. Three guys (G = \{g_1, g_2, g_3\}) are carrying a box (B = \{b_1\}).
   c. Three guys (G = \{g_1, g_2, g_3\}) are carrying a box (B = \{b_1, b_2, b_3\}).

Representation (5b) indicates that the set of guys, G, has exactly three members, as determined by the *NumQ three in three guys*, whereas the set of boxes, B, is a one-member set consisting only of \{b_1\}. The domain restriction of a *box* to a singleton (one-member) set is a semantic option always available to a singular indefinite NP (Schwarzschild, 2002). Because a *box* is restricted to a *singleton indefinite* in (5b), the collective interpretation is derived whereby all three guys are carrying one and the same box. The other interpretive option (5c) is available when a singular indefinite NP is within the *scope* of a NumQ, a derivation permitted when the Num phrase occurs in subject position.² In this case, the domain of a box can be restricted to a plural set, \{b_1, b_2, b_3\}. Accordingly, all members of the set of guys, G, distribute individually to different members of the set of boxes, B, yielding the distributive interpretation of (5a). These interpretive options are analogous to the options available for UQ-NP sentence (3) above, *Every boy is climbing a tree*. With UQs, however, the cardinality of the UQ is not specified as it is with the NumQ (e.g., in 5 above, G = \{3\}); instead, *all* members of the quantified set are involved in the proposition of the sentence, whatever the cardinality of that set happens to be.

**NP-Num sentences.** With respect to a sentence like (4) above, in which the indefinite NP occurs in subject position and the Num phrase occurs in object position (an *NP-Num* sentence), the interpretive options reflect a fundamental difference from those in analogous NP-UQ sentences. As indicated below, the collective derivation as in (6b) represents an available and effectively the only interpretation of (6a).

(6) a. A mother is bathing three babies.
   b. A mother (M = \{m_1\}) is bathing three babies (B = \{b_1, b_2, b_3\}).
   c. *A mother (M = \{m_1, m_2, m_3\}) is bathing three babies (B = \{b_1, b_2, b_3\}).

In (6b), *a mother*, a singleton indefinite referring to one member \{m_1\} of the set M, is bathing all members of the set of babies, B, restricted explicitly to three members by the NumQ *three*. With respect to (6c), to obtain the relevant distributive derivation, the Num phrase *three babies* would move via Quantifier Raising to a position to the left of *a mother*, from which it would take scope over *a mother* and restrict the
domain of a mother to a plural set, \{m_1, m_2, m_3\}. The picture task depiction of that derivation shows three mothers, each of whom is bathing one baby. However, that interpretation is unavailable for (6a). 3

Based on the characteristics of English NumQ sentences discussed above and on other issues relevant to quantifier sentence interpretation, specific hypotheses regarding deaf and hearing students’ picture-task performance on NumQ sentences are articulated in the Method section. The more detailed description of the picture task provided there offers an explicit context in which to ground the hypotheses.

**Method**

**Participants**

Seven groups of student participants took part in this study of the comprehension of English NumQ sentences—four groups of deaf students and three groups of hearing students. Table 1 lists the participant groups according to hearing status and educational level, the number of participants per group and the group means and standard deviations for age, gender, and pure-tone average (PTA) hearing loss for the four deaf groups. The group means for PTA hearing loss indicate that the deaf students are in the severe-to-profound categories of hearing loss (Levitt, 1989). Note, however, that the deaf middle school students, the smallest participant group \((n = 18)\), had the lowest PTA \((M = 78.5)\) of the four deaf groups. In addition, the deaf middle school students were all mainstreamed in regular classes and all had hearing parents.

The deaf middle school group (DF-ms) included students in Grades 7 and 8, and the deaf high school group (DF-hs) included students in Grades 9–12. The hearing middle school (HR-ms) and high school (HR-hs) groups represented the same grade levels as their deaf peers. At the college level, there were two deaf participant groups but only one hearing participant group. The DF-assoc group included students pursuing no higher than associate’s degrees. There was no parallel hearing group, but there were two baccalaureate-level groups, the deaf group DF-bacc and the hearing group HR-bacc, each comprised of students pursuing bachelor’s degrees at the same university. The inclusion of two college-level deaf groups was motivated by the fact that, in contrast to the deaf bachelor’s level students, the deaf students pursuing at most an associate’s degree historically exhibit lower overall English language proficiency and experience a greater challenge in the improvement of these skills and lower degree completion rates (Cuculick & Kelly, 2003). With respect to age, on average the deaf students at each equivalent educational level are approximately 1 year older than their hearing peers. This age discrepancy is attributable to the fact that deaf students generally spend additional time completing grade advancement and degree requirements in comparison to their hearing peers.

Finally, although almost all the participating deaf students possessed sign language skills, the vast majority would not be considered native L1 ASL signers. For the participating deaf college students, depending on their college entry cohort, 90–93–96% of them

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographic information on participant groups</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>DF-ms</td>
</tr>
<tr>
<td>n</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>13.3</td>
</tr>
<tr>
<td>SD</td>
<td>0.8</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
</tr>
<tr>
<td>PTA hearing lossa</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>78.5</td>
</tr>
<tr>
<td>SD</td>
<td>21.0</td>
</tr>
</tbody>
</table>

DF = deaf, HR = hearing; ms = middle school, hs = high school, assoc = college students pursuing \(\leq\) associate’s degrees, bacc = college students pursuing baccalaureate degrees.

*Pure Tone Average hearing loss measured in dB in the better ear at 500, 1000, and 2000 Hz.*

Comprehension of English Numeral Quantifiers

423

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came from families where both parents were hearing (NTID Annual Report, 2005), and approximately 85% graduated from mainstream educational programs rather than residential schools for the deaf. Thus, there was not sufficient numbers of native signers available to consider or include ASL knowledge as a variable in this study.

English Sentence Picture Task: Quantifiers

Task design. The English Sentence Picture Task: Quantifiers (Berent et al., 2008) was developed for the purpose of assessing students’ knowledge of English quantifier sentences containing the UQs each, every, and all (10 items each) and sentences containing NumQs (10 items). An additional 10 filler items contained only NPs and no UQs or NumQs. Altogether, the picture task contained 50 items and a total of 250 depictions. Four randomized versions of the task were developed to address any potential order effects among task items. This article reports on students’ performance on the 10 NumQ items. As previously noted, students’ performance on the 30 UQ items was reported in Berent et al. (2008).

Half of the 10 numeral quantifier items contain Num-NP sentences as in (1a) above, and half of the items contain NP-Num sentences as in (2a). The Appendix lists the Num-NP and NP-Num target sentences along with a sample picture task item of each type, specifically the items associated with sentences (1a) and (2a). As illustrated in the Appendix, each picture task item consists of a target sentence accompanied by five artist’s drawings that either do or do not represent a possible depiction of the meaning of the sentence. Each of the five pictures within an item requires a separate judgment. Student participants received simplified instructions explaining the task format and procedures and emphasizing that, in each item’s set of five pictures, at least one picture matches the meaning of the target sentence, other pictures might also match the meaning of the sentence, and at least one picture does not match the meaning of the sentence. Participants were instructed to read the target sentence of an item, to study the five pictures, and to circle NO under any picture that they felt did not match the meaning of the target sentence and to circle YES under any picture that they felt did match the meaning of the sentence.

Sentence interpretations. Each target sentence on the picture task contains an agent, or (potential) performer of an action, and an object, or entity (potentially) affected by the activity performed by the agent. For example, in the sample Num-NP item in the Appendix, three guys in the target sentence Three guys are carrying a box is the agent and a box is the object. In the sample NP-Num item, a mother in the target sentence A mother is bathing three babies is the agent and three babies is the object.

Table 2 lists the depiction types associated with the Num-NP and NP-Num target sentences, a brief description of each depiction type, the specific picture in the sample Num-NP item (I) and sample NP-Num item.

<table>
<thead>
<tr>
<th>Depiction</th>
<th>Description</th>
<th>Picture</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Num-NP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No object</td>
<td>Potential agents, no objects</td>
<td>C</td>
<td>NO</td>
</tr>
<tr>
<td>Insufficient</td>
<td>Too few agents</td>
<td>B</td>
<td>NO</td>
</tr>
<tr>
<td>Collective</td>
<td>All agents acting on one object</td>
<td>E</td>
<td>YES</td>
</tr>
<tr>
<td>Distributive</td>
<td>Agent-object one-to-one pairs</td>
<td>A</td>
<td>YES</td>
</tr>
<tr>
<td>Extra object</td>
<td>One-to-one pairs plus one superfluous object</td>
<td>D</td>
<td>YES</td>
</tr>
<tr>
<td>II. NP-Num</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No object</td>
<td>Potential agent, no objects</td>
<td>C</td>
<td>NO</td>
</tr>
<tr>
<td>Distributive</td>
<td>Agent-object one-to-one pairs</td>
<td>E</td>
<td>NO</td>
</tr>
<tr>
<td>Collective</td>
<td>One agent acting on all objects</td>
<td>B</td>
<td>YES</td>
</tr>
<tr>
<td>Extra object</td>
<td>One agent acting on all objects plus one extra unaffected object</td>
<td>D</td>
<td>YES</td>
</tr>
<tr>
<td>Superfluous</td>
<td>One agent acting on all objects plus a second agent acting on an additional object</td>
<td>A</td>
<td>YES</td>
</tr>
</tbody>
</table>
item (II) in the Appendix that corresponds to each depiction type, and the expected judgment (NO or YES) for each sentence-picture match. In addition to the issues of collective versus distributive interpretations and the symmetry effect, the depictions included picture choices designed to assess participants’ knowledge of the most fundamental properties of NumQ sentences, specifically the requirement that the pictorial context must include both the agents and objects referred to in the target sentence and that it must also depict no fewer than the number of set members specified in the Num phrase.

Depiction types. For both Num-NP and NP-Num sentences, participants should provide an NO response to the no-object depiction (e.g., to pictures I.C and II.C; see the Appendix for all references to specific pictures) because, in the absence of objects, the truth-values of the target sentences cannot be satisfied. In addition to the recognition of this obvious fact, high participant scores in rejecting no-object depictions would indicate that participants were paying attention during completion of the picture task and not responding randomly. For Num-NP insufficient depictions, truth-values cannot be satisfied because the depiction displays too few agents relative to the numerically specified NumP subject of the target sentences. For example, Appendix picture I.B shows only two guys, rather than three, carrying a box. For both sentence types, the collective depictions straightforwardly portray the meanings of the sentences without extraneous entities in the pictures (I.E and II.B) and should be acceptable as matches to their associated sentences.

The Num-NP and NP-Num sentence types are semantically distinct with respect to distributive depictions, as discussed in the Introduction. Unlike analogous UQ sentences contained in the picture task, for which both the UQ-NP and NP-UQ sentence types permit a distributive interpretation, with the NumQ sentences it is only the Num-NP sentences that permit a distributive interpretation. Therefore, on NP-Num items participants should reject sentence-picture matches for the distributive depiction (picture ILE) of this sentence type. In view of this distinction between Num-NP and NP-Num sentences, the extra object depictions of the two types also differ fundamentally. With Num-NP items, the extra object depiction is associated with a distributive depiction, as in picture I.D; with NP-Num items, the extra object depiction can only be assessed using a collective depiction, as in picture II.D, because the distributive interpretation of NP-Num sentences is unacceptable under any circumstance.

Finally, an NP-Num superfluous depiction was included on the picture task for two reasons. First, it provides a third possible YES response option and is thus consistent with all other experimental items on the picture task in the proportion of YES to NO responses. Secondly, this option is unique relative to all other depictions associated with the experimental task items. Specifically, as its Table 2 description indicates and as picture II.A shows, the truth-value of the superfluous depiction can be satisfied by the mother bathing three babies but potentially falsified by the mother bathing only one baby. Inclusion of such depictions permitted the opportunity to assess whether differences might emerge between groups in the ability to accept a sentence-picture match in which one agent-object pairing properly depicts the meaning of the target sentence but the other agent-object pairing does not.

Hypotheses

Overall knowledge. In view of the linguistic properties of English NumQ sentences discussed above, the hypotheses articulated in (7)–(9) below were tested. The hypotheses in (7) pertain to overall linguistic knowledge of NumQ sentences.

(7) a. The hearing participant groups will exhibit greater overall knowledge of the interpretation of English NumQ sentences than the deaf participant groups.

b. All participant groups will exhibit full knowledge of the fundamental properties of English NumQ sentences by rejecting sentence-picture matches (i) with no-object Num-NP and NP-Num depictions and (ii) with Num-NP insufficient depictions

In view of the consequences of hearing loss for the acquisition of spoken language knowledge, especially
under circumstances of severely restricted access to spoken input from early childhood, the hypothesis for (7a) predicts less overall knowledge of NumQ sentences, on average, among deaf students than among hearing students. Nevertheless, in view of all language learners’ access to universal principles of grammar that guide and constrain language acquisition, the hypothesis for (7b) predicts that both deaf and hearing students at the educational levels assessed will exhibit complete knowledge of the domain restrictions of Num phrases, which require participation of the number of set members of the agent set or object set specified by the NumQ. Thus, participants are predicted to provide NO answers for (i) no object depictions (pictures I.C and II.C) as well as for (ii) Num-NP insufficient depictions (picture I.B).

Collective and distributive interpretations. The hypotheses articulated in (8) pertain to the collective/distributive ambiguity of quantifier sentences.

(8) a. All participant groups will accept the collective depictions of both sentence types.
   b. The hearing groups will accept more Num-NP distributive interpretations than the deaf groups accept.
   c. All participant groups will reject NP-Num distributive interpretations.

Hypothesis for (8a) predicts that all participant groups will accept collective depictions (picture I.E, picture II.B), which are the derivationally most economical of the potential sentence interpretations of the targeted NumQ sentences. Nevertheless, with Num-NP sentences, the distributive derivations are possible, even if less economical, derivations in comparison with the collective derivations. In view of this greater derivational complexity, the hypothesis for (8b) predicts that the distributive interpretations (picture I.A) will be relatively less accessible to the deaf participant groups in view of the greater learnability challenge of acquiring English under conditions of restricted access to the input. Because of the virtually unobtainable distributive interpretations of NP-Num sentences (picture II.E), the hypothesis for (8c) predicts that all participant groups will reject the distributive depictions of those sentences.

Extraneous elements. The hypotheses articulated in (9) pertain to sentence-picture matches in which the pictorial discourses contain extraneous elements, that is, extra objects or extra agent-object (superfluous) pairs. Together these hypotheses imply that the hearing participant groups will be better able to manage pragmatic pressures imposed by the presence of extraneous entities in depicted discourses (see Discussion).

(9) a. The deaf participant groups will accept fewer extra object depictions than the hearing groups accept but will accept more NP-Num than Num-NP extra object depictions.
   b. In contrast to the hearing participant groups, the deaf groups will accept more NP-Num “simple” collective depictions than extra object (collective) depictions and more extra object than superfluous (collective) depictions.

In the context of the pragmatic pressures imposed by extraneous discourse elements on sentence interpretation, the hypothesis for (9a) predicts that the deaf groups will accept more extra object depictions of NP-Num sentences (picture II.D) than of Num-NP sentences (picture I.D) because, despite the presence of the extraneous elements, the NP-Num depictions are derivationally economical collective depictions whereas the Num-NP depictions are derivationally more complex distributive depictions. The hypothesis for (9b) predicts that the burden imposed by the presence of extraneous entities will have differential effects. In addition to the acceptance of fewer NP-Num extra object depictions, which contain an extraneous element (picture II.D), than NP-Num simple collective depictions (picture II.B), the hypothesis for (9b) maintains that the deaf groups will accept still fewer NP-Num superfluous depictions (picture II.A). The cognitive load is even greater in superfluous depictions with additional intrusive elements (the extra agent-object pair) and the contradiction in truth-value that they create.

Analyses and Results

Although hypotheses articulated in (7)–(9) are framed in terms of either the performance of all groups or else differences in performance between the hearing and deaf groups, each associated analysis included a Group
variable consisting of seven levels—i.e., representing each of the seven participant groups. Even though the deaf students were predicted, as a special class of language learners, to exhibit knowledge of English NumQ sentences globally influenced by restricted auditory access to the target input, the seven groups otherwise differed along an educational continuum from middle school through college. This analysis approach facilitates the discovery of any developmental factors distinguishing participants, deaf or hearing, across educational levels.

Basic Knowledge of NumQ Sentences

The hypothesis in (7a) was tested with a one-way analysis of variance (ANOVA) for Group (7) \times Total Score on the picture task NumQ items. A total score on the 10 NumQ items was 50 (10 items \times 5 pictures). In the scoring of the NumQ items, a correct response constituted an NO response to the sentence-depiction matches indicated by “NO” in the right column of Table 2 and an YES response to the sentence-depiction matches indicated by “YES.” Because of variation in preferences for specific interpretations, even for interpretations that are grammatically possible, and because of uncertainty as to how participants would respond to the superfluous depictions of NP-Num sentences, a “perfect score” of 50 was not an expectation of any given participant. However, in general, the higher the total score, the greater the indication that the participant had linguistic knowledge of (un)available interpretations, recognized the ambiguity of NumQ sentences, and was able to connect sentence meanings to conceivable discourses.

The results of the total score ANOVA yielded a significant main effect for Group, $F(6, 298) = 17.56$, $p < .0001$. The total mean scores (and SDs) of the seven participant groups were as follows: DF-ms, 38.6 (6.4); DF-hs, 36.4 (5.4); DF-assoc, 36.0 (6.3); DF-bacc, 39.3 (6.2); HR-ms, 40.9 (6.1); HR-hs, 44.0 (4.9); HR-bacc, and 44.3 (5.0). In percentage terms, these scores ranged from a high of 88.7% for the HR-bacc group to a low of 72.0% for the DF-assoc group. Post hoc pairwise comparisons using Scheffé’s $F$ (Scheffé, 1953) revealed differences between groups (all $p < .05$) that patterned largely according to hearing status. The HR-bacc group outperformed all four deaf participants groups. The HR-hs group outperformed all deaf groups with the exception of the DF-ms group. The HR-ms group outperformed only the DF-assoc group. These results provide considerable support for hypothesis (7a), which predicted that the hearing groups would exhibit greater overall knowledge of the interpretation of English NumQ sentences than the deaf groups. In this total score analysis and in some analyses described below, the DF-ms group stands out as an exception relative to the other deaf groups. This group ($n = 18$) was smaller than all other groups and, along with its less severe degree of hearing loss (PTA = 78.5, Table 1), in all likelihood is not representative of typical deaf students at the middle school level.

The hypothesis articulated in (7b) was addressed with two one-way ANOVAs, one targeting performance by group on the no object depictions, Group (7) \times No Object (10 depictions), and one targeting performance by group on Num-NP insufficient depictions, Group (7) \times Insufficient (5 depictions). The no object ANOVA revealed no significant differences between groups, $F(6, 298) = 1.19$, $p = .31$, as predicted. The mean score of all seven groups was 9.9 or higher out of 10. Thus, all groups overwhelmingly rejected no object depictions (Table 2) of Num-NP and NP-Num sentences, affirming their knowledge that a proper discourse for these sentence types requires the presence of both the specified agents and the specified objects. The insufficient ANOVA likewise revealed no significant differences between groups, $F(6, 298) = 1.93$, $p = .076$. Thus, in rejecting insufficient depictions of Num-NP sentences (picture I.B), participants affirmed their knowledge that the interpretation of these NumQ sentences cannot involve fewer members of the agent set than the number specified in the Num phrase. The results of these two ANOVAs support hypothesis (7b) and verify that all participant groups possessed knowledge of the most fundamental syntactic and semantic properties of the targeted NumQ sentence types.

Acceptance of Collective and Distributive Interpretations

All three hypotheses articulated in (8) were assessed with a repeated measures ANOVA that compared...
group performance on the collective and distributive depictions of the two sentence types: Group (7) × Interpretation (4), with repeated measures on the four dependent variables—Num-NP collective, Num-NP distributive, NP-Num collective, and NP-Num distributive. For this analysis, responses to the NP-Num distributive depictions, which are predicted to be rejected by all participant groups (hypothesis 8c), were converted to acceptance values. That is, although a NO response to these sentence types was considered correct (NO = a score of 1) and was used in the total score analysis, for this analysis, a YES response was assigned a score of 1 to assess relative acceptance rates of all four collective/distributive sentence-picture matches.

The collective/distributive ANOVA yielded significant main effects for Group and for Interpretation, as well as a significant Group × Interpretation interaction, F(18, 894) = 4.57, p < .0001. The mean scores associated with this interaction are plotted in Figure 1. The figure reveals that all participant groups fully accepted the collective interpretations of Num-NP and NP-Num sentences, in support of hypothesis (8a). The collective interpretations exhibit the greatest derivational economy, involving no Quantifier Raising, and the NPs in these derivations are singleton indefinites and are thus isomorphic in morphosyntactic and semantic number (i.e., both singular). Figure 1 also illustrates participants’ overwhelming rejection of NP-Num distributive interpretations, in support of hypothesis (8c). The source of the Group × Interpretation interaction is therefore clearly the variation across groups in the degree of acceptance of the derivationally less economical Num-NP distributive interpretations. As illustrated, the hearing groups accepted more Num-NP distributive interpretations than the deaf groups did, supporting hypothesis (8b). However, among the deaf participants, the performance of the DF-ms group was again an exception; they accepted as many Num-NP distributive depictions as the HR-bacc group did.

Performance Relative to Extraneous Elements

Acceptance of extra object depictions. The hypothesis articulated in (9a) predicted that the deaf groups would accept fewer extra object depictions than the hearing groups but would accept more NP-Num than Num-NP extra object depictions. This hypothesis was assessed using a Group (7) × Extra Object (2) ANOVA with repeated measures on the two dependent variables Num-NP and NP-Num. The repeated measures analysis yielded significant main effects for Group, F(6, 298) = 14.59, p < .0001, and for Extra Object, F(1, 298) = 281.00, p < .0001, with no interaction effect. Figure 2 illustrates the mean scores for acceptance of Num-NP and NP-Num extra object depictions by group. The plotted means indicate that, cumulatively, the deaf groups accepted fewer extra object depictions than the hearing groups in support of the first part of hypothesis (9a). Furthermore, the plotted means show that the deaf groups indeed accepted more NP-Num than Num-NP extra object depictions, in support of the second part of (9a). However, the figure reveals further that the hearing groups also accepted more NP-Num than Num-NP extra object depictions. The deaf and hearing groups’ parallel performance in accepting more NP-Num than Num-NP extra object depictions is confirmed by the main effect for Extra Object and the absence of a Group × Extra Object interaction. Thus, even the hearing native speakers were sometimes derailed from accepting a compatible sentence-picture match when an extraneous entity was present. However, as seen, this occurred mostly with Num-NP depictions, as the hearing groups accepted the vast majority of the NP-Num extra object depictions. In this regard, the DF-bacc group most closely approximated the performance of the hearing groups.

Relative acceptance of extra object and superfluous depictions. The hypothesis articulated in (9b) relates only to NP-Num sentences and predicted that, relative to the hearing participant groups, the deaf groups would accept fewer extra object depictions than simple collective depictions but more extra object than superfluous depictions. This hypothesis was tested with an ANOVA for Group (7) × Collective Type (3) with repeated measures on the dependent variables simple, extra object, and superfluous. The ANOVA yielded significant main effects for Group and Collective Type as well as a significant Group × Collective Type interaction.
interaction, $F(12, 596) = 15.50, p < .0001$. The means plotted in Figure 3 illustrate the groups’ relative acceptance of each of these NP-Num depiction types.

First of all, in support of the hypothesis in (9b), a comparison of the left and middle bars for each group confirms that, relative to the hearing groups, the deaf groups accepted fewer NP-Num extra object depictions than simple collective depictions. The hearing groups’ relative acceptance of these two depiction types was nearly equivalent. Furthermore, Figure 3 also supports the prediction in (9b) that the deaf participant groups would accept more extra object than superfluous depictions. However, the middle and rightmost bars for the hearing groups reveal a progression by grade level in their relative acceptance of extra object and superfluous depictions. The HR-ms group’s differential acceptance of the two depiction types was much greater than the HR-bacc group’s acceptance rates, which were essentially equivalent. These results suggest that hearing students’ abilities to manage confounding discourse-pragmatic influences improve with age.

**Discussion**

**General Knowledge of NumQ Sentences**

The results of this study demonstrate that deaf students in the severe-to-profound ranges of hearing loss who participated in this study have a high level of comprehension of the fundamental properties and the interpretive options of the kinds of English NumQ sentences targeted in the study. Despite the potential...
acquisitional consequences of restricted access to English language input, the deaf participants, like the hearing speakers of English who participated, exhibited robust knowledge of the Num-NP and NP-Num sentences listed in the Appendix. Although the overall performance of the hearing participant groups on the English Sentence Picture Task: Quantifiers was, as predicted, relatively higher than the performance of the deaf participant groups, all groups fully accepted the derivationally economical collective interpretations of the NumQ sentences (Figure 1). Furthermore, they all rejected the anomalous NP-Num distributive derivations. What distinguished the deaf and hearing groups were the relative extents to which they accepted the derivationally more complex Num-NP distributive interpretations. In such sentences, the indefinite NP receives its domain restriction to a plural set within the scope of the NumQ (see 5c above and picture I.A). Accordingly, the indefinite NP is morphosyntactically singular but semantically plural. The hearing participants accepted more of these more complex distributive interpretations than the deaf participants did but many fewer relative to their virtually total acceptance of the Num-NP collective interpretations.

This performance pattern parallels the performance by the same participants on English UQ sentences reported in Berent et al. (2008). In that study, all participants, deaf and hearing, accepted the majority of collective interpretations of sentences such as (3) and (4) above containing a UQ (each, every, all) and a singular indefinite NP. Like the NumQ sentences, the collective derivations of the target UQ sentences involve no costly Quantifier Raising and their indefinite NPs have a singleton indefinite interpretation (singular in both form and meaning). In contrast, the singular NPs in the distributive derivations of (3) and (4) are variables within the scope of the UQ and, though singular in form, they are semantically plural. The greater derivational and semantic complexity of the UQ distributive sentences made their interpretation considerably less accessible to the deaf participants and a less preferred option for the hearing participants.

As in that study, the results of this article reveal the impact of Minimalist pressures on language acquisition and use, along with the greater impact of these pressures on learners whose English acquisition has occurred under conditions of restricted access to the target language input. Nevertheless, despite this restriction, the deaf learners’ attainment of NumQ sentence knowledge was shown to be relatively successful.

**Contexts Containing Extra Objects**

*Symmetry effect as singleton effect.* Whereas the issues associated with deaf and hearing participants’ knowledge of the basic interpretive properties of NumQ sentences are relatively transparent, participants’ judgments of depictions containing extraneous elements involve additional, more obscure factors. As
explained in the Introduction, the results of Berent et al. (2008) established that the symmetry effect occurs among deaf learners from middle school to college in their judgments of UQ distributive depictions containing an extraneous element. The symmetry effect was also observed to some extent even among the hearing English speakers in that study. This article offers parallel as well as new findings: (a) the symmetry effect is not isolated to sentence-picture matches of English UQ sentences but also occurs in sentence-picture matches of English NumQ sentences, and (b) the symmetry effect is not limited to extra object distributive depictions of target sentences but also occurs in judgments of extra object collective depictions.

With respect to UQ sentence comprehension, Berent et al. (2009) explained the symmetry effect by expanding on Rakhlin’s (2007a, 2007b) explanation of the effect in young children. Rakhlin’s explanation tapped Schwarzschild’s (2002) analysis of singular indefinite NPs, which draws on the flexibility with which their domain can be restricted to a singleton (one member) set. For example, with respect to a UQ sentence like (3) above, Every boy is climbing a tree, the domain of the NP a tree can be flexibly restricted to a singleton indefinite representing one specific tree (the collective interpretation) or to a plural set within the scope of every boy, whose members then distribute to members of an available set of trees (the distributive interpretation). In his broader semantic theory of singleton indefinites, Schwarzschild demonstrated how, given the flexibility of singular indefinite NPs, a speaker (or writer) and hearer (or reader) can restrict the domain of such an NP differently, a phenomenon he refers to as a “speaker-listener asymmetry.” For example, although a speaker’s intention might be to restrict an NP’s domain to a singleton set, the hearer might interpret it as a multimember set via an “implicit domain restriction.” Therefore, in evaluating a sentence on a picture task in a depicted extra object context, a participant whose attention is diverted to a lone extraneous entity, for example, an extra tree, has the option to restrict a tree in the target sentence to a singleton set referring to that extra tree.

Rakhlin (2007a, 2007b) attributed this phenomenon in young children to their undeveloped pragmatic knowledge required to “manage discourse” and, in the case of a picture task, to rule out less likely interpretations in favor of more likely interpretations. That is, with fully developed pragmatic knowledge, a participant would be more likely to rule out a singleton restriction caused by the presence of an extra object in a depicted discourse and to assign a plural restriction to the relevant NP. Although research on deaf learners’ pragmatic knowledge for managing discourse is virtually nonexistent, there is some evidence that they do face challenges in this domain. In Jeanes, Nienhuys, and Rickards (2000), deaf students aged 8–17 years were shown to lag well behind their age-equivalent hearing peers in pragmatic knowledge required for successful face-to-face conversation. It is therefore reasonable to assume that underdeveloped English pragmatic knowledge might also account for the singleton effect observed in deaf learners.

**Insufficiency of the singleton explanation.** With regard to the symmetry effect observed with Num-NP extra object depictions in this article, the singleton indefinite account indeed provides a principled explanation of the phenomenon, just as it did in Berent et al. (2009) for judgments of extra object depictions of both UQ-NP and NP-UQ sentences (see 3 and 4 above). However, with respect to NP-Num sentence-picture matches, the unanticipated differential acceptance (more prevalent in the deaf groups) of simple and extra object collective depictions (Figure 3, left and middle bars per group) cannot be explained on the basis of the singleton effect. Unlike Num-NP sentences, the extra object in an NP-Num sentence is associated with a set denoted by a plural Num phrase (e.g., three babies). In this case, there is no way that the plural Num phrase could refer to one extraneous entity in the depicted discourse. The rejection of NP-Num extra object depictions therefore requires some other explanation.

**Pragmatic Knowledge**

**Conversational implicatures.** Despite this difference between Num-NP and NP-Num sentences, what they have in common is that their target sentences become under-informative in their extra object contexts in accordance with Grice’s (1975) Maxim of Quantity, one
of the maxims of his Cooperative Principle. With respect to rational human discourse, the Maxim of Quantity specifies (paraphrased) that a speaker’s contribution to a conversation (a) should be as informative as is required for the purposes of the exchange and, conversely, (b) should not be more informative than is required. In other words, a communicative expectation is that an utterance will be neither underinformative nor overinformative relative to its discourse context.

On the English Sentence Picture Task: Quantifiers, both Num-NP and NP-Num target sentences are under-informative in their extra object contexts because they do not explicitly refer to the presence of a salient extra entity. For example, in their depicted contexts I.D and II.D in the Appendix, “cooperative” utterances would be along the lines of sentences (10a) and (10b), respectively.

(10) a. Three guys are carrying three of the four boxes.
   b. A mother is bathing three of four babies.

In evaluating a target Num-NP sentence in its extra object context, a participan might be able to suppress the “pragmatic violation” of the Maxim of Quantity and accept the sentence-picture match or be unable to manage the pragmatic violation and gravitate to the only remaining semantic solution: associating the singular indefinite NP (a box) with the single extra object (one box). As seen in the results of the extra object ANOVA (Figure 2), the hearing participant groups were better able than the deaf participant groups to manage intrusive pragmatic factors, as reflected in their higher acceptance of Num-NP extra object depictions. (Recall that overall lower acceptance of these depictions in Figure 2 is also a consequence of the greater derivational complexity of the distributive interpretation generally.)

The interpretation of any sentence in a given context hinges on the hearer’s (or reader’s) inferences about the speaker’s (or writer’s) intended meaning over and above the literal meaning of the sentence. These inferences are conversational implicatures (Grice, 1975, 1989). As an example, if person A asks person B, “Do you want to go to that restaurant?” and B responds, “There’s always a forty-five minute wait,” person A forms the implicature from B’s utterance that “B doesn’t want to go to that restaurant.” This is not the literal meaning of B’s utterance but is instead B’s implicated meaning, as inferred by A. When implicatures are formed in association with certain quantifiers, including numeral quantifiers, they are known as scalar implicatures (Horn, 1972, 1989) because of the implicational scales that such quantifiers naturally form. For example, on the scale of numerals, … five > four > three > two …, any numeral on the scale entails all the numerals to its right but not those to its left. Thus, if a person has exactly four children, by entailment that person also has three children or two children but does not have five children. In accordance with the Maxim of Quantity, the use of a weaker scale item in a sentence implies that the speaker/writer was not in a position to use a stronger (more informative) scale item or else would have done so.

Consistent with the entailment relations on the scale of numerals, Levinson (2000) argued that a numeral has a lower bound “at least n” semantic interpretation, which pragmatically induces an upper bound “at most n” scalar implicature. The “at least n” semantic meaning together with the “at most n” scalar implicature is what provides the “exactly n” interpretation of a Num phrase. Under these assumptions, the literal meaning of sentence type II is (11a) below. Because this is assumed to be the informationally strongest statement a speaker/writer is making, (11a) induces scalar implicatures like (11b) or (11c), equivalent to an “exactly three” interpretation.

(11) a. A mother is bathing at least three babies.
   b. A mother is bathing at most three babies.
   c. A mother is not bathing four babies.

However, a property of scalar implicatures is that they are cancellable (or “defeasible”; Grice, 1989) because they do not reflect the semantic meaning of a sentence but rather its pragmatically implicated meaning. As the facts of a discourse change, what was the informationally strongest utterance can be strengthened as in (12a) but not weakened as in (12b).

(12) a. A mother is bathing three babies. In fact, she is bathing four.
   b. A mother is bathing three babies. *In fact, she is bathing two.
In an NP-Num depicted extra object context such as II.D, it is the salience of the fourth baby that presumably motivates the cancellation of the “at most three” scalar implicature to provide a revised meaning like (12a).

On the English Sentence Picture Task: Quantifiers, the motivation to cancel the “at most” scalar implicature would be enhanced by the fact that the target sentences all contain verbs marked for present tense, progressive aspect. Therefore, unlike past tense verbs, these forms convey an activity in progress that has not reached completion as well as a possible future time meaning. The likely result is inferred interpretations such as the following, which are motivated by the fact that the context includes four salient babies but the associated sentence “oddly” makes no reference to all four of them (i.e., the sentence is under-informative in that context):

(13) a. A mother is in the process of bathing four babies but hasn’t gotten to the fourth baby yet.
b. A mother is going to bathe a total of four babies.

This discourse-pragmatic phenomenon accordingly yields inferences that render a type II sentence false in its extra object context, resulting in a NO response to the sentence-picture match. In other words, whereas greater pragmatic control, as expected of a hearing native speaker of English, would make it easier not to cancel the “at most” scalar implicature formed in association with the semantics of the Num phrase three babies and to stay with the literal meaning of the sentence, lesser pragmatic control more easily allows the learner to proceed with a (pragmatically acceptable) cancellation of the “at most” scalar implicature and to infer a context-induced interpretation in which three babies really means “four babies.” This cancellation of the scalar implicature invokes a NO rather than a YES response for depiction II.D. See further discussion below.

NP-Num superfluous depictions. Additional factors come into play with respect to participants’ judgments about the matching of target sentence type II to its superfluous depiction II.A. Figure 3 revealed that the deaf groups accepted very few of these sentence-picture matches, whereas the hearing groups each accepted more than half of the depictions with an increase across educational level to a near-total acceptance by the HR-bacc group. In II.A, the mother bathing three babies satisfies the truth-value of the sentence whereas, paradoxically, the mother bathing one baby does not. The performance patterns indicate that the hearing groups more readily accepted the one semantically compatible mother-baby set in satisfaction of the truth-value of the target sentence, ignoring the semantically incompatible one mother–one baby set.

Clearly, the superfluous depiction greatly increases the cognitive load on sentence interpretation in that context because of the contradictory truth-values that the depiction introduces. Therefore, the relatively greater acceptance of extra object than superfluous depictions, a prediction of hypothesis (9b), is an understandable result. What was not predicted was the hearing participants’ relatively lower acceptance of NP-Num superfluous depictions. As seen in Figure 3, acceptance of the superfluous depictions increased with grade level, with the hearing middle school students exhibiting the greatest differential between extra object and superfluous acceptance levels. This result suggests that the ability to manage intrusive pragmatic factors increases over time even among hearing native speakers of English.

Responding to pragmatic intrusion. Although the results of the analyses associated with extraneous elements suggest that deaf students and, to some extent, younger hearing students are vulnerable to the effects of pragmatic violations in sentence interpretation, these results do not actually reflect a deficiency in English pragmatic knowledge. Instead, they suggest that deaf students are less adept than their hearing peers at managing discourse-pragmatic factors. Specifically, the results show that deaf students are more prone to react to intrusive pragmatic factors. In Num-NP extra object contexts, the deaf students more readily gravitated to the only other available semantic interpretive option (the singleton restriction) and, in NP-Num extra object contexts, they more readily cancelled scalar implicatures induced by numeral quantifiers, opting for an inferred informationally stronger interpretation.
Despite the need for two principled explanations for performance on the two targeted sentence types in their extra object contexts, the two processes are motivated by the same quantity-based pragmatic violation: a sentence that is under-informative in its discourse context (as defined by Grice’s, 1975, 1989, Maxim of Quantity).

Concluding Remarks

Like the results of Berent et al. (2008), the results of this article support the view that, under conditions of severely restricted access to spoken language input, deaf learners have greater interpretive access to sentences exhibiting greater derivational economy and less access to sentences exhibiting less derivational economy (i.e., greater derivational complexity). For both universal and numeral quantifier sentences, participants exhibited ease of access to the most derivationally economical collective interpretations but relatively lower access to the Num-NP and UQ-NP distributive interpretations. The deaf participants exhibited the least access to the derivationally most costly NP-UQ distributive interpretation, which can only be derived via the operation of Quantifier Raising. This is also true of the NP-Num distributive interpretation, which is in fact typically an underivable interpretation. The deaf participants demonstrated this knowledge by appropriately rejecting virtually all the NP-Num distributive interpretations.

It is not only deaf learners of English whose performance on the targeted universally and numerically quantified sentence types reveals relative access to different interpretations. In Berent (2009) and Berent et al. (in press), hearing college-aged speakers of English as an L2 exhibited performance patterns that were parallel to the performance patterns of the college-aged deaf students in the studies. First of all, such findings provide further acquisitional support for the learnability predictions for relative access to specific sentence interpretations based on the relative economy of their derivations. Second, the findings explain the parallel performance commonly observed between deaf learners of English and hearing second-language learners in other domains of target language knowledge (Berent, 2009). Under conditions of restricted access to English language input, learners’ acquisition in specific domains is guided by economy pressures, with greater access to more economical derivations and lower access to less economical derivations. In the case of deaf learners, the input restriction is the consequence of hearing loss; in the case of hearing L2 learners, the input restriction is the consequence of commonly recognized cognitive-linguistic factors and other learner variables affecting later, second-language acquisition (Doughty & Long, 2003; Ritchie & Bhatia, 2009).

With respect to discourse-pragmatic knowledge, the deaf participants in this article were less effective than the hearing participants in managing the effects of intrusive discourse elements, as evidenced by their lower acceptance of Num-NP and NP-Num extra object and NP-Num superfluous depictions. Similarly, the deaf participants in Berent et al. (2008) accepted fewer extra object depictions of UQ sentences than the hearing participants did. It was argued in this article that such performance does not reflect underdeveloped English pragmatic knowledge but instead reflects an overreaction to intrusive discourse elements that in fact invokes alternative explicit and implicit interpretive options, specifically, singleton indefinite restrictions, and the cancellation of scalar implicatures. Although this phenomenon has been observed in these studies in the domain of quantifier sentence interpretation, it may be indicative of a more general strategy of language acquisition and use that directly impacts deaf students’ skills in reading comprehension and written expression. For example, their reading and writing might be driven disproportionately by pragmatic factors, with deleterious consequences for the processing and production of academic text. Investigating this hypothesis should be a high priority for future research on deaf students’ English language and literacy development.

Notes

1. The term “deaf” is used to refer to both deaf and hard-of-hearing students.
2. Constituent B is within the scope of constituent A when A is in a structural configuration (c-command) in which it precedes B and is “higher” than B in the syntactic structure. A quantifier, A, must take scope over constituent B (i.e., B must be
within the scope of A) in order for the domain of that quantifier to restrict the domain of B.

3. Ioup (1975) demonstrated long ago that the interpretations of sentences containing quantifiers cross-linguistically are influenced by a variety of intricate factors, including the inherent meaning of the quantifier, the position of the QP within the sentence, discourse factors, etc. With respect to sentences containing numeral QPs, Reinhart (2006) has noted simply that, with a singular indefinite NP subject and NumTQ object, the distributive interpretation is virtually impossible to obtain but the precise reason is not fully clear. Thus, as illustrated in this article, the NP-Num sentences, by virtue of the semantics of numerals and associated factors, admit only the collective interpretation.

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Conflicts of Interest

No conflicts of interest were reported.

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