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Semantic Treatments for Word and Sentence Production Deficits in Aphasia

Mary Boyle, Ph.D.[1]

ABSTRACT

The cognitive domains of language and memory are intrinsically connected and work together during language processing. This relationship is especially apparent in the area of semantics. Several disciplines have contributed to a rich store of data about semantic organization and processing, and several semantic treatments for aphasic word and sentence production impairments have been based on these data. This article reviews the relationships between semantics and memory as they relate to word and sentence production, describes the aphasic language impairments that result from deficits in these areas, and summarizes treatment approaches that capitalize on what we have learned about these domains and how they work together.

KEYWORDS: Semantics, language, cognition, memory, aphasia rehabilitation

Learning Outcomes: As a result of this activity, the reader will be able to (1) discuss the components of memory and semantics that are involved in word production; (2) list semantic treatments that have resulted in improved word production; (3) describe a semantic treatment for remediating an aphasic word production impairment.

When people with aphasia describe their word-retrieval difficulty, they typically say something like, "I cannot remember the words I want to say." This illuminates the intrinsic connections between the cognitive domains of language and memory. There is a rich and ongoing history of examining the elements of word meanings, their organization, and the interactions between language and memory during language comprehension and production. These investigations cross many disciplines, including speech-language pathology, psycholinguistics, and cognitive neuropsychology. Several semantic treatments aimed at improving word and sentence production

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impairments in aphasia have drawn directly from this work. The goal of this article is to review the relationships between semantics and memory as they relate to word and sentence production, to describe the aphasic language impairments that result from deficits in these areas, and to summarize treatment approaches that capitalize on what we have learned about these domains and how they work together.

A BRIEF REVIEW OF MEMORY

Effective communication requires close cooperation between language and memory. This cooperation is especially evident when we consider semantics. Therefore, before considering semantic organization and processing, it is useful to briefly review memory, particularly as it relates to semantics.

Memory is a component of cognition that enables us to learn, store, and retrieve information. Current models characterize memory as consisting of different systems and processes.[1,2] The major memory systems are long-term memory and working memory (Figure 1).[2]

Long-term memory is usually described as a storage system containing different types of information, with each type handled by its own subsystem.[3] There is not universal agreement about all of the subsystems that comprise long-term memory. Most models specify semantic memory and episodic memory as components of this system,[1–3] although questions have been raised concerning the distinctiveness of these subsystems.[1,4–7] Semantic memory deals with knowledge of the world, including knowledge about words.[1,3] The term *mental lexicon* or *lexical memory* refers to the part of this system responsible for words, including meaning, phonology, and part of speech.[1,3,8,9] Episodic memory concerns knowledge of events or episodes that have happened in a person's life and includes information about the circumstances in which the events occurred (participants, time, location, etc.).[1,3]

Semantic and episodic memory are considered to be types of explicit or declarative memory. Nondeclarative memory, also called implicit memory, is another component of long-term memory. The label implicit indicates that knowledge represented in this system is acquired without conscious effort or awareness.[1] A subsystem of nondeclarative memory that has been investigated in relation to word retrieval is priming. In priming, recognition of a target improves if that target, or an item very similar
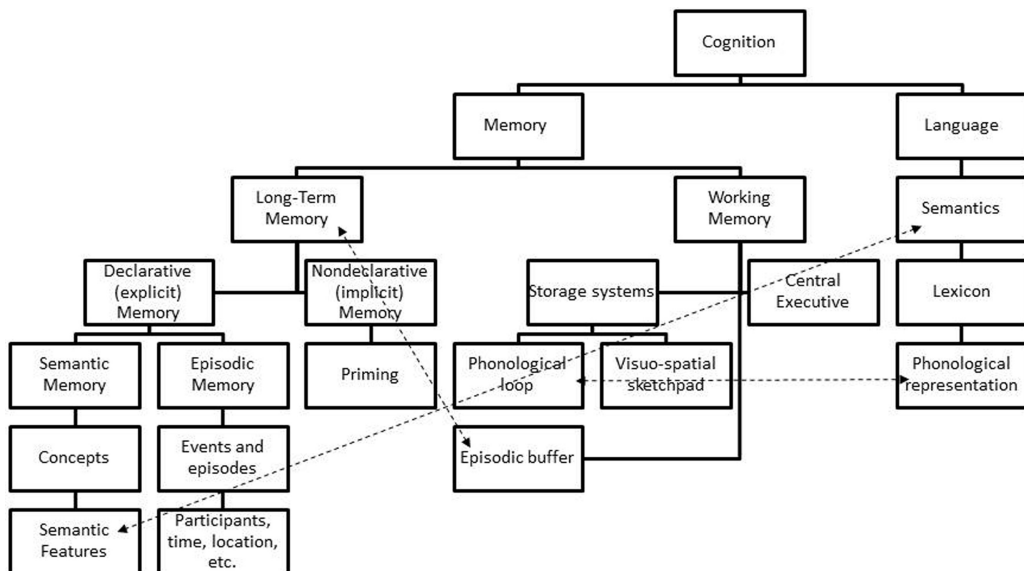

Figure 1 Components of memory and language involved in semantic processing.

to it on some perceptual dimension, has been presented previously, even when the previous presentation is so quick that the person is not consciously aware that the item was presented.[1]

Working memory is a system with limited capacity that allows temporary storage and manipulation of information for a variety of cognitive activities, including language.[10] The current conception of working memory includes three components: temporary storage systems, one for speech and sound (the phonological loop) and one for visual-spatial information (the visuospatial sketchpad); an episodic buffer that holds episodes and links the components of working memory with each other and with long-term memory and perceptual information; and a central executive that can focus attention, temporarily store multimodal information, and make decisions.[10]

SEMANTIC ORGANIZATION AND PROCESSING

In linguistics, semantics is the study of meaning. In cognitive neuropsychology, semantic memory is the part of long-term memory that encompasses our knowledge of the world, including words and their meanings (as described earlier). Thus, language and memory are both involved in understanding and producing words.

Current models conceive of the semantic system as a network of concepts.[11–14] A concept consists of features or properties that comprise the meaning of the concept. A concept is "defined" by several semantic features and each semantic feature is typically related to several concepts. Concepts that share semantic features are more strongly related than concepts that do not share semantic features, and concepts that have more features in common are more strongly related than those that have fewer features in common. For example, the concepts *strawberry* and *raspberry* are more strongly related than *strawberry* and *radish*. All three share features of being [food], [red], and [small], but *strawberry* and *raspberry* share the additional feature of being [fruit], which *radish* does not. According to norms collected from 725 college students, *strawberry* also has [used for making pies] as one of its semantic features, but *raspberry* does not.[14] When we try

to retrieve the word for the concept we want to convey, the features for that concept are activated and the activation spreads to the item in the lexicon associated with the features. The lexical item that receives the greatest amount of activation is selected. If for the sake of simplification we just consider the features listed in the example (because each of the concepts listed have many more features than those we are considering), when we think of *strawberry*, its features would be activated and because it has more features than the other concepts, the activation would cause the associated lexical item, "strawberry," to be selected. The activation spreads from the selected lexical item to the phonological representation associated with it, and then a motor program executes the production of the spoken word.[15] There is some debate about whether the activation happens in sequential order from the semantic level to the lexical level to the phonological level or whether the activation is interactive, providing feedback to all levels during retrieval,[16–18] but there is general agreement on the components of the model. Although tests of naming usually assess ability to retrieve one word at a time (in confrontation picture naming tasks, for example), people typically produce language in connected speech as part of discourse. There is evidence that suggests that during connected speech we plan at the phrase level, and that we attempt to activate all of the lexical-semantic representations for the phrase we want to say before we begin the phonological retrieval for the phrase.[19] It is presumed that this advance planning relies on working memory resources to keep the representations of several words active and available prior to their production.

There is general agreement in the literature about how objects or entities (represented linguistically by the grammatical class of nouns) are represented by semantic features. Their semantic features consist of characteristics or properties. For example, semantic features include *superordinate category*, *physical properties* (like color, shape, or size), *component parts*, *function*, *behavior or action*, and *location*, among others.[14] Some semantic features are shared by many concepts whereas others are related to few concepts and are therefore considered to be distinguishing features for those concepts. For

example, the functional feature [used for cider] is a distinguishing feature for *apple* because it distinguishes it from other fruits, whereas the physical-property feature [has seeds] is not a distinguishing feature because all fruits have seeds.[14,15]

The representation of actions and events (represented linguistically by the grammatical class of verbs) in the semantic network is currently less well-defined than the representation for objects and entities. Some researchers have used the same semantic features to characterize verbs that they use to characterize nouns. For example, Vigliocco and colleagues asked speakers to define and describe objects and actions, then classified the speaker-generated features for both into the same five feature categories: *visual*, *nonvisual perceptual*, *functional* (the purpose of an object or the goal of an action), *motoric* (how an object is used or moves), and *other* (all other features, including super-ordinates).[20,21] Other researchers suggest that additional features unique to verbs are thematic roles.[5,8,22] In linguistics, thematic roles (e.g., agents, patients, and themes) are considered to be semantic and denote the roles that participants play in the action or event denoted by the verb.[5] They are realized syntactically as the argument structures of the verb (e.g., subjects and objects). Thus, in the sentence "The girl ate the apple," *the girl* serves the thematic role of agent (because she is the one who did the eating), and *apple* serves the thematic role of patient (because the action of eating was performed on it and its state changed as a result). In this view, a verb's thematic roles are concepts that we develop through everyday experiences and/or exposure to hearing or reading linguistic descriptions of who and what play specific roles in specific situations (that is, we develop these concepts via episodic memory). A thematic role can be viewed as a set of semantic features of the noun concepts that typically fill that role.[6,7] So, for the concept *frighten*, semantic features for the thematic role of agent include [is mean] , [is scary] , and [is ugly] and semantic features for the thematic role of patient include [is scared] , [is small] , and [is weak] .[5] Still other researchers contend that verbs have two levels of semantic representation: one level that is an event template that includes information about argument structure and that is common to all verbs within a semantic class, and another level that represents unique features for each verb and that differentiates verbs within the same semantic class from each other.[23]

APHASIC IMPAIRMENTS ARISING FROM DEFICITS

Word Production Impairments

When people with aphasia cannot successfully retrieve the word they want to say, several different things can happen, and these provide clues about what part of the systems or processes might be impaired. Aphasia might cause people to take a longer than normal amount of time to retrieve the word, resulting in a pause. The literature suggests that pauses that occur within clauses reflect word retrieval difficulty, whereas pauses that occur at clausal boundaries likely reflect sentence-planning issues.[24,25] Alternatively, people with aphasia may produce circumlocutions (generating semantic features of the concept, e.g., "the sharp metal thing to cut food"/*knife*), signifying that the concept and at least some of its semantic features have been activated, but the lexical form has not been successfully triggered for retrieval.[3] Various kinds of paraphasias (substitutions) may also occur. Semantic paraphasias (word substitutions semantically related to the target word, e.g., "fork"/*knife*) might occur if the activation of the lexical item is weak or unstable, allowing another word to be selected. Phonemic paraphasias (error productions that are phonologically related to the target word, e.g., "pife"/*knife* or "fife"/*knife*) might occur when phonological activation is weak or unstable, resulting in production of nonwords or real but semantically unrelated words. Sometimes error productions are both semantically and phonologically related to the target word (mixed semantic-phonemic paraphasias, e.g., "cat"/*rat*) when semantic and phonological activation converges on a lexical item that is related both semantically and phonologically to the target.[18] Sometimes there is no obvious relation between the error production and the target word, resulting in an unrelated word (e.g., "tissue"/*knife*) or a neologism (e.g., "spookle"/*knife*). In these

instances, the semantic and/or phonological activation appears to be severely impaired.

Sentence Production Impairments

Some theories of language hypothesize that the verb is the core of a sentence and that thematic roles must be assigned before the syntactic and phonological aspects of sentence production can occur.[26,27] Problems with verb retrieval, or weak relationships between thematic roles and their associated verbs, can therefore result in impairments in producing complete, grammatical sentences.[28–30]

SEMANTIC TREATMENTS

This section reviews select treatments for word and sentence production in aphasia that are based on our current understanding of semantics as outlined in the preceding sections. Studies that combined semantic treatments with other elements (gestures or phonological cues) are not included. In each of the treatments, the clinician guides the person with aphasia through exercises designed to activate semantic features of concepts and to strengthen connections between those features and the lexical items with which they are associated. The treatments differ in their linguistic targets (nouns, verbs, or sentences) and in the depth of processing required of the people with aphasia (e.g., recognizing features versus generating features) during the exercises.

Semantic Feature Analysis for Objects

Semantic feature analysis (SFA) is based on the model of lexical retrieval described earlier in this article. Its goal is to improve the ability of people with aphasia to retrieve and produce the names of objects by providing an organized method of activating semantic networks.[31,32] The clinician places a picture to be named in the center of a chart that has a box for each semantic feature surrounding the picture (most investigations used the features *superordinate category, use, action, physical properties, location,* and *association*). After an initial naming attempt by the person with aphasia, the clinician guides the generation and production of the semantic features of the target, writing each feature in the

appropriate box as it is produced by the participant. The clinician reads printed cues on the chart to elicit feature generation (e.g., "What do you use it for?") and produces features (orally and in writing) that the person with aphasia is not able to generate independently. As the clinician is guiding the feature generation, care is taken to include the target's most distinguishing features, because these help to activate the target preferentially over other category members. Initially, the clinician plays a primary role in cuing the participant to generate the semantic features but gradually fades prompts so that as treatment progresses the burden is shifted to the participant. All of the features are reviewed and, finally, the participant attempts to name the item again. If the participant cannot name the item, the clinician says the name and the participant repeats it.[15,33–35]

Over the years, the methodology used by researchers to deliver SFA treatment in single-subject experimental designs has varied. Almost all participants (19 of 23) who received SFA treatment maintained naming above baseline levels at follow-up testing, which occurred from 1 month to 1 year posttreatment.[33–43] A recent evidence-based systematic review of SFA reported that of 18 studies considered for review, 7 were eliminated because they combined SFA with other therapy methods or because they hybridized the SFA protocol.[44] Eight of the 11 remaining studies reported generalization of improved naming to untreated items.[33–36,40,41,43,45] All eight studies used imageable nouns as treatment targets and required participants to generate five to six semantic features for a target. Of the three studies that reported no generalization, one included treatment targets that were abstract (e.g., *piece, charge, ingredients*),[42] another focused solely on verbs,[46] and the third restricted participants to generating only three features per target.[38] These methodological differences might explain the lack of generalization to untreated items reported by these studies. Although not all SFA studies have assessed changes in structured discourse that reflect improved word retrieval posttreatment, such changes have been reported in most studies that assessed it.[33,34,36,43,45]

Some investigations have used SFA treatment in a discourse (rather than a confrontation naming) context. The specific methodologies have varied. Peach and Reuter used complex pictures to elicit narrative discourses and applied SFA to problem words after production of the discourse.[45] Others used SFA in group treatment sessions that involved increasingly naturalistic discourse tasks, moving from promoting aphasic's communicative effectiveness (PACE) barrier-task activities to retells of movie plots.[47,48] SFA was used during discourse production when participants had trouble retrieving object names. All three studies noted improvements in discourse production following treatment.

Semantic Feature Analysis for Actions

Several researchers have applied SFA to verb retrieval.[45,46,49,50] In these studies, the semantic feature categories used during treatment were modified from the ones used for object naming to make them more appropriate for generating semantic features for actions, but the other aspects of treatment were the same. The feature categories used were *subject, purpose of action, part of body or tool used to carry out the action, description, usual location,* and *association*. The category *subject* corresponds to the thematic role of agent and the *part of body or tool used to carry out the action* corresponds to the thematic role of instrument. Thus, the investigators attempted to include thematic roles, which some researchers consider to be a part of an action's semantic features.[7] All of the investigations reported that action naming accuracy improved and that the improvement was maintained after treatment. However, they found minimal to no generalization to untreated actions. All of the studies also reported improved discourse production following treatment. The reason for the lack of generalization to untreated actions (compared with that reported for objects) is not clear, but might be related to the current uncertainty about the exact elements that comprise semantic features of actions. For example, it might be that a feature category that strongly influences retrieval of action names was not included in the feature categories included in the treatment. Clearly, this is an area that merits additional research as our understanding of the semantic feature composition of actions improves.

Semantic Feature Review for Object Naming

Another treatment that uses semantic features has been called semantic feature review (SFR) treatment to differentiate it from SFA treatment.[15] In this treatment, the person with aphasia attempts to name a pictured object, selects the written labels for the semantic features of the item from a set of features and distractors, answers yes or no questions regarding the item's features, and then again attempts to name the item. If the person with aphasia cannot name the item, the clinician says the name and the person repeats it.[51,52] SFR resulted in improved naming of treated words, but only three of seven participants maintained the improvement after treatment ended. It is important to note that all of the participants who received SFR were bilingual whereas all of the participants who received SFA were monolingual English speakers. In terms of generalization to untreated items, the pattern was inconsistent across the participants, and sometimes only occurred on translations of the treated words in the untreated language rather than improved retrieval of words that were not treated in either language. It is not clear whether the maintenance and generalization outcomes were weaker than those for SFA because of the bilingualism of the participants, and this is a question that deserves attention. It may also be the case that SFR requires a shallower level of semantic processing than SFA, which requires participants to generate semantic features. Research in semantic memory has shown that deep semantic processing is superior to shallow semantic processing for retrieval.[53–56] However, questions concerning treatment effects in bilingual versus monolingual people, or regarding the superiority of deep versus shallow processing, can only be answered by investigations that provide direct comparisons of the variables in question.

Modified Semantic Feature Analysis Plus Semantic Feature Review for Verbs

One treatment for verb retrieval combined aspects of SFA and SFR.[57] This treatment was based on the theory of a two-level semantic

representation for verbs outlined earlier, and hypothesized that treating verbs of the same semantic class would repeatedly activate (and thus strengthen) the template-level semantic representation, which should result in improved retrieval of untrained members of the same verb class. For each target verb, the treatment protocol required the participant to name the action after viewing it in a video, to generate three semantic features of the target verb, to select written labels for the semantic features of the verb from a set of features and distractors, and to produce a sentence using the target verb. After treatment, one participant improved his ability to produce the target verbs but the other participant did not, and neither demonstrated generalized verb naming improvement to untrained verbs either within or across semantic classes. However, both participants improved verb-naming performance on a standardized test. As was noted in comments on the lack of generalization in studies that used SFA for action naming, it is possible that the current lack of agreement about the semantic representation of verbs means that we have not yet identified the features that might be most potent in promoting generalization of improved verb retrieval. Another possible reason for the outcomes found in this study is that generation of only three features might not be sufficient to result in improved action naming or in generalization to untrained verbs.

Verb-as-Core Treatment

In a series of studies, Loverso and his colleagues explored a treatment (variously called verb-as-core, verbing, and cueing verbs) based on the idea that verbs are the core of a sentence, so that focusing treatment on the verb and its thematic roles should result in improved sentence production.[28,58–60] The clinician presented written action names as the core of a sentence and then used *wh*-questions as cues to elicit the thematic roles of agent and patient/theme, resulting in production of simple sentences (agent-action or agent-action-patient/theme). The person with aphasia was first required to repeat and copy a sentence containing an agent plus an action. Next, the clinician provided the written and spoken verb, the written and spoken *wh*- cue for

agent (*who*), and a choice of words to fill the agent role, including a target and foils that would fulfill thematic roles of location, instrument, and time. The participant was required to choose the word to fill the agent role and then produce the sentence orally and in writing. In the next step, the clinician provided the spoken and written verb and the spoken and written *wh*- cue (but no choices to fill the agent role). The participant was required to generate an agent-action sentence verbally and in writing. The same set of steps was followed to elicit sentences containing agents, actions, and patients/themes. The treatment resulted in improved scores on a standardized aphasia test and anecdotal reports of improved functional communication. However, the investigators did not directly assess whether verb or sentence production improved as a result of the treatment.

Verb Network Strengthening Treatment

Verb network strengthening treatment (VNeST) is similar to the verb-as-core treatment. However, in VNeST there is no requirement for the person with aphasia to repeat a sentence initially or to produce written responses during treatment, and VNeST elicits more than one agent and patient/theme for each verb.[29,61] A tutorial explains the rationale and outlines the protocol for this treatment.[61] A recent review of a series of VNeST studies reported that after treatment, 19 of 22 participants improved in noun naming ability, 11 of 19 improved their ability to name verbs, 14 of 20 were able to produce grammatically accurate sentences, 6 of 15 improved the informativeness of their discourses, and 10 of 17 produced more complete utterances in discourses.[29] Thus, VNeST appears to improve confrontation noun naming for most participants, and to result in improved verb naming and improvements in sentence and discourse production for most participants.

Contextual Repetition Priming

Treatments that use priming are based on the premise that if a set of semantically related words is primed repeatedly, the priming will

strengthen the lexical-semantic connections because of the increased activation of shared features among the words in the set.[18] In a study by Nadine Martin and her colleagues, the treatment protocol required the person with aphasia to choose a picture that matched a word spoken by the clinician from an array of pictures, immediately repeat the word, and repeat the word again after a delay.[62] These steps were performed for five semantically related items and the whole procedure was repeated four times. The two people with aphasia were purposely chosen for the investigation because they demonstrated impaired access to lexical-semantic representations and the authors predicted that such an impairment would result in a short-term, but no long-term, benefit from the treatment. The authors' hypothesis was supported.

Mapping Therapy for Sentence Production

Several groups of researchers tried to improve sentence processing in people with agrammatic Broca's aphasia by guiding them to identify the meaning relationships in sentences. This approach, mapping therapy, is based on the premise that speakers with agrammatism have difficulty encoding thematic roles and mapping those roles onto the syntax of a sentence.[18,63] Whereas most investigations of mapping therapy focused on comprehension, one investigation targeted production.[30] In this study, the clinician provided a picture of the target sentence and information about the verb and its thematic roles before asking the participant to produce a sentence beginning with a specific word. So, for example, in level 1 of the treatment, the clinician presented a picture and identified the verb orally. Then the clinician identified the agent and the theme of the sentence and asked the participant to make a sentence starting with the agent (e.g., "In this picture the one being chased is the tall teacher [theme]. The one doing the chasing is the nurse (agent). Please make a sentence starting with the nurse.").[30 (p.35)] Level 2 was similar but asked the participant to start the sentence with the theme. Level 3 focused on both agent and theme, and level 4 varied between focusing on the agent or the theme randomly. All three

participants who received the treatment improved production of the trained sentence structures and demonstrated generalization to untrained structures and to a narrative task.

SUMMARY AND CONCLUSION

The cognitive processes of language and memory are intrinsically connected and work together during language processing. This relationship is especially apparent in the area of semantics. Several disciplines have contributed to a rich store of data about semantic organization and processing, and several semantic treatments for aphasic word and sentence production impairments have been based on this data. Most of these treatments have resulted in improved naming or sentence production, and these improvements have been maintained after treatment stops. There have been mixed results regarding generalized improvement to untrained words and sentences, but some treatments have reported some benefits and it is likely that treatment efforts in this area will become more successful as our understanding of semantic organization and processing continues to improve.

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