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Junior/Senior Honors Thesis
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Semantic Relatedness and Its Effect on the Timing of Language Production

Abstract

Introduction

Language Production Models

The ultimate goal of language production is to generate an utterance to be understood by a conversational partner. Speakers must conceptualize abstract, non-linguistic, non-temporal thoughts, organize grammatical and linguistic knowledge into language-specific patterns, and articulate the formulated message in a comprehendible way. Although speakers carry out this task with relative ease, sentence production is a complex process governed by various grammatical constraints and cognitive resource limitations.

Models of sentence production attempt to explain the processes involved in converting nonlinguistic thoughts into spoken language. It is largely accepted that models of language production include message, grammatical, and phonological components (Bock 1995; Griffin & Ferreira, 2006; Bock & Levelt, 1994; Dell, 1986; Gillespie, Pearlmutter, & Shattuck-Hufnagel, 2012). Bock and Levelt (1994) introduced a language production model with an initial message-level component, in which speakers generate an abstract, prelinguistic representation of the intended message. The preconceived message proceeds to a grammatical encoding stage that incorporates morphological, grammatical, and semantic information while assigning constituents positions and syntactic roles. There is some disagreement ~~throughout~~ in the literature regarding the finer details of the grammatical encoding stage (e.g., Ferriera & Engelhardt, 2006; Griffin & Ferreira, 2006 – need these here?).

order alpha by auth, pers year

fine, I'd say

Are we going on to Piss?

Several researchers argue that this stage of language production, in which content words are accessed, is further divided into functional and positional levels. Lemmas selected during the functional level specify semantic information and grammatical function; lexemes selected in the positional level determine the content word's phonological characteristics (Bock & Levelt, 1994; Schriefers, Meyer, & Levelt, 1990; Bock, 1995). Others propose a single grammatical encoding stage that does not include separate lexeme and lemma selection processes; a conceptual message would **flow down only one level to affect syntactic role assignment and serial order position [reword]** (DiBattista & Pearlmutter, 2011; add more). Speech error studies have shown evidence favoring both single-stage models of grammatical encoding and two-stage models (cf. Schriefers, Meyer, & Levelt, 1990; DiBattista & Pearlmutter, 2011).

Researchers do widely agree that the grammatical component precedes a phonological processing stage, during which the phonological structure of the intended message is organized (Bock, 1995; Bock & Levelt, 1994). The speaker then uses articulatory processes to actually produce the utterance. Although speakers usually construct utterances effectively and efficiently, each stage of sentence production is affected by processing constraints, resource demands, and cognitive limitations. Errors in language production are studied extensively to identify points in production planning and execution processes in which speakers are subjected to the most trouble.

[Also argued in literature: influences of hierarchical relationships, clause-boundedness, and scope of planning on subject-verb agreement computation processes (See Gillespie & Pearlmutter, 2013, etc. for reviews on each of these)…]

[Description of scope of planning account (Gillespie & Pearlmutter 2011) needed?]

Language production errors

Language production research often focuses on speech errors, which are considered to be consequences, rather than failures, of the production system's productiveness and flexibility (Dell, 1986; add more?). Mistakes in spoken language are commonly believed to provide productive insight into underlying production planning mechanisms, perhaps more so than successful, errorless speech (cite?).

In order to produce a grammatical English sentence, a speaker needs to select, organize, and appropriately convey (among other things) syntactic and morphological information. For example, English predominately uses subject-verb-object word order and marks specific grammatical features with inflectional morphemes, such as *–s* indicating a plural noun. An utterance like *The boys were playing hockey* suggests that the speaker is talking about multiple people. The speaker must utilize conceptual-level representations (the idea of several boys playing hockey) and apply language-specific grammatical encoding rules (including a plural noun marker and appropriate verb inflection, as well as assigning elements the correct word positions) in order to produce a grammatical English sentence.

Sentence completion and picture description tasks are commonly-used experimental paradigms that allow researchers to examine whether speakers are able to produce sentences with appropriate grammatical inflections and correct serial word order in complex linguistic contexts. Agreement and exchange errors are both syntactic in nature and therefore arise in the grammatical encoding stage of language production planning, but they reflect different components of the system: agreement errors, marking of grammatical inflection, and exchange errors, serial word positioning. Recent research has investigated agreement and exchange errors resulting from manipulations of semantic integration. The next section first describes semantic

integration and then reports findings from studies in which integration influences language production error patterns.

Semantic Integration

Semantic integration, the degree to which pieces of an utterance (i.e., head and local noun) are conceptually related, focuses on the relationship between the head and local noun within a very particular context (Solomon and Pearlmutter, 2004; Penta & Pearlmutter, 2013). Solomon and Pearlmutter (2004) introduced the term *semantic integration* as they investigated the syntactic planning system in language production. The phrase *the ketchup or the mustard* is considered semantically unintegrated because, although *ketchup* and *mustard* are semantically related to each other (i.e., have similar meanings), the conjunction *or* allows no further relationship to be established between those nouns. On the other hand, *the bracelet made of silver* is a semantically integrated phrase, since *made of* signifies a very tight relationship between *bracelet* and *silver* (DiBattista & Pearlmutter, 2011).

Agreement Errors and Semantic Integration

A typical experimental paradigm, the subject-verb agreement error elicitation task, involves linguistic properties at both the message and grammatical levels, and can demonstrate how they interact during language production. Subject-verb agreement in English is grammatically inflexible in that nouns and verbs must match in number no matter how are apart they appear in the sentence (e.g., *The guys who stayed up all night playing high-stakes poker are*) (Bock & Miller, 1991); more intervening material between the subject and verb strains agreement computation processes [add refs].

In experiments investigating subject-verb agreement, sentence preambles are presented to participants, who are instructed to read or repeat the fragments and form sentence completions.

Preambles contain complex noun phrases that manipulate the plurality of the head and local (distractor) nouns (i.e., *The key(s) to the cabinet(s)…*) (Bock & Miller, 1991). The most widely observed trend in this research is one of unequal distribution of production errors: a head-local mismatch effect. Subject-verb agreement errors occur much more often in preambles with a singular head noun and plural distractor noun (i.e., *The key to the cabinets *were…*) than the other way around (i.e., *The keys to the cabinet *was…*) (Bock & Miller, 1991; Bock & Cutting, 1992; Bock & Eberhard, 1993; Eberhard, 1997; Barker, Nicol, & Garrett, 2001; Solomon & Pearlmutter, 2004). Experiments using pictorial rather than written or spoken stimuli have also shown the head-local mismatch effect (Gillespie & Pearlmutter, 2011b).

Solomon and Pearlmutter (2004) conducted the first research investigating influences of semantic integration on subject-verb agreement, hypothesizing that results would support either a serial-based or parallel-activation based system of language production planning. Five experiments utilized a subject-verb agreement error elicitation paradigm in the form of spoken sentence completion tasks. The degree of semantic integration was manipulated by using different prepositions in a NP PP structure, specifically, *of* in tightly integrated stimuli, and *with* in unintegrated stimuli. Head nouns were singular, while local nouns varied in plurality. Mismatch conditions, in which the plurality of each noun differed (i.e., *the drawing of/with the flowers*), were predicted to produce more subject-verb agreement errors.

Solomon and Pearlmutter (2004) hypothesized that a serial-based system would produce fewer agreement errors in highly integrated *of*-PP phrases; since memory-dependent processes are involved in serial planning systems, moving from a tightly linked NP to a PP would be relatively simple. Parallel-activation systems consider multiple representations simultaneously, hypothetically causing highly integrated phrases to be planned at the same time, or with

significant overlap, leading to more agreement errors. In other words, the simultaneity in timing of production planning causes the later noun and its plural marker to be active at the same time as the singular head noun, increasing errors in subject-verb agreement computation due to an influence of the local noun's plurality.

Experiments 1-4 showed clear and uniform affects of semantic integration on subject-verb agreement. More errors occurred in plural local noun conditions, as well as within tightly integrated phrases. Subject-verb agreement errors consistently occurred in those contexts, even after several experimental stimuli adjustments were made: altering the semantic relationship of the highly integrated preposition (Experiment 2); altering the argumenthood status of the PP (*of* was replaced with *for*; Experiment 3); creating preambles with the same preposition but semantically different PPs (*the pizza with the yummy toppings* versus *the pizza with the tasty beverages*; Experiment 4).

Solomon and Pearlmutter (2004) concluded that the degree of semantic integration within a phrase regularly forecasts the likelihood of subject-verb agreement errors, and semantic integration can affect the timing of planning of phrasal elements. Results support a parallel-activation based system of production planning that prepares pieces of tightly integrated phrases with significant overlap.

Exchange Errors and Semantic Integration

[Include info from Garrett (1975) and others as introduction to exchange errors/what they say about the production system]

Pearlmutter and Solomon (2007) conducted several experiments investigating the effect of semantic integration on ordering errors, predicting that highly integrated elements (those that are planned with simultaneity in a parallel-activation based production planning system) would increase the risk of ordering errors. One such error is the exchange error, in which two nouns [content words?] switch positional roles, such as *Although murder is a form of suicide* when the intended utterance is *Although suicide is a form of murder* (Garrett, 1975).

Participants were visually presented with and then described simple grayscale drawings of objects varying in semantic integration (i.e., integrated: an apple with a spot on it; unintegrated: a sink with a shelf above it). Higher rates of ordering errors were observed in integrated conditions in all experiments, supporting the hypothesis that closely planned elements cause more disruption in the grammatical encoding process, leading to more word order errors.

Although Pearlmutter and Solomon (2007) demonstrated a straightforward effect of semantic integration on ordering errors, it was unclear whether the exchange errors occurred at the phrase- or word-level. An error like *the apple on the spot* (intended: *the spot on the apple*) could involve the swapping of phrases, *the apple* and *the spot*, or swapping of single words, *apple* and *spot.* DiBattista and Pearlmutter (2010) used a nearly identical experimental design and procedure, but added color to the original Pearlmutter and Solomon (2007) stimuli. Visual presentation of a colored picture of, for example, a blue apple with a green spot on it, could elicit exchange errors of phrases (*the blue apple on the green spot*), nouns (*the green apple on the blue spot*), or adjectives (*the blue spot on the green apple*).

The DiBattista and Pearlmutter (2011) experimental design allowed distinctions to be made regarding whether integration affected entire phrases or individual lexical items, thus suggesting whether those affects occur at the functional and/or positional level of grammatical

encoding. Two experiments where participants completed picture-description tasks presented similar results: word errors were more likely when the picture showed highly integrated objects. Ninety-eight percent and 97% of error responses in Experiments 1 and 2, respectively, were exchange errors, supporting the **hypothesis [change word]** that highly integrated elements are activated with significant overlap during production planning processes (Solomon & Pearlmutter, 2007). Overall, results suggested that semantic integration influences at least the functional level of grammatical encoding (as shown by ~~word order errors involving lemmas),~~ and potentially into the positional level of language production (DiBattista & Pearlmutter, 2011).

Semantic integration has been shown to disrupt the production planning mechanism, resulting in subject-verb agreement errors (specifically, the head-local mismatch) and ordering errors (specifically, exchange errors). Agreement and exchange errors are both syntactic in nature and therefore arise in the grammatical encoding stage of language production planning, but they reflect different components of the system: agreement errors, marking of grammatical inflection, and exchange errors, serial word positioning.

[Consider putting new subsection title here]

Gillespie, Pearlmutter, and Shattuck-Hufnagel (2012) conducted the first studies that illustrated, using prosodic analyses, that words between highly integrated sentential elements were ~~produced more quickly than~~ words between unintegrated items. Prosody is able to reflect ongoing language planning processes; for example, the availability of sentential elements greatly influences prosodic boundaries, with more predictable words uttered more quickly than unpredictable ones (cite).

Two experiments used sentence completion tasks to investigate whether semantic integration influences timing of syntactic planning. Temporal durations of words in between

highly integrated elements were predicted to be shorter than those in unintegrated conditions. Stimuli in Experiment 2 were originally from Solomon & Pearlmutter (2004, Experiment 4), and included head NP PP local NP sentence preambles. Word durations were coded using ToBI and Praat software, and linear mixed-effect models that included speech rate, phonological environment, and accessibility/predictability control predictors were used to predict word duration measures.

Results from Experiment 2 showed effects of semantic integration on temporal separation of words. Words intervening between highly integrated elements were shorter in duration (i.e., said faster) than in unintegrated conditions. Semantic integration effects were only significant in word positions in between the head and local nouns, suggesting that effects are present when highly integrated elements are simultaneously activated in the production planning system.

Overall, results in Gillespie et al.'s Experiment 2 matched the predictions and results from Solomon & Pearlmutter (2004), providing further evidence for the influence of semantic integration on the timing of (syntactic) production planning.

Semantic Relatedness

Semantic relatedness concerns the connection of two words based on their meanings. Two words' meanings can be related to synonymity (i.e., *package–parcel, trash–garbage*), taxonomic category (i.e., *dog–cat, bread–cake*), part-whole relation (i.e., *button–shirt, page-book*), or contextual relation (*bread–butter, dog–bone)*, among other associations (e.g., Meyer & Schvaneveldt, 1971). Semantic relatedness differs from semantic integration in that the former considers two words in isolation, detached from any specific utterance, while the latter is dependent on linguistic context (Penta and Pearlmutter, 2013).

Priming paradigms are common experimental methods to examine effects of semantic relation on ~~language~~ production processes. Evidence has shown that semantic relatedness can impact word retrieval (Vigliocco, Lauer, Damian, & Levelt, 2002), syntactic organization, and sentence structure (Bock, 1986). Two studies to date have used sentence-completion tasks to analyze influences of semantic relatedness on agreement computation.

[Description of Barker et al. (2001) here]

Penta and Pearlmutter (2013) conducted two experiments that ~~independently~~ tinkered semantic integration and semantic relatedness in order to examine the relationship between them. Their Experiment 1 included a sentence-completion task in which local noun number, semantic relatedness, and semantic integration were all manipulated, creating a two by two by two design. Relatedness was manipulated by using head and local nouns that were either highly semantically related (i.e., the nouns had similar meanings) or semantically unrelated, and degree of semantic integration was determined by individual prepositions: integrated phrases linked head and local NPs with *for* or *with*, and unintegrated utterances, with *near* or *by*. Previous norming studies provided the baseline ratings for related/unrelated and integrated/unintegrated conditions (see Penta & Pearlmutter, 2013 for descriptions of integration, relatedness, and association norming procedures). Sentence preambles were of the form head NP PP local NP. Across conditions, all nouns, adjectives, and prepositions in the preambles were matched for frequency, length (in characters, phonemes, and syllables), plausibility, and animacy. An example of a trial set is seen in (1) below.

(1)

a. The necklace with the colorful diamond(s) (Related – Integrated)

b. The necklace near the colorful diamond(s) (Related – Unintegrated)

c. The necklace with the colorful feather(s) (Unrelated – Integrated)

d. The necklace near the colorful feather(s) (Unrelated – Unintegrated)

Stimuli were presented on a computer screen to subjects, who were asked to read aloud and complete each sentence as quickly as possible, although no strict time constraints were enforced. Subjects' agreement error rates were calculated and compared across the singular and plural local noun number conditions. The experimental procedure and scoring system were identical to that in Solomon and Pearlmutter (2004).

Participants produced more subject-verb agreement errors in conditions where the head noun was singular and local noun was plural, providing further evidence for the mismatch effect described earlier. There was no mismatch effect observed in integrated conditions, not replicating previous research (i.e., Solomon & Pearlmutter 2004). More agreement errors were seen in related than unrelated conditions, similar to results found by Barker et al. (2001).

An issue in experiments that manipulate semantic links between words is that defining semantic relationships is not straightforward (cite). Semantic relation is typically specified in terms of shared characteristics (i.e., words belonging to the same taxonomic category) or of the degree of association between two elements; words are considered associated if the presence of one increases the likelihood of observing the other (cite). Another issue in this line of research is that semantic relationships often overlap with associative relationships: *cat* and *dog* belong to the same taxonomic category, but the presence of one (*cat*) quickly activates the other (*dog*). Since both semantic relation and association influence and activate these nouns, and probably speed up production of the second-retrieved word (CITE), results may not be able to tell apart effects of

semantic overlap and effects of association; this type of problem occurs in priming studies in particular (CITE).

[Description of Penta & Pearlmutter Exp. 2 needed?] — Nope — can mention Exp 2 tried to tease apart rel'n and assoc. — but beyond scope of your thesis

Experiment

Past studies involving subject-verb agreement errors (Gillespie & Pearlmutter, 2011; Solomon and Pearlmutter, 2004), phrase and word exchange error rates (DiBattista & Pearlmutter, 2011), and ordering errors (Solomon, 2004; Pearlmutter & Solomon, 2007) demonstrated that highly integrated elements caused more difficulties in language production planning than did unintegrated elements. Research has also shown the influence of semantic integration on the timeline of production planning (Gillespie et al., 2012; add more).

The current experiment investigates how the degree of language production planning overlap and changes in the timing of planning are affected by semantic integration and semantic relatedness, separately or in conjunction with each other. If semantic relatedness influences word durations similarly to semantic integration, intervening material in semantically related utterances will be shorter in duration compared to words in semantically unrelated utterances (Gillespie et al., 2012). The magnitude of the potential interaction between integration and relatedness is unknown~~, and therefore may be subadditive or superadditive~~.

Method [need separate Participants/Materials section?]

Data in the current experiment were gathered by analyzing the original recordings of Penta and Pearlmutter (2013), using different measures, specifically, word duration measures [reword]. Thirty-two of the most fluent participants from Penta & Pearlmutter (Experiment 1),