

## PHONOLOGICAL PRIMING IN APRAXIA OF SPEECH AND APHASIA

The purpose this study was to elucidate speech planning impairments in aphasia and apraxia of speech (AOS), with a focus on planning of the sound structure of speech, using an on-line task that taps into the speech planning process (preparation priming; Meyer, 1990). We developed and tested two hypotheses: (1) AOS affects the retrieval of *metrical frame information*; (2) aphasia affects the retrieval of *segment information*.

### Background

#### *Speech Planning*

Current models of speech production assume two levels of speech sound planning: *phonological planning* and *speech motor planning* (Levelt et al., 1999). Phonological planning involves generating a word's abstract sound structure by first retrieving from memory separately the segments and a metrical frame, and second, inserting the segments into the frame. The resulting phonological representation is then transformed into motor commands during speech motor planning.

Evidence for the separate retrieval of segments and frames comes from *preparation priming* studies (Damian, 2003; Meyer, 1990; Roelofs & Meyer, 1998). In this task, people name pictures under two conditions: a *homogeneous* condition in which all names share a property (e.g., *cat-comb-cake*; shared first segment), and a *heterogeneous* condition in which they differ (e.g., *cat-bomb-sun*). Reaction times (RTs) are shorter in the homogeneous context ('priming'), but only when frames are also shared (Roelofs & Meyer, 1998). Thus, speakers can prepare some aspects of the speech plan in advance: they can retrieve the first sound and the frame before seeing the picture, and they can put the first sound into the frame. At that point, they have to stop until the picture appears to retrieve the remaining segments and insert them into the frame. The absence of priming when only the first segment or the frame is shared indicates that segments and frames are retrieved separately and that both retrieval processes take the same amount of time. If one process took longer, then pure priming should occur for that retrieval process, because the longest process determines RT.

#### *Speech Planning in AOS and Aphasia*

Speech characteristics of AOS include slow, non-fluent speech, speech sound distortions, and prosodic abnormalities (Ballard et al., 2000; Duffy, 2005). The problem with prosody is one of the hallmarks of AOS. Speech characteristics of aphasia may include sound substitutions and misorderings in the context of well-articulated speech with normal prosody (McNeil et al., 2009). Although phonological planning is often considered intact in AOS (Ziegler, 2009), some RT findings suggest slow activation of phonological information resulting in problems downstream during motor planning (Rogers et al., 1999). Because prosody (including lexical stress) is a hallmark problem in AOS, we hypothesize that **AOS disrupts frame retrieval**. As for aphasia, Wilshire et al. (2007) showed excessive segment priming in aphasia using a cross-modal priming task, suggesting a possible segment retrieval problem (they did not assess frame retrieval). Based on these findings and the nature of speech errors in aphasia with fluent speech, we hypothesize that **fluent aphasia disrupts segment retrieval**.

## Methodology

### *Participants*

Data collection is ongoing; participants to date include 1 left-handed man with Broca's aphasia and moderate-severe AOS (age 63; AQ 32.2), 10 age-matched controls (AMCON; mean age 58(7); 6F, 4M), and 12 younger adult controls (YCON; mean age 22(4); 7F, 5M).

### *Tasks & Procedures*

In the preparation priming task, participants name the same pictures in a *homogeneous* set in which all words share some form property, and a *heterogeneous* set in which they do not. The experiment involved 18 sets of pictures, presented in separate blocks (9 homogeneous, 9 heterogeneous). Before each block, the experimenter showed and named the pictures of that block, and asked the participant to name the pictures. Once participants had named the pictures correctly at least once, the block started. Picture presentation was accompanied by a brief tone to enable acoustic RT measurement. After the response, the experimenter judged response accuracy. Incorrect responses (wrong word, self-corrections, RT > 5 sec.) were rerun at the end of each block (Maas et al., 2008), until 6 correct responses were collected for each target (with a maximum of 10 trials per target). In each block, pictures were presented in random order; the order of conditions was counterbalanced across participants; order of sets within each condition was randomized.

### *Materials*

Materials consisted of 27 color line-drawings to create nine homogeneous sets of three words, three sets per Overlap condition: Frame-only (F; e.g., *bucket-carrot-singer*), Segment-only (S; e.g., *carpenter-castle-cage*), and Frame+Segment (FS; e.g., *saddle-sausage-sailor*). The pictures were recombined into nine heterogeneous sets of three words. Overlap conditions were matched for word frequency, phonotactic probability, word length, and initial sounds.

### *Design & Analysis*

Dependent variables were error rate and RT (measured from acoustic recording). Control data were analyzed with 2 (Group) x 3 (Overlap) x 2 (Context) ANOVAs. Patient data were analyzed using a 3 (Overlap) x 2 (Context) ANOVA on raw data (cf. Wilshire et al., 2007). Predictions were: (1) Controls will show priming only for FS; (2) AOS patients will show priming for F and FS but not for S; (3) Aphasic patients will show priming for S and FS but not for F. The general rationale is that priming may reduce retrieval difficulties.

## Results

### *Control Speakers*

*Errors.* Control speakers produced few errors. Analysis revealed a marginal Group effect (YCON > AMCON), a significant effect of Overlap (F > S), and a significant Group x Context interaction (YCON > AMCON in heterogeneous sets but not in homogeneous sets).

*Reaction Times* (Figure 1). Analysis of median RT (correct responses only) showed a significant Group effect (AMCON > YCON) and a marginal Overlap effect (S < F, FS). Critically, the Overlap x Context interaction was significant, indicating priming only for FS. There was no hint of a three-way interaction or any other effects.

## **Patient**

*Errors.* The patient's overall error rate was 20.7%, with the highest error rate in FS-homogeneous sets (32.5%) and the lowest error rate in F-heterogeneous sets (10.4%).

*Reaction Times* (Figure 2). Analysis of median RT (correct responses only) revealed no significant effects, though there was a hint for a Context effect, suggesting *longer* RT for homogeneous sets than heterogeneous sets. The RT pattern differs qualitatively both from the controls and from the prediction, especially for FS (trend in follow-up analyses).

## **Discussion**

Results from control speakers replicated previous findings (Damian, 2003; Roelofs & Meyer, 1998; Santiago, 2000): priming occurred only when both the frame and the initial segment were shared, supporting the idea that frames and segments are retrieved independently and in parallel (Levelt et al., 1999). Older adults were slower overall than younger adults; however, the absence of a three-way interaction suggests that phonological planning does not change fundamentally with aging.

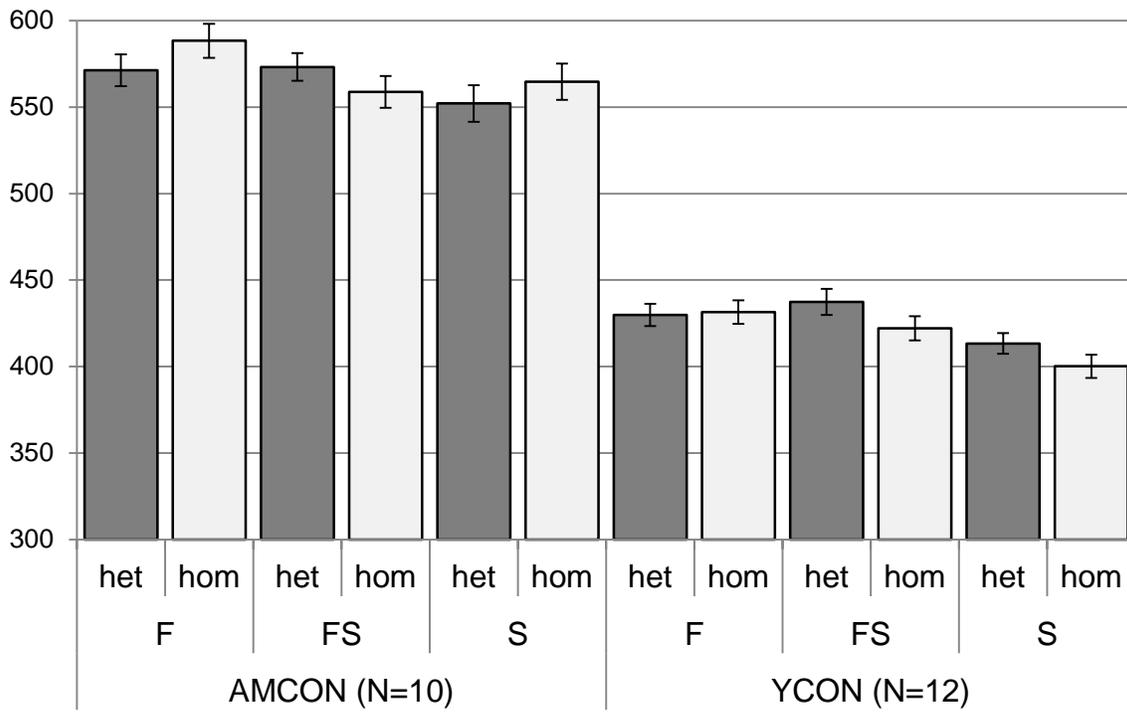
The patient data did not reveal significant effects, although the numerical RT pattern was surprising: rather than priming, the pattern suggests possible *interference*, especially when both frame and segment are shared (also evident in the error data). If this pattern holds up with additional patients, these unexpected findings may further enlighten the nature of speech planning in AOS. Since this paradigm reflects processing at the interface between phonological and phonetic encoding (Cholin et al., 2004; Levelt et al., 1999), such a pattern would suggest a disruption at this processing stage. Theoretical and clinical implications of these findings will be discussed.

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**Figure 1.** RT data for controls. Errors bars represent standard error.



**Figure 2.** RT data for the patient. Error bars represent standard error.

