



NEUROPSYCHOLOGICAL EVIDENCE ON THE ROLE OF SHORT-TERM MEMORY IN SPEECH PRODUCTION

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INTRODUCTION

Previous research has demonstrated that some patients show a semantic short-term memory (STM) deficit on memory span tasks whereas others show a phonological STM deficit. Martin and Freedman (2001) reported that patients with semantic STM deficits (but not those with phonological STM deficits) had difficulty producing phrases with several prenominal adjectives, which they attributed to their difficulty in maintaining several semantic representations simultaneously prior to phonological retrieval. The present experiments extended this research to a different phrasal structure, examining onset latencies for the production of conjoined noun phrases describing semantically related (e.g., "dress and shirt") vs. unrelated (e.g., "ball and faucet") pictured objects. Results from normal control subjects revealed a semantic interference effect, i.e., significantly longer onset latencies for related than unrelated pairs (41 ms effect), indicating that both nouns were planned simultaneously at the semantic level prior to the onset of articulation. Two patients with phonological STM deficits showed an interference effect within normal range. In contrast, two patients with semantic STM deficits demonstrated semantic interference effects that were 14 times (for patient ML) and 7.5 times (for patient GR) larger than the mean for controls. A second experiment replicated the semantic interference effect for young control subjects and showed that the effect did not appear for associatively related items (e.g., monkey-banana). On these materials, ML again showed a greatly exaggerated semantic interference effect, but no associative effect. The results support the contention that the semantic retention capacity tapped by memory span tasks is involved in planning for production.

Subjects

ML and GR: Patients with semantic STM deficits
EA and SJ: Patients with Phonological STM deficits
12 age-matched controls

Materials

Normed pictures from eight different categories (Snodgrass and Vanderwart, 1980). Each category contained ten pictures. Pairs were considered semantically related if they were within the same category.

Procedure

Block 1: Unrelated paired pictures (Each item was from a different category)
Block 2: Related paired pictures (Both items were from the same category)

Subjects viewed two pictures simultaneously and were instructed to form a phrase by naming both pictures in succession, e.g., "cat and dog".

Onset latencies were measured.



Semantic STM is used to retain lexical-semantic information in phrase production. Semantic STM patients displayed extremely long onset latencies (relative to phonological STM patients and controls) producing phrases from single pictures in which several lexical-semantic representations are maintained up to the lexical head of a phrase, e.g., "the small green leaf" (Martin and Freedman, 2001).

Evidence indicates that interference occurs while naming pictures when a semantically related distractor is presented prior to presentation or simultaneously (Damian and Martin, 1999; Schriefers, Meyer, and Levelt, 1990).

The following experiment tests whether two pictures presented simultaneously will elicit interference effects when producing a phrase for two semantically related pictures.

Control subjects and phonological STM patients will display longer onset latencies while producing phrases for two semantically related pictures compared to unrelated pictures, e.g., "cat and hammer".

Relative to control subjects and phonological STM patients, semantic STM patients will display an exaggerated interference effect since semantic STM is needed to maintain lexical-semantic representations prior to production.

	Semantic STM Deficit		Phonological STM Deficit		Controls
	ML	GR	EA	SJ	
Unrelated	1530	1363	1587	1222	868
Related	1957	1670	1600	1198	909
Interference Effect	-427**	-307**	-13	24	-41**
				*Range of interference effect for controls: 20 - 142 ms **p<0.001 ***p<0.05	

- Controls showed a significant interference effect (41 ms) for semantically related pairs, implying that they were planning both nouns simultaneously
- Phonological patients showed interference effects in the range of controls
- Semantic and Phonological patients had similar onset latencies for unrelated pairs, but the semantic patients had much longer times for the related pairs.
- The exaggerated interference effect in the semantic patients is attributed to their specific semantic STM deficit.

Subjects

ML: Patient with semantic STM deficits
EA and SJ: Patients with Phonological STM deficits
6 age-matched controls

Materials

The same pairs from 1a were used, except the pairs in this experiment were words

Procedure

Block 1: Unrelated paired words (Each item was from a different category)
Block 2: Related paired words (Both items were from the same category)
Subjects viewed two words simultaneously and were instructed to form a phrase by naming both words in succession, e.g., "cat and dog"
Onset latencies were measured.

Picture naming requires the speaker to access the lexical-semantic representation of the word, whereas word naming does not.

Controls subjects, phonological and semantic STM patients should not show interference effects for semantically related word pairs compared to unrelated pairs.

	Semantic STM Deficit		Phonological STM Deficit		Controls
	ML	EA	SJ		
Unrelated	1027	803	973		658
Related	1019	767	958		641
Interference Effect	8	36*	15		17**
			*Range of facilitation effect for controls: 2 - 26 ms. **p<0.05 ***p<0.01		

Controls, phonological, and semantic STM patients displayed facilitation effects for word pairs in the semantically related conditions.

Although the related word pairs were not designed to share phonemic segments, perhaps some of the related pairs also commonly co-occur in speech or text, e.g., "cat and dog."

Shelton and Martin (1992) provided evidence that facilitation occurs for written word pairs that are associatively related.

They hypothesized that connections between lexical-phonological and orthographic representations are established in the lexicon as subjects are exposed to commonly co-occurring word associates.

Facilitation may occur as subjects receive automatic priming for the associates via access to the orthographic and lexical-phonological connections.

It is unclear whether the facilitation effects in 1a and 1b were due to semantic or associative relatedness.

Previous picture naming studies using visual word distractors suggest that interference effects occur for pictures presented with semantically related distractors, while facilitation effects occur with associatively related distractors (Alario, Segui, and Ferrand, 2000).

Experiment 2 uses the same paradigm as 1a, except that the stimuli were paired according to semantic and associative relatedness.

Subjects

42 Rice Students
ML: Patient with semantic STM deficit
6 age-matched controls

Materials

Picture pairs were related or unrelated.

The related pairs were of three types:

- Semantically related/Not associated; e.g., mouse and rabbit
- Semantically related/Associated; e.g., cat and dog
- Associated/Not semantically related; e.g., monkey and banana

Procedure

Subjects named picture pairs as in Experiment 1a, with "and" joining names

	ML				Controls N=6			Rice Students N=42		
	Sem only +Sem/Assoc	Sem only	Sem/ Assoc	Assoc only	Sem only	Sem/ Assoc	Assoc only	Sem Only	Sem/ Assoc	Assoc Only
Unrelated	5100	5200	5100	6900	994	950	922	899	883	829
Related	7300	7400	7200	7100	996	971	910	913	911	833
Interference Effect	-2200*	-2200	-2100	-100	-2	-21	+12	-14*	-28*	-4
	*p = 0.019							*p<0.005		

Rice students, controls, and ML displayed longer onset latencies for semantically related picture pairs compared to pairs that were unrelated.

Average interference effects ranged from 2 to 29 ms for Rice students and controls, while ML showed an exaggerated interference effect of 2 seconds in the semantic conditions.

These results are consistent with those from Experiment 1 in that subjects displayed interference effects in the semantically related conditions, suggesting that semantic STM is involved in planning prior to production.

Interference appears to be due to the constraints placed on semantic STM to maintain several similar (sem related) representations prior to production.

Interestingly, subjects did not show significant facilitation effects. Why would this occur in the distractor-picture paradigm by Alario et al. (2000) but not in the present experiment?

Perhaps facilitation effects only occur when the subject is primed with an associatively related item and forms an expectation as to what item will appear next.

The important point is that associatively related items did not cause interference in the present study. This would indicate that the interference effect is not just due to relatedness, but from two lexical-semantic representations that share similar features.

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