

Non-antecedent Suppression in American Sign Language

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Previous studies have suggested that ASL pronouns may not suppress the activation of non-antecedents during sentence processing. Using a probe recognition task, Experiment 1 investigated whether lack of suppression may be due to the morphological ambiguity of an ASL pronoun when it is unassociated with a spatial locus. Suppression was predicted for unambiguous repeated nouns but not for spatially unassociated pronouns. The results indicated that neither repeated nouns nor ASL pronouns suppressed non-antecedents. The lack of suppression by repeated nouns was surprising and may have been due to the presence of a new discourse participant in the control sentence. Experiment 2 used a before-anaphor baseline condition, and the results indicated that both ASL pronouns and repeated nouns suppressed the activation of non-antecedents. These findings suggest that (1) spatial loci which disambiguate antecedents of ASL pronouns may be similar to gender marking in English with respect to ambiguity resolution and non-antecedent suppression, and that (2) probe recognition taps a level of representation at which pronouns and spatial loci are associated. Overall, the results indicate that spoken and signed languages use the same processing mechanisms in resolving co-reference relations.

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INTRODUCTION

The expression of pronominal reference and anaphora is an area in which American Sign Language (ASL) is highly conditioned by the visual modality. ASL pronominal reference differs from English and other spoken languages in a number of ways which reflect the visual-spatial nature of sign. Nominal signs can be associated with loci in the plane of signing space, and a pronominal sign directed towards a spatial locus is interpreted as co-referential with the nominal associated with that locus. The association of a locus with a referent remains throughout the discourse until changed by the signer. Associations between a referent and a spatial locus can be established by articulating the sign for the referent at a locus in space, by producing the sign and then pointing to the locus, or by gazing in the direction of the locus while making the sign (Lillo-Martin, 1986; Padden, 1983). Once a noun phrase has been associated with a particular locus, the signer may then refer back to it by using a pronominal sign directed at the locus. Thus ASL pronouns are marked for their antecedent via spatial location, rather than for the person or gender features of their antecedent. In this manner, ASL pronouns usually pick out specific antecedents, rather than a class of possible antecedents (such as third-person males).

In two previous sentence-processing studies, we found evidence that ASL pronouns reactivate their antecedents during on-line sentence processing (Emmorey, Norman, & O'Grady, 1991; Emmorey & Lillo-Martin, 1995). Our studies used a probe recognition technique in which subjects decided as quickly as possible whether a probe word appeared in a sentence (Chang, 1980; Dell, McKoon, & Ratcliff, 1983). For example, Chang (1980) presented sentences such as "Mary and John went to the store and he bought some milk". The response times to the probe word "John" (the antecedent of the pronoun) were shorter than the response times to "Mary" (the non-antecedent).¹ In our ASL studies, videotaped sentences were presented to deaf ASL signers, and probe signs were edited in either immediately or 1 sec following a pronoun. At the 1 sec delay, subjects were faster at recognising a probe sign that was the antecedent of a pronoun compared to a probe sign that was a non-antecedent. Subjects were also faster at recognising a probe sign when it was the antecedent of a pronoun compared to when the probe appeared in a control condition in which no anaphoric element was present. These results suggest that comprehension of the

¹ The terms "non-antecedent" and "antecedent" are preferred to the terms "non-referent" and "referent" because the definition of antecedent is more applicable and appropriate than the definition of referent. Trask's (1993) definition of antecedent is "an item from which an anaphor derives its meaning or reference" (pp. 16-17), and his definition of referent is "the entity in the real or conceptual world which is associated with a noun phrase in a particular sentence or utterance" (p. 233).

pronoun invokes the backward activation of its antecedent in both spoken and signed languages (for evidence from English, see Chang 1980; Corbett & Chang, 1983). The study by Emmorey and Lillo-Martin (1995) also found that zero anaphors (*pro*) licensed by verb agreement morphology also reactivate their antecedents. Thus antecedent reactivation occurs with both null and overt pronominals and appears to be modality-independent.

Several studies with English have also found evidence for inhibition or suppression of activation for the non-antecedent (Dell et al., 1983; MacDonald & MacWhinney, 1990). According to some researchers, non-antecedent suppression is indicated by slow response times to a probe noun that is *not* co-referential with an anaphor occurring in a later clause. Response times are slower for the non-antecedent noun compared to a control condition in which no co-referential element has appeared. Gernsbacher (1989, 1990) defines non-antecedent suppression more narrowly as a decrease in the level of activation of the non-antecedent from the level measured at a point prior to the anaphoric element. One effect of non-antecedent suppression is to improve the accessibility of the co-referent nominal by suppressing the activation of those nominals that are not antecedents. In particular, Gernsbacher (1989) has argued that the more unambiguous and “explicit” a co-referential element is, the more quickly it can be used to suppress non-antecedents. She found that unambiguous pronouns (pronouns whose gender matched only one potential antecedent) showed lower levels of non-antecedent suppression than repeated noun phrases. In ASL, pronominal reference via spatial loci allows explicit co-reference which is almost always unambiguous. However, neither Emmorey et al. (1991) nor Emmorey and Lillo-Martin (1995) found evidence for non-antecedent suppression in ASL. These surprising results raise several important questions: Is non-antecedent suppression a universal processing mechanism or is it language-specific? Is this process dependent upon the type of pronominal system within a language? The experiments reported here were designed to investigate these questions.

The fact that ASL pronouns are not marked for third person or gender but are nonetheless unambiguous will help to distinguish between processing models which rely on the “explicitness” of co-referential devices as opposed to morphological information in determining levels of suppression and/or activation. One possible reason that we did not observe non-antecedent suppression in our experiments may be that non-antecedents were identified by the spatial locus of the pronoun, rather than by syntactic factors. Syntactically, either noun phrase in the stimuli used in both the Emmorey et al. (1991) and the Emmorey and Lillo-Martin (1995) studies could have been the antecedent of the pronoun. That is, the pronoun was free to refer to either noun phrase without violating any syntactic constraints. In addition, in those experiments which have found suppression of non-antecedents for

spoken language, the non-antecedent was identified as such either by morphological marking (person, number and gender agreement; Gernsbacher, 1989) or by syntactic structure (e.g. clause structure determined the potential antecedent of a pronoun; Nicol, 1988). Hence, it is possible that the identification of non-antecedents by person and gender features (or by syntactic structure) results in suppression, while the spatial identification used in ASL does not result in suppression.

Furthermore, it is possible that spatial information may not be represented along with the ASL pronoun at the level of representation that is tapped by the probe recognition technique. That is, the ASL sign PRONOUN, which is morphologically marked only as first or non-first person (see Meier, 1990), is represented at one level and the associated spatial locus might be represented at a different level (perhaps an interpretive level where the pronoun and locus are associated). In fact, Emmorey et al. (1991) found some evidence for a dissociation between spatial loci and pronouns. In their experiment 2, the probe locus was varied so that it either matched or did not match the locus used in the target sentence. To our surprise, response times were not significantly longer for mismatched probe locations compared to matching locations. This result provides some evidence that the spatial location specifying reference is irrelevant to processing at the level tapped by the probe recognition task. At a level without spatial locus representation, a referent cannot be uniquely assigned to the pronoun. Thus at this lexical level, ASL pronouns would actually be more ambiguous than English pronouns because they would have fewer morphological features. If this is the level of representation tapped by probe recognition, then the processor would not be able to easily identify, and therefore suppress, non-antecedents.

In sum, one possible explanation for the lack of suppression of non-antecedents found in our experiments is that non-antecedent suppression may occur only when antecedents are identified through morphology (e.g. person or gender marking) or through syntactic structure. The identification of antecedents through spatial association may not lead to non-antecedent suppression. A second possibility is that pronouns are ambiguous at the lexical level (before they are associated with a spatial locus) and, if probe recognition taps this level, then we should not observe non-antecedent suppression for pronouns, but we should find non-antecedent suppression for lexically explicit referential devices. The following experiment explores these possibilities by comparing overt noun phrase references (i.e. repetitions of a definite noun phrase) with overt pronouns. It is predicted that explicit noun phrases will cause non-antecedent suppression, whereas a pronoun will not—if probe recognition taps the level at which pronouns in ASL are ambiguous (i.e. prior to the association of the pronoun with the spatial locus and its associated referent). Such a finding would indicate that

non-antecedent suppression does occur in ASL, but only when the antecedent can be identified through surface lexical form (e.g. an explicit noun).

Previous studies with English compared non-antecedent suppression with pronouns and with definite noun phrases (e.g. *the stewardess*) or proper names (e.g. *Ann*). For example, using a probe recognition experiment, Gernsbacher (1989) compared sentences in which the antecedent was identified by a repeated name or by a pronoun, as in examples (1) and (2):

1. Ann predicted that Tim would lose the track race, but *Tim* came in first very easily.
2. Ann predicted that Tim would lose the track race, but *he* came in first very easily.

Gernsbacher (1989) found that repeated names had a greater suppression effect on non-antecedents compared to unambiguous gender marked pronouns. She also found that when the pronoun could not distinguish potential antecedents by gender marking because both antecedents were the same gender (e.g. Ann and Pam), non-antecedent suppression was weaker and delayed compared to the suppression observed with a repeated name. Gernsbacher (1989) also found stronger antecedent reactivation with repeated names than with either ambiguous or unambiguous pronouns.

In the following experiment, definite noun phrases, rather than proper names, were chosen as a lexically explicit referential device. In ASL, proper names are almost always fingerspelled. In a fingerspelled name, distinct handshapes correspond to particular letters in the spelling of the English name (e.g. A-N-N). Name signs (e.g. a C handshape tapping the chin twice) are reserved for family, friends and some well-known people. The phonological structure of fingerspelled signs is quite different from that of native signs. Therefore, with respect to the probe recognition paradigm, proper names present methodological difficulties that are not present with common nouns (e.g. THIEF). Common nouns do not have a phonological structure that differs strongly from other words in the sentence. Furthermore, Garrod, Freudenthal and Boyle (1994) have found that proper names and definite noun phrases behave similarly with respect to reference resolution and discourse integration for spoken language.

Unlike English, ASL does not mark definiteness with definite versus indefinite determiners. A noun phrase can be identified as definite if it has been assigned a locus in signing space. Non-specific noun phrases are not assigned loci within signing space, and Engberg-Pedersen (1993) has shown that nominals which are high on a referentiality scale are much more likely to be associated with a spatial locus than nominals which have low referentiality (e.g. nominals that are mentioned only once or that are of little thematic relevance to the discourse). In English, nominals that are high on a

referentiality scale are marked with a definite determiner. The following experiment compared non-antecedent suppression with pronouns or with repeated noun phrases associated with a spatial locus. If the probe recognition technique taps a lexical level without spatial indexing, then non-antecedent suppression is predicted only with a repeated noun phrase and not with a pronoun because the repeated noun is lexically unambiguous at this level, but the pronoun is not.

EXPERIMENT 1

Methods

Subjects. Twenty-four deaf subjects who were fluent in ASL participated in the experiment. All subjects were born deaf. Eighteen subjects had deaf parents (mean age = 25 years) and six subjects had hearing parents (mean age = 26 years). The mean age at which these signers learned ASL was 7 years.² All subjects used ASL as their primary and preferred language. The subjects were tested either at Gallaudet University or at The Salk Institute and were paid for their participation.

Materials and Procedure. The same stimuli used by Emmorey et al. (1991) were used in this experiment with some modifications.³ All stimuli were re-filmed with a different native ASL signer. The signer produced each sentence with an overt pronoun, a repeated noun phrase, or with no anaphoric elements (the control condition). The experimental sentences contained two clauses conjoined by the ASL conjunctions: HAPPEN, UNEXPECTEDLY or BUT. The first clause of each sentence contained two possible antecedents that were established spatially to the right and left in signing space. Spatial assignment of a noun to a spatial locus was signalled by (1) producing the sign at that locus, (2) body shift and/or (3) eye gaze. Three second clauses for each experimental sentence were prepared: one clause contained a pronoun, one clause contained a repetition of one of the nouns in the first clause, and one clause contained no anaphoric co-reference devices. When articulating the pronoun or repeated noun, the signer often

² Previous research has found little difference between ASL signers exposed to ASL from birth and "near-native signers" who were exposed to ASL early in childhood (Mayberry, 1994; Newport, 1990, 1991).

³ Two test stimuli were eliminated, and some small changes in the sentences were made (e.g. substituting a synonym that was preferred by the new signer who produced the stimuli). Four filler sentences were also eliminated. Further details concerning the probe and sentence stimuli can be found in Emmorey et al. (1991).

shifted his eye-gaze towards the spatial locus associated with the antecedent. Below is an illustration of the three experimental conditions:⁴

Pronoun

ONE-YEAR-AGO S-F HIGH JUDGE_a DECIDE PUT-DOWN PRISON-AGENT_b LIFE JAIL, UNEXPECTEDLY PRONOUN_b HEART-ATTACK DIE.

Probes: PRISON-AGENT (antecedent), JUDGE (non-antecedent).

“A year ago, a high court judge from San Francisco decided to sentence a prisoner to life in jail, but unexpectedly he (prisoner) had a heart attack and died”.

Repeated noun

ONE-YEAR-AGO S-F HIGH JUDGE_a DECIDE PUT-DOWN PRISON-AGENT_b LIFE JAIL, UNEXPECTEDLY PRISON-AGENT HEART-ATTACK DIE.

Probes: PRISON-AGENT (antecedent), JUDGE (non-antecedent).

“A year ago, a high court judge from San Francisco decided to sentence a prisoner to life in jail, but unexpectedly the prisoner had a heart attack and died”.

No anaphora control

ONE-YEAR-AGO S-F HIGH JUDGE_a DECIDE PUT-DOWN PRISON-AGENT_b LIFE JAIL, UNEXPECTEDLY LAWYER FIND NEW EVIDENCE.

Probes: PRISON-AGENT, JUDGE.

“A year ago, a high court judge from San Francisco decided to sentence a prisoner to life in jail, but unexpectedly a lawyer found some new evidence”.

In the pronoun and repeated noun conditions, the second clause was designed such that either participant in the first clause could be the antecedent. Emmorey et al. (1991) verified the reference plausibility intuitions by presenting the test sentences to native signers for judgements. Whether the pronoun or noun phrase referred back to the first or second participant was chosen at random and was counterbalanced across stimuli.

⁴ Words in capital letters represent English glosses for ASL signs. The gloss represents the meaning of the unmarked, unmodulated root form of a sign. Multiword glosses connected by hyphens are used when more than one English word is required to translate a single sign (e.g. PRISON-AGENT). Subscripts are used to indicate spatial loci; nouns and pronouns are marked with a subscript to indicate the loci at which they are signed (e.g. PRONOUN_a, JUDGE_a).

The design of the experiment was 3 (sentence type: overt pronoun, repeated noun, no anaphora) \times 2 (probe type: antecedent *vs* non-antecedent). Probes were presented 1 sec after the anaphoric element or, in the no-anaphora condition, 1 sec after the second word. The signers did not see the remainder of the sentence after the probe. A 1 sec delay was chosen because our previous experiments demonstrated antecedent reactivation at this delay (Emmorey et al., 1991; Emmorey & Lillo-Martin, 1995), and this delay equates the number of words that an English speaker would read in 500 msec (a delay often used in reading experiments) with the number of signs that an ASL signer would see after 1000 msec (see Emmorey et al., 1991, for further discussion).

Six videotapes were created to counterbalance sentence type and probe type such that no subject saw the same sentence or probe twice. There were 54 test items and 56 filler sentences. The filler sentences were the same on all tapes. One-third of the filler sentences contained a pronoun, one-third contained a repeated noun phrase and one-third contained no anaphoric element. Filler sentences almost always required a “no” response (the probe was not contained in the sentence), and the probes varied in lexical category. The subjects were asked to decide as quickly and as accurately as possible whether a probe sign had appeared in the sentence. Response time was measured from the onset of the probe sign. Eight practice items preceded the test trials. Twenty-nine “yes/no” comprehension questions which related only to the first clause of the test sentence were interspersed throughout the experiment. The comprehension questions were designed to help ensure that the subjects were processing the sentences for meaning.

Results

Only correct responses were analysed, and response times that were more than two standard deviations above or below each subject’s mean reaction time were deleted from the analysis (this procedure eliminated only 4% of the data). Two separate ANOVAs were conducted with subjects and items as random factors (Clark, 1973).

Response Times. The mean reaction times are listed in Table 1.⁵ There was a main effect of sentence type with the subjects analysis [$F_1(2,46) = 5.43$, $P < 0.01$], but not with the items analysis [$F_2(2,106) = 1.77$]. Responses were slowest for the no-anaphora control condition. There was also a main effect

⁵ Signers who learned ASL early in childhood ($n = 6$) had significantly longer response times compared to signers who acquired ASL from birth [$F(1,22) = 6.43$, $P < 0.02$]. However, the response patterns of the two groups was similar. If the non-native ASL signers are excluded from the analyses, the pattern of results does not change. Error rates did not differ significantly for the two groups.

of probe type [$F_1(1,23) = 23.72, P < 0.001; F_2(1,53) = 5.25, P < 0.05$]. Responses to antecedent probes were faster than to non-antecedent probes. The expected interaction between sentence type and probe type was also significant, although the items analysis was marginal [$F_1(2,46) = 4.83, P < 0.02; F_2(2,106) = 2.67, P = 0.07$]. Planned comparisons revealed a pattern that mirrored our previous results with overt pronouns. That is, responses to antecedent probes were faster than to non-antecedent probes in the pronoun condition [$t_1(23) = 1.88, P < 0.05; t_2(53) = 1.67, P < 0.05$, one-tailed]. In addition, responses to antecedent probes in the pronoun condition were significantly faster than responses to probes in the no-anaphora control condition with the subjects analysis [$t_1(23) = 2.40, P < 0.025$], but not with the items analysis [$t_2(53) = 1.35$]. This pattern of results replicates our previous results with pronoun anaphors and indicates that antecedent reactivation occurs in ASL via an overt pronoun. Furthermore, as in our previous studies, there was no evidence of non-antecedent suppression from a pronoun anaphor: response times to non-antecedents in the pronoun condition were not significantly longer than in the no-anaphora control condition.

As expected, we also found that repeated noun phrases reactivated their antecedents: responses to antecedent probes were faster in the repeated noun condition than in the no-anaphora control condition [$t_1(23) = 3.59, P < 0.005; t_2(53) = 3.32, P < 0.005$]. Furthermore, within the repeated noun condition, responses to antecedent probes were significantly faster than to non-antecedent probes [$t_1(23) = 3.60, P < 0.005; t_2(53) = 2.23, P < 0.025$]. The reactivation from repeated noun phrases was even stronger than that observed from pronouns, and this pattern follows what has been found for English.

However, contrary to our predictions, we found no evidence for non-antecedent suppression with repeated noun phrases: reaction times to non-antecedents were not longer in the repeated noun condition compared to the no-anaphora condition.

Error Rates. The mean error rates are listed in Table 1. The pattern of error rates generally mirrored the pattern for response times, but the data were statistically less sensitive. There was no main effect of sentence type [$F_1(2,46) = 2.03; F_2(2,106) = 1.38$], but there was a main effect of probe type [$F_1(1,23) = 9.68, P < 0.005; F_2(1,54) = 10.62, P < 0.005$]. Error rates to antecedent probes were lower than to non-antecedent probes. The interaction between sentence type and probe type was significant [$F_1(2,46) = 3.84, P < 0.05; F_2(2,106) = 6.74, P < 0.005$]. Planned comparisons revealed that error rates dropped for antecedent probes presented in the repeated noun condition compared to the no-anaphora condition [$t_1(23) = 3.3, P < 0.005; t_2(53) = 3.42, P < 0.005$], but error rates did not drop for

TABLE 1

Mean±Standard Error Response Times (msec) and Error Rates (%) for Experiment 1

<i>Probe Type</i>	<i>Type of Anaphor in the Sentence</i>		
	<i>Repeated Noun</i>	<i>Pronoun</i>	<i>No Anaphora</i>
Antecedent	1343±46 2.3%	1399±50 10.7%	1473±51 10.7%
Non-antecedent	1482±48 16.7%	1465±50 14.3%	1474±47 16.7%

antecedent probes in the pronoun condition compared to the no-anaphora condition (t_1 and $t_2 < 1$). In addition, error rates were lower for antecedent probes compared to non-antecedent probes in the repeated noun condition [$t_1(23) = 4.25, P < 0.001$; $t_2(53) = 5.95, P < 0.005$], but the error rate difference between antecedent and non-antecedent probes was not significant for the pronoun condition (t_1 and $t_2 < 1$). Finally, there were no significant changes in error rates for the non-antecedent probes across the three sentence conditions, again indicating that non-antecedent suppression did not occur with either pronouns or repeated noun phrases.

Discussion

As in our two previous studies, we found evidence suggesting that overt pronouns reactivate their antecedents during sentence comprehension. As expected, we also found that repeated noun phrases also reactivate their antecedents to an even greater degree. However, neither the response time nor the error rate data indicated that repeated noun phrases suppress non-antecedents. This result is quite surprising, because it indicates that non-antecedent suppression does not occur at all when signers are processing ASL sentences. It suggests that a fundamental linguistic processing mechanism for spoken languages is not at work for signed languages. There is no reason to expect such a difference given that there is no difference in linguistic structure or conceptual representation for repeated noun phrases in English and ASL. We therefore conducted a second experiment that tapped the time-course of non-antecedent suppression using a different technique. In Gernsbacher's (1990) series of experiments, evidence for non-antecedent suppression was found using a different control condition. In these experiments, response times were compared for probes presented before the co-referential element (at the end of the first clause) and for probes presented after the co-referential element, either a pronoun or repeated noun. Gernsbacher found longer response times for non-antecedent probes after a co-referential element compared to

response times to the same probe before the pronoun/repeated noun. In Experiment 2, we adopted Gernsbacher's methodology to further investigate the apparent lack of non-antecedent suppression in ASL.

EXPERIMENT 2: PROBE PRESENTATION BEFORE AND AFTER CO-REFERENTIAL ELEMENTS

Methods

Subjects. Eighteen deaf ASL signers participated in the experiment, 11 of whom were native signers with deaf parents (mean age = 24 years) and 7 of whom were fluent signers with hearing parents (mean age = 29 years). These signers were exposed to ASL at a mean age of 6 years and had an average of over 20 years of signing experience. Sixteen subjects were born deaf, and the other two subjects became deaf before age 2 years. The subjects were tested either at The Salk Institute or at Gallaudet University and were paid for their participation.

Materials and Procedure. The same stimuli as in Experiment 1 were used in Experiment 2. The videotapes from Experiment 1 were re-edited onto a new set of test videotapes with the following critical change: the no-anaphora control condition was replaced with a condition in which probes were presented prior to the anaphoric element. Thus the design of this study was 2 (probe type: antecedent vs non-antecedent) \times 3 (probe presentation position: before anaphor, after pronoun anaphor, after noun anaphor). For the before-anaphor condition, probes were presented after the last word of the first clause (before the conjunction in Example 1). For the after-anaphor conditions, the probes were presented 1 sec after the pronoun or the noun. The same procedure as for Experiment 1 was used.

Results

Only correct responses were analysed, and response times that were more than two standard deviations above or below each subject's mean reaction time were deleted from the analysis (this procedure eliminated less than 4% of the data). Two separate ANOVAs were conducted with subjects and items as random factors.

Response Times. The mean response times are given in Table 2.⁶ The results mirror those found by Gernsbacher (1990). There was a main effect of probe type [$F_1(1,17) = 30.85, P < 0.001; F_2(1,53) = 14.64, P < 0.001$].

⁶ Signers who learned ASL early in childhood ($n = 7$) and signers who were exposed to ASL from birth did not differ significantly in their response times or error rates. Exclusion of the non-native signers does not alter the pattern of results.

TABLE 2

Mean±Standard Error Response Times (msec) and Error Rates (%) for Experiment 2

Probe Type	Probe Position		
	Before Anaphor	After Repeated Noun	After Pronoun
Antecedent	1091±36 3.7%	1089±47 1.2%	1157±42 9.3%
Non-antecedent	1079±46 5.6%	1258±52 15.4%	1183±42 9.3%

Responses to antecedent probes were faster than to non-antecedent probes. There was also a main effect of presentation position of the probe [$F_1(2,34) = 14.09, P < 0.001; F_2(2,106) = 5.13, P < 0.01$]. Responses to probes presented prior to the anaphor were faster than probes presented after either a pronoun or a repeated noun phrase. Finally, the interaction between probe type and presentation position was significant [$F_1(2,34) = 8.75, P < 0.001; F_2(2,106) = 10.31, P < 0.001$].

Planned comparisons revealed that responses to non-antecedent probes were significantly slower after either a pronoun [$t_1(17) = 4.66, P < 0.001; t_2(53) = 3.15, P < 0.005$] or after a repeated noun [$t_1(17) = 5.70, P < 0.001; t_2(53) = 3.82, P < 0.001$] compared to the response times for the probe presented before the anaphor. As found by Gernsbacher using this paradigm, response times did not differ significantly for antecedent probes presented after a pronoun anaphor compared to response times for the probe presented prior to the anaphor [$t_1(17) = 1.10; t_2(53) = 1.01$]. Unlike Gernsbacher's results, response times also did not differ for antecedent probes following a repeated noun (t_1 and $t_2 < 1$).

Error Rates. The mean error rates are given in Table 2. As with the response time data, there was a main effect of probe type [$F_1(1,17) = 8.14, P < 0.02; F_2(1,53) = 8.35, P < 0.01$]. Error rates were higher for non-antecedent probes than for antecedent probes. There was no main effect of probe position for error rates [$F_1(2,34) = 2.57; F_2(2,106) = 2.49$]. The interaction between probe type and presentation position was significant [$F_1(2,34) = 4.92, P < 0.02; F_2(2,106) = 7.05, P < 0.005$].

Planned comparisons revealed that error rates to non-antecedent probes increased significantly when probes were presented following a repeated noun compared to before the noun [$t_1(17) = 2.01, P < 0.05; t_2(53) = 3.04, P < 0.01$], but there was no significant change in error rate for non-antecedent probes following a pronoun anaphor [$t_1(17) = 1.00; t_2(53) = 1.00$]. For antecedent probes, there was a surprising increase in error rates

for probes presented after the pronoun compared to before the pronoun [$t_1(17) = 1.18, P < 0.05; t_2(53) = 2.02, P < 0.05$], but there was no significant change in error rates for antecedent probes presented before and after a repeated noun [$t_1(17) = 1.46; t_2(53) = 1.43$].

GENERAL DISCUSSION

We began this set of studies by hypothesising that ASL pronouns might fail to suppress non-antecedents because at the lexical level, where there is no association with a spatial locus, ASL pronouns are quite ambiguous. It was predicted that definite noun phrases which are lexically unambiguous would lead to non-antecedent suppression, unlike the pronouns. However, Experiment 1 indicated that neither pronouns nor repeated noun phrases suppress non-antecedents. The finding that definite noun phrases did not suppress non-antecedents was quite surprising, because there is no reason to predict that ASL signers should process repeated noun phrases differently than English speakers. We therefore investigated the nature of the baseline condition against which non-antecedent suppression was measured. Experiment 1 measured suppression with respect to a sentence which contained no anaphoric element. In Experiment 2, non-antecedent suppression was measured by comparing response times to probes presented prior to and after the anaphor. The results of Experiment 2 indicated that both pronouns and repeated noun phrases suppress non-antecedents, which suggests that our previous failure to find non-antecedent suppression may have been due to the type of baseline against which suppression and reactivation were measured.

The fact that we observed non-antecedent suppression for ASL pronouns in Experiment 2 suggests that the probe recognition task does indeed tap a level of representation at which pronouns are specified for a spatial locus. The association of a lexical pronoun with a spatial locus creates a representation in which the antecedent of the pronoun is unambiguous, and therefore it should cause non-antecedent suppression. Thus with respect to suppression mechanisms, the spatial distinctions expressed by ASL pronouns function similarly to gender distinctions in English. That is, pronoun gender in English can disambiguate between two potential antecedents that differ in gender, and Gernsbacher (1989) found greater suppression effects in these cases compared to cases where gender marking did not distinguish between antecedents. ASL pronouns linked to spatial loci also disambiguate between potential antecedents, and they do so to an even greater extent than English pronouns because they pick out a unique referent—the referent previously associated with the spatial locus. In fact, with further testing, we might find this greater explicitness of ASL pronouns reflected in the time-course of suppression: non-antecedent suppression

may occur earlier with ASL pronouns than with English pronouns. Note that we found suppression effects before the end of the sentence, 1000 msec after the pronoun, whereas Gernsbacher (1989) found suppression effects only sentence finally.

Our finding that probe recognition appears to tap a level of representation at which pronouns are associated with spatial loci also helps clarify our previous finding that mismatched spatial locations did not slow response times (Emmorey et al., 1991). This lack of interference cannot be explained by the level tapped by probe recognition; rather, the lack of interference may have been due to the fact that purely referential loci carry very little semantic weight, such that mismatches are not particularly disruptive when the task is to determine whether the noun itself appeared in the sentence, regardless of its referential locus. Support for this hypothesis was provided by Emmorey, Corina and Bellugi (1995), who discovered that mismatched spatial loci caused significant interference effects in a probe recognition task when the loci carried semantic information about object *location*—for example, where the nominal is specified as located in some real (or imagined) place.

Experiments 1 and 2 also shed some light on the use of different baselines for measuring antecedent reactivation and non-antecedent suppression. MacDonald and MacWhinney (1990) have suggested that the before-anaphor baseline used in Experiment 2 fails to distinguish between a “natural” decline in the activation level of a noun and actual suppression of that noun by an anaphoric element. However, the non-antecedent suppression effects that we observed in Experiment 2 cannot be solely due to a natural decline in activation because of the differential decline for non-antecedents associated with pronouns versus repeated noun phrases. That is, responses to non-antecedent probes were slower and less accurate following an explicit noun phrase compared to when they followed a pronoun.⁷ Both types of non-antecedents should have equally slow responses if the only change that occurs is a decline in activation across the sentence.

Neither Gernsbacher’s (1990) studies nor the present study with ASL provide evidence that the antecedents of pronouns are reactivated when response times are compared for probes presented before and after the pronoun. Using this baseline, we also did not find significant changes in activation for repeated noun phrases, possibly due to the use of common nouns rather than repeated names (see Gernsbacher, 1990, for discussion). The before-anaphor baseline may be less sensitive to differences in

⁷ The difference between non-antecedent probes following a pronoun versus a repeated noun was statistically reliable for response time with the subjects analysis [$t_1(17) = 1.96, P < 0.05$], but missed significance for the items analysis [$t_2(53) = 1.63$]. The difference between probe types was also significant for error rate with both analyses [$t_1(17) = 2.40, P < 0.02$; $t_2(53) = 1.75, P < 0.05$].

antecedent activation levels because of an interaction between the natural decline in activation of nouns and the presence of a pronoun. That is, the activation of the antecedent noun in the first clause may decline over time until the pronoun is encountered in the second clause. The pronoun may reactivate the noun to a level of activation similar to when it was first mentioned (before the pronoun). Therefore, we might find little or no difference between response times measured at the before-anaphor position compared to the after-anaphor position, because the pronoun may have reactivated the noun to the level of activation it had at the before-anaphor position.

If this is the case, then the no-anaphora baseline condition used in Experiment 1 may be better designed to measure differences in activation levels for both pronominal and repeated noun phrase antecedents. In the no-anaphora sentences, if one assumes that the activation of the “antecedent” noun has continued to decline at the point where response time is measured (more than 1000 msec into the second clause), then in the pronoun sentences, the natural decline in activation of the antecedent noun might have been halted or reversed by the presence of the pronoun at the same point within the second clause. Thus we might observe faster response times for probes in the pronoun condition compared to the no-anaphora condition because we are measuring response time at roughly the same point in time within the two sentence types. Note, however, that the no-anaphora baseline does not allow us to observe *changes* in the activation level of an antecedent because only one point in time is measured. We can only observe *differences* in activation levels when an anaphoric element is present versus absent.

Although the no-anaphora baseline condition can detect differences in activation levels for antecedents, it may not easily detect non-antecedent suppression effects. MacDonald and MacWhinney (1990) have pointed out that the no-anaphora control sentences may introduce a topic shift or a change in discourse focus, and this may make it difficult to detect non-antecedent suppression. For example, in Experiment 1, the no-anaphora control sentences contained a third noun which was introduced before the probe sign was encountered. It is possible that this new potential discourse participant suppressed the activation of the two nouns in the preceding discourse. If so, then the non-antecedent noun was suppressed in both the pronoun condition (via the pronoun) and in the no-anaphora condition (via the new noun), which would lead to no difference between these conditions for the non-antecedent. In addition, if this is the case, then the antecedent reactivation observed in Experiment 1 (and in our previous studies) may have been overestimated, because the “antecedent” noun would have been suppressed in the no-anaphora baseline condition. Thus it is important that subjects do not view a new discourse participant prior to

probe presentation when a no-anaphora baseline condition is used to measure antecedent reactivation.

In conclusion, these experiments have shown that the same suppression and reactivation processes are involved in interpreting anaphors in a language that uses spatial representations as part of its co-reference system. The evidence indicates that ASL pronouns reactivate their antecedents and suppress non-antecedents. The results also suggest that within the probe recognition paradigm, the spatial indexing of ASL pronouns is similar to gender marking in English with respect to picking out an unambiguous antecedent and suppressing non-antecedents. For non-antecedent suppression to occur during sentence processing, what appears to be critical is the degree of ambiguity or “explicitness” of a pronoun, rather than the type of morphological marking on the pronoun. Thus we can see from these studies that despite great differences in surface form, signed and spoken languages use at least some of the same processing mechanisms in resolving and interpreting co-reference relations.

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