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Stressed and Unstressed Pronouns: Complementary Preferences

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Stressed and Unstressed Pronouns: Complementary Preferences

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Abstract

I present a unified account of interpretation preferences of stressed and unstressed pronouns in discourse. The central intuition is the Complementary Preference Hypothesis that predicts the interpretation preference of a stressed pronoun from that of an unstressed pronoun in the same discourse position. The base preference must be computed in a *total* pragmatics module including commonsense preferences. The focus constraint in Rooth's theory of semantic focus is interpreted to be the salient subset of the domain in the local attentional state in the discourse context independently motivated for other purposes in Centering Theory.

1 INTRODUCTION

Stressed pronouns present a peculiar class of anaphoric expressions. Informally, they communicate “old” as well as “new” information. They are also at odds with the Topic–Focus Articulation (TFA) (Sgall, Hajičová, and Panevová, 1986) — *contextually bound*, which is typical of Topic, in spite of being in an intonational focus, which is a defining property of Focus and common for a *contextually unbound* expression. They can also exemplify the different notions of “focus” — *psychological*, *semantic*, or *contrastive* focus (Gundel, this volume) — and can even combine them all at once. Unstressed pronouns (e.g., *he*, *she*, *it*, *they*) and their stressed counterparts (e.g., *HE*, *SHE*, *THAT*, *THEY*) often lead to drastically different interpretations.¹ (Henceforth, stressed pronouns are in all uppercase.)

An account of the semantics and pragmatics of stressed pronouns needs to explicate their peculiar hybrid behaviors and relation to unstressed pronouns. Example (1) below shows two alternative continuations of the first utterance

— using an unstressed *he* and stressed *HE*. The preferred interpretations indicated in the parentheses are opposite from each other.

- (1) John hit Bill. Then {*he* | *HE*} was injured.
(*he* := Bill)(*HE* := John)

Similarly, variations of Lakoff's (1971) example, (2) and (3) below, show opposite preferred interpretations.

- (2) Paul called Jim a Republican. Then *he* insulted *him*.
(Paul insulted Jim)
- (3) Paul called Jim a Republican. Then *HE* insulted *HIM*.
(Jim insulted Paul)

In (2), the preferred interpretation of the unstressed pronouns establishes grammatical parallelism between the two utterances. In (3), the preferred interpretation of the stressed pronouns is the opposite from (2), and the discourse acquires an additional assumption that “x insults y” follows from “x calls y a Republican.”

The present approach focuses on the interpretation differences between the *stressed and unstressed counterparts* — the stressed and unstressed versions of the same pronominal form in the same *position* in discourse as well as in a sentence. I assume that stressed and unstressed counterparts have exactly the same denotational range — the same range of *possible* values. They also share the same interpretation problem of choosing the *preferred* value. The difference then comes from the latter. What is the difference in the preferred values of unstressed and stressed counterparts? Is there a systematic relation between them? Does one preferred value *predict* the other?

I claim that the difference between stressed and unstressed counterparts is in the *presuppositions*, and that there is a systematic relation between them coming from the interaction between the *semantic focus interpretation* of the stressed pronoun and the *centering principles* associated with its unstressed counterpart. The centering principles here are extended in the sense that they are part of the *total pragmatics* that includes commonsense preferences.

Under this unified approach, the systematic relation between the stressed and unstressed counterparts is that of a *complementary preference* within a suitable subset of the domain.

2 THE STRESSED PRONOUN AND SEMANTIC FOCUS

Rooth (1992) develops a theory of focus interpretation in terms of *restricted alternative semantics*, where the focus semantics introduces a presupposed constraint using a *focus interpretation operator* \sim . A focus phrase (or sentence) α has a focus interpretation operator with a variable C ($\sim C$). C may denote either individuals or sets of objects of the same type as the denotation of α , which are the elements or subsets of the *focus semantic value* of α (henceforth $[[\alpha]]^f$). C must contain the *ordinary semantic value* of α (henceforth $[[\alpha]]^o$) and at least one more element or subset of C distinct from $[[\alpha]]^o$, which is the *contrasting element or subset* for $[[\alpha]]^o$. Rooth points out that the value of C is a discourse entity to which C is anaphoric, and that the important question is how to constrain it. This opens up focus interpretation to all sorts of discourse-pragmatic effects. In this paper, I will notationally distinguish two types of presuppositional constraints after Rooth (1993) — C for a set of propositions and F for a set of entities (individuals or groups of individuals).

The Semantics of Stressed Pronouns. According to this theory of semantic focus, a stressed HE presupposes a constraint $\sim F$ that there is a contextually determined set of entities ($[[HE]]^f = \{x \mid x \in F \subseteq E\}$ where E is the domain of individuals) with at least two members — the denotation of HE ($[[HE]]^o$) and at least one more contrasting individual. F is the *contextually available alternatives* or the *focus semantic value* of HE . $[[HE]]^o$ is an element of F , and F is a subset of E ($[[HE]]^o \in [[HE]]^f = F \subseteq E$). An utterance (i.e., a sentence token in a context) with a focused element presupposes a constraint $\sim C$ that there is a contextually determined set of propositions obtained by instantiating a set abstraction with the alternative values of the focused element — for instance, “ HE was injured” presupposes a constraint $\sim C$ whose value is a set of propositions obtained by instantiating the focus semantic value $\{injured(x) \mid x \in E\}$ with the alternative values of $[[HE]]^f$. The ordinary semantic value of the utterance is a truth value

that is an element of the focus semantic values ($[[HE \text{ was injured}]]^\circ \in \{injured(x) \mid x \in F\} \subseteq \{injured(x) \mid x \in E\}$).

The Pragmatics of Stressed Pronouns. Given the above focus semantics, interpreting a stressed HE in an utterance U involves four pragmatic subroutines. These subroutines are listed approximately in the following bottom-up processing order, but no strict sequential order is assumed:

- *Locate* $F \subseteq E$, where F is a contextually determined set of entities that may contain more than one potential referent for HE .
- *Choose* a member of F as $[[HE]]^\circ$.
- *Discharge* $\sim C$ for U (which may contain other focused phrases) in the current discourse context — in terms of a pending question or contrasting proposition.
- *Establish Coherence* of $[[U]]^\circ$ in the current discourse context; that is, contribution of the utterance content to the evolving information state must somehow make sense.

Each pragmatic subroutine consists of an interacting set of preferences, and the combination of all the subroutines may or may not converge into a single preferred interpretation of U . We will focus here on the preferences that affect the *locate* and *choose* subroutines, with illustrations of how they interact with the *discharge* subroutine. How is the relevant set of alternatives located? How is the preferred value chosen? Rooth does not discuss these cases where focus interpretation may also involve choosing among multiple alternatives. This paper proposes an approach that spells out the missing detail in his notion of restricted alternatives.

3 THREE BACKGROUND HYPOTHESES

Our present aim is to account for the systematic interpretation difference between the stressed and unstressed counterparts. I motivate here the claim that the interpretation of the *unstressed* counterpart should be the basis from which to predict the interpretation of its stressed counterpart. The claim rests on the following analogous characterization of the semantics and pragmatics of the unstressed pronoun such as *he* and *him*.

An unstressed *he* presupposes a constraint $\sim B$ that there is a contextually determined set of entities ($[[he]]^{f'} = \{x \mid x \in B \subseteq E\}$) with at least *one* member — the denotation of *he* ($[[he]]^o$). $[[he]]^o$ is an element of B and B is a subset of E ($[[he]]^o \in [[he]]^{f'} = B \subseteq E$). Given this semantics, interpreting an unstressed *he* in an utterance U involves the following pragmatic subroutines:

- *Locate* $B \subseteq E$, where B is a contextually determined set of entities that may contain more than one potential referent for *he*.
- *Choose* a member of B as $[[he]]^o$.
- *Establish Coherence* of $[[U]]^o$ in the current discourse context.

Note that the sets of pragmatic subroutines for the stressed and unstressed pronouns correspond one-on-one *except* for the additional *discharge* constraint on the utterance containing a stressed pronoun. This indicates that the sum of the pragmatic constraints on the use of stressed pronouns may be greater than on their unstressed counterparts. I therefore hypothesize the following:

HYPOTHESIS 1 *Given the range β of felicitous uses of unstressed pronouns in discourse and the range α of felicitous uses of their stressed counterparts, $\alpha \subset \beta$.*

The above hypothesis is borne out by examples of *asymmetry* such as the following:

- (4) Babar went to a bakery. *he* greeted the baker.
 $\{he \mid ??HE\}$ pointed at a blueberry pie.

The infelicity of the stressed HE is due to the difficulty in discharging the presupposed focus constraint on the utterance (“x pointed at a blueberry pie”) in terms of a pending question (“Who pointed at a blueberry pie?”) or contrasting proposition (e.g., “someone did not point at a blueberry pie”).

Assuming the above hypothesis, we may conclude that if the preferred interpretation of either the stressed or unstressed counterpart serves as the basis for deriving the other preferred interpretation, the base preference should come from the unstressed counterpart, hence the second background hypothesis:

HYPOTHESIS 2 *The preferred value of a stressed pronoun can be predicted by the preferred value of its unstressed counterpart.*

There are remaining questions. What is the “contextually relevant subset” B for the unstressed pronoun? What constraint, if any, does an utterance containing an unstressed pronoun presuppose? In other words, is there an unstressed pronoun analogue of $\sim C$? I will propose an answer only to the first of these questions. I will define the *currently salient subset* of the domain of individuals in terms of the centering model of discourse (see the next section), and motivate the third background hypothesis:

HYPOTHESIS 3 *Stressed and unstressed counterparts choose their values from the same salient subset of the domain of individuals (i.e., $F = B$).*

If we are lucky, then, what we have is an integrated account of the semantics and pragmatics of stressed and unstressed pronouns. Note that in order for this hypothesis to work, we need to explain the discrepancy that the set F for a stressed pronoun must contain at least two members, whereas B may sometimes contain only one. I will argue that when the salient subset is a singleton, the contrasting members are accommodated into the context to satisfy the focus constraint of the stressed pronoun.

4 THE UNSTRESSED PRONOUN AND CENTERING

The problem of choosing among alternative values for pronouns has been investigated in the framework of Centering Theory (Grosz, Joshi, and Weinstein, 1983, 1986, 1995).² It is part of an overall theory of discourse structure and meaning (Grosz and Sidner, 1986) that distinguishes among three components of discourse structure — a linguistic structure, an intentional structure, and an attentional state — and two levels of discourse coherence — global and local. *Attentional state* models the discourse participants’ focus of attention determined by the intentional and linguistic structures at any given point in the discourse. It has global and local components corresponding to the two levels of discourse coherence. The global-level component is a stack of focus spaces, where each focus space holds entities and propositions

associated with a discourse segment, which is associated with a discourse segment purpose in the intentional structure. Centering models the local-level component of attentional state — how the speaker’s linguistic choices for describing propositional contents affect the *inference load placed upon the hearer* in discourse processing.

An utterance in discourse (not a sentence in isolation) has entities called *centers* that link the utterance with other utterances in the same discourse segment. They are the set of *forward-looking centers* (Cf) partially ordered by relative prominence. One member of the Cf may be the *backward-looking center* (Cb) that connects with a member of the Cf of the previous utterance. The speaker’s linguistic choices define centering transitions that affect the local coherence of the discourse. In English discourse, pronouns and grammatical subjects are the main indicators of centering transitions (Grosz et al., 1983, 1986, 1995; Kameyama, 1985, 1986; Brennan, Friedman, and Pollard, 1987). *Unstressed* pronouns, in particular, are primarily used to indicate the Cb in English-type languages (Kameyama, 1985:Ch.1).

Dynamic Preference Model. Kameyama (1996) develops an initial model of *interacting preferences* for dynamically updating a multicomponent context data structure in discourse processing. Centering preferences, stated in terms of the attentional notion of *salience*, systematically interact with structural and commonsense preferences to predict the preferred interpretation of unstressed pronouns. The perspective is that of *total* pragmatics that includes both linguistic and commonsense preferences. This *dynamic preference model* is summarized below. (A preference is stated as a defeasible rule in the form of either “normally p ” or “if p then normally q .”)

- *Discourse* is a sequence of utterances, U_1, \dots, U_n . Each utterance U_i defines a *transition relation* between the *input context* C_{i-1} and the *output context* C_i .³
- Context C is a multicomponent data structure $C_i = \langle \phi_i^k, A_i, D_i, \dots \rangle$ including:⁴
 - ϕ_i^k (LF Register) — the preferred interpretation k of the last utterance U_i in a logical form that preserves aspects of the syntactic structure of U_i .

- A_i (Attentional State) — a set of currently “open” propositions with the associated entities, into which a new utterance content can potentially be integrated. The entities in A_i are partially ordered by *salience*, and the most salient subpart of A_i is the *local attentional state*, A_i^{LOC} (see below).
- D_i (Discourse Model) — a structured information state for what the discourse has been about (situations, eventualities, entities, and relations among them), including the content of A_i .
- A_i^{LOC} (Local Attentional State)⁵ — the entities realized⁶ by ϕ_i^k (corresponding to the Cf). One of them may be $Center_i$ (corresponding to the Cb)⁷ — the entity on which the current discourse segment is centered. I assume that $Center_i$ may be missing in A_i , especially at the onset of a new discourse segment.
- In utterance interpretation, there are interacting preferences for updating different context components. Some come from the linguistic knowledge, and others come from the world knowledge.

The Role of the Attentional State. Various factors affect salience dynamics — including utterance forms, discourse participants’ purposes and perspectives, and the perceptually salient objects in the utterance situation. Here we focus on the factor of utterance forms.

Two default linguistic hierarchies are relevant to the dynamics of salience — *grammatical function hierarchy* (GF ORDER) and the *nominal expression type hierarchy* (EXP ORDER):⁸

GF ORDER: Given a hierarchy [SUBJECT > OBJECT > OBJECT2 > OTHERS], an entity realized by a higher-ranked phrase is normally more salient in the *output* attentional state.

EXP ORDER: Given a hierarchy [ZERO PRONOMINAL > PRONOUN > DEFINITE NP > INDEFINITE NP],⁹ an entity realized by a higher-ranked expression type is normally more salient in the *input* attentional state.

Since matrix subjects and objects cannot be omitted in English, the highest-ranked expression type is the (unstressed) pronoun (Kameyama, 1985:Ch.1).

From EXP ORDER, it follows that a pronoun normally realizes a *maximally salient entity* (of an appropriate gender–number–person type) in the input A . This accounts for the preference for a pronoun to corefer with the matrix subject in the previous utterance as in the following example:¹⁰

- (5) 1. John hit Bill. $A_1: [[\text{John} > \text{Bill}]_{\phi_1} \dots]$
 2. Mary told him to go home. $him := \text{John} < \text{Bill}$

The centering model is reinterpreted as follows:

CENTER: $Center_i \in A_i$ is normally more salient than other entities in A_i .

EXP CENTER: An expression of the highest-ranked type in U_i normally realizes $Center_i$ in the *output* attentional state A_i .¹¹

EXP ORDER and EXP CENTER combine to make a pronoun either *establish* or *chain* the Center (Kameyama, 1985, 1986).¹² $Center_i$ is “established” ($Center_{i-1} \neq Center_i$) when a pronoun picks a salient non-Center in A_{i-1} and makes it the Center in A_i . It is “chained” ($Center_{i-1} = Center_i$) when a pronoun picks $Center_{i-1}$ and outputs it as $Center_i$.

The *maximally salient entity* may be determinate in some attentional state and indeterminate in others, depending on whether the GF-based salience ordering and the Center-based one converge. A highest-ranked GF and the Center may converge or diverge in the *input* A , affecting the preferred interpretation of a pronoun.¹³ For instance, the Center realized by a sentence-initial matrix subject pronoun is the single most salient entity, but the Center realized by a nonsubject pronoun competes with the entity realized by the subject, resulting in an indeterminacy.¹⁴ The different effects are illustrated here:

- (6) 1. Babar went to a bakery. $A_1: [[\text{Babar} > \text{Bakery}]_{\phi_1} \dots]$
 2. *he* greeted the baker.
 $A_2: [[[\text{Babar}]_{Center}^{Subj} > \text{Baker}]_{\phi_2} > \text{Bakery} \dots]$
 3. *he* pointed at a blueberry pie. $he := \text{Babar} < \text{Baker}$

- (7) 1. Babar went to a bakery. $A_1: [[\text{Babar} > \text{Bakery}]_{\phi_1} \dots]$
2. The baker greeted *him*.
 $A_2: [[\text{Baker} < > [\text{Babar}]_{\text{Center}}^{\text{Obj}}]_{\phi_2} > \text{Bakery} \dots]$
3. *he* pointed at a blueberry pie. $he := \text{Baker} \prec ? \text{Babar}$

Example (6) shows the effects of determinate salience ranking in terms of a chain of subject Centers. The preferred value of *he* in (6)–3 is determinate. In contrast, the salience ranking in A_2 is indeterminate in example (7). The weak preference in (7)–3 comes from the interaction of attentional preference and the separate preference for grammatical parallelism stated below.

The Role of the LF Register. The grammatical parallelism of two adjacent utterances in discourse affects the preferred interpretation of pronouns (Kameyama, 1986), tense (Kameyama, Passonneau, and Poesio, 1993), and ellipses (Pruest, 1992; Kehler, 1993). This general tendency warrants a separate statement. Parallelism is achieved, in the present account, by a computation on the pair of logical forms, one in the LF register in the context, and the other being interpreted:

PARA: The LF register in the input context and the utterance being interpreted seek maximal parallelism.¹⁵

We have observed in example (7) that this parallelism preference kicks in when the salience-based preference is indeterminate.

The Role of the Discourse Model. Both linguistic semantics and commonsense preferences apply on the same discourse model. Lexically triggered conventional presuppositions, for instance, constrain possible discourse models. Preferential rules assign a partial order on these models. Commonsense preferences consist of all that an ordinary speaker knows about the world and life. There will be a relatively small number of linguistic pragmatic rules that systematically interact with and *control* an open-ended mass of commonsense rules. Our aim is to describe the former as fully as possible, and specify how the “control mechanism” works. Linguistic rules should be stable across examples and domains, while there will be different commonsense rules for each new example and domain. Example (1) illustrates a type of causal knowledge:

HIT: When an agent x hits an agent y , y is normally hurt.

Preference Interactions. Preferences relevant to unstressed pronoun interpretation fall into three *preference classes* corresponding to the preferred transitions of the three context components. CENTER, GF ORDER, EXP ORDER, and EXP CENTER are defeasible *Attentional Rules* (ATT) stating the preferred A -transitions. PARA is an example of defeasible *LF Rules* (LF) stating the preferred LF-transitions. HIT is an example of defeasible *Commonsense Rules* (WK) stating the preferred D -transitions. These preference classes independently conclude the preferred interpretation of an utterance, and these class-internal conclusions combine in a certain general pattern to produce the final preference. Crucially, preferences *can override* other preferences that contradict them. Ambiguities persist only when mutually contradictory preferences are equally strong.

We have identified the following general patterns of preference interactions in pronoun interpretation:¹⁶

- Indefeasible syntax and semantics (SYN+SEM) can override all preferences.
- Commonsense preferences can override attentional or parallelism preferences. This overriding can be difficult, however, when the latter is extremely strong, producing garden-path phenomena. Observe the difference between “*John hit Bill. He was severely injured.*” ($he := \text{Bill} \leftarrow \text{John}$) and “*Tommy came into the classroom. He saw Billy at the door. He hit him on the chin. ??He was severely injured.*” ($he := \text{Tommy}$ is first chosen but retracted, and results in Billy).
- Attentional preferences can override parallelism preferences except for the cases of parallelism induced by conventional presuppositions.

This general overriding pattern is schematically shown here, where \geq represents a “can override” relation:

$$\boxed{\text{SYN+SEM} \geq \text{WK} \geq \text{ATT} \geq \text{LF}}$$

We have thus a fairly rich theory of interacting preferences in unstressed pronoun interpretation. The question is the following — are they related to, or better, predictive of the preferences relevant to the stressed counterpart?

5 COMPLEMENTARY PREFERENCE HYPOTHESIS

I claim that the preferred value of a stressed pronoun in discourse is predictable from the preferred value of its unstressed counterpart, and that they draw their values from the same ‘currently salient’ subset of the domain. This salient subset is the presupposed constraint F for the stressed pronoun and B for the unstressed pronoun in Hypothesis 3.

In this unified view, this salient subset is the *local attentional state*, A^{LOC} , or the “center of attention” in the dynamic context.

Salient Subset Hypothesis (SSH): *An unstressed pronoun and its stressed counterpart in utterance U_i draw their possible values from the input local attentional state ($A_{i-1}^{LOC} = F = B$).*

Although the exact specification of A^{LOC} is still open (see note 5), we take the standard view in Centering Theory as the starting point in this paper — it is the set of entities realized by the previous utterance in the given discourse segment. It corresponds to the entities associated with the logical form in the LF register in the present dynamic preference model.

Given the common presupposed subset of the domain, I hypothesize that the preference order among the alternative values for a stressed pronoun is the *complement* of the preference order for its unstressed counterpart:

Complementary Preference Hypothesis (CPH): *A focused pronoun takes the complementary preference of the unstressed counterpart.*

Restricting the salient subset is also crucial in this account, in order to avoid an infinite regression into the least preferred entity in the entire universe of discourse to get at the most preferred value for a stressed pronoun.

Computation of the Preferred Value. Given the CPH, the preferred value of a stressed pronoun in utterance U_i is computed with the following algorithm:¹⁷

- *Locate* the local attentional state B_{i-1} in the input context C_{i-1} . B_{i-1} contains a nonempty set of entities partially ordered by *salience* ($B_{i-1}^{salience}$).¹⁸
- *Compute Base Preference Order* for $B_{i-1}^{salience}$ for the *unstressed counterpart* of the stressed pronoun, in terms of the interaction of LF rules, attentional rules, and commonsense rules.¹⁹ The output is a subset H_{i-1} of B_{i-1} partially ordered by *preference* (H_{i-1}^{pref}), where $H_{i-1} \subseteq B_{i-1}$ contains only the possible values of the pronoun within B_{i-1} .
- *Compute Complementary Preference Order* for H_{i-1}^{pref} as follows: $x \prec y$ becomes $y \prec x$, and $x \prec \triangleright y$ does not change. With the CPH, this outputs the possible values of the stressed pronoun partially ordered by preference ($H_{i-1}^{pref^U}$).
- *Discharge* the presupposed constraint $\sim C$ for U_i (which may contain other focused phrases). If B_{i-1} is a singleton set, at least one additional contrasting individual is *accommodated* (see below).
- *Establish Coherence* of $[[U_i]]^c$.

The algorithm is illustrated with example (1) (repeated here):

1. John hit Bill. $C_1: B_1^{salience} = \{\text{John} \triangleright \text{Bill}\}$
- 2b. Then *HE* was injured.
 $B_1 \supseteq H_1^{pref} = \{\text{Bill} \prec \text{John}\} \rightsquigarrow H_1^{pref^U} = \{\text{John} \prec \text{Bill}\}$
 $\rightsquigarrow HE := \{\text{John} \prec \text{Bill}\}$

The local attentional state in the input context for U_{2b} contains John and Bill, with John more salient than Bill. Both John and Bill are possible values of *he*. The base preference for the unstressed counterpart results from the WK rule (HIT) overriding ATT and LF rules, with Bill preferred over John. The complementary preference makes John preferred over Bill for the stressed pronoun. This preference then survives the presupposition discharging, which recognizes the (indirect) contrast between “John was injured” and “John hit Bill” and coherence establishing, which recognizes the Cause–Effect relation between U_1 and U_{2b} .

The following variant of (1) illustrates a case where not all the entities in B are possible values for the pronoun:

1. John hit Bill in front of Mary.

$$C_1: B_1^{salience} = \{\text{John} > \text{Bill} > \text{Mary}\}$$

2. Then *HE* was injured.

$$B_1 \supseteq H_1^{pref} = \{\text{Bill} \prec \text{John}\} \rightsquigarrow H_1^{pref^u} = \{\text{John} \prec \text{Bill}\}$$

$$\rightsquigarrow HE := \{\text{John} \prec \text{Bill}\}$$

Here, B_1 contains three individuals, John, Bill, and Mary, of which only two are possible values of *he*. The interpretation of stressed *HE* in U_2 is exactly the same as in the previous example, however, since the base preference is on the same subset H_1 .

Nakatani (1993) found in spontaneous narratives that a stressed subject pronoun tends to signal (1) a *local shift* to a non-Cb in the Cf or (2) a *global shift* to an old Cb within the segment. (1) is highly consistent with the present account. (2) would also follow if the local attentional state contains old Cbs in the segment as well as the Cf.

Indeterminate Preferences. This unified account predicts that when the preferred value of an unstressed pronoun is indeterminate, the preferred value for its stressed counterpart is likewise indeterminate because the complement of an indeterminate order is still indeterminate. This prediction is borne out in the following example:

(8) Jack and Bob are good friends. $\{??he \mid ??HE\}$ is from Louisiana.

Neither Jack nor Bob is more salient than the other in the conjoined NP, and neither parallelism nor commonsense preferences distinguish them, hence the indeterminate preference for *he*. Its complement for *HE* is also indeterminate.

Unambiguous Stressed Pronouns. The proposed mechanism correctly predicts that when the pronoun in question is unambiguous, stressing does not change its values. Since the stressed and unstressed counterparts draw their possible values from the same singleton set, $|H| = 1$, the complementation operation produces the same possible value for the stressed counterpart. The following examples illustrate such unambiguous pronouns:

(9) Jack and Mary are good friends. $\{he \mid HE\}$ is from Louisiana.

$$\{he \mid HE\} := \text{Jack}$$

- (10) Jack is a physicist. $\{he \mid HE\}$ is from Louisiana.
 $\{he \mid HE\} := \text{Jack}$

The interpretation process of the stressed HE in example (9) is illustrated here:

- (9) 1. Jack and Mary are good friends.
 $C_1: B_1^{salience} = \{\text{Jack} \langle \rangle \text{Mary}\}$
- 2b. HE is from Louisiana.
 $B_1 \supseteq H_1^{pref} = \{\text{Jack}\} \rightsquigarrow H_1^{pref^u} = \{\text{Jack}\} \rightsquigarrow HE := \{\text{Jack}\}$

The preference complementation operation yields the correct unambiguous value of the stressed pronoun, $[[HE]]^o$, with no additional stipulations. A possible alternative to the CPH such as “rule out the most preferred value in H_1^{pref} ” would not naturally extend to an account of unambiguous pronouns.

Recall the focus constraint $\sim F$ on stressed pronouns. The focus semantic value of HE , F , must have at least two members — the denotation of HE ($[[HE]]^o$) and at least one more contrasting individual. These contrasting individuals also instantiate contrasting propositions that discharge the focus constraint $\sim C$ on the utterance as a whole. Under the present proposal, F is the set of entities in the local attentional state, which is also presupposed for unstressed pronouns ($F = B = A^{LOC}$), so A^{LOC} must provide the contrasting individuals. The question is — are they always supplied from A^{LOC} rather than A ?

The present account makes use of nested subsets of the entities in A — $H \subseteq B = A^{LOC} \subseteq A$. Our examples in this paper indicate that these regions are all potential sources for the contrasting individuals. We have seen the following three sources for contrasting individuals:

- Alternative values within $H \subseteq A^{LOC}$ — examples (1) and (3)
- Individuals in A^{LOC} that are not possible values of the pronoun but belong to a common general class with the pronoun referent such as PERSON — example (9)²⁰
- Not found in A^{LOC} but potentially found in A — example (10).

I will discuss what may happen in the third case.

When A^{LOC} does not provide contrasting individuals, the focus constraint for the stressed pronoun $\sim F$ is satisfied by discharging the focus constraint on the utterance $\sim C$ by *accommodation* (Lewis, 1979) into the input attentional state. For example, utterance U_{2b} in both (9) and (10) generates the same focus constraint $\sim C$ — “x is from Louisiana.” In (9), A^{LOC} contains the contrasting individual, Mary, and $\sim C$ is discharged by accommodating a contrasting presupposition “Mary is not from Louisiana.” In (10), A^{LOC} does not contain contrasting individuals, and $\sim C$ is discharged by accommodating a question “Who is from Louisiana?” This question presupposes other persons in the domain, and if no persons have been explicitly mentioned, a set of persons is implicitly accommodated into the current attentional state A . A more precise formulation of this process will be left for a future task.

The present framework offers an explicit proposal about how the focus constraints at both the phrase and utterance levels are discharged within the nested structure of attentional state, and how contrasts are accommodated when presuppositions do not immediately follow from the explicit discourse.

6 FURTHER QUESTIONS

There are a number of related questions, which I will only note here.

- The local attentional state is supposed to be relevant only for utterance processing within a discourse segment. What happens to stressed and unstressed pronouns in a segment-initial utterance? More generally, how does the *discourse structure* affect pronoun interpretation?
- *Intrasentential* pronominal anaphora for both stressed and unstressed pronouns is widely studied in syntax (e.g., Akmajian and Jackendoff, 1970; Lakoff, 1976; Williams, 1980; Lujan, 1985; Hirschberg and Ward, 1991). How does the present account relate to these syntactic facts? How does it extend to the pragmatics of intrasentential pronominal anaphora (e.g., Kameyama, to appear)?

7 CONCLUSION

I have presented a unified account of interpretation preferences of stressed and unstressed pronouns in discourse. The central intuition is expressed as the Complementary Preference Hypothesis taking the interpretation preference of the unstressed pronoun as the base from which to predict the interpretation preference of the stressed pronoun in the same discourse position. This base preference must be computed in a *total* pragmatics module including commonsense preferences. I have also made a concrete proposal for the pragmatically determined focus constraint in Rooth's theory of semantic focus. The salient subset of the domain in this proposal makes use of the dynamically updated local attentional state in the discourse context independently motivated for other purposes in Centering Theory. As a consequence, the overall discourse processing can unify the interpretation process for the two kinds of pronouns while explaining the source of the curious complementarity in their interpretation preferences.

NOTES

¹Note that *it* cannot be stressed, and its stressed counterpart is *THAT*.

²Centering Theory synthesizes previous work on discourse focusing (Grosz, 1977, 1981), immediate focusing (Sidner, 1979, 1983), and discourse centering (Joshi and Kuhn, 1979; Joshi and Weinstein, 1981).

³Utterance *U* need not be a sentence in the standard syntactic sense. In fact, it is more natural to think of *U* as a tensed clause, allowing multiple intrasentential transitions within a complex sentence (see Karneyama, to appear). This paper focuses only on intersentential anaphora, however.

⁴Indexical Context is notably omitted here.

⁵There are other highly salient entities that we are not considering in this paper — for instance, the entities associated with the current discourse segment *purpose*, the old *Center* entities in the current discourse segment, and the entities realized by possible antecedents in the current utterance.

⁶In the examples in this paper, *realize* simply means *denote*, but it combines a variety of factors in a full account (see Grosz et al., 1995).

⁷*Center* corresponds to “topic proper” in TFA (Sgall et al., 1986).

⁸Both linguistic hierarchies are in fact recurrent in functional and typological studies of language. The GF ORDER closely resembles Keenan and Comrie's (1977) Accessibility Hierarchy, Givón's (1979) Topicality Hierarchy, and Kuno's (1987) Thematic Hierarchy, all of which predict the preferred syntactic structure for describing the things that a sentence is "mainly about" within and across languages. The EXP ORDER resembles the linguistic correlates of Gundel, Hedberg, and Zacharski's (1993) Givenness Hierarchy, which is closely related to Prince's (1981) Familiarity Scale, which predicts the relative *degrees* of accessibility of referents. It is of interest that virtually the same hierarchies are relevant to the computational interest in how grammar controls inferences in language use.

⁹The distinction between stressed and unstressed pronouns in EXP ORDER in an earlier version (Kameyama, 1994) has been removed because the ordering UNSTRESSED PRONOUN > STRESSED PRONOUN follows from the present independent account of stress.

¹⁰I will henceforth notate the relation *more_salient_than* with >, indeterminate salience ordering with <>, *preferred_over* with <, *weakly_preferred_over* with <?, and indeterminate preference ordering with <?. Preferences in the subsequent examples come from the survey data discussed in Kameyama (1996).

¹¹The "highest-ranked type" in EXP CENTER can be interpreted as either relative to each utterance or absolute in all utterances. Under the relative interpretation, a non-pronominal expression type can also output the Center as long as there are no pronouns in the same utterance. Under the absolute interpretation, only the pronominals (either zero or overt, depending on the syntactic type of the language) can output the Center. I will take the absolute interpretation in this paper following Kameyama (1985, 1986), based on the rationale that the choice of the highest-ranked pronominal forms in a language should reflect a certain absolute sense of salience threshold.

¹²*Chain* corresponds to what I have previously called *retain*. It covers both CONTINUE and RETAIN distinguished in Grosz et al. (1986, 1995).

¹³Discussions with Becky Passonneau helped clarify this point.

¹⁴Under the present perspective, the proposal to distinguish between CONTINUE and RETAIN transitions (Grosz et al., 1986, 1995) focuses on the convergence of the highest-ranked GF (Cp) and the Center (Cb) in the *output* attentional state.

¹⁵For a specific definition of parallelism, see, e.g., Pruest (1992), Kameyama (1986).

¹⁶See Jaspars and Kameyama (1996) for a model of discourse logic that incorporates the notion of preference classes.

¹⁷The subset H_{i-1} was overlooked in the earlier formulation of the algorithm in Kameyama (1994).

¹⁸Actually, this set can also be empty, in which case a plausible assumption is that an accommodation takes place and obtains an indexically salient entity.

¹⁹The salience order controls this computation.

²⁰I assume a general sort hierarchy for the domain of individuals as proposed by, e.g., Bosch (1988) and Prevost (1996), to compute the notion of ‘a common general class’ under which a contrast is established.

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REFERENCES

- Akmajian, Adrian and Ray Jackendoff. 1970. Coreferentiality and Stress. *Linguistic Inquiry*, 1(1), 124–126.
- Bosch, Peter. 1988. Representing and Accessing Focussed Referents. *Language and Cognitive Processes*, 3(3), 207–231.
- Brennan, Susan, Lyn Friedman, and Carl Pollard. 1987. A Centering Approach to Pronouns. In *Proceedings of the 25th Annual Meeting of the Association for Computational Linguistics*, 155–162.
- Givon, Talmy. 1979. *On Understanding Grammar*, Academic Press, New York, NY.
- Grosz, Barbara. 1977. The Representation and Use of Focus in Dialogue Understanding. Technical Report 151, SRI International, Menlo Park, CA.
- Grosz, Barbara. 1981. Focusing and Description in Natural Language Dialogues. In Joshi, Aravind, Bonnie Webber, and Ivan Sag, eds. *Elements of Discourse Understanding*, Cambridge University Press, Cambridge, England, 85–105.
- Grosz, Barbara, Aravind Joshi, and Scott Weinstein. 1983. Providing a Unified Account of Definite Noun Phrases in Discourse. In *Proceedings of the 21st Meeting of the Association of Computational Linguistics*, 44–50.
- Grosz, Barbara, Aravind Joshi, and Scott Weinstein. 1986. Towards a Computational Theory of Discourse Interpretation. Unpublished manuscript. [The final version appeared as Grosz et al. 1995.]
- Grosz, Barbara, Aravind Joshi, and Scott Weinstein. 1995. Centering: A Framework for Modelling the Local Coherence of Discourse. In *Computational Linguistics*, 21(2), 203–226.
- Grosz, Barbara and Candy Sidner. 1986. Attention, Intention, and the Structure of Discourse. *Computational Linguistics*, 12(3), 175–204.
- Gundel, Jeanette, Nancy Hedberg, and Ron Zacharski. 1993. Cognitive Status and the Form of Referring Expressions in Discourse. *Language*, 69(2), 274–307.

- Hirschberg, Julia and Gregory Ward. 1991. Accent and Bound Anaphora. *Cognitive Linguistics*, 2(2), 101–121.
- Jaspars, Jan and Megumi Kameyama. 1996. Preferences in Dynamic Semantics. In Paul Dekker and Martin Stokhof, eds., *Proceedings of the 10th Amsterdam Colloquium*, Institute for Logic, Language, and Computation, University of Amsterdam, Amsterdam, 445–464.
- Joshi, Aravind and Steve Kuhn. 1979. Centered Logic: The Role of Entity Centered Sentence Representation in Natural Language Inferencing. In *Proceedings of International Joint Conference on Artificial Intelligence*, Tokyo, Japan.
- Joshi, Aravind and Scott Weinstein. 1981. Control of Inference: Role of Some Aspects of Discourse Structure — Centering. In *Proceedings of International Joint Conference on Artificial Intelligence*, Vancouver, Canada, 385–387.
- Kameyama, Megumi. 1985. *Zero Anaphora: The Case of Japanese*. Ph.D. Thesis, Stanford University.
- Kameyama, Megumi. 1986. A Property-sharing Constraint in Centering. In *Proceedings of the 24th Annual Meeting of the Association for Computational Linguistics*, New York, NY, 200–206.
- Kameyama, Megumi. 1994. Stressed and Unstressed Pronouns: Complementary Preferences. In Bosch, Peter and Rob van der Sandt, eds., *Focus and Natural Language Processing*. Institute for Logic and Linguistics, IBM, Heidelberg, 475–484.
- Kameyama, Megumi. 1996. Indefeasible Semantics and Defeasible Pragmatics. In Kanazawa, Makoto, Christopher Piñon, and Henriëtte de Swart, eds., *Quantifiers, Deduction, and Context*. CSLI, Stanford, CA, 111–138.
- Kameyama, Megumi. To appear. Intrasentential Centering. In Walker, Marilyn, Ellen Prince, and Aravind Joshi, eds., 1997. *Centering in Discourse*, Oxford University Press, Oxford, England.
- Kameyama, Megumi, Rebecca Passonneau, and Massimo Poesio. 1993. Temporal Centering. In *Proceedings of the 31st Meeting of the Association of Computational Linguistics*, Columbus, OH, 70–77.
- Keenan, Edward and Bernard Comrie. 1977. Noun Phrase Accessibility and Universal Grammar. *Linguistic Inquiry*, 8(1), 63–100.
- Kehler, Andrew. 1993. The Effect of Establishing Coherence in Ellipsis and Anaphora Resolution. In *Proceedings of the 31st Meeting of the Association of Computational Linguistics*, Columbus, OH, 62–69.
- Kuno, Susumu. 1987. *Functional Syntax*, Chicago University Press, Chicago, IL.
- Lakoff, George. 1971. Presupposition and Relative Well-formedness. In Steinberg, Danny and Leon Jakobovits, eds., *Semantics: An Interdisciplinary Reader in Philosophy, Linguistics, and Psychology*. Cambridge University Press, Cambridge, England.

- Lakoff, George. 1976. Pronouns and Reference. In James McCawley, ed., *Syntax and Semantics*, Vol.7, Academic Press, New York, NY, 275–335.
- Lewis, David. 1979. Scorekeeping in a Language Game. *Journal of Philosophical Logic*, 8, 339–359.
- Lujan, Marta. 1985. Stress and Binding of Pronouns. *Papers of the 21st Regional Meeting*, Chicago Linguistic Society, Chicago University, 248–262.
- Nakatani, Christine. 1993. Accenting on Pronouns and Proper Names in Spontaneous Narrative. In *Proceedings of the ESCA Workshop on Prosody*, Lund, Sweden.
- Prevost, Scott. 1996. An Information Structural Approach to Spoken Language Generation. In *Proceedings of the 34th Meeting of the Association of Computational Linguistics*, Santa Cruz, CA, 294–301.
- Prince, Ellen. 1981. Toward a Taxonomy of Given–New Information. In *Radical Pragmatics*, Academic Press, New York, NY, 223–255.
- Pruett, Hub. 1992. *On Discourse Structuring, VP Anaphora and Gapping*. Ph.D. Thesis. University of Amsterdam.
- Rooth, Mats. 1992. A Theory of Focus Interpretation. *Natural Language Semantics* 1(1), 75–116.
- Rooth, Mats. 1993. A Hybrid Architecture for Focus. An invited lecture at the Ninth Amsterdam Colloquium.
- Sgall, Petr, Eva Hajičová, and Jarmila Panevová. 1986. *The Meaning of the Sentence in its Semantic and Pragmatics Aspects*, Reidel, Dordrecht and Academia, Prague.
- Sidner, Candy. 1979. *Towards a Computational Theory of Definite Anaphora Comprehension in English Discourse*. Ph.D. Thesis, Technical Report 537, Artificial Intelligence Laboratory, MIT.
- Sidner, Candace. 1983. Focusing in the Comprehension of Definite Anaphora. In Brady, M. and R. Berwick, eds., *Computational Models of Discourse*, The MIT Press, Cambridge, MA, 267–330.
- Williams, Edwin. 1980. Remarks on Stress and Anaphora. *Journal of Linguistic Research*, 1(3).

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