Pronoun Resolution in American Sign Language:

A Literature Review to Motivate Neurocognitive Experimentation

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I. Introduction

At the most fundamental level, language can be considered as a system of communication governed by specific relationships and rules. Many of these rules and relationships, the linguistic structure of a language, have been found to be universal across all known languages. The existence of linguistic universals presents the neuro- and psycho-linguist with the opportunity to manipulate the structure of a language in order to expose the underlying mechanism by which a certain feature is implemented. The ultimate goal is thus to empirically address the universal aspects of language to define the exact manner in which the human brain interprets and implements language and characterize those elements which are not universal for the sake of documenting and elucidating the capacity of the human language faculty. Integration of data cross linguistically and across modalities is thus a crucial aspect of linguistic investigation. To that end, the current paper intends to provide a closer look at the language universal phenomenon of anaphoric reference as it is implemented in the auditory and visual/manual modalities. The primary goal herein is to better answer the question: How are pronouns processed in signed language? With a clearer picture of the current knowledge of signed language pronoun implementation, we will be better able to integrate this data with that of spoken language pronoun processing, revealing where further research is required in order to add to the large body of evidence that point to the language and modality independence of the human language faculty.

American Sign Language (ASL), the predominant language of the deaf community in North America, was developed independently without significant influence from spoken language. Indeed, ASL is a complete language system with a unique morphology, phonology, semantics, pragmatics, and syntax.[1] A signed language such as ASL thus presents the linguist with a compelling paradigm: it is a linguistic system that is "essentially identical to that of spoken language in terms of its underlying linguistic structure, but it is implemented in a radically different perceptual signal."[2] From an experimental perspective, the study of a signed language can provide invaluable insights with regards to the language processor by exposing the variable of modality on the neurocognitive implementation of a language in normal populations. Current research points to the conclusion that the processing requirements of language determine its cortical organization and implementation, that is, language is hypothesized to be modality dependent. It is thus a goal of the current discussion to highlight the current state of on-line experimental research in signed language, specifically, ASL, in an attempt to support this hypothesis.

ASL, and all documented signed languages for that matter, relies on spatial relationships to not only to produce individual signs, but also to complete complex grammatical functions. The use of space in signed language is the most salient effect of the modality contrast between signed and spoken language. Crucial to the current paper is the fact that even though hand shapes may differ between signed languages, all signed languages use the same type of pronominal system.[1] In identifying a specific function that is rooted in the unique spatial nature of signed language, on-line experimentation can examine the processing mechanisms correlated to the use of linguistic space and thus offer a contribution toward precisely defining the extent to which the human language processor is modality independent. A function well documented in both signed and a spoken language is that of pronominal reference and thus provides a platform for fine-grained examination of the processing mechanisms which give rise to its successful completion during normal discourse comprehension across modality.

The remainder of this paper will be organized in the following manner: first I present a brief review of Morton Gernsbacher's seminal on-line experiments aimed at elucidating the process of pronoun resolution in spoken language, next a brief account of the ASL pronominal system will be provided as a foundation for a thorough examination of three crucial publications from Karen Emmorey, that, when considered together, present the most complete account of ASL pronoun resolution to date. Next, an account of recent electrophysiological findings in cases of pronominal ambiguity will be discussed in order to motivate similar experimentation in signed language.

II. Referential Access in Spoken Language: Insights from On-Line Data

In 1989 Morton Ann Gernsbacher published a set of experiments in which the on-line processing mechanisms associated with referential access and pronominal resolution were investigated. Gernsbacher outlines a general model of lexical access: in brief, upon encountering a word, the language processor activates all possible lexical items that could be associated with this entity, this process is termed "recognition."[3] Then, the incremental overlay of linguistic constraints "identifies" the most potential candidates and their activation is enhanced. After a certain time-course, the most robustly activated lexical item facilitates comprehension of the intended lexical representation. The lexical representation of a given word is then "incorporated into the comprehender's developing discourse representation."[3] The goal around which Gernsbacher's experiments were designed was to elucidate the connection between this general model of lexical access and the comprehension of anaphor constructions in spoken language. Specifically, Gernsbacher posits that the mechanisms of enhancement and inhibition allow for the differentiated activation levels of lexical items in a given discourse representation.[3] In the case of pronominal reference, Gernsbacher suggests that the trigger for enhancement and inhibition is the reception of information that uniquely identifies an anaphor's antecedent. Indeed, Gernsbacher suggests that the extent of information encoded in an anaphoric element is directly correlated to the accessibility of the antecedent.[3] Antecedent accessibility is thus improved by the mechanisms of enhancement and inhibition to the extent that these processes utilize explicit information provided by the anaphor to uniquely identify the proper antecedent.[3] The concept of anaphoric explicitness as a trigger of antecedent enhancement and non-antecedent suppression is equitable to the models of lexical retrieval based on a tuning fork analogy: namely, a tuning fork vibrating a certain frequency will elicit other forks of the same or similar frequencies to vibrate.[3] In this way, the explicitness of an anaphor can be conceived as a certain resonant frequency that prompts the vibration of a similar antecedent: the closer the resonant frequencies of the anaphoric element and its antecedent, the more robust is the antecedent's activation. Gernsbacher's experiments empirically examine this model of lexical access during pronominal resolution and present conclusions relevant to the examination of sign language pronoun processing. Using a probe recognition task with word-by-word stimuli presentation, Gernsbacher presents six experiments (a further explanation of the probe recognition methodology will be undertaken in Section III). A brief overview of three selected experiments from this work and their contributions to our understanding of referential access and the mechanisms behind pronominal resolution in spoken English will be highlighted.

Gernsbacher's first experiment under consideration examined the difference between reaction time to probes presented before or after an anaphoric element.[3] Three variables were considered in Gernsbacher's design: The degree of explicitness of the anaphor (repeated name of anaphor), whether the probe referred to the antecedent of the anaphor or the non-antecedent of the anaphor, and where the probe was located relative to the anaphor (before or after). Sentences like (1) were used in this experiment:[3]

1) David saw that Brian was fixing a flat tire and David/he stopped to offer some help.

Results indicate that response times to antecedent probes were faster than to non-antecedent probes in the presence of an explicit, repeated name anaphor, confirming the procedure of referent activation upon anaphor processing.[3] Response times to non-antecedent probes after the repeated name anaphor were slower than to the non-antecedent probe presented before the anaphor, suggesting an active non-antecedent suppression mechanism.[3] In the pronoun (less explicit) condition, there was no change in activation levels (no difference in response time) before or after the pronoun, in both the antecedent and non-antecedent conditions.[3] Gernsbacher concludes that: "explicit name anaphor immediately improve their antecedent's accessibility by both suppression and enhancement."[3] In explaining the lack of evidence for referential accessibility mechanisms in the pronoun condition, Gernsbacher suggests that an "anaphors informational content affects how rapidly they affect their antecedent's accessibility" and that "less explicit anaphors, such a pronouns that match the gender, number, and case of multiple participants, do not immediately affect the activation of either their antecedents or non-antecedents."[3]

The next contribution from Gernsbacher investigated the possibility that non-explicit anaphors (ambiguous pronouns as in (1)) also suppress nonantecedents, but over a slower time course than evidenced by explicit anaphors, as in the previous experiment.[3] The design and stimuli of the experiment mimicked that presented above, except that a probe was placed directly after the anaphor and another was placed sentence finally.[3] The reasoning behind this probe placement was supported by two motivations: 1) the after-anaphor probe response times could be compared to those reported in the same position in the previous experiment and 2) comparison between response times to probes directly after the anaphor and at the end of a sentence could provide an account of the differential time course of activation levels due to the explicitness of the anaphor.[3] Results were as follows: response times to antecedents were faster than to non-antecedents in both the repeated noun and pronoun conditions, responses to probes directly after the anaphor were faster than to probes presented sentence finally, the difference between response times to repeated nouns and pronouns was greatest directly after the anaphor, and response times to the non-antecedents in the pronoun condition were significantly slower sentence finally than immediately after the anaphor.[3] From this data, Gernsbacher argues that the activation of antecedents and non-antecedents did not differ directly after the anaphor, but there was an effect of non-antecedent inhibition at the conclusion of the sentence. Gernsbacher relates these results to the mechanisms of inhibition and enhancement in the following manner: "pronouns also improve their antecedent's referential access by triggering the suppression of other concepts, but they do so more slowly (and perhaps less powerfully)."[3] The conclusion is thus that since pronouns are semantically less explicit than repeated name anaphors, the degree of suppression effects is reduced and is elicited over a greater time course.

The final Gernsbacher experiment under consideration attempts to support this conclusion in hypothesizing that if a pronoun were more explicit, then the mechanism of non-antecedent inhibition is expected to be more robust and occur over a shorter time-course.[3] Accordingly, this investigation mimicked the previous experiment in design, probe location, and stimuli, except for the fact that the stimulus sentences contained two discourse participants of contrasting gender, such that the pronoun anaphor could only refer to one unique antecedent. Stimuli for this experiment were of the following form:[3]

2) Chuck saw that Janet was in very serious trouble and Chuck/he ran quickly for some help.

The results from this experiment confirm the building intuition that the degree of explicitness of an anaphor determines the amplitude of antecedent enhancement and non-antecedent inhibition mechanisms in on-line processing: response times were faster to antecedents than to non-antecedents when probes were presented directly after the anaphor, response times to probes were faster directly after the anaphor than sentence finally, immediately after the pronoun, the difference between response times between antecedents and non-antecedents was insignificant, but the response time to non-antecedents in the pronoun condition were significantly slower sentence finally than were responses to the antecedent.[3] The difference in response time between probes presented sentence finally and directly after the anaphor between non-antecedents was greater in the case of an explicit pronoun (gender specific) than to non-explicit (ambiguous) pronouns.[3] That is, the third experiment elicited a stronger inhibition effect due to the extra gender information provided by the pronoun.

In sum, we can gather three important insights from the brief discussion of Gernsbacher's 1989 study:

i) Repeated noun anaphors robustly trigger the simultaneous processes of antecedent re-activation and non antecedent suppression,

ii) Less explicit or ambiguous pronouns (those that can refer to either one of two equally plausible discourse participants presented in the first clause of a sentence) trigger non-antecedent suppression by the end of a sentence, and

iii) In cases of non-ambiguous pronominal reference, where the gender of a pronoun matches only one discourse participant, suppression is triggered to greater amplitude.[3]

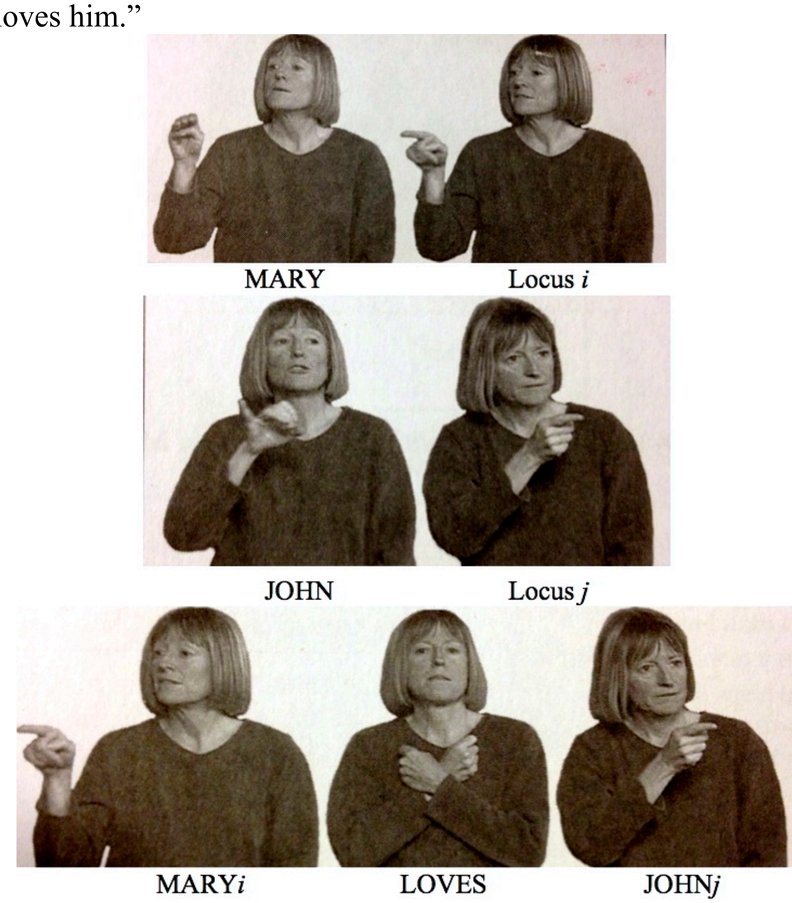
Taken in concert, these results point to a model of anaphoric processing in which the concurrent processes of inhibition and re-activation hinge upon on the degree of information encoded in the anaphoric element. Upon encountering an anaphor, the language processor entertains competing mental representations of possible antecedents, and the final decision to associate an anaphor with an indexed nominal element introduced earlier in a discourse is facilitated by antecedent re-activation and non-antecedent suppression. In order to address the ultimate goal of the current paper, these data must be borne out in signed language in order to equate the neurocognitive process of pronominal reference resolution across modality. Section III introduces three crucial studies that support this motivation. Only with a better understanding of the processing mechanisms that underlie anaphoric processing in signed language can we turn to the electrophysiology of pronominal resolution for further support of the modality-independence of reference establishment and implementation during discourse comprehension.

III. Pronoun Processing in ASL: On-Line Accounts of Signer's Unique Use of Space

A. The Pronominal System of American Sign Language

Overt pronouns in ASL are realized by assigning discourse referents a specific location in signing space.[1] Signing space is defined as the approximately 50 in^2 circle that encapsulates the head, torso, and extended arms of the signer.[4] Referents are assigned an arbitrary locus in the signing space, and "imagined" at this location as a pronoun sign is directed toward it.[5] Pronoun signs distinguish between first and non-first person and number. There is no gender marking (except for in the special case of Japanese Sign Language) or differentiation between second and third person pronouns in the signed pronominal system.[1] With regards to the feature of person, a signer creates a first-person sign and directs it toward his or her sternum.[1,4] Second person signs are directed toward the addressee, often accompanied by eye-gaze and third person signs are implemented by pointing toward the locus established for the referent.[1,4] In the case where a referent in physically present as the signed discourse unfolds, a pronoun sign is merely directed toward the location of the referent.[1,4] It is clear then, that there is no distinction between second and third person pronouns since both involve pointing to the location of the referent in signing space. For clarification, the following is an example of signed language pronoun completion in the sentence "Mary loves John" from Sandler and Lillo-Martin, 2006.[1] Note how the signer establishes s specific spatial loci for each discourse participant and directs the pronominal hand shape toward that locus for pronoun production. (3) is the traditional orthographic transcription convention of ASL which will be adhered in the remainder of this paper. English glosses of signs are presented in capital letters, and when more than one word is required to represent the meaning of a single sign a hyphen will be used. Locations in signing space are denoted with subscripts: in the case of referential indices, letters represent the different spatial loci.

3) MARY$_i$ LOVES JOHN$_j$.
"She loves him."



The spatial morphology of pronominal reference in ASL raises a compelling difference between spoken and signed language: namely, a signed language can potentially refer to an infinite number of unambiguous pronouns, each with its own locus in the signing space. Lillo-Martin and Kilma argue that this infinite feature is unacceptable, and propose that pronoun signs are represented in two domains: one in the lexicon, and one in the referential index.[6] Since a referential index is assigned to every NP, the critical indices of antecedents are overtly and unambiguously realized in the signing space.[1,6] Important to recognize at this point is the fact that even though referential indices are overtly realized in signed and not spoken language, the syntactic representation of pronouns does not differ across auditory and visual/manual modalities. In the words of Sandler and Lillo-Martin, "in both modalities, pronouns bear a referential index and are subject to the same constraints."[1]

B. Referent Activation in ASL Pronoun Resolution

One of the pre-eminent linguists working toward a more thorough understanding of native signers' use of pronouns is Karen Emmorey of the Salk Institute for Biological Studies in La Jolla, CA . Emmorey presents three compelling probe recognition experiments that consider the unique spatial morphology inherent to signed language pronouns and this features' impact on the online processing of reference. Each study will be considered in detail and the relevant conclusions that point toward an understanding of pronominal processing in American Sign Language will be highlighted.

In 1991, Emmorey et al. began their empirical examination of ASL pronouns with a probe recognition task designed to investigate the occurrence of referent re-activation upon the interpretation of a pronoun. As discussed earlier, the comprehension of a pronoun in normal sign language discourse involves the "backward activation" of the intended antecedent, from previous online studies in spoken language, we can be confident that the probe recognition paradigm allows the proper resolution for examination of the on-line assignment of referents to pronouns. Emmorey et al. created stimuli in which native deaf signers watched videos of recorded ASL sentences with probe signs inserted at specific delays post-pronoun.[7] Two experiments are presented, the first was aimed at identifying the existence of referent activation in the visual/manual modality.[7] The experimental stimuli used in the first experiment consisted of sentences in which the first clause introduced two equally plausible noun referents, and the second either a pronoun that referred to one of the noun referents introduced in the first clause or in the control condition, or no pronoun but rather a third discourse participant.[7] An example of a minimal pair from Emmorey et al. 1991 illustrates the design; in (1) the pronoun condition is illustrated, (2) is an example of a control sentence:[7]

4) A-FEW REALLY STRICT LIBRARY-AGENT$_a$ FORBID BIG-HEAD STUDENT$_b$ TAKE OUT BOOK, HAPPEN THEY$_b$ CONTACT PRINCIPAL COMPLAIN.
   "A few really strict librarians refused to allow disruptive students to check out books, as it happens they (students) contacted the principal and complained.

5) A-FEW REALLY STRICT LIBRARY-AGENT$_a$ FORBID BIG HEAD STUDENT$_b$ TAKE OUT BOOK, HAPPEN PRINCIPAL FIND-OUT UPSET.
   "A few really strict librarians refused to allow disruptive students to check out books, as it happens they principal found out and was upset."

Probes consisted of either a) the correct referent or b) the incorrect referent (STUDENT or LIBRARY-AGENT respectively from (1) above).[7] In order to differentiate between the sentence and probe, the signer wore a contrasting color when signing a probe.[7] Participants were instructed to respond via a button press whether or not the probe had appeared in the preceding sentence. The probe nouns were inserted at two different time points post pronoun in Emmorey et al. 1991's design, either directly after the pronoun sign was completed (the hand shape was associated with its locus) or 1000 msec after pronoun offset. Emmorey et al. explain that the 1000 msec delay condition could be informative due to the inherently slower nature of manual sign production could result in a delay in processing of co-reference.[7] This intuition is supported by work by Klima and Bellugi in which the time to articulate a sign was found to be nearly twice that of a spoken word.[8] In this way, Emmorey et al. 1991 also began an assessment of the time course of referent reactivation in ASL.

The predictions presented in Emmorey et al. 1991 stem from conclusions drawn from similar experiments in spoken language, that is, response times to the probe of the correct referent noun were predicted to be faster in the pronoun condition than in the no-pronoun condition and that responses to probes of the correct referent would be faster than probes of the incorrect referent in the pronoun condition.[3,7] Emmorey maintains that results following this expected pattern would evidence referent re-activation in ASL and "indicate that at least some of the processes involved in the comprehension of co-reference relations hold cross-modally (as well as cross-linguistically)."[7] In addition to addressing the instance of referent re-activation in signed language, Emmorey et al. 1991 suggest that the design of their experiment could also contribute to an understanding of non-referent inhibition in the following manner: following the insights from Gernsbacher 1989, as previously discussed, the presence of a pronoun not only reactivates the proper referent, but also suppresses, or inhibits the activation of the non-referent.[3,7] The robustness and time-course of suppression is correlated to the extent of ambiguity in the co-reference between a pronoun and its antecedent. In other words, pronominal ambiguity is inversely proportional to non-referent inhibition and thus the strength of referent activation. With this evidence in hand, Emmorey et al. 1991 predict that if an unambiguous instance of co-reference is associated with a fast and robust suppression of non-referents, then the unambiguous nature of ASL pronouns should result directly in strong non-referent inhibition.[7]

The experiment showed that response time in the zero-delay condition was faster than after the1000 msec delay, and that responses were faster for the referent probe than for the non-referent probe in the pronoun condition.[7] In the no-pronoun condition, there was not a significant difference in reaction time between the pronoun and no-pronoun conditions when the zero delay and 1000 msec delay conditions were compared.[7] Further, the response times to the correct referent in the pronoun condition did not significantly differ between the zero and 1000 msec delay, while the response times to the non-referent declined at 1000 msec when compared to the zero delay condition.[7] The results presented in Emmorey et al. 1991 support at least part of the prediction: the correct referent is indeed activated after a pronoun in ASL, and therefore cross-modally, yet non-referent inhibition increases in strength over time and the activation of the referent remains constant. The unexpected observation was a lack of referent activation in the pronoun condition (compared to the no-pronoun condition) directly after the pronoun offset (zero-delay).[7] Finally, the results did not evidence non-referent inhibition as predicted in light of the unambiguous nature of ASL pronouns; even though responses to the non-referent noun probe were slower than responses to the referent noun probe, there was not a significant difference in reaction time between the pronoun and no-pronoun conditions, suggesting that the pronoun did not robustly suppress activation of the non-referent.[7] To further characterize the on-line mechanisms of pronominal and co-referential processing in ASL, Emmorey et al. 1991 pose an important question in a second experiment: if a referent is reactivated upon interpretation of the pronoun in ASL, what specifically is being activated?[7] Since pronouns in ASL consist of two distinct units and, namely, the pronominal hand shape and the locus with which it is indexed, Emmorey et al. 1991's second experiment aimed to determine whether it is the mental representation of the referent that is activated during anaphoric processing or if the spatial locus of the referent is also activated.[7]

The contribution of the second experiment becomes apparent when considering the competing theories of location fixing and referential equality. Referential Equality, a theory supported in part by the work of Friedman, Loew, Wilbur, and Lillo-Marti & Klima, suggests that in a signer's mental discourse representation, the spatial locus associated with a particular referent is identical to and denotes the intended referent.[6,9,10,11] On the contrary, Liddell upholds that the locus associated with a particular referent does not in fact represent the referent but merely the location at which the referent is located for the duration of a given discourse, this theory is known as Location Fixing.[5] The theoretical discord between the Referential Equality and Location Fixing hypothesis is schematized below:[5]

i) Referential Equality $\text{referent}_a = \text{locus}_a$

ii) Location Fixing referent_a is at locus_a

If a referent and its locus hold the same semantic weight in the lexicon (by the referential equality hypothesis) then one would expect an equally robust activation of the indexed locus to accompany that of the referent. The design and stimuli of Emmorey et al. 1991's second experiment was a near mirror of the first, except that only referent probes were used, and they were signed at either the proper or incongruent locus; probe signs articulated at an incongruent locus were predicted to elicit a longer response time in comparison to probes presented at the correct locus. Moreover, the referential equality hypothesis would predict a significant interference effect due to incongruous spatial loci in the referent condition.

Data from Emmorey et al. 1991's second experiment support the results from the first, namely, reaction times to the referent noun in the pronoun condition were faster than in the no-pronoun condition, confirming their conclusion that a pronoun in ASL re-activates its referent during sentence comprehension and this process is modality independent.[7] With regards to the locus condition (congruent or incongruent), no significant interference effect was reported.[7] These results stand in opposition to the referential equality hypothesis, but support the location-fixing hypothesis, which suggests a weaker relationship between a spatial locus and its referent than does the referential equality hypothesis, namely, that the spatial locus indexed with a referent is merely represented as the fixed location of the referent for the duration of a given discourse, and this fixed location is neither lexically nor referentially equivalent.[5]

From Emmorey et al. 1991, we can continue the characterization of pronominal processing in ASL with three well-supported conclusions:

i) Referents are re-activated by pronouns in ASL.
ii) The spatial locus of a referent is not activated to the same degree as the referent, supporting the location-fixing hypothesis of ASL spatial loci.
iii) Referent re-activation occurs at least 1000 msec after the pronoun offset.[7]

What remains un-answered in the discussion is a clear reason, aside from the temporal constraints of sign articulation, why referent activation was only found in the 1000 msec condition. Clearly, more data that speaks to the time course of referent activation is required. In addition, the study points to further investigation of non-referent inhibition, evidence for which was not elicited in Emmorey et al. 1991 even in the presence of a "completely unambiguous" pronominal system.[7]

C. Non-referent Inhibition in ASL Pronoun Resolution

The next topic for close examination in our analysis of ASL pronoun processing addresses non-referent inhibition in greater detail by presenting Emmorey 1997, which presents a probe recognition experiment that attempts to define the underlying reason for the apparent lack of non-antecedent suppression reported in Emmorey et al. 1991.[12] In the context of the current discussion, non-antecedent suppression is defined as a processing mechanism "to improve the accessibility of the co-referent nominal by suppressing the activation of those nominal that are not antecedents," as discussed previously.[12] Briefly, two experiments are presented to answer the question: is non-antecedent suppression a modality independent process? Emmorey takes a fine-grained approach to proposing an answer by considering: a) the morphological and lexical ambiguity of an ASL pronoun before it is associated with a spatial index and b) the relative strengths of non-referent inhibition directly before and 1000 msec after an anaphor.[12] Emmorey aimed to elicit the effect of non-antecedent suppression reported in the Gernsbacher 1989 study of spoken language.[3] Briefly, an instance of non-antecedent suppression was attributed to the morphology of the non-antecedent; that is, the marking for features such as person, number, and gender allowed for unambiguous retrieval of the proper antecedent and the simultaneous suppression of the non-antecedent during visual sentence comprehension.[3] The motivation for Emmorey's 1997 study is to identify the role of ASL pronouns' unique spatial morphology in pronominal processing and to integrate empirical evidence from ASL with Gernsbacher's model of antecedent activation and suppression.[12] The theoretical question thus become: if ASL pronouns are in fact "almost never ambiguous," as argued by Lillo-Martin and Klima, then what factors contributed to the lack of non-antecedent suppression reported in Emmorey et al. 1991?[6] There are two possible reasons for the failure to elicit non-antecedent suppression in ASL that Emmorey identifies: first, the analysis of ASL pronominal morphology and semantics could be misinformed and secondly, there could be a methodological flaw that washed out any effect of suppression, if it did indeed exist.[12]

In order to incorporate Emmorey's results from both the 1991 and 1997 experiment sets, we must first tackle the linguistic process that Emmorey 1991 suggests upon the interpretation of a pronoun in ASL. With this understanding, we can better contextualize her approach to the 1997 experiment and provide a clearer understanding of the processing mechanism behind pronominal processing in ASL. From Emmorey 1991's second experiment, it can be argued with relative confidence that the spatial location associated with an ASL pronoun is not reactivated to the same degree as the referent nominal itself, which supports Lidell's Location Fixing hypothesis.[5,7] The observation to be made at this point is critical: the reported instances of non-antecedent suppression in Gernsbacher 1989 were attributed to the unambiguous nature of the co-referential relationship tested, that is, the morphology of the pronoun and its ability to select one unique referent from a set of possible referents was directly correlated to the degree of non-antecedent suppression.[3] The unambiguous nature of the ASL pronoun is only fully realized once the pronominal hand shape has been associated with its spatial locus, which, as Lidell and Emmorey 1991 claim, is the unique location of the referent in signing space that permits its identification and activation by the language processor.[5,7] What is interesting is that ASL pronouns, although able to unambiguously select a referent, do not do so via gender or person marking. There is no overt morphology, aside from number, that contributes to referent activation. Thus, non-antecedent suppression may be triggered by morphological features that are simply not present in ASL.[12] In other words, Emmorey 1991's finding that an insignificant interference effect in reaction time occurred with mismatched probe loci suggests that the probe recognition task may not have the capacity to identify the level of processing in which the spatial information associated with a pronoun disambiguates co-reference.[7, 12] This phenomena leads to the following predictions: only antecedents selected by morphology or syntax (but not spatial association) can elicit non-antecedent suppression and therefore ASL pronouns are truly ambiguous before the hand shape is associated with its locus in the lexicon.[12] It would seem that the "surface lexical form" is the critical factor in triggering antecedent activation and non-antecedent suppression.[12] In light of the critical observation that ASL morphology alone does not provide enough lexical information for proper pronoun disambiguation, Emmorey predicted that in a probe recognition task, a repeated noun would elicit non-antecedent suppression but a pronoun would not.[12]

The first experiment of Emmorey 1997 attempted to test this expectation by comparing the reaction times to referent and non-referent probes presented in three conditions: sentences whose first clause contained two equally plausible antecedents and a second clause that contained either: a repeated noun, a pronoun, or a new discourse participant (no-anaphora); the same stimuli from Emmorey 1991 was used (recorded with a different signer).[12] The probes (a nominal sign for either the non-referent or the referent) were presented 1000 msec after the overt pronoun or second sign of the second clause (in the no anaphora control condition).[12] Even though the stimuli in Emmorey et al. 1991 and Emmorey 1997 were the same, an example from Emmorey 1997 is given to illustrate the 6) pronoun, 7) repeated noun, and 8) no anaphora conditions of interest to elucidating the mechanism behind non-antecedent suppression. In the following stimuli, the referent probe was PRISON-AGENT and the non-referent probe was JUDGE.[12]

6) ONE-YEAR-AGO S-F HIGH JUDGE$_a$ DECIDE PUT-DOWN PRISON-AGENT$_b$ LIFE JAIL, UNEXPECTEDLY HE$_b$ HEART-ATTACK DIE.
"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."

7) ONE-YEAR-AGO S-F HIGH JUDGE$_a$ DECIDE PUT-DOWN PRISON-AGENT$_b$ LIFE JAIL, UNEXPECTEDLY PRISON-AGENT HEART-ATTACK DIE.
"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."

8) ONE-YEAR-AGO S-F HIGH JUDGE$_a$ DECIDE PUT-DOWN PRISON-AGENT$_b$ LIFE JAIL, UNEXPECTEDLY LAWYER$_c$ FIND NEW EVIDENCE.
"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."

Results from Experiment 1 supported the findings from Emmorey 1991 in that responses to antecedent probes were faster than to non-antecedent probes in the pronoun condition.[12] Similar to pronouns, evidence that repeated nouns re-activated their antecedents was found in the faster response times to antecedent probes in the repeated noun condition when compared to the no-anaphora baseline condition.[12] Interestingly, Emmorey did not find evidence in support of non-antecedent suppression.[12] That is, the response time to non-antecedent probes in the pronoun sentences were not significantly slower than response to non-antecedent probes in the no-anaphora control sentences; in addition, the same trend (similar response times to the non-antecedent probes in the pronoun and no-anaphora sentences) appeared in the repeated noun condition, which is in direct opposition to Gernsbacher 1989.[3,12] The lack of evidence supporting non-antecedent inhibition in the repeated noun condition cannot be explained by the distinction made between the morphologies of ASL and spoken language pronouns. Since the repeated noun is a surface lexical form, with all disambiguating information overtly expressed (as opposed to being encoded in an association with a spatial index), the expectation was that non-antecedent suppression would be present in the repeated noun condition and, if the location fixing hypothesis held true, not in the pronoun condition.

These surprising results motivated Emmorey to precisely examine her experimental design and present a second experiment aimed at eliciting non-antecedent inhibition in ASL. At first glance, Emmorey's data suggests that there is no indication of non-referent inhibition in signed language.[12] But Emmorey maintains that there is "no difference in linguistic structure or conceptual representation for repeated noun phrases in English and ASL" and that non-antecedent inhibition should be most robust in the repeated noun condition, following the intuitions from Gernsbacher 1989.[12] She argues further that in the no-anaphor condition (in which a third nominal element was introduced to the discourse), the non-antecedent may have been suppressed by the new nominal element.[12] This would pose problems when comparing the no-anaphor condition as a baseline to the pronoun condition, since even if the pronoun had indeed suppressed the non-antecedent in the pronoun condition, the fact that the third nominal in the no-anaphor baseline could have suppressed the non-antecedent would not yield a comparison between the no-anaphor and pronoun conditions which could identify the presence of non-antecedent suppression.

The primary difference between the Gernsbacher 1989 and Emmorey 1997's design is that the control baseline was not a no-anaphor condition, but rather a before anaphor condition.[3] In other words, response times to referent and non-referent probes were compared based on the location of their placement within the same sentence: Gernsbacher evidenced non-antecedent suppression by longer reaction time to the non-referent probe presented after the pronoun than when it was presented before the pronoun. Emmorey's second experiment follows the before and after anaphor conditions in pronoun and repeated noun sentences.[12] In the repeated noun sentence, the probe was placed after the second sign of the second clause (mimicking Emmorey et al. 1991 and the first experiment of Emmorey 1997).[12] Example sentence 9) below illustrates the re-configured probe placement (◆ marks the before and after anaphor positions, respectively) that was predicted to better elucidate the non-antecedent suppression in ASL if it is indeed a salient processing mechanism:[12]

9) SPRING WARM INSPIRE BUTTERFLY$_a$ LOVE CUTE BUG$_b$ BUT ◆ IT$_a$ ◆ SHY AFRAID.
"On a warm spring day, a butterfly fell in love with a cute bug, but it (butterfly) was very shy and timid."

The results from the second confirmed that similar reactivation and inhibition mechanisms contribute to the processing of ambiguous cases of co-reference in both spoken and signed language.[12] Response times to non-antecedent probes after an anaphor or repeated nouns were significantly slower than response times to the non-antecedent probe presented before the anaphor or repeated noun. An interesting note is that the response times to antecedent probes did not differ between the before and after anaphor conditions, which is unexpected on the heels of Emmorey et al. 1991's conclusion that pronouns reactivate the antecedent in ASL. This is attributed to the phenomenon of a "natural decline in activation" of nominal elements during sentence processing.[7] Specifically, if the magnitude of activation for a nominal element declines over time, the pronoun could have re-activated the nominal to its previous level (before the anaphor).[3] Thus when comparing the before anaphor and after anaphor reaction time differences and accounting for natural decline, the lack of evidence for antecedent re-activation in second experiment could be justified.

In sum, Emmorey's reformulation of the experimental design was able to elucidate the process of non-antecedent suppression in ASL and supports the growing body of evidence that the language processor invokes the same mechanisms during sentence comprehension, regardless of modality. It seems the original hypothesis that in a probe recognition task, a repeated noun would elicit non-antecedent suppression but a pronoun would not was not confirmed. It is not a matter of the difference in pronominal surface morphology between ASL and English that determined the disambiguating capacity of a pronoun, but rather, Emmorey argues, that the crucial factor in non-antecedent suppression must be "the degree of ambiguity or the 'explicitness' of a pronoun."[12] Certainly, the "explicitness" variable was constant in both the Gernsbacher 1989 and Emmorey 1997 studies since there were two equally plausible nominal elements introduced into discourse context in the first clause (before the interpretation of the pronoun) and thus the processor was forced to concurrently re-activate the antecedent and suppress the non-antecedent.[3, 12]

The Emmorey group's 1991 and 1997 studies are the most well-reasoned and well-formulated empirical approaches to ASL pronominal processing found in the literature to date. With a thorough exploration and review of this body of work, it is clear that referential relationships in ASL are processed in an equivalent manner to spoken language. Specifically, in cases when there exist two plausible nominal referents in a given discourse and a pronoun is introduced to identify an antecedent, the mechanism by which the processor selects the intended referent is by simultaneously suppressing the non-antecedent and re-activating the intended antecedent over the time course of sentence processing to create a salient and unambiguous referential relationship. This processing strategy has been well documented in spoken language, and, as the discussion of Emmorey's work illustrates, has been well characterized in ASL. Yet the picture of signed language pronouns is far from complete; an interesting aspect of spatial loci in ASL is that they are inherent to two different linguistic functions: the establishment of co-reference between a noun and a pronoun (referential use), and 2) conveying "real word" spatial information (locative or topographic use) such as in interpreting the relationship between the subject and object of an agreeing verb and the direct representation of locative information to communicate the spatial relationships between different discourse entities in describing a scene.[13] It would be naive to overlook the topographic use of space in supporting a model of pronominal processing in ASL. The overt similarity between the locative and referential functions of spatial loci is quite compelling and could pose problems to an analysis of pronoun disambiguation attributing the association of a nominal referent to a spatial index with a pronominal hand shape. Moreover, fact that spatial loci are actively employed to serve the locative function could create an empirical compound since any conclusion regarding reference processing and the ASL signer's linguistic use of space must address the locative function.

D. Differentiating Referential and Locative Uses of Spatial Loci in ASL Pronoun Resolution

By the same overt process in which a nominal is associated with a discrete spatial locus for the establishment of coherent referential indices, discourse participants are assigned spatial loci for the purpose of conveying their "real-world" spatial relationships.[4] For example, the following sentence illustrates how the signer of ASL will assign nominal entities specific locations in the plane of signing space to communicate their real-world spatial relationship. Note that the location in signing space of each nominal element is provided in the subscript (left, center, right), accompanied by its co-referential index (a, b, c):[13]

10) TABLE MESS BLUSH$_{right,\ c}$ BREAK NAIL-POLISH$_{left,\ a}$ SPILL PERFUME$_{center,}$ $_{b}$EMPTY.
"My (vanity) table is a mess. The case for my blush which is on the right is broken. My nail polish on the left has spilled, and my perfume bottle in the center is empty."

Crucially, a referent can be assigned a locus for simultaneous topographic and referential function as evidenced by the referential indices a, b, and c in sentence (10) above. Interestingly, in the use of agreeing verbs in sign language necessitates that one nominal element be associated with two distinct spatial locations to convey that the same referent changed its relative location; this phenomenon is termed "locus doubling."[14] In locus doubling, "if the same referent participates in two events that have two distinct spatial settings, the signer may use two locations in signing space for that referent."[14] The following sentence from Emmorey and Falgier 1995 illustrates the unique case of locus doubling:[14]

11) MY WONDERFUL MOTHER B-U-S-Y, WENT-TO$_{left}$ STOREl$_{eft}$ BUY FOOD, FINISH. $_{left}$BRING$_{right}$ KITCHEN$_{right}$ PREPARE. HAPPEN SHE$_{left}$ FORGOT BUY ONION.
"My wonderful mother is very busy. She went to the store and shopped for food. Then she brought it to her kitchen where she prepared it. As it happens, she forgot to buy onion while she was at the store."

While referentially simple and unambiguous (only one possible antecedent for the pronoun SHE), sentence (11) is topographically complex. Locus doubling occurs because the referent participates in events at multiple spatial locations and these locations are associated with unique spatial loci (left and right signing space). (11) highlights the case of locus doubling because during this discourse “the mother” was both at STORE and in the KITCHEN. These spatial loci are used to simultaneously establish a referential relationship between MOTHER and SHE, but also to locate the PRONOUN in two distinct spatial settings. From Emmorey et al. 1991 and Emmorey 1995, the processes of antecedent reactivation and non-antecedent suppression in ASL pronoun resolution have been identified.[7,12] An instance of locus doubling must be examined in light of these findings; the observation that the spatial morphology of the ASL pronominal system does not differ from the morphology of the locative use of space (both referential and locative functions are accomplished upon the association of a pronominal hand shape with an indexed locus) suggests the possibility that the sign language parser would also reactivate the conceptual location of a referent.

Emmorey and Falgier 1995 explore the processing effects of locus doubling on the interpretation of pronominal reference with a probe recognition task similar to Emmorey et al. 1991 and Emmorey 1997 discussed above.[14] The experiment was designed to investigate whether the interpretation of a pronoun would activate the spatial location associated with the locus of the referent in the case of locus doubling.[14] Specifically, their questions were as follows: “When an ASL pronoun that specifies a referent at a specific location, does the pronoun serve to activate both the location noun and the referent noun? Or does the pronoun only serve to activate the referent noun?”[14] Stimuli were designed to introduce a particular referent with two conceptual locations in a conversational discourse.[14] The control condition was a continuation sentence that did not contain a pronoun, and the experimental condition contained anaphora that referred to the first location of the referent.[14] Probes were positioned 1000 msec after the completion of the pronoun in the experimental condition and 1000 msec after the second sign in the control (no anaphora) condition.[14] Three types of probes were used to elucidate the degree of processing associated with a case of locus doubling: 1) the referent of the pronoun, 2) the first location of the referent or 3) the most recent (second) location, which was not associated with the pronoun.[14] Example (12) below illustrates a stimuli from Emmorey and Falgier 1995’s experiment (probe locations are marked by a ◆).[14]

12) Introductory Discourse:
LAST SATURDAY, MY BEST-FRIEND WENT$_{left}$ THEATRE$_{left}$ WATCH$_{left}$, FINISH. $_{left}$ZOOM$_{right}$ LIBRARY$_{right}$, STUDY.
"Last Saturday, my best friend went to the theatre where she watched (a play). Then, she zoomed off to the library to study."

Experimental Continuation: Anaphor Condition
BEFORE SHE LAUGH-HA◆RD REAL FUNNY!
"Earlier she (at the theatre) laughed really hard it was so funny!

Control Continuation: No-anaphor Condition
BEFORE SURPRISE OLD SWEETHEA◆RT APPEAR.
"Earlier an old sweetheart unexpectedly showed up."

Emmorey and Falgier hypothesized, based on earlier research presented above, that the pronoun would re-activate the antecedent and that response times to the referent probes would be faster in the anaphora condition than in the non-anaphora condition.[14] Reaction times to the location of referent probes were also predicted to be faster in the anaphor condition if pronouns also re-activate the location of their indexed referent.[14] Emmorey and Falgier expected no difference in reaction time to probes of the most recent location that was not associated with the referent between the anaphor and no-anaphor conditions.[14] With insights from Emmorey 1995, this experiment was not concerned with confounding effects of non-referent location suppression caused by the pronoun, since, as discussed previously, non-antecedent suppression was not observed with a no-anaphor control.[12]

Results were as follows: response times to the referent probes were faster in the presence of a pronoun than in the no-anaphor condition, response times to the referent location probes and the most recent location probes were not significantly different, and in the experimental pronoun condition, response times to the referent probes were faster than responses to probes of the referent's location and probes of the most recent location.[14] The expected re-activation of the referent's location was not observed, and therefore the hypothesis that ASL pronouns re-activate both the referent and the location of the referent was not confirmed. Indeed, the data presented by Emmorey and Falgier 1995 support the conclusion that the ASL pronominal system does not re-activate the conceptual location of an antecedent upon comprehension of a pronoun; only the nominal referent of a pronoun is reactivated during the time course of pronominal resolution.[14] This finding is exceptionally interesting because the location of a referent determines the overt morphology of an ASL pronoun, but is not considered in pronoun resolution. Information encoding the location of an antecedent and it's referential index is included in the same spatial locus, yet it seems that the signed language processor is able to differentiate these two information types and selectively integrate only the required indexical information for successful pronoun resolution, suggesting the existence of a resilient mechanism for referential analysis and resolution resembling that of the spoken language processor. Indeed, the results presented in this experiment provide clear empirical support that the processing of pronoun resolution in ASL does not differ from that of spoken language, since equivalent effects of antecedent re-activation and non-antecedent inhibition are evidenced across the visual/manual and auditory modalities suggesting that the processing mechanisms underlying these effects are in fact identical.

IV. A Neurocognitive Account of Referential Ambiguity in Spoken Language

For a more fine-grained description of the establishment and processing of referential relationships, we must turn our attention back to spoken language. As evidenced by the conclusions of Gernsbacher 1989 presented in Section II, successful parsing of a referential relationship rests on the ability of the language processor to select from a class of possible referents (all discourse participants) that which best correlates to the information encoded in a given pronoun and this selection process is mediated by the mechanisms of antecedent re-activation and non antecedent inhibition as in the sentence below:[3]

13) Joe_i and Sue_j wanted to see the play, but $\text{he}_{i/j*/k}$ forgot their tickets home.

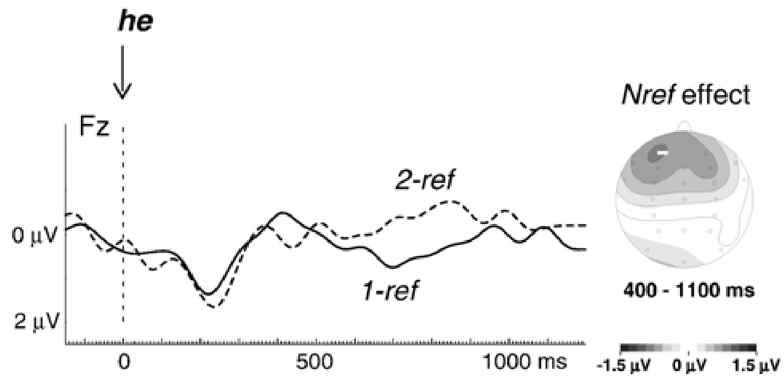
The model for pronoun resolution that we have been building over the course of this paper is applied to sentence (13) in the following manner: when the language processor encounters the pronoun *he* a search process is initiated to determine its correct antecedent and trigger the mechanisms of inhibition and re-activation. In the case of sentence (13) the processor combs through the set of available referents (Joe *i*, Sue *j*, or an outside participant *k*) to select that which coincides with the features encoded in the anaphoric element (a third person singular male). Due to the explicit information encoded in the pronoun *he*, the processor is able enhance the activation of *Joe* and suppress that of *Sue* over the time course of pronoun interpretation for successful selection of *Joe* for integration into a coherent discourse representation and the ultimate goal of successful sentence comprehension.

But what occurs when the information encoded in a pronoun is insufficient to resolve the reference relationship? That is, how can this model apply to cases where the relative activation of one referent is not significantly greater than that of the other? Example sentence (14) below provides an example of an ambiguous pronoun (equivalent to (1) in Section II), the processing correlates of which the following discussion intends to identify:

14) David_i shot at John_i as $\text{he}_{i/j/k}$ jumped over the fence.[15]

It appears that reaction time data cannot sufficiently elucidate the nature of competition between two equally plausible referents that ultimately results in activation of the intended referent (see section II's discussion of Gernsbacher 1989). A convincing explanation of ambiguous pronoun resolution that seems to be in line with the conclusions presented herein is that upon encountering an ambiguous pronoun, the parser simply cannot select an antecedent with the mechanisms of enhancement and suppression alone. Nieuwland and Van Berkum 2008 suggest that the resolution of referential ambiguity is ultimately completed by inferential processes to restore referential coherence based upon the " discourse prominence" of one referent relative to other equally plausible referents in a given sentence.[16] The general intuition presented by Van Berkum 2008 is that "when competing antecedents resonate in equal amounts, this referential ambiguity may trigger additional retrieval from episodic discourse memory, associated with a search for additional clues that might help to infer the most plausible referent."[16] It is clear, then, that the behavioral data presented thus far cannot uniquely identify the existence of this inference process that relies on a coherent discourse representation to gather the required information for the resolution of ambiguous reference. Certainly, evidence for the instantiation of this retrieval process will contribute to and extend the conclusions made by Gernsbacher 1989 and the model of anaphoric processing they support.

To this end, Van Berkum et al. 2003, 2004, 2007, and Niuewland and Van Berkum 2008 provide a well-supported account of the neural systems recruited by ambiguous reference processing.[15,16,17,18] In brief, they used event related potentials (ERP) from electroencephalography (EEG) to selectively track the process of referential analysis in the face of anaphoric ambiguity (in both the cases of an ambiguous noun phrase and an ambiguous pronoun.)[16,18] The Van Berkum et al. group reports a unique ERP effect termed the *Nref* that is morphologically distinct from previously identified ERP waveforms such as the N400 or P600 which have been extensively associated with semantic and syntactic processing, respectively. The Nref is described as a sustained frontal negativity originating 300 ms after the onset of an ambiguous anaphor.[15,16,18] The following figure, borrowed from Van Berkum et. al 2007, illustrates the morphologic characteristics of the Nref effect in sentence (14) as compared to a control with only one plausible discourse referent in the same context:[17]



In sum, Van Berkum et al. 2003, 2004, and 2007 argue that the process of referential analysis in cases of anaphoric ambiguity can be selectively tracked with ERP.[15,16,17,18] They situate their conclusions within the model of referential processing in arguing that when a noun or pronoun is encountered during sentence comprehension, speakers inspect their situation model that has been created from the incremental development of a coherent discourse representation for "suitable discourse entities" in order to assign a specific antecedent to an anaphor and resolve the ambiguity.[17] In light of these findings, it is possible to attribute the Nref effect to the inference processes involved in ambiguous pronoun resolution that rely upon a triggered search mechanism that entertains all plausible referents introduced in a given discourse. In other words, the mechanism by which the language processor retrieves an antecedent from episodic discourse memory in cases of referential ambiguity is uniquely correlated to the Nref effect.

V. Toward Further Research in the Neurocognition of ASL Pronouns

The interpretation of these data and the saliency of the Nref effect point to an intuition that is currently unexplored in signed language; the remainder of this report will discuss the motivations for the application of ERP methodology to the study of ASL ambiguous pronoun resolution. Emmorey contextualized the motivations for her reaction time experiments aimed at elucidating the modality independence of referent re-activation and non-referent inhibition when resolving a pronoun in ASL in order to provide empirical support to a language-universal model of referential processing. In much the same way, the field of signed language research could benefit from a neurolinguistic contribution that explores the possible modality independence of the mechanism of ambiguous pronoun resolution. Specifically, the presence of an Nref effect in signed language processing would be excellent empirical support for the modality independence of reference processing. The review of the ASL pronominal system and Emmorey's experimentation in Section III clearly support the unique status of signed language pronouns: even in cases of anaphoric ambiguity, where two equally plausible discourse entities could be the intended referent of an anaphor, upon association of the pronoun hand shape with its indexical spatial locus, "ASL referential pronouns are almost always unambiguous."[7] The prediction thus becomes: if ASL pronouns are formally unambiguous due to the unique spatial morphology of the ASL pronominal system, application of ERP methodology to referential processing would not identify an Nref effect, if the Nref effect is a true indication of a unique search mechanism aimed at extracting from the discourse representation further cues to assign an antecedent to an ambiguous anaphor. Upon closer examination, this prediction is not hypothesized to be borne out because it is only upon completion of the ASL pronoun that full pronoun disambiguation is accomplished. Emmorey states that "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."[12]

A clear experimental approach is motivated by these intuitions, namely, if EEG were used to track sentence processing in cases of ambiguous reference, an ERP window could be positioned such that the processing of referential ambiguity could be examined before the pronoun hand shape was paired with its intended spatial index upon completion of the pronoun. The presence of an Nref effect in signed language would thus support the language universal nature of reference processing that the body of this review has supported. Moreover, in the context of spoken language, the pronoun hand shape would equate to the presence of an ambiguous pronoun, and the spatial locus that eventually provides all disambiguating information is similar to contextual information encountered after an ambiguous pronoun is presented in a sentence of spoken or written language. Since the language processor cannot consistently anticipate the reception of essential disambiguating information after an ambiguous pronoun, the antecedent search mechanism is triggered by a pronoun in spoken language, as evidenced by the data presented in support of the Nref effect in Section IV. Appendix I of this report consists of an abstract and EPrime script of a potential ERP experiment using a newly recorded version of Emmorey 1997's stimuli aimed at exploring the possibility of the Nref effect in the context of ambiguous pronoun processing in ASL. An experiment of this sort would not only be the first attempt to selectively track reference processing in a signed language, and one of the few applications of ERP methodology to signed language, but would also provide a necessary and compelling insight into the electrophysiology of pronoun resolution in the visual/manual modality. The remarkable contrast between the pronominal systems of signed and spoken language has not yet been correlated to differential anaphoric processing mechanisms, and an ERP experiment aimed at elucidating the Nref effect in ASL, if successful, would only further support the conclusions and model of referential analysis presented herein.

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VII. Appendix I: Pronominal Resolution in American Sign Language: An ERP Investigation

A. Abstract

In this preliminary event-related brain potential (ERP) experiment, we examined the electrophysiology of referential analysis during signed language discourse comprehension. In spoken language, the processing mechanisms that establish a co-referential relationship between a pronoun and its antecedent when two equally plausible entities are available for retrieval have previously been explored with electroencephalography (EEG). A sustained frontal negativity that originates 300 ms after pronoun onset (termed *Nref*) has been associated with ambiguous pronoun resolution.[18] Contrary to spoken language, referential indices in signed language are overtly and unambiguously realized in signing space.[1] The current study aims to identify and characterize the possible effect that this disambiguating feature of signed language has upon the linguistic processing of pronominal resolution. We recorded a native deaf signer of ASL signing experimental stimuli from a previously published reaction time study in American Sign Language (ASL) (Emmorey 1997). Stimuli contained complete sentences with two equally plausible discourse entities in order to investigate the possibility of an *Nref* effect after the onset of a pronoun hand shape in deaf native signers of ASL. The contributions of the current project are to track referential analysis and pronominal resolution in ASL using ERP, to support the predominant view that the human language faculty is modality independent, and to motivate further neurocognitive investigations in signed languages.

B. Experimental Script (EPrime 2.0 Professional)

Note: This script is designed to be executed on a PC running Windows XP or newer operating system. A parallel port is used to establish accurate communication between the stimuli presentation computer and the NeuroScan system. EEG scalp potentials travel from the electrode cap to a SynAmp Amplifier, which transmits the EEG traces to the NeuroScan system for accurate data recording and processing.