Do you know who that is?

Representational detail affects discourse focus and anaphor resolution

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Abstract

Establishing referential relations among text elements is critical to establishing discourse coherence. Although resolution of coreference between anaphors and their antecedents is central to many theories of text processing, most address the semantic features of antecedent entities in a minimal way (e.g., via morphological features such as gender and number). However, research shows that semantically rich entities are represented in a different manner than semantically empty ones (e.g., *Bill Clinton* versus *Bill Smith*), and that such differences have processing consequences in a variety of cognitive tasks. In two experiments, we investigated how the semantic features of discourse referents affected coreferential processing. Our results indicate that increasing the semantic detail associated with the characters in our experimental sentences increased their psychological prominence in the discourse representation. In Experiment 1, semantic detail increased the relative availability of antecedent entities in memory when they were uniquely identifiable by an anaphoric expression. In Experiment 2, semantic detail also affected the online resolution and integration of anaphor – antecedent relations: semantically rich antecedents that were not otherwise focused in the discourse reliably elicited the repeated-name penalty, an effect known to reflect discourse prominence. In addition, semantic detail seemed to permit recovery from lingering effects of the repeated-name penalty. Our results are consistent with recent evidence that the quality of discourse information affects the construction of a coherent representation, even when it is incidental to structural and referential relations in a text. Models of text processing must incorporate a role for this kind of representational information.

Keywords: Anaphor resolution, Coreference, Discourse Processing, Semantic Memory

Referential expressions – pronouns, names, and definite descriptions – permit readers to specify the semantic entities in their mental representation of a text. Coreferential processing, by which readers determine that two (or more) referential expressions (i.e., *anaphors*) refer to the same semantic entity, permits readers to track who is doing what to whom. Most theories of text processing assert that resolving coreferential relations in a text is critical for establishing and maintaining discourse coherence (e.g., Gernsbacher, 1990; Kintsch, 1988, 1998; Myers & O'Brien, 1998; Sanford & Garrod, 1981, 1998, 2005; for review see McNamara & Magliano, 2009). Models of coreference have been developed (e.g., Almor & Nair, 2007; Garnham & Cowles, 2008; Gordon & Hendrick, 1998) and used to test an array of syntax-, semantic-, and discourse-based sources of information that comprehenders may use to guide anaphor resolution (for review, see Garnham, 2001). In this article, we assess coreferential processing in light of the semantic "richness" of discourse entities. Specifically, we investigate whether semantic information that elaborates discourse entities, but is otherwise peripheral to resolving an anaphor's antecedent, ultimately affects coreferential processing. We report two experiments that investigate readers' knowledge about candidate antecedent entities in the context of (1) mechanisms that modulate the relative availability of discourse entities in memory, and (2) the online integration processes that support coreference. Determining whether such information affects the establishment of referential relations has important implications for models of both coreferential processing and reading comprehension.

Anaphors that are used in research rarely refer to actual people (or objects, or events). For example, this sentence (from Gernsbacher, 1989) introduces two characters, identified by proper names in the first clause:

- (1) Bill handed John some tickets to a concert but he took the tickets back immediately.

A mental representation of this sentence should contain two entities, *Bill* and *John*, both licit antecedents for the ambiguous pronoun *he*. Both candidate antecedents have a largely overlapping set of semantic features (e.g., male, singular). However, *Bill* and *John* are referentially "empty names" – proper names denoting entities with no real world referents – and the sentential context provides no additional information about these characters; thus, they will be represented in a comprehender's mental model as minimally specified, largely similar entities (Cohen, 1990). In contrast, consider the referential representations that result if a comprehender is told that sentence (1) is about *Bill Clinton* and *John Travolta*. For many readers, the characters in the sentence are now associated with a wealth of information from long-term memory, including details about these individuals' physical appearances, their professions, and so on. Thus, the reader's mental representation of these particular entities is semantically rich relative to the more common experimental *Bills* and *Johns*, about whom the reader has no prior knowledge.

Several lines of research indicate that differences in semantic "richness" – *Bill* vs. *Bill Clinton*, *John* vs. *John Travolta* – are not trivial. For example, numerous studies report increased difficulty associated with semantically empty proper names relative to those associated with well-known celebrities in face processing tasks, including recognition memory (e.g., Prabhakaran & Thompson-Schill, 2010), naming (e.g., Brédart, Valentine, Calder, & Gassi, 1995), and matching the identity, gender, and orientation of a target face to a cued one (Balas, Cox, & Conwell, 2007; see also Stevenage & Osborne, 2006; Richards & Ellis, 2008). In each of these studies, participants were required to retrieve, process, and integrate critical semantic information from memory. There is also evidence that the semantic neighborhoods of empty proper names differ significantly from famous names. Using the Hyperspace Analogue to Language (HAL) model of memory, Burgess and Conley (1999) determined that the closest

semantic neighbors of empty names are other empty names (e.g., the closest neighbors to *John* are *David*, *Peter*, and *Paul*). In contrast, this is not the case for famous names, for whom associations are generated on the basis of their greater semantic detail (e.g., the closest neighbors to *Reagan* are words related to the presidency: *Clinton*, *Bush*, *republican*, *democrats*, and so on). Burgess and Conley suggest that these differences may underlie some of the processing effects mentioned above, such as the difficulty associated with retrieving semantically empty proper names relative to proper names associated with famous entities (see also Hollis & Valentine, 2001). Findings such as these suggest that the semantic richness of potential referents could be important during the establishment of coreferential links, especially when coupled with evidence that knowledge about real world entities (people, places, objects, events, etc.) is applied to sentence processing in parallel with other sources of information (Hagoort, Hald, Bastiaansen & Petersson, 2004; see also Filik & Leuthold, 2008, 2013; Hald, Steenbeek-Planting, & Hagoort, 2007).

Despite the potential importance of this kind of semantic information, only one model of text processing, Scenario Mapping and Focus (SMF) theory, provides a detailed account of how entities are represented in a comprehender's mental model (Sanford & Garrod, 1981, 1998, 2005; see also Garrod & Sanford, 1990; Sanford & Emmott, 2013). According to SMF theory, incoming linguistic input is immediately related to background knowledge in memory prior to the construction of a propositional network from which the discourse model is built. Such information is retrieved quickly and automatically, in a manner that is consistent with fast, autonomous resonance-based retrieval (e.g., Hintzman, 1986; Ratcliff, 1978). Consequently, an entity's semantic features are "a function of how entities are mapped onto background knowledge" (Sanford & Garrod, 1998, p.182). SMF theory adopts Johnson-Laird's (1983) mental

models terminology in suggesting that discourse entities accumulate informational 'tokens' that are used during text comprehension. For example, in sentence (1), separate tokens for *Bill* and *John* are established because they are different names, and should therefore refer to discrete entities. Each also receives tokens denoting maleness, number, and animacy. In addition, *Bill* and *John* will accrue tokens specifying their agentive roles because verbs "denote quite complex things and serve as frames through which the rest of the sentence can be organized" (Sanford & Garrod, 1998, p.163): *Bill* will have a token identifying him as a giver (and, by the end of the sentence, the taker), and *John* will have a token identifying him as a receiver. When reference is 'empty', no other information from long-term memory accumulates to characters such as *Bill* and *John*, resulting in semantically shallow character representations. However, introducing semantic information from background knowledge produces more complex representations, with additional tokens denoting semantic details that have been retrieved automatically from LTM.

We are not aware of any research investigating the potential effects of this kind of background semantic knowledge on coreferential processing. However, this issue is related to research indicating that the degree to which an entity is elaborated affects coreference. In these studies, *elaboration* corresponds to the number of propositions associated with an antecedent noun phrase, which includes both its relations to other entities in the discourse model and, more pertinent to the current investigation, semantic detail about the antecedent itself. To illustrate, consider an example of the antecedent NP *desk* (from Albrecht & Myers, 1995):

(2a) The captain sat at his desk.

(2b) The captain sat at his large desk.

In sentence (2), the representation of *desk* includes a proposition describing the desk's relation to the captain (sat-at, captain, desk). Sentence (2b), however, also contains a proposition describing

a distinguishing semantic feature (large, desk). When antecedents were elaborated with a semantic detail (i.e., with a prenominal adjective, as in *large desk*, *leather couch*, etc.), subsequent anaphoric NPs elicited faster reading times, and antecedent probes elicited faster responses relative to the less elaborated antecedents (e.g., Albrecht & Myers, 1995, 1998; see also O'Brien, Plewes, & Albrecht, 1990; O'Brien, Albrecht, Hakala, & Rizella, 1995). Findings such as these are consistent with SMF theory, which proposes that greater semantic elaboration increases the salience (or cognitive prominence) of the elaborated entity, reflecting the application of discourse focus (Garrod & Sanford, 1988; Sanford & Garrod, 1981; 2005). Researchers investigating prenominal elaboration of an antecedent have suggested that increased discourse focus is a consequence of increased attention and/or deeper processing at encoding. That is, the semantic information provided by the prenominal adjectival modifier signaled that its NP was important, and this focus affected both encoding and subsequent coreferential processing (see also Garnham, Oakhill, & Cain, 1997; Klin et al., 2004; Sedivy, Tanenhaus, Chambers, & Carlson, 1999).

Of course, there are differences between this kind of elaboration and the type of semantic detail that background knowledge provides about famous people, objects, or events. For example, the semantic neighborhoods associated with Bill and with Bill Clinton differ, but those of desk and large desk may not. Nevertheless, the conceptual parallel between the two types of elaboration is clear and, in light of evidence that discourse focus that is derived from other sources (e.g., syntax, prosody; for review see Garnham, 2001) can affect anaphor processing, strongly suggests that the potential effects of background semantic knowledge bears investigation. Thus, our goal in this study is to examine the possible effect(s) of the semantic richness of discourse entities on phenomena associated with anaphor resolution. In our first

experiment, we investigated whether differences in semantic detail affect discourse referents' availability in memory, as indexed by relative activation during sentence processing. Our second experiment addressed the potential effects of semantic detail on the resolution and integration of coreferential relations.

EXPERIMENT 1

There are now many studies that have assessed the availability of discourse referents (and other discourse information) during online processing. An antecedent's availability in memory is measured (typically by monitoring its level of activation via, for example, reaction times; see McKoon & Ratcliff, 2015) relative to the availability of other potential referents in the discourse representation. In most studies, anaphor resolution is characterized as a memory retrieval process: the anaphor is the retrieval cue, and the antecedent is the target; the target is retrieved based on its featural overlap with the anaphor. As such, anaphors such as repeated names, which exactly match the form of an antecedent, should elicit qualitatively different effects than less explicit referential expressions, such as pronouns. In an influential series of experiments, Gernsbacher (1989) assessed the activation of characters in sentences like (1).

- (1a) Bill handed John some tickets to a concert but he took the tickets back immediately.
- (1b) Bill handed John some tickets to a concert but Bill took the tickets back immediately.

Using a probe verification paradigm, Gernsbacher measured the activation of both characters before and after participants read the anaphor in the second clause (i.e., the pronoun in 1a, the repeated name in 1b). She consistently found no reaction time differences to probes of both the antecedent and non-antecedent prior to the anaphor, suggesting that both entities were similarly activated. She also consistently observed reaction time differences after encountering an

anaphor. After a repeated name anaphor, as in (1b), the antecedent was more activated than before, and the non-antecedent was less activated. These effects manifested immediately following the anaphor, and persisted throughout the sentence. After a pronoun, as in (1a), the reaction times to antecedent probes were unaffected, but reaction times to non-antecedent probes were slower, rendering the antecedent relatively more available in memory; moreover, this effect emerged only at the end of the sentence. Gernsbacher proposed that the immediacy of effects related to repeated names stem from the complete overlap of the semantic features of the anaphor and the antecedent; likewise, the relatively delayed onset of effects following pronominal reference reflect the smaller degree of overlap. This pattern of results is reported in many studies of anaphor resolution, using sentences and/or passages of varying length (e.g., Chang, 1980; Corbett & Chang, 1983; Dell, McKoon, & Ratcliff, 1983; Dopkins & Nordlie, 2011; Gordon, Hendrick, & Foster, 2000; Greene, Gerrig, McKoon, & Ratcliff, 1994; Long & De Ley, 2000; Love & McKoon, 2011; MacDonald & MacWhinney, 1990; McDonald & MacWhinney, 1995; McKoon & Ratcliff, 1980).

The goal of this experiment was to evaluate discourse referents' availability in memory while manipulating the semantic detail of their representations. Following the method of Gernsbacher (1989; Experiment 1), participants in this experiment read simple, two-clause sentences like (1), with two potential referents in the first clause and a coreferential expression in the second. Prior to each sentence, the characters were identified as either semantically "empty" (e.g., *Bill Smith, John Jones*) or "rich" (e.g., *Bill Clinton, John Travolta*). Activation of the characters in memory was assessed immediately before and after participants read the anaphor by means of a probe verification task. The test probe was either the antecedent (e.g., *Bill*) or the non-antecedent (e.g., *John*), and participants verified whether the probe name had appeared in

the sentence that they were reading. Verification latencies were used as an index of activation, with faster reaction times signifying greater availability in memory, and slowed reaction times signifying reduced availability. Table 1 provides examples of the stimuli, including the probe test points.

INTRODUCTIONS

Empty reference

The following sentence is about the fictional people Bill Smith and John Jones.

Rich reference

The following sentence is about the famous people Bill Clinton and John Travolta.

TARGET SENTENCES

Pronoun sentence:

Bill handed **John** some tickets to a concert and ¹**he**² asked for nothing in return.

Repeated name sentence:

Bill handed **John** some tickets to a concert and ¹**Bill**² asked for nothing in return.

Table 1. Example stimuli for Experiments 1 and 2.

Note: anaphors are italicized and antecedents are boldfaced, but were presented to participants in normal font. Probe test points in Experiment 1 are numerically identified. Regions of interest used in Experiment 2 are underlined.

Previous studies using this paradigm consistently report comparable activation for both sentence characters prior to the anaphor (test point 1). This oft-replicated finding is typically uncontroversial, inasmuch as the stimuli in these studies are identical prior to the anaphor. However, in the current study, the semantic characteristics of the stimuli differ prior to the anaphor, which could affect early probe verification times. For example, if additional semantic information strengthens the memory traces of the characters in the first clauses, then all semantically rich entities may be more strongly activated than empty ones at test point 1, eliciting faster probe responses even before encountering an anaphor. However, the increased

discourse focus evoked by additional semantic detail may not increase the overall activation of the famous characters. Instead, it may only have consequences after retrieval is initiated by an anaphor. In this case, as in previous research, probe verification latencies at test point 1 should not differ according to the semantic detail of sentence characters.

After the anaphors, previous studies consistently report that sentence characters' level of activation depends on the type of probe and the type of anaphor. In the current study, semantic detail may also play a role. In the semantically empty conditions, we expect the same pattern of results as reported by Gernsbacher (1989) and others: after a repeated name, the antecedent should be the most available discourse entity, by virtue of the strong resonance elicited by the match between anaphor and antecedent *and* the reduced activation of the competing non-antecedent entity. Specifically, when the anaphor is a repeated name, probe verification latencies immediately after the anaphor (test point 2) should decrease for *Bill* and increase for *John* relative to test point 1. In contrast, reaction times to probes of either discourse referent should be comparable following a pronominal anaphor. In those conditions, additional information is required to disambiguate the pronoun's referent, so reaction times at test point 2 should be similar to test point 1.

The conditions with semantically rich referents permit us to examine whether more elaborated antecedent representations modulate the activation of discourse entities. One possibility is that the amount of semantic detail associated with each character in the sentence will not affect either characters' availability. In this case, reaction times to the probe names should closely track those obtained in the semantically empty conditions. Alternatively, greater semantic detail may induce processing differences after encountering an anaphor. Because

antecedent and non-antecedent activation is known to vary according to the type of anaphor (e.g., Gernsbacher, 1989), we consider predictions for pronouns and repeated names separately.

Because the semantic details in the rich conditions provide no disambiguating information, the pronouns in these conditions remain as ambiguous as those in the semantically empty conditions. Thus, semantic detail may not influence reaction times following a pronoun, resulting in similar reaction times at test points 1 and 2. However, if the elaborated antecedents are more distinctive (e.g., Foraker & McElree, 2007), then post-pronoun reaction times may show evidence of increased availability regardless of the name being probed, as both the antecedent and the non-antecedent may be relatively more available. Whether such facilitation is related to coreferential processing will depend on whether the semantic detail of the sentence characters also affected probe response times before the anaphors.

When the anaphor is a repeated name, increased focus may result in both antecedent *and* non-antecedents being relatively more available. In this case, probes of both antecedent and non-antecedent names may elicit faster reaction times than when the sentence characters are semantically empty. For non-antecedent probes, this kind of facilitation could reduce or eliminate the longer response times typically associated with a repeated name anaphor (e.g., O'Brien et al., 1990). In contrast, SMF theory suggests that, by virtue of their semantic specificity, non-antecedent entities in discourse focus will be more easily differentiated from antecedent entities than non-antecedent entities that are semantically empty (Sanford & Garrod, 2005). Consequently, probes of semantically rich entities may elicit stronger effects, reflecting the greater distinction between these and the antecedent representations. In this case, the typical pattern of reaction times – faster responses to antecedent probes, and slower responses to non-antecedent probes - should emerge, but responses to semantically rich antecedent probes may be

even faster, and to non-antecedent probes even slower, than those to probes of empty targets at position 2.

Method

Participants. One-hundred and thirty-two undergraduates at the University of California, Davis, participated for course credit. All were native English speakers.

Materials. The materials were the 64 experimental sentence sentences from Gernsbacher (1989, Experiment 1) and 48 filler sentences. All were two-clause sentences in which two characters were mentioned in the first clause, one of which was anaphorically referenced in the second. In the experimental sentences, the second-clause anaphors were repeated names or pronouns; half of these referred to the first-mentioned character, and half referred to the second-mentioned character. In the filler sentences, two-thirds of the anaphors followed the same pattern as the experimental conditions (i.e., names or pronouns). The anaphor in the remaining 16 filler sentences was the plural pronoun *they*, as in *Ellen encountered Susan on the steps outside the museum and they decided to meet later for coffee*. The names in each sentence were stereotypically unambiguous as to gender. Within each sentence, characters were of the same gender; across all stimuli, half were male and half were female.

Prior to each sentence, participants read an introduction identifying the characters in the subsequent sentence as either semantically empty (e.g., "The next sentence is about the fictional people Bill Smith and John Jones.") or semantically rich (e.g., "The next sentence is about the famous people Bill Clinton and John Travolta."). In order to ensure that characters in the latter condition were associated with relatively detailed memory representations, we collected

normative data. One-hundred students at the University of California, Davis, who did not participate in the main experiment, were asked to complete a name recognition survey. They received 285 names of well-known people from a variety of domains (film, television, politics, science, music, history, and other newsworthy domains). Participants were asked to rate each person on a 1 – 7 recognizability scale; a rating of '7' corresponded to 'very familiar- I am certain I know this person and have knowledge about them', and a rating of '1' corresponded to 'not at all familiar- I don't know who the person is and know nothing about them'. Only names with an average recognition rating of 5 or higher were used for the experimental items; for the filler items, only names with an average rating of 3 or lower were used.

Each sentence contained a probe name. Participants reading the sentences were interrupted by the probe name, at which time they verified whether or not they had seen the name in the sentence. The test point in the sentences varied. In the experimental sentences, the probe appeared immediately before the anaphor on half of the sentences, and immediately after the anaphor on the other half. In the filler sentences, half of the items included probes before or after the anaphor and half included probes that were earlier (i.e., in the first clause) or later (i.e., near the end) in the sentences. We created sixteen counterbalanced lists, within which each experimental item occurred only once, and across which each experimental item occurred in all conditions. All lists contained the same 48 filler sentences, resulting in 112 items per list.

As in Gernsbacher (1989), all experimental sentences were followed by a two-alternative WHO comprehension question (see below). Half of the questions were about the sentences' first clause and half about the second. The type of anaphor in each sentence determined the nature of the comprehension question. If the anaphor was a repeated name, then the question was about the first clause; of these, half concerned the first-mentioned character and half were about the second

character. For example, for the target sentences in Table 1, participants might have been asked, "Who handed someone some tickets?" (answer: *Bill*) or, "Who was handed some tickets?" (answer: *John*). If the anaphor was a pronoun, then the question pertained to the second clause; as noted by Gernsbacher (1989), this permitted an assessment of whether participants understood which characters were the pronouns' antecedents. For example, for the target sentences in Table 1, participants might have been asked, "Who took the tickets back immediately?" (answer: *Bill*).

Procedure. Participants received verbal instructions describing the task, followed by the same instructions in written form. They then received a short set of practice trials to familiarize the participants with the task. After the practice items, the participants verbally confirmed that they understood the task and then began the experiment.

Participants read the introduction identifying the sentence characters. They pressed a button on the keyboard to indicate that they had read the introduction and were ready to receive the next sentence. A fixation cross (+) appeared in the center of the screen for 750 ms. Each word in the target sentence was presented in the center of the screen for 300 ms in a rapid serial visual presentation (RSVP) format, with an inter-stimulus interval (ISI) of 100 ms. Probe names were presented in a spatially distinct location (at the top of the screen) and appeared in capital letters. Participants decided whether the probe name had appeared in the sentence they were reading by pressing 'yes' or 'no' on the keyboard. Probe names remained onscreen until a response was recorded or 2.5 seconds elapsed (at which point no response was recorded and the target sentence resumed). The probes in the experimental sentences were the sentence characters, (e.g., BILL or JOHN) to which the correct response was YES. On half of the trials, the probe was the antecedent name, and on half the probe was the non-antecedent name. The probes in the

filler sentences were names that did not appear in the sentences, to which the correct response was NO.

Comprehension questions appeared 300 ms after the final word of the target sentences, and were preceded by the word *Test*, which appeared at the bottom of the screen. The comprehension questions were presented in the center of the screen, with the two character names from the sentence presented in the lower left and right quadrants. The names appeared in all capitals and both question and answers remained onscreen until participants responded with a left button press to indicate that the name on the left was the answer or with a right button press to indicate that the name on the right was the answer. Participants received feedback; the word "Correct!" if they chose the correct answer and the word "Incorrect!" if they selected the wrong answer. In the event that participants made no response, the question and answers vanished after ten seconds. The next trial began 300 ms after participants responded to the comprehension question (or after the ten seconds elapsed with no response).

Results

All statistical analyses were carried out with the R statistical software, version 3.2.2 (R Development Core Team, 2015). We used mixed-effect modeling (Baayen, 2004, 2008; Baayen, Davidson, & Bates, 2006) to analyze the data, using package *lme4* (Bates, Maechler, Bolker, & Walker, 2015). The models included fixed effects of Probe Name (antecedent vs. non-antecedent), Test Point (before vs. after the anaphor), Anaphor Type (repeated name vs. pronoun), and Semantic Detail (empty vs. rich), as well as their interactions. Deviation coding was used for all factors in order for their effects to be interpretable as "main effects", and for lower order interactions to be interpretable as such. For example, for the factor *Probe Name*,

antecedent conditions were coded -0.5, and non-antecedent conditions were coded 0.5. We attempted to fit models with maximal random effects structures (Barr, Levy, Scheepers, & Tily, 2012), but those models failed to converge. Therefore, we used models with reduced random effect structures: all models included random intercepts for all fixed effects (and their interactions) by participants and by items. We report the *t*-values associated with our analyses, adopting the convention whereby any effect with an absolute *t*-value that exceeds 2 is considered significant (Gelman & Hill, 2007).

Participants were excluded if their probe verification accuracy was less than 85%, or if their comprehension accuracy was less than 80%. These cutoffs are slightly lower than those used by Gernsbacher (1989), because performance in this experiment was somewhat poorer than in Gernsbacher's first experiment. This is likely the result of our use of a faster stimulus presentation rate: our experiment presented sentence words for 300 ms with a 100 ms ISI, and Gernsbacher presented words for 300 ms + 16.667 ms/character, with an ISI of 150 ms. Probe verification latencies were trimmed prior to analysis. Response times that were lower than 200 ms were excluded from analysis. In addition, individual outliers were identified for each participant and item using quantile-quantile plots and removed manually from the data set (see Baayen, 2008). These procedures together led to the exclusion of 5.5% of the data. Mean response times to the probes appear in Table 2, and all effects and interactions are listed in Table 3. We found one significant main effect, such that probe verification times were faster when the probe name was the antecedent (940 ms) instead of the non-antecedent (986 ms). This replicates Gernsbacher (1989) and others who have used this paradigm (e.g., Corbett & Chang, 1983).

EMPTY REFERENCE

Anaphor Type	Probe name	Before	After
Repeated Name	Antecedent	961	859
Repeated Name	Non-antecedent	963	1032
Pronoun	Antecedent	965	962
Pronoun	Non-antecedent	967	978

RICH REFERENCE

Anaphor Type	Probe name	Before	After
Repeated Name	Antecedent	975	869
Repeated Name	Non-antecedent	963	1064
Pronoun	Antecedent	960	966
Pronoun	Non-antecedent	970	954

Table 2. Mean reaction times (ms) to probes in Experiment 1.

	β Estimate	S.E.	<i>t</i> -value	
(Intercept)	963.60	13.03	73.95	*
Probe Name	46.79	4.69	9.99	*
Test Point	4.51	4.69	0.96	
Anaphor Type	-5.46	4.69	-1.16	
Semantic Detail	-5.05	4.69	-1.08	
Probe Name x Test Point	-95.52	9.37	-10.19	*
Probe Name x Anaphor Type	88.09	9.37	9.40	*
Probe Name x Semantic Detail	4.06	9.37	0.43	
Test Point x Anaphor Type	10.22	9.38	1.09	
Test Point x Semantic Detail	6.48	9.38	0.69	
Anaphor Type x Semantic Detail	-17.71	9.38	-1.89	
Probe Name x Test Point x Anaphor Type	-180.76	18.74	-9.64	*
Probe Name x Test Point x Semantic Detail	-0.7687	18.75	-0.04	
Probe Name x Anaphor Type x Semantic Detail	-9.35	18.75	-0.50	
Test Point x Anaphor Type x Semantic Detail	23.62	18.76	1.259	
Probe Name x Test Point x Anaphor Type x Semantic Detail	78.75	37.48	2.101	*

Table 3. Summary of statistical output for Experiment 1.

In addition, we also observed two significant two-way interactions – between Anaphor Type and Probe Name, and between Probe Name and Test Point – as well as a three-way interaction among these factors (Anaphor Type, Probe Name, and Test Point). Although these interactions (and their directions) are identical to those reported in Gernsbacher (1989), we also observed a reliable four-way interaction of Semantic Detail, Probe Name, Anaphor Type, and Test Point. In the following, we first consider reaction times to probes of antecedent names, and then consider responses to probes of non-antecedent names.

When the Probe Name was the antecedent, we observed no effect of, nor interactions with, Semantic Detail (all t s < 1). Rather, for antecedent probes, we observed an interaction of Anaphor Type and Test Point ($t = 7.77$), in which reaction times were faster after the repeated names than before ($t = -11.32$), but did not differ before and after pronouns ($t < 1$). These results replicate the pattern of results reported by Gernsbacher (1989), and is depicted in Figure 1a.

Figure 1a. Probe verification latencies (ms) in semantically empty conditions in Experiment 1.

When the Probe Name was the non-antecedent, the basis for the significant four-way interaction becomes evident: here, we observed a significant interaction of Anaphor Type, Test Point, and Semantic Detail ($t = 2.23$). When the anaphors were pronouns, we observed no difference in probe verification latencies, either as a function of probe position or semantic content ($t_s < 1$). When the anaphors were repeated names, reaction times were slower after the anaphor names than before ($t = 5.91$). These two effects once again replicate the pattern of results reported by Gernsbacher (1989), as shown in Figure 1b.

Figure 1b. Probe verification latencies (ms) in semantically rich conditions in Experiment 1.

Although Semantic Detail had no effect on reaction times before the repeated names ($t < 1$), it did have an effect when the probe appeared after the repeated name ($t = -2.47$). Responses to non-antecedent probe names (e.g., *John*) were 32 ms slower when *John* was *John Travolta* rather than *John Jones*. This effect is depicted in Figure 2.

Figure 2. Reaction times (ms) to non-antecedent probes following repeated names in Experiment 1.

Discussion

We entertained three hypotheses about the potential effect of background semantic information about discourse referents on coreferential processing. The first – that reaction times would be insensitive to the additional semantic detail – is not supported by our data. Our results also do not support the second hypothesis, which was that both semantically rich characters, by virtue of increased discourse focus, would be more activated in memory, eliciting broadly

facilitated reaction times. Rather, the results of Experiment 1 are generally in line with the third hypothesis, derived from SMF theory, that increasing discourse focus would permit better differentiation of antecedent and non-antecedent entities. Specifically, we found that semantic elaboration increased the relative availability of an antecedent by reducing the activation of a competing non-antecedent entity. We consider our results in detail below.

The first thing that is apparent from this study is that entities represented with greater semantic detail did not have higher baseline activation than empty, unfamiliar entities. We observed no differences in probe verification latencies prior to the anaphors, suggesting that the characters in each sentence were similarly activated at the onset of the second clause. Thus, despite semantic differences that could have differentially strengthened candidate antecedents' memory representations via increased attention and/or processing effort during encoding, we found no evidence that the character representations differed in overall strength. Rather, processing differences emerged only after a referring expression initiated contact with the candidate antecedent representation. This is consistent with SMF theory, which states that focus may not directly affect the baseline availability of a discourse referent itself, instead facilitating processing by modulating the availability of associated information (Sanford & Garrod, 2005). For example, Birch & Garnsey (1995) observed priming in naming latencies when a target word (e.g., *farmer*) had been previously focused in a sentence, but no priming for semantically related words (e.g., *gardener*). They suggested that this was a direct result of the semantic detail of the representation, with high-detail representations inhibiting irrelevant or unwanted associates (see also Dagenbach, Carr, & Barnhardt, 1990).

It is also apparent that semantic elaboration affected processing only after encountering an unambiguous referring expression. As in previous studies, repeated name anaphors triggered

faster reaction times to antecedent probes, and slower reaction times to probes of non-antecedent names. Further, our results show that reaction times to probes of non-antecedent names elicited greater slowing when the discourse referents were semantically rich. In contrast, semantic elaboration did not affect processing immediately after encountering a pronoun. Reaction times to post-pronoun probes were statistically indistinguishable across conditions, and were also not significantly different from pre-anaphor reaction times. Because the additional detail in the semantically rich conditions does not disambiguate the pronouns' antecedents, we suggested that it might not have any immediate effect on referential availability. This pattern of results is consistent with previous findings that ambiguous pronouns only modulated their antecedents' availability after disambiguating information is encountered (Gernsbacher, 1989; Greene, McKoon, & Ratcliff, 1992; MacDonald & MacWhinney, 1990; McDonald & MacWhinney, 1995; see also Foraker & McElree, 2007; Stevenson & Vitkovich, 1986).

SMF theory suggests that semantic elaboration permits comprehenders to more easily discriminate between entities in discourse. This interpretation receives supports from two aspects of our data. First, the effect of semantic elaboration was not due to inherent differences in representational distinctiveness or strength; thus, it is clearly attributable to the processing of the anaphoric expression. Second, the effect depended on the type of anaphor that initiated antecedent retrieval, with an antecedent's relative availability increasing immediately after repeated name anaphors, but not after ambiguous pronouns. This suggests, in line with previous research, that modulating an antecedent's availability depends not just on feature matching – after all, both candidate antecedents matched the gender cues of the ambiguous pronouns – but on the ability to unambiguously identify an anaphor's referent.

Although levels of activation may be informative about the probability of successfully identifying an anaphor's antecedent, they do not directly assess the instantiation of a coreferential dependency. Long & Lea (2005) argue that activation does not itself inevitably result in integration, pointing out that some studies of coherence-related processes clearly show that (re)activated information is *not* subsequently incorporated into readers' mental representations. For example, some readers activate predictive inferences during processing, but these inferences are not always included in the discourse model (Cook, Limber & O'Brien, 2001; see also Cook et al., 2014). Long and Chong (2001) reported evidence that all readers in their experiments activated information relevant for maintaining global coherence, but some failed to use this activated, available information during the ensuing integration process. Finally, Johns and colleagues showed that being more available in memory does not necessarily correspond to facilitated processing, with repeated names resulting in problematic coreferential processing despite increasing the availability of prominent antecedents (Johns, Gordon, Long, & Swaab, 2014). Therefore, in our next experiment, we examined the effect of increased semantic detail on coreference in the context of two phenomena that associate antecedents' salience in a discourse with the resolution of coreferential relations.

EXPERIMENT 2

In this experiment, we examined whether discourse focus effects derived from semantic elaboration are comparable to well-established effects of structural prominence on anaphor resolution (for review see Garnham, 2001). There are many ways by which an entity can become focused in a discourse representation, including structural, semantic, and discourse-based devices. In both this and the previous experiment, there are several reasons to expect that the

first-mentioned characters were focused in our participants' mental representations. For example, Gernsbacher has shown that first-mentioned characters enjoy a privileged place in comprehenders' memory representations (the "advantage of first mention"; Gernsbacher, 1989, 1990; Gernsbacher & Hargreaves, 1988; see also Givón, 1986). First-mentioned characters are often interpreted as sentential subjects, which typically confers processing advantages (Ferreira, 2003; Keenan, 1976; Kemmerer, 2012). In addition, a first-mentioned character is often interpreted as the sentential topic (Chafe, 1976; Fletcher, 1984; Lesgold, Roth, & Curtis, 1979; see also Grosz, Joshi, & Weinstein, 1995), which is known to facilitate coreference (Anderson, Garrod, & Sanford, 1983; Clifton & Ferreira, 1986; Lesgold et al., 1979; see also Arnold, 2010). Conversely, none of these factors amplify the discourse focus on the second-mentioned characters in a comprehender's mental model. That is, the second-mentioned characters are not typically subjects in the first clauses; there is no structural or semantic heuristic that might enhance their topicality; and there are no reported instances of an analogous "advantage of second mention."

The consequences of an antecedent's status in the discourse vary according to the type of anaphor that refers to them. There are many studies that provide evidence that repeated name anaphors, despite unambiguously identifying a previously mentioned discourse entity, may nonetheless elicit processing difficulty. This *repeated-name penalty* (Gordon, Grosz, & Gilliom, 1993) depends upon the prominence of the antecedent entity in the discourse representation. When an entity is in discourse focus (i.e., rendered more prominent/salient via syntax, semantics, prosodic cues, etc.), repeated names elicit impaired processing relative to pronouns, and to names referring to unfocused entities (Almor, 1999; Camblin, Ledoux, Gordon, Boudewyn, &

Swaab, 2007; Garrod et al., 1994; Gordon et al., 1993; Gordon & Searce, 1995; Johns et al., 2014; Ledoux, Camblin, Swaab, & Gordon, 2006; Swaab, Camblin, & Gordon, 2004).

Conversely, pronouns are generally processed more easily than repeated names, and are thought to most quickly establish coreference with previous text elements (Cloitre & Bever, 1988; Garrod et al., 1994; Gordon et al., 1993; Gordon & Hendrick, 1997). Indeed, pronouns are processed more easily than repeated names even when they are ambiguous and do not identify a unique referent (Gordon & Searce, 1995). As we previously discussed, there are many studies showing that readers may delay interpretation of ambiguous pronouns until disambiguating information is encountered (e.g., Gernsbacher, 1989; Greene, McKoon, & Ratcliff, 1992; MacDonald & MacWhinney, 1990; McDonald & MacWhinney, 1995; and our first experiment, among others). However, it is not the case that referential ambiguity necessarily delays the process of accessing a referential representation. Readers actively search for an antecedent as early as 180 ms after processing an anaphor (Van Berkum, Koornneef, Otten, & Nieuwland, 2007) and there is evidence that, under certain circumstances, readers may assign a "default" antecedent to an ambiguous pronoun prior to any disambiguating information (Gordon & Searce, 1995; see also Gordon, Hendrick, Ledoux, & Yang, 1999). The circumstances under which this occurs depend upon the prominence of the entities in the discourse, with focused entities preferred as default antecedents. Hence, when an ambiguous pronoun's antecedent turns out to be a non-prominent entity, a post-pronoun garden-path effect may result, reflecting the need to revise the initial interpretation of the pronoun.

Gordon and Hendrick incorporated findings such as these into a model of coreferential processing, Discourse Prominence Theory (DPT) (Gordon & Hendrick, 1998; see also Gordon, 1993; Gordon & Hendrick, 1997). According to DPT, pronouns and repeated names elicit

different antecedent retrieval processes, both sensitive to the cognitive status of candidate antecedent entities in the discourse. Pronouns and other reduced referring expressions that are, in a sense, lexically transparent (i.e., they take their meaning from the discourse context) are most felicitous for referring to antecedents that are prominent in the discourse. In contrast, names primarily function to introduce entities into a discourse (see, e.g., Almor et al., 2007); thus, repeated names are initially misinterpreted as establishing a new referent. They are subsequently reinterpreted as anaphoric expressions which, by virtue of their relatively rich semantic detail, are most felicitous for referring to antecedents that are not prominent in the discourse (Garrod et al., 1994; Gordon et al., 1993; Gordon & Searce, 1995; Johns et al., 2014; Sanford & Garrod, 1981, 1993, 1998; Swaab, Camblin, & Gordon, 2004). The repeated-name penalty is therefore a consequence of the need to resolve the initial disjoint reference, in which a new trace elicited by use of a coreferential proper name must be integrated with an existing discourse referent in memory (Almor & Nair, 2007; Huang, Hopfinger, & Gordon, 2014; Swaab et al., 2004).

SMF theory (Sanford & Garrod, 1981, 1998, 2005) is largely consistent with DPT with regard to the discourse function of different types of referring expression: relative to more semantically specific anaphors, pronouns are best used to refer to entities in discourse focus; in contrast, proper names are the primary vehicle for introducing discourse entities and, when coreferential, most felicitously take antecedents that are not in discourse focus (e.g., Garrod et al., 1994). Thus, the repeated-name penalty again arises from initial misinterpretation and subsequent repair processes. However, while DPT is almost exclusively concerned with structural determinants of discourse prominence – specifically, the salience of an antecedent in a discourse depends upon, on its first occurrence, its height in the sentence's syntactic structure – SMF theory is primarily concerned with semantic and pragmatic determinants of discourse

focus. Although SMF theory predicts that *semantic* focus will place an antecedent in a psychologically prominent cognitive state, DPT does not directly do so. Conversely, DPT predicts that ambiguous pronouns will be assigned a prominent default interpretation, whereas SMF theory does not do so directly. Rather, it states that pronouns initially "bond" with all entities in a local discourse that match their morphosyntactic features (i.e., number and gender cues); and, although this early bond contains no semantic detail, it forms the basis for subsequent resolution when disambiguating information is encountered, and may be dropped without penalty if the link proves erroneous.

Our first experiment provided evidence about the availability of antecedents by using a probe verification paradigm. In order to assess whether an antecedent's semantic richness affects online resolution and integration, participants read the same sentences as in the first experiment (except for one detail; see Materials) and answered the same comprehension questions in a self-paced reading paradigm. Based on previous studies, we expected that repeated name anaphors that referred to salient characters would elicit a processing penalty relative to pronouns. Thus, first-mentioned antecedents should always result in a repeated name penalty, whereas second-mentioned antecedents should only elicit a penalty when they are elaborated with additional semantic detail. This prediction is consistent with both DPT and SMF theory.

DPT also predicts that readers will identify the most salient entity in the mental model as the default antecedent for an ambiguous pronoun. Therefore, if the antecedent is the second-mentioned, semantically empty character, we may observe a post-pronoun garden-path effect when the initial link between the pronoun and the first-mentioned candidate antecedent proves to be incorrect. However, when both potential referents are focused – the first-mentioned character for myriad structural reasons, the second via semantic elaboration – readers may postpone a

coreferential interpretation. This prediction is consistent with previous work showing that garden-path effects that rely on structural cues (such as subject status, etc.) can be eliminated by contextual information (e.g., Crain & Steedman, 1985), and that ambiguous pronouns with two salient candidate antecedents are not automatically interpreted (e.g., Greene et al., 1992). Consequently, when discourse entities are semantically detailed, there should be no need to repair an initial, erroneous anaphoric commitment, and no corresponding post-pronoun garden-path effect. In contrast to DPT, SMF theory does not make predictions about differences in the way pronouns are processed based on either antecedent position or semantic quality. Rather, in sentences such as ours, ambiguous pronouns should bond with both candidate antecedents, and subsequent resolution will be unencumbered by the provisional early bond to the non-antecedent.

Method

Participants. Fifty-three undergraduates at the University of California, Davis, participated for course credit. All were native English speakers.

Materials. The materials were identical to Experiment 1 with one modification. We adjusted 31 of the 64 experimental sentences so that the conjunction connecting the two sentence clauses was always the word 'and'. Although 'and' was the most frequent connective in the original materials from Gernsbacher (1989), many experimental items used other connectives (e.g., 'but', 'then', 'while', or 'after') to link the two sentential clauses. We chose to standardize the connectives in our materials because connectives are known to influence coherence-building by communicating information about different types of relations between events (e.g., temporal, causal, etc.; Sanders & Noordman, 2000; Traxler, Bybee, & Pickering, 1997; van Silfhout, Evers-Vermeul, &

Sanders, 2014), with corresponding effects on coreference (Kehler & Rohde, 2013; Stevenson, Knott, Oberlander, & McDonald, 2000). We chose the connective 'and' because it is non-specific about event relations (Knott & Sanders, 1998; Koornneef & Sanders, 2013), and neutral with regard to establishing coherence (Cain & Nash, 2011).

Four counterbalanced material sets were created, in the same manner as in Experiment 1. In the first list, an equal number of the 64 experimental sentences were pseudo-randomly assigned to one of four conditions (repeated name/semantically empty, pronoun/semantically empty, repeated name/semantically rich, pronoun/semantically rich). Each item rotated through the remaining conditions such that each appeared only once per list, in a different condition in each list. All lists also contained the same 48 filler items as in Experiment 1.

Procedure. As in Experiment 1, participants received both verbal and written instructions and a short set of practice trials to familiarize them with the task, after which they confirmed that they understood the task and began the experiment.

All stimuli were presented using a non-cumulative word-by-word self-paced reading paradigm. Stimuli were presented using the Slider moving window program (written by Don Donaldson, Senior Computer Research Specialist, Florida State University, Department of Psychology). For each trial, participants viewed two separate screens. The first was an introduction screen identical to Experiment 1, which identified the two sentence characters as semantically empty (i.e., fictional) or semantically rich (i.e., famous). This screen remained until participants pressed a button on the keyboard to proceed to the second screen. The second screen in each trial contained a sentence (either experimental or filler). All words in the sentence were replaced with dashes on the screen, but spaces and punctuation were visible. Participants read by

pressing one of the response buttons, which revealed the sentences one word at a time. After the first word, each button press also caused the previously visible word to revert to a series of dashes.

After reading each experimental sentence (i.e., pressing a response button after reading the last word), the sentence was replaced by a comprehension question. If an experimental item had not been changed, the comprehension question was the same as in Experiment 1. If an experimental item had been adjusted, the comprehension question was also adjusted, according to the parameters described in Experiment 1. Comprehension questions were presented as in Experiment 1. After participants answered the comprehension question, the prompt "Press for next" appeared on the screen. Participants started the next trial by pressing one of the response buttons.

Results

We defined four regions of interest: the First Name region, the Second Name region, the Anaphor region, and the Spillover region (see Table 1). The First Name region was the first-mentioned character in the sentence. Likewise, the Second Name region was the second-mentioned character. The Anaphor region was the repeated name or pronoun in each sentence. The Spillover region was comprised of the five words, from immediately after the anaphor to the end of each sentence.

Participant inclusion criteria, data preparation, and statistical analyses were identical to Experiment 1. For the First and Second Name regions, mixed-effects modeling assessed fixed effects of Semantic Detail (empty vs. rich) because the First and Second Name regions are identical across the Anaphor Type and Antecedent Position conditions. For the Anaphor region

and the Spillover region, mixed-effects models included fixed effects of Anaphor Type, Antecedent Position, and Semantic Detail, as well as their interactions. Outliers comprised 5.4% of the data and were excluded from all analyses. As before, we report the t -values associated with our analyses. Tables 4 and 5 present average reading times by region and summaries of statistical effects, respectively.

EMPTY REFERENCE

Antecedent	Anaphor	First Name	Second Name	Anaphor	Spillover
NP1	Repeated Name	411	416	382	2121
NP1	Pronoun	405	407	357	2047
NP2	Repeated Name	393	400	364	2027
NP2	Pronoun	405	407	360	2115

RICH REFERENCE

Antecedent	Anaphor	First Name	Second Name	Anaphor	Spillover
NP1	Repeated Name	379	384	372	1999
NP1	Pronoun	368	384	352	2059
NP2	Repeated Name	387	402	390	2079
NP2	Pronoun	375	379	349	2099

Table 4. Mean reading times (ms) for critical regions in Experiment 2.

		β Estimate	S.E.	<i>t</i> -value	
First Name	(Intercept)	392.67	10.48	37.49	*
	Semantic Detail	28.99	3.50	8.27	*
Second Name	(Intercept)	401.04	15.03	26.69	*
	Semantic Detail	18.37	4.38	4.20	*
Anaphor Region	(Intercept)	368.17	12.73	28.93	*
	Anaphor Type	-21.81	3.75	-5.82	*
	Antecedent Position	0.79	6.98	0.11	
	Semantic Detail	0.07	3.76	0.02	
	Anaphor Type x Antecedent Position	-1.56	7.50	-0.21	
	Anaphor Type x Semantic Detail	11.91	7.52	1.58	
	Antecedent Position x Semantic Detail	-11.68	7.53	-1.55	
	Anaphor Type x Antecedent Position x Semantic Detail	34.42	15.04	2.29	*
Spillover Region	(Intercept)	2079.06	68.15	30.51	*
	Anaphor Type	32.18	18.31	1.76	
	Antecedent Position	23.91	36.13	0.66	
	Semantic Detail	21.23	18.38	1.16	
	Anaphor Type x Antecedent Position	76.56	36.61	2.09	*
	Anaphor Type x Semantic Detail	-25.43	36.73	-0.69	
	Antecedent Position x Semantic Detail	-63.85	36.76	-1.74	
	Anaphor Type x Antecedent Position x Semantic Detail	194.15	73.48	2.64	*

Table 5. Summary of statistical output for Experiment 2

First and Second Name Regions. Names of semantically detailed, famous entities were read significantly more quickly than were names of semantically empty entities. This was true for both first-mentioned characters (377 ms vs. 404 ms) and second-mentioned characters (387 ms vs. 407 ms). The main effect of Semantic Detail is shown in Figure 3.

Figure 3. Reading times (ms) for first- and second-mentioned antecedents in Experiment 2.

Anaphor Region. We observed a significant main effect of Anaphor Type, such that pronouns were read more quickly than repeated names (355 ms vs. 377 ms). However, the interaction was qualified by a significant three-way interaction of Anaphor Type x Antecedent Position x Semantic Detail (Figure 4). The basis of this interaction is the finding that Semantic Detail modulated the effect of Anaphor Type observed for both first- and second-mentioned antecedents ($t = -3.94$ and $t = -4.29$, respectively). Specifically, Semantic Detail did not modulate

the effect of Anaphor Type when the antecedent was the first-mentioned entity ($t < 1$), but interacted with Anaphor Type when the antecedent was the second-mentioned entity ($t = 2.76$).

In the semantically empty conditions, repeated name anaphors were read more slowly than pronouns when the antecedent was the first-mentioned entity ($t = -3.10$), but not when the antecedent was the second-mentioned entity, in which anaphor reading times were statistically similar ($t = -1.01$). In the semantically rich conditions, we again observed slower reading times for repeated names when they referred to the first-mentioned entity ($t = -2.49$). However, in contrast to the semantically empty conditions, we also observed this pattern when the antecedent was the second-mentioned entity ($t = -5.18$). Thus, when an antecedent was highlighted, either structurally or semantically, we observed a repeated-name penalty.

This pattern appears to be driven by the way in which semantic elaboration differentially affected the prominence of first- and second-mentioned antecedents. First-mentioned antecedents were always prominent regardless of the amount of semantic detail in their representations ($t = 1.14$). However, the addition of semantic details brought second-mentioned antecedents into heightened discourse focus, such that repeated names referring to semantically rich entities were read more slowly than when they referred to semantically empty characters ($t = -2.78$). Finally, anaphor reading times for pronouns were statistically similar across all conditions (all $ts < 1.50$).

Figure 4. Reading times (ms) for the Anaphor Region in Experiment 2.

Spillover Region. There were no significant main effects in this region. We observed two significant interactions. One was between Anaphor Type and Antecedent Position. This interaction was qualified by the significant three-way interaction involving Anaphor Type, Antecedent Position, and Semantic Detail. The interaction is shown in Figure 5. The basis of the interaction is the finding that, for semantically empty characters, Anaphor Type interacted with Antecedent Position ($t = 3.34$), but for semantically rich characters, there was no such interaction ($t < 1$).

Figure 5. Reading times (ms) for the Spillover Region in Experiment 2.

In the semantically empty conditions, reading times were slower after a repeated name than after a pronoun when the antecedent was the first-mentioned character ($t = -1.923$, $p = .0548$). In contrast, we observed the reverse when the antecedent was the second-mentioned character: reading times were slower after pronouns than after repeated names ($t = 2.973$). Thus, using a repeated name seemed to facilitate rather than impair subsequent processing relative to a

pronominal anaphor when the referent was not focused. In addition, reading times were also slower after a repeated name that referred to the first-mentioned character than after a repeated name that referred to the second-mentioned character, ($t = -1.97, p = .0503$). In contrast, we observed no such differences in the semantically rich conditions, in which reading times in the spillover region were statistically similar regardless of Antecedent Position or Anaphor Type (all $ts < 1.60$). We also observed that reading times following a repeated name with a semantically detailed antecedent were significantly faster than in the corresponding semantically empty condition only when the antecedent was the first-mentioned character ($t = 3.14$; $t = -1.53$ when the antecedent was the second-mentioned character). Finally, spillover reading times following pronouns were statistically similar across all conditions (all $ts < 1.50$).

Discussion

The results of this experiment confirm that increasing the level of semantic detail about potential referents increases their psychological prominence in the discourse representation. Furthermore, our results are consistent with previous evidence that anaphor resolution is sensitive to a referent's discourse prominence. In this experiment, the semantic richness of the antecedent modulated the repeated-name penalty, in which a repeated name anaphor is processed more slowly than a pronoun when the antecedent is prominent. However, we observed no evidence – regardless of semantic elaboration – for a post-pronoun garden-path effect, whereby an ambiguous pronoun is initially interpreted as referring to a prominent antecedent. We discuss the implications of these results below.

First, we briefly consider reading times for the First Name and Second Name regions. We were interested in these regions because previous research has shown that the effects of discourse

focus on encoding processes are inconsistent. There is evidence that focusing a discourse constituent can result in slower, more effortful processing at encoding (e.g., Hofmeister, 2011; see also Albrecht & O'Brien, 1998; McKoon, Ward, Ratcliff, & Sproat, 1993); faster, more efficient encoding processes (e.g., Birch & Rayner, 2010); or no processing differences during encoding at all (e.g., Ward & Sturt, 2007). In this experiment, names in the first clauses of our experimental sentences that referred to semantically detailed entities were read more quickly than those of semantically impoverished entities. Although this suggests that our semantic manipulation facilitated encoding processes, there is a significant caveat to this interpretation. In our experiments, we instantiated differences in the semantic richness of our participants' discourse representations by first having them read a screen identifying the characters. Because of this, the proper names in the sentences' first clauses are actually repeated references to mental representations activated prior to construction of a discourse representation. We believe that the introductory screen probably elicited a relatively list-like representation of the sentence characters: characters were identified, but were not presented in a narrative context *per se*. Thus, we speculate that facilitation in the first clause regions may be a recognition memory priming effect. However, our first experiment suggests that this effect was short-lived, as all sentence characters were equally activated prior to encountering the anaphor, regardless of semantic detail. This contrasts with the coreferential processes executed during the second clause, in which referential relations between the anaphors and antecedent representations in a discourse representation must be established.

We turn now to the findings in the Anaphor and Spillover regions. In our semantically empty conditions, only the first-mentioned character was in focus, by virtue of several factors (e.g., first-mention, subjecthood, etc.). When repeated name anaphors referred to the first-

mentioned character, we observed a repeated-name penalty. The penalty was immediately apparent on reading the repeated name and continued into the spillover region. When a repeated name referred to the second-mentioned character, we observed no processing difficulty at the anaphor: repeated names were read just as quickly as pronouns. Furthermore, in this condition, reading times in the spillover region were faster than those following a pronoun. This suggests that using a repeated name to refer to a non-prominent character can facilitate processing, as it can be interpreted as an explicit signal to shift focus away from the first-mentioned entity (Fletcher, 1984; Gordon & Chan, 1995; Vonk, Hustinx, & Simons, 1992). Finally, we consider the spillover reading times for pronouns with first- and second-mentioned antecedents, in which we expected a post-pronoun garden path effect. Although participants read the spillover region more slowly when it disambiguated to the second-mentioned antecedent rather than the first, the effect was not statistically significant ($t = 1.49, p = .14$). Given this, we suggest that our participants did *not* assign a default referent to the ambiguous pronoun, and that the slower pronoun spillover reading times relative to repeated names when the referent was the second-mentioned character reflect the ongoing search for an antecedent.

Our pattern of results replicates previous observations of the repeated-name penalty. For example, Gordon and Searce (1995) had participants read short containing two same-gender characters and either repeated name or ambiguous pronoun anaphors. They reported an earlier repeated-name penalty when the antecedent was the first-mentioned character, and no penalty when the antecedent was the second-mentioned character (Experiment 2). Gordon and Searce also noted that their results were unlikely to be explained by basic differences between names and pronouns (e.g., length), citing the persistence of the repeated-name penalty in post-anaphor regions. This was also observed in our results, with the addition that repeated names were read

more quickly than pronouns with second-mentioned antecedents (i.e., despite differences in length). Thus, the current experiment provides additional evidence that the repeated-name penalty derives from the nature of antecedent representations in the discourse model, rather than from superficial differences between names and pronouns (see also Gordon & Chan, 1995; Gordon et al., 1993).

One difference between our findings and those of Gordon and Searce (1995) is that they observed differential processing of pronominal relations based on discourse prominence whereas, in our analogous condition with semantically empty discourse referents, we did not. This could stem from differences in the materials. Gordon and colleagues used multi-sentence passages in which an intervening sentence reinstated both discourse referents via pronominal anaphor prior to their critical sentences. This additional reference (and its attendant resolution of the reference relation) could have reinforced the relative prominence status of the characters in their passages, promoting a preference for the structurally favored entity. In the single sentences in our experiment, however, there was no structural, semantic, or other manner in which either potential referent could be reiterated/reinstated prior to encountering the pronouns.

In contrast to the semantically empty conditions, second-mentioned characters were more focused in the semantically rich conditions. Evidence for this claim derives from three complementary findings. First, repeated name anaphors elicited a processing penalty relative to pronouns regardless of antecedent position; we observed a repeated-name penalty with both first- and second-mentioned antecedents. Second, unlike the empty conditions, repeated names in the semantically rich conditions were read similarly regardless of antecedent position. Third, repeated name anaphors referring to second-mentioned characters were read more slowly than those referring to the corresponding semantically empty characters, who were not focused or

otherwise highlighted in the discourse. (The latter finding provides additional evidence that differences between name and pronoun length were not responsible for the observed effects: second-mentioned names were identical across conditions, differing only in semantic richness.) Finally, the pattern of effects in the spillover region also differed from that in the semantically empty conditions, in that there was no evidence that the early repeated-name penalties continued to cause processing difficulty. This suggests that the additional semantic information about the sentence characters facilitated recovery from the earlier repeated-name penalties – a finding we consider in more detail in the General Discussion.

We initially predicted that our participants would not adopt a "default" interpretation of the ambiguous pronouns when both candidate antecedents were focused in the discourse representation. The absence of a post-pronoun garden path effect might therefore provide indirect support for this prediction (see also Greene et al., 1992). However, there are two reasons to be cautious about this interpretation. First, we also observed no such garden-path effect in our semantically empty conditions, suggesting that the pronouns may not have been immediately interpreted regardless of semantic detail. Second, unlike the semantically empty conditions, there was no spillover RT advantage for using a repeated name (rather than a pronoun) when the antecedent was a second-mentioned character. This difference supports an account in which our ambiguous pronouns did not adopt "default" antecedents, regardless of the candidate antecedents' semantic detail. In addition, it suggests that when both sentence characters were prominent, there was less need for an explicit signal to signal a topic shift (i.e., from the first- to the second-mentioned character).

Finally, these results are consistent with SMF theory's account of semantic influence on discourse prominence, both for repeated names and pronouns. DPT, on the other hand, does not

directly predict these results; it specifies only structural bases of discourse prominence, and does not discuss semantic influences on an antecedent's cognitive status. Although DPT is agnostic about non-syntactic focusing devices (Gordon, personal communication; see also Johns et al., 2014), it acknowledges that discourse focus may be determined by semantic factors (Ledoux, Gordon, Camblin, & Swaab, 2007). Thus, to the extent that phenomena such as the repeated-name penalty are associated with discourse focus regardless of its provenance, our repeated name results are also consistent with the spirit, if not the text, of DPT. However, SMF theory more explicitly and directly accounts for the pattern of reading times in the pronoun conditions.

General Discussion

The goal of this research was to determine whether semantic information about discourse entities would affect anaphor processing. We were interested in this issue because of evidence from a variety of sources indicating that semantic details of this kind have consequences for the representation of information in memory (e.g., Burgess & Conley, 1999; Sanford & Garrod, 2005) and the cognitive status of information in a discourse model (Sanford & Garrod, 1981, 1998, 2005). The issue is particularly interesting in light of evidence that such information is applied to online sentence processing in parallel with other sources of local information (e.g., Hagoort et al., 2004), and previous research suggesting that discourse focus based on semantic elaboration can facilitate coreference (Albrecht & Myers, 1995, 1998; Klin et al., 2014).

Consistent with SMF theory (Sanford & Garrod, 1981, 1998, 2005), semantically rich non-antecedents were less activated than semantically empty non-antecedents following an explicit, repeated name anaphor, supporting our hypothesis that semantic detail improves the availability of antecedent entities in memory. SMF theory suggests that the additional semantic

information about potential discourse referents made it easier to discriminate between them, possibly by inhibiting competing non-antecedent entities more strongly. This interpretation is supported by evidence that the additional semantic information did not result in stronger memory traces overall; and that the effect depended on the use of a repeated name anaphor, which permitted the immediate exclusion of the non-antecedent from consideration. Also consistent with SMF theory, we found that referring to an antecedent that was focused in the discourse – either by structural factors, semantic elaboration, or both – with a repeated name anaphor resulted in a processing penalty, reflecting difficulty in establishing an anaphoric relation to the antecedent representation.

Although our results support the hypothesis that semantic elaboration places an antecedent entity into a prominent (focused or salient), "cognitive state", it is important to note that this state was reliably elicited only when the referring expression was an explicit, unambiguous anaphor – a repeated name. When the referring expression was a pronoun, we observed no effects of semantic detail, either at the pronoun itself or, in our second experiment, when it was disambiguated. These results are consistent with previous studies of repeated name anaphors that examined both antecedent availability and effects related to referential integration (e.g., Johns et al., 2014). They are also in line with some studies of ambiguous pronouns indicating that such anaphors do not modulate the availability of discourse referents (e.g., Greene et al., 1992), especially immediately after the anaphor (e.g., Gernsbacher, 1989, *inter alia*). However, our pronoun results are not completely consistent with previous research, given some studies that have directly manipulated the discourse prominence of antecedent representations in memory. As before, we suggest that this inconsistency could be the result of differences in the

experimental materials, such as the use of sentence pairs or discourse passages (e.g., Foraker & McElree, 2007; Gordon & Searce, 1995).

Overall, our results support the view that readers' knowledge about candidate antecedents can play an important role in the identification of an antecedent in the discourse model, its availability in memory, and the eventual success of coreferential processing. These findings have important implications for models of both coreference and text processing, which must be able to account for the representational and processing implications of differences in the semantic richness of discourse information. Specifically, models of text processing uniformly assume that comprehenders quickly and easily populate their mental models with discourse entities. Semantic details about discourse entities are retrieved from both discourse memory and a comprehender's world knowledge automatically, autonomously, and regardless of their relevance to comprehension of the immediate text input (for review see McNamara & Magliano, 2009; see also McKoon & Ratcliff, 1998). However, even in the subset of models that assign critical importance to referential coherence, the details of how individual entities are represented are commonly underspecified, and whether such details may affect coreferential processing is unaddressed. Only SMF theory (Sanford & Garrod, 1981, 1998, 2005; see also Garrod & Sanford, 1990; Sanford & Emmott, 2013) offers a detailed account of the semantic specification of discourse entities and how the granularity of referential representations corresponds to cognitive status in a discourse model. SMF theory proposes that additional semantic detail translates into more fine-grained, detailed representations without additional effort during encoding, and that this detail elicits discourse focus effects during subsequent processing. Discourse focus is one of the principal mechanisms for managing coherence relations in SMF theory (Sanford & Garrod, 1998; see also Sanford & Garrod, 1981). SMF theory states that focus

may not simply produce a more primed, available element in the discourse representation; rather, it suggests that a focused element may instead reduce the availability of other, competing information. Furthermore, it predicts that increased focus may reduce the accessibility of a discourse referent when the anaphor is a repeated name, because repeated names permit access to focused representations only after alternative interpretations prove to be incorrect. Finally, SMF theory suggests that pronouns will initially bond with all matching candidate antecedents, irrespective of structural information (e.g., first-mention) or semantic detail, resulting in similar processing across conditions. Thus, our experiments support SMF theory's predictions for effects of semantic elaboration on memory availability and referential access, for both repeated names and pronominal anaphors.

The importance of discourse focus is also incorporated, either explicitly or implicitly, in many other accounts of text processing. For example, discourse focus "falls right out of [the] basic architecture" of the Construction-Integration model (Kintsch, 1998, p. 156). Nevertheless, unlike SMF theory, these models make predictions that do not fit well with our results. For example, the Resonance model (Myers & O'Brien, 1998; see also Myers et al., 1994) predicts an overall priming benefit for elaborated representations, resulting in greater priming for both antecedent and non-antecedent entities (e.g., O'Brien et al., 1993). This is because it supposes that semantic elaboration prompts relatively greater attention and effort at encoding, which results in qualitatively stronger memory traces that prime related nodes in the discourse model (e.g., Albrecht & O'Brien, 1998; see also Kintsch, 1998; Ratcliff & McKoon, 1978; McKoon & Ratcliff, 1998). That is, the model The Construction-Integration model (Kintsch, 1988, 1998) similarly predicts potentially greater antecedent priming, and either no reaction time difference to non-antecedent targets (i.e., non-antecedent activation, if not enhanced by detail, may not be

suppressed below some pre-anaphor baseline; Kintsch, 1998) or a performance decrement contingent on increased antecedent priming (e.g., McNamara & McDaniel, 2004). The Structure Building Framework (Gernsbacher, 1990) makes no accommodation for this kind of information at all. Thus, these models offer no clear explanation for the observed effects on antecedent availability. Finally, none of these models readily accommodates the repeated-name penalty, because they uniformly hold that the complete semantic overlap of the repeated name should make it a very efficient, effective retrieval cue, which should facilitate coreference.

The repeated-name penalty is, however, predicted by several models of coreference, including DPT (Gordon & Hendrick, 1998), the Informational Load Hypothesis (ILH) (Almor, 1999; Almor & Nair, 2007), and the JANUS model of coreference (Garnham & Cowles, 2008). Although DPT does not explicitly predict (or rule out) the effects that we report (see our discussion of Experiment 2), neither the ILH nor the JANUS model are able to accommodate them. This is because both the ILH and JANUS models state that a repeated name will be felicitous when it avoids the kind of referential ambiguity that would result if multiple referents match the morphological features of a pronominal anaphor. That is, when the alternative is referential ambiguity, both models predict that a repeated name will not cause processing problems because it fulfills the function of uniquely identifying its antecedent. Therefore, both models predict that, with materials such as those used in our experiments (and others, e.g., Gordon & Searce, 1995), there should be no repeated-name penalties, irrespective of the semantic detail of the discourse referents.

Finally, one aspect of our results is suggestive about the ultimate success of the coreferential process. Although we observed processing problems in the spillover region, this was only evident in the absence of semantic detail about the sentence characters. We suggested

that the additional semantic information permitted rapid recovery from both the repeated-name penalty and the early default interpretation of the pronoun. This interpretation is consistent with a number of recent findings. For example, Johns and colleagues reported that violation effects associated with referentially failing pronouns (i.e., a P600 effect when the pronoun 'she' followed the introduction of stereotypically male characters such as 'Bill' and 'John') persisted until the end of the sentence, where they observed an N400 effect on the sentence-final word. However, this only occurred when Bill and John were semantically empty. When the discourse referents were semantically rich, there was no evidence of processing difficulty on the sentence-final word (Johns, Long, & Swaab, 2010). Similarly, Filik and Leuthold (2013) reported that readers recovered rapidly from processing difficulty following a character-inconsistent action – but only when the critical character was a semantically rich, entity (e.g., the Incredible Hulk or Scooby Doo versus an empty proper name, such as Terry).

The research described in this article provides further support for accounts of coreferential processing that suggest that the cognitive status of discourse entities has implications both for the probability of retrieving an anaphor's antecedent and for the ultimate success of resolution and integration processes. Previous studies of anaphor processing have provided a wealth of information about the factors that constrain the instantiation of a coreferential dependency, including many syntactic, semantic, and discourse-based factors (see Garnham, 2001). Our results suggest that the semantic detail of the representations in a discourse model is one such factor. In addition, our results further suggest that a discourse model comprised of semantically detailed, "rich" representations may be more adaptable and flexible in the face of processing difficulty than one composed of less flexible, low-dimensional representations. Especially in light of recent research exploring individual differences in the

impact of representational detail on online processing and comprehension (e.g., Hamilton, Freed, & Long, 2013; Van Dyke, Johns, & Kukona, 2014; see also Johns, Matsuki, & Van Dyke, 2015), the present study has significant implications for the development of comprehensive models of coreferential processing and discourse comprehension.

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