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Cognitive Supports and Cognitive Constraints on Comprehension of Spoken Language

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Abstract

Although comprehension of spoken language is ordinarily conducted without apparent effort, it is among the most complex of human activities. We illustrate this complexity by outlining the operations involved at the perceptual, attentional, and linguistic levels necessary for successful comprehension of speech in sentences and discourse. We describe how challenges to speech comprehension imposed by hearing loss and cognitive limitations in the capacity of attentional and working memory resources can be counterbalanced to a significant degree by utilization of linguistic knowledge and contextual support, including the use of naturally-occurring speech prosody. We conclude by considering factors that may affect one's willingness to expend the attentional effort that may be necessary for successful listening behavior and comprehension performance.

Key Words: Cognition, speech processing, language processing, attention

Sumario

Aunque la comprensión del lenguaje hablado se conduce ordinariamente sin esfuerzo aparente, se encuentra entre las más complejas actividades humanas. Ilustramos esta complejidad describiendo las operaciones involucradas en los niveles de percepción, atencional y lingüístico necesarios para una comprensión exitosa del lenguaje en frases y en discurso corrido. Describimos cómo pueden contrarrestarse, hasta cierto grado, los retos para la compresión del habla, impuestos por los trastornos auditivos y las limitaciones cognitivas en relación con la capacidad de los recursos de memoria de atención y de trabajo, por medio de la utilización del conocimiento lingüístico y del apoyo del contexto, incluyendo el uso de prosodia del habla que ocurre en forma natural. Concluimos considerando los factores que pueden afectar la disposición del individuo de usar el esfuerzo de atención que puede ser necesario para un comportamiento auditivo y un desempeño en la compresión exitosos.

Palabras Clave: Cognición, procesamiento del habla, procesamiento del lenguaje, atención

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A loss of hearing acuity, whether due to age, disease or traumatic injury, becomes especially devastating when it disrupts the ability to comprehend speech. The centrality of language in human interaction is evident in its universal appearance early in childhood and the presence of rule-governed languages in all societies of the earth. Although varying in detail from one language to another, all human languages share at least two features. The first is a *lexicon*: the words of the language that express specific concepts such as objects (nouns), actions (verbs), and modifiers of nouns (adjectives) and verbs (adverbs). The second is a *syntax*: a system of rules for combining these lexical elements into sentences that allow one to represent complex thoughts and intentions. This rich system of communication is carried by large-scale neural networks that include the cognitive resources necessary to implement these rules for effective comprehension (Wingfield and Grossman, 2006; see also Hickok and Poeppel, 2000).

An intact auditory system (or in the case of reading, intact vision) is the necessary conduit for the sensory data that will be used by these linguistic and supporting cognitive systems. An important concern is that, even when perception is successful in the context of a poor quality auditory signal (e.g., mild hearing loss, background noise), this success may come at the cost of processing effort. That is, successful perception may draw on resources that might otherwise be used for higher-level operations such as comprehending sentences with complex syntax (Wingfield et al, 2006) or encoding in memory what has been heard (McCoy et al, 2005; Murphy et al, 2000; Rabbitt, 1991; Suprenant, 1999; see Pichora-Fuller and Souza, 2003, for a good discussion of effortful listening and its potential draw on processing resources). Analogous arguments have been made for comprehension and memory of written material in the context of degraded vision (Dickinson and Rabbitt, 1991).

The focus of this discussion is on speech comprehension at the sentence and discourse levels, or the question of how the cognitive and linguistic systems deal with the input once it has been registered and encoded by the nervous system. In so doing we will note the use of cognitive supports, such as the use of linguistic context to aid word recognition, as well as constraints on higher-level processing consequent to limited resources such as the capacity of verbal working memory. Our goal will be also to suggest potentially promising areas for future research at the intersection of hearing science and cognitive science.

CONSTRAINTS ON LANGUAGE COMPREHENSION

The naturalness of language comprehension can belie the complexity of the task and its attendant demands on cognitive resources. This complexity begins with the quality of the signal itself. In audiometric testing verbal stimuli are typically presented with clear enunciation. However, this is not the rule in everyday speech, where many words are under-articulated to the extent that they would be unrecognizable if they were heard in isolation from their linguistic context (Pollack and Pickett, 1963; Wingfield et al, 1994). The perceptual task is often further burdened by the need to discriminate a target speaker from background noise or the presence of one or more additional speakers in the background. On the left side of Figure 1 we represent this symbolically as a single complex waveform containing the combined sensory input from two speakers, one giving medication instructions and one talking about the weather. To follow the medication instructions the listener must be able to separate these overlapping signals by source (source discrimination), based on such acoustic features as intensity and phase differences that may cue spatial location of the two speakers, and by different vocal characteristics of the two speakers such as differences in metrical pattern, fundamental frequency or perceived vocal tract length.

Once the two (or more) speech streams have been perceptually segregated, in itself an impressive perceptual operation, the listener must engage an attentional filter to determine which of the two signals will receive primary attention. Young adults with good hearing acuity are quite adept at controlling attention in this way, to the degree that the ability to report the speech content from one speaker is diminished

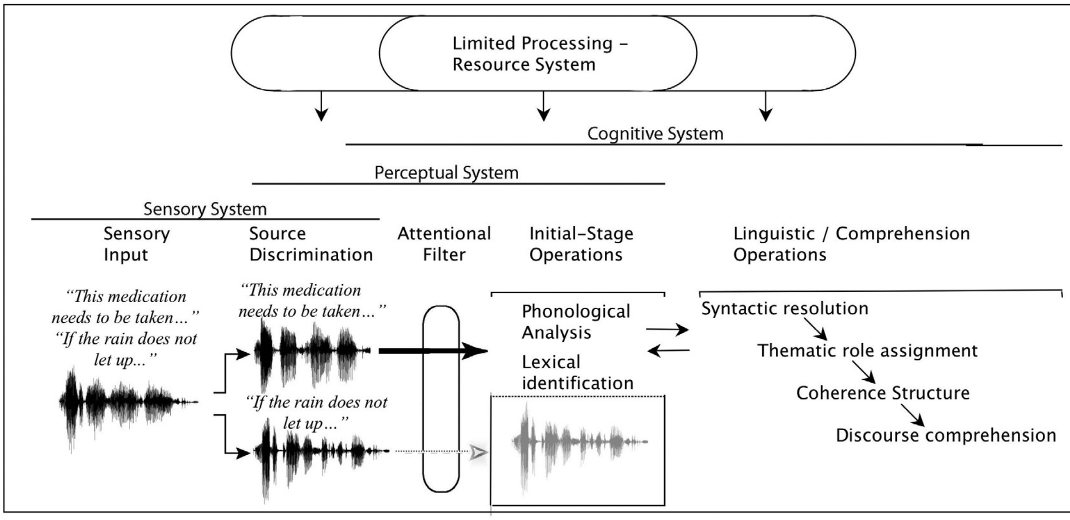

Figure 1. Operations required for comprehension of speech at the word, sentence, and discourse levels as constrained by a limited capacity processing-resource system. Although displayed sequentially, many of these operations are interactive, with information flowing in both directions.

only slightly by the presence of a background speaker (Broadbent, 1971; Treisman, 1964; Tun and Wingfield, 1999). This ability to withstand both energetic masking (e.g. acoustic interference from background noise or speech) and informational masking (e.g. interference from the meaning or semantic content of concurrent speech) decreases in older adulthood (Carhart and Nicholls, 1971; Gordon-Salant, 2005). For example, a to-be-ignored background speaker speaking in a familiar language (i.e., informational masking) causes more interference with a target voice than the same speaker speaking in an unfamiliar language (Tun et al, 2002).

Although one may be consciously aware of only the attended message when two people are speaking simultaneously, some information, such as a person's name, can often break through the attentional filter. This is made possible by occasionally sampling from a very short-lasting trace of the content of the unattended channel (Broadbent, 1971; Treisman, 1964; Wood and Cowan, 1995). We have represented the primary, to-be-attended, message ("This medication needs to be taken...") with a solid horizontal arrow crossing the attentional filter. We have represented the unattended message ("If the rain does not let up...") with the lower dotted horizontal arrow, and the hypothesized transient store of its content as the faded waveform to the right of the attentional filter. The transience of this information, however, means that although one can detect one's name in an otherwise ignored conversation this will occur on average only one third of the time (Wood and Cowan, 1995).

As indicated in Figure 1, the listener must conduct a phonological analysis of the speech and identify the lexical elements these phonemes represent. The listener must also rapidly determine which are the nouns, the verbs, and the other elements of the sentence (syntactic resolution). As a part of this syntactic operation the listener must determine how these elements are related to the theme of the sentence. We refer to this in Figure 1 as thematic role assignment. At the discourse level these operations include determination of the propositional content of the message and integration of this content both within and across sentences to establish the full coherence structure of the discourse. All of this must be done as the speech is arriving at ordinary speech rates of 140 to 180 words per minute. Although in Figure 1 we show these operations in a sequential fashion, many of these operations are necessarily interactive, with information flow moving in both directions.

Working Memory and Attentional Resources

At the top of Figure 1 we attempt to indicate that these perceptual and cognitive operations are constrained by a limited processing-resource system. The notion of limited resources that must be allocated among concurrent activities has a long history in cognitive science, from Titchener (1908), who referred to allocatable "psychic energy," to Kahneman (1973), who introduced the modern notion of perceptual and cognitive operations that draw on a limited pool of attentional resources. "Resources" remains somewhat of a placeholder term in cognitive science that has variously been characterized as a maximum rate of processing, or in terms of the capacity of a working memory system that both holds and allows manipulation of information in immediate awareness. For our purposes we take the position closest to Kahneman (1973), who defined resources in terms of attentional capacity: a limited resource that must be allocated among concurrent perceptual and mental activities. We also see this position as compatible with the characterization of resource allocation in terms of upregulation of cortical areas associated with task difficulty (see Wingfield and Grossman, 2006), for data and theory on patterns of neural activation observed during language comprehension in response to complexity of the speech materials in young and elderly adults).

Speech processing involves at least three operations that imply the need for a working memory system to hold temporarily the phrases and clauses of syntactically complex sentences in order to determine the correct sentence meaning. Consider, for example, the question of who had red hair in the sentence, "The mechanic who fixed the car for the woman had red hair." To understand this sentence one must overlook the intervening clause, "who fixed the car," while focusing on the long-distance dependency, "The mechanic had red hair," all of which must be done within a working memory trace of what has been heard. Note also that the ability to use the structure of the sentence must be strong enough to overcome the potentially distracting pull of the adjacent words, "the woman had red hair" (Martin and Romani, 1994).

The term "working memory" refers to the ability to hold recently received information for a brief period in a limited-capacity "computation space" in which the materials may be internally monitored or manipulated (Baddeley, 1996; Carpenter et al, 1994; Engle et al, 1999). Some authors have argued that this limited-capacity working memory system constrains how long or how syntactically complex a sentence one can easily understand (e.g., Carpenter et al, 1994). Debate remains as to whether all linguistic operations are constrained by a single working memory resource or whether on-line syntactic operations are conducted independently of this general resource (Caplan and Waters, 1999).

FACTORS THAT FACILITATE AUDITORY SENTENCE COMPREHENSION

As a counterbalance to the perceptual and cognitive challenges described thus far, there aspects of natural speech that aid successful processing. One of the better-researched areas in speech processing is the role of linguistic context as an aid to word identification. This follows the general principle in perception that the more probable a stimulus, the less sensory information will be needed for its correct identification (Morton, 1969). One sees this effect in tests in which degraded words are shown to be more perceptible when heard in a highly predictable sentence context than in a neutral context (Pichora-Fuller et al, 1995). Whether dealing with degraded written or spoken words, this context effect is a graded one, in which the probability of correct word recognition varies with the likelihood of its occurrence based on the prior linguistic context (Morton, 1969; Wingfield et al, 1991). In part this is due to a priming effect that serves to lower the recognition thresholds for words made more probable by the linguistic context and/or by inhibiting activation of phonologically similar lexical alternative that have a weaker fit with the linguistic context (cf., Goldinger et al, 1989; Marslen-Wilson, 1987; Morton, 1969). A contributing factor may also be a post-perceptual response bias that favors lexical possibilities that have a good fit with the listener's understanding of the linguistic-semantic context. Any or all of these so-called "top-down," or context-supported factors may reduce the processing load that might otherwise be required for the perceptual identification of a degraded signal. This support would, in turn, free up resources for higher-level operations such as comprehension and memory for the content of the speech.

Use of Speech Prosody to Aid Syntactic Parsing

Less research attention has been focused on the role of speech prosody, the "melody" of speech, and the way it may aid in resolution of syntactically complex sentences that might otherwise challenge working memory resources. One example is the case of temporary syntactic ambiguities, in which the representation of the underlying linguistic structure of the utterance (how to "parse" the sentence) remains temporarily ambiguous until it is clarified by words that follow later in the sentence. Consider the following two sentences: (1) "When Roger leaves the house / it's dark." and (2) "When Roger leaves / the house is dark." Although both sentences share the same first five words (*When Roger leaves the house*) the major clause boundary in the first sentence occurs between *the house* and *it's dark* while in the second sentence the clause boundary occurs between *leaves* and *the house* (as indicated by the slash lines in the two sentences.)

In these two examples the ambiguity of where the clause boundary occurs happens when the word *house* is encountered but is quickly resolved when the disambiguating words, *is* or *it's* are heard. Considerable research has shown that listeners (and readers) have a preferred interpretation at that instant of ambiguity that is consistent with a "late closure" structure: in this example, assuming that the house is part of the initial clause (sentence 1) and not the beginning of a new clause (sentence 2). Even in cases like this one, in which the syntactic ambiguity is not maintained for very long, the strategy of assuming a late-closure structure is considered to be less computationally demanding because it does not require construction of a new syntactic clause at the point of the ambiguity (Frazier, 1987; Speer et al, 1996).

This default late-closure interpretation may incur a cost to working memory resources when a sentence has an early-closure structure (e.g. Frazier, 1999). For example, in the case of sentence 2 this would cause an initial parsing error that would have to be repaired when the rest of the sentence is heard. Fortunately, because late-closure structures are more common in everyday speech, this default analysis remains on average an efficient one. In word-by-word reading time studies, this automatic late-closure preference results in longer reading times for early-closure sentences at the point of disambiguation, and more visual backtracking to that region when eye-movements are measured (see Frazier, 1987, for a review).

Unlike reading, where local ambiguity can be resolved only by reading more of the text, in the case of speech, potential ambiguity can be averted by the prosodic structure of the sentence. *Prosody* is a generic term that includes the full array of suprasegmental acoustic features that accompany natural speech. These include the intonation pattern (pitch contour) of a sentence that is carried by variation in the fundamental frequency (Fo) of the voice, and word stress, a complex subjective variable based on loudness (amplitude), pitch and syllabic duration. *Prosody* also includes variations in timing pattern, such as the pauses that sometimes occur between major syntactic elements of a sentence and the lengthening of words that often occurs prior to a clause boundary (Shattuck-Hufnagel and Turk, 1996; Speer et al, 1996). Experimental studies of spoken language have verified the important role of prosody in helping a listener avoid a misanalysis of a temporary syntactic ambiguity by indicating that a clause boundary has been reached (Marslen-Wilson et al, 1992; Speer et al, 1996).

Figure 2 illustrates that speech prosody can be used to avoid a syntactic misinterpretation and hence ease the computational burden on the listener when an early-closure sentence is encountered. Titone et al (2006) presented listeners with recorded sentences that were heard spoken with three prosodic patterns: (1) *Syntactically consistent* (the prosodic and syntactic boundaries coincided), (2) *neutral prosody* (a subdued prosodic pattern that did not favor either an early- or late-closure interpretation) or (3) *conflicting prosody* (the prosodic marking occurred at a misleading location in terms of the syntactic structure of the sentence). These were created by digitally cross-splicing the two normal prosody sentences after the ambiguous noun phrase (*the house*, in the earlier example).

Following a self-paced presentation of each sentence, listeners, who were university undergraduates with normal hearing acuity, were asked to recall the sentence as completely and accurately as possible. A syntactic interpretation was scored as correct even if some words were omitted or changed in the recall, so long as the listener's response produced a sentence with the same morpho-syntactic phrase structure as the original sentence.

As can be seen in Figure 2, when sentences were heard either with a neutral or misleading (conflicting) prosody, listeners were more likely to give the correct syntactic interpretation for late-closure sentences, that would be in accord with listeners' interpretation bias, than for early-closure sentences that would not be in accord with this bias. This illustrates how the previously noted bias of listeners toward a less memory-demanding late-closure structure would have to be actively overcome when an early-closure sentence is encountered. The accuracy pattern shown for prosodically neutral and prosodically conflicting sentences can be contrasted with the sentences presented with syntactically consistent prosody in which the prosody supported the correct syntactic interpretation. In the latter case one sees that the early-closure sentences were interpreted as accurately as the late-closure sentences.

These results were part of a larger study that examined effects of adult aging on the use of prosody, and the timing patterns listeners adopted when self-pacing the speech input (see Titone et al, 2006). The two points we wish to make here, however, are (1) that for these young adult listeners with normal hearing one sees excellent use of prosody to aid syntactic parsing, an important step toward comprehension of what has been heard, and (2) that this prosodic support reduces what might otherwise be a significant drain on working memory resources if a sentence is incorrectly parsed and requires a "second-pass" reanalysis. Although there is some evidence that age-related hearing loss does not impair comprehension of affective prosody (Orbelo et al, 2005), an important area for research is how hearing loss, whether in the form of a peripheral loss or a central auditory processing deficit, may affect this ability to detect and use speech prosody as an aid to rapid syntactic parsing.

LISTENING STRATEGIES AND LISTENING GOALS

Effective listeners take an active part in the communicative enterprise, allocat-

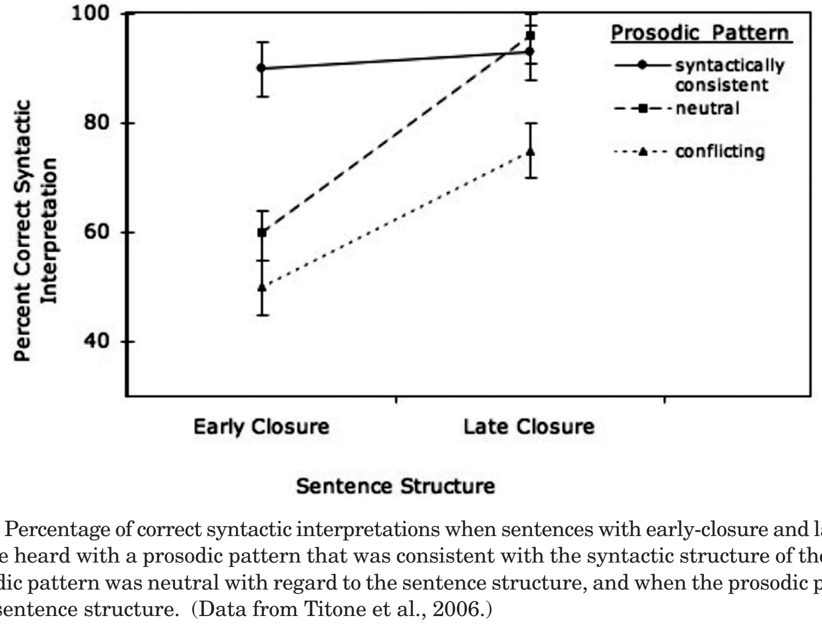

Figure 2. Percentage of correct syntactic interpretations when sentences with early-closure and late-closure structures were heard with a prosodic pattern that was consistent with the syntactic structure of the sentence, when the prosodic pattern was neutral with regard to the sentence structure, and when the prosodic pattern conflicted with the sentence structure. (Data from Titone et al., 2006.)

ing attention as needed for the comprehension task. One method that we have used to explore allocation of attentional resources while listening is to present recorded sentences in a word-by-word or clause-by-clause fashion, with listeners instructed to press a key when they are ready to hear the next segment of the speech message. In this way the listener continues through the passage on a segment-by-segment basis, controlling the flow of information at his or her own rate. It is presumed that if a listener requires more time to process a particular segment he or she will exhibit disproportionately longer pauses before initiating the next segment of the sentence. This technique has been referred to as an "auditory moving window" technique (Ferreira et al, 1996) by analogy to the "moving window" technique used to conduct similar analyses in reading-time studies (e.g., Stine, 1990).

Figure 3 shows pause times taken from one condition of a larger study using the auditory moving window technique, conducted by Fallon et al (2006). In this condition university undergraduates with normal hearing were allowed to control the input of sentences (spoken with normal prosody) with various syntactic forms. The figure shows the average pattern of pause durations for sentences with a fairly complex object-relative center-embedded clause structure such as the one shown along the abscissa of the figure ("The author that the critic insulted hired a lawyer"). Participants were told that after the sentence was finished they would be asked either to recall the sentence verbatim, or to answer a comprehension question such as "who hired the lawyer?" The listener was always told in advance whether verbatim recall or comprehension would be tested; our interest was in how they would allocate their attentional resources as they were listening to the sentence, depending on their listening goals.

Figure 3 shows the mean pause times for the two listening conditions (listening for verbatim recall or for comprehension questions). One can see that in both listening conditions participants paused especially long after the verb ("insulted") that marks the end of the major syntactic clause, "The author that the critic insulted." Once this clause had been completed, and perhaps temporarily stored in working memory, in both cases the listener re-set to shorter pauses as the next clause began. Somewhat longer pauses, especially for the comprehension condition, were also seen at the end of the sentences. This configuration is sometimes referred to as a sentence "wrap up," where the listener now integrates the elements for full sentence coherence.

Thus, regardless of the listening goals, individuals demonstrated a listening pattern that is sensitive to the syntactic structure of the sentences, a common finding in both listening-time (Waters and Caplan, 2001) and reading-time studies (Stine-Morrow et al, 2006). We see the effects of listening goals, however, in the relatively longer pause times at the major clause boundary of a sentence and a larger wrap-up effect when the listening goal was to prepare oneself to answer a comprehension question. Because these were short

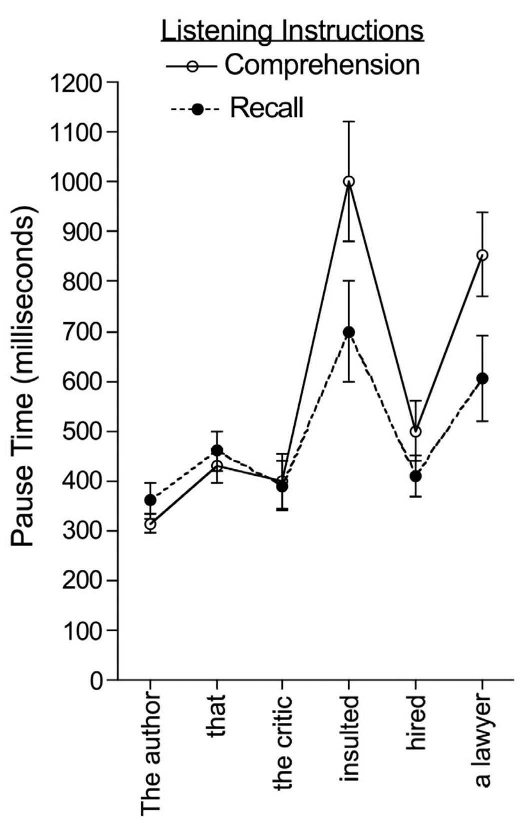

Figure 3. Pause durations across segment positions when listeners were allowed to self-pace a sentence presentation. Shown are the pacing patterns when instructions were to listen in order to be able to answer comprehension questions or to be tested for verbatim recall of the sentence. (Data from Fallon et al., 2006.)

sentences that were within memory span for most individuals, listening for verbatim recall apparently resulted in less need for the clause and sentence-final wrap-up that was required for comprehension. Longer, more demanding sentences might be expected to show a different pattern, with heavier demands on abstracting sentence meaning to support recall. (See Fallon et al, 2006, for a more complete discussion of listening goals and expectation effects.) One can thus see the implications of studies such as these for attentional resources in persons with hearing loss. That is, to the extent that hearing impairment depletes resources by requiring extra processing effort, listeners with even a mild hearing loss may consequently be deprived of processing resources that might otherwise be available for integration and consolidation of spoken discourse.

PERCEPTUAL EFFORT AND PERCEIVED SELF-EFFICACY

Kahneman (1973) and others have suggested that although attentional resources may be limited they are not necessarily fixed. Specifically, the argument is that motivational factors might lead not only to an increase in the resources allocated to a difficult task, but that a willingness to commit special effort might also temporarily increase resource capacity itself. This notion is based on a limited resource hypothesis that has two components.

The first element of the hypothesis is that for successful performance of a cognitive task, allocation of resources to the target activity should be proportional to the resource demands required by the task. When demands are low, resource capacity will not be reached and performance should be at a good level. For example, a study by Wingfield et al (2006) showed relatively good comprehension performance for individuals with mild-to-moderate hearing loss for syntactically simpler sentences that did not place inordinate demands on working memory. A corollary to this is that performance can suffer if task demands exceed available resources. This was illustrated in the same study by a significant negative effect of hearing loss on comprehension when sentences, spoken by the same speaker and at the same intensity, had a more complex syntactic structure that put especially heavy demands on working memory resources (Wingfield et al, 2006).

Pichora-Fuller and Souza (2003) extended this principle of resource allocation to the observation that individuals with hearing loss sometimes tend to dominate conversations in contrast to the usual social practice of frequent turn-taking with another speaker. In a conversation with another person one must allocate resources both to comprehending what the other person is saying and to planning one's own response. When faced with effortful listening attendant to diminished hearing acuity, it is more economical to expend these limited resources on the less effortful talking relative to the potentially extensive effort required for successful listening. In this way, longer turn-taking that favors speaking relative to listening, although often socially inappropriate, may represent a cost-strategy that offers the greatest protection of one's naturally limited processing resources (Pichora-Fuller and Souza, 2003). Pichora-Fuller and Souza's account can thus be seen to fit well with the notion of limited resources that must be shared among processing operations.

Self-efficacy and Control Beliefs

There is an additional aspect of the limited-resource argument that has received less attention in language processing research. This is the notion in the psychology literature that an individual will invest effort in successful task performance only to the extent that he or she believes that successful performance is possible (Bandura, 1997; West et al, 2003). For example, a common belief is that aging brings inevitable memory loss. As a consequence, many older adults may not expend the necessary effort to engage in effective encoding strategies, such as "chunking" of memory materials, that might significantly mitigate these memory complaints (Miller and Lachman, 2000). In this literature the term "self-efficacy" is used to refer to one's beliefs about one's cognitive ability or competence, and "control beliefs" to the belief that cognitive performance can be positively influenced by one's efforts or strategies (Bandura, 1997; Lachman and Andreoletti, 2006). Research shows that individuals with a strong sense of self-efficacy will attempt to control their processing strategies to a degree that a person with low perceived self-efficacy will not (Lachman and Andreoletti, 2006).

Our concern in this discussion is that hearing loss may lead to an analogous lowering of self-efficacy, and thus weaken personal control beliefs. Indeed, research has reported a strong association between hearing loss and low general self-efficacy (Ormel et al, 1997). To the extent that hearing loss reduces an individual's belief in his or her ability to succeed in processing spoken language, it may reduce the likelihood that the individual will attempt the challenge of effortful listening and to engage in potentially adaptive listening strategies. As such, control beliefs could have a significant effect on performance, whether the task is recalling speech or attempting to understand a rapidly spoken sentence with complex syntax. The proposal is thus that control beliefs could affect performance regardless of the absolute level of raw cognitive or sensory ability. It is of course the case that when sensory input is severely degraded it may be that no amount of effort will improve performance, what Norman and Bobrow (1975) referred to as a "data-limited" situation. Our focus here is on "resource-limited" situations, where there is sufficient sensory information to allow benefit from additional processing effort.

The question of whether self-efficacy is domain specific (for example, specific to memory), or even task specific (for example, specific to remembering grocery lists), or whether an individual's concerns in one area may overflow into a general loss in control beliefs is a subject of discussion in the literature (West and Berry, 1994). That is, in addition to the influence of cognitive function on the effective use of hearing aids (Lunner, 2003), a similar argument can also be made for the influence of control beliefs on their effective use. In the domain of hearing acuity Smith and West (forthcoming) have developed a measure of self-efficacy that shows a relationship between an individual's degree of hearing loss and his or her belief that they can profit from aided listening. An important question is whether control beliefs can be modified. For example, it is possible that strategies that have been demonstrated to enhance one's sense of self-efficacy, such as practicing easier skills before moving on to more complex ones, can be helpful in audiologic rehabilitation (Smith and West, 2006).

We suggest that developments in our understanding of language comprehension in individuals with hearing loss, and developments in our understanding of the effects of cognitive self-efficacy and control beliefs, may encourage a marriage of the two fields of study in order to gain deeper insight into the multiple sources underlying hearing acuity, effort, and individual differences in successful speech comprehension.

CONCLUSIONS

The ease with which we ordinarily process spoken language in our everyday lives can lead one to underestimate the complexity of the perceptual and cognitive operations involved. Comprehension involves successful operations at many levels, including phonological analysis, lexical identification, and complex linguistic processes including syntactic and semantic resolution of the sensory input. In order to be accomplished successfully, these operations must be carried out with an appropriate allocation of attentional resources, guided by listening strategies and effort.

Well-fitted hearing aids and other assistive listening devices can significantly improve speech audibility within constraints as might be imposed by higher-level processing deficits such as the temporal and spectral processing deficits often encountered in older adults (Pichora-Fuller and Souza, 2003). In this discussion we have focused on effective listening in its broadest sense. We suggest that efforts to assist individuals with hearing impairment in optimizing their comprehension and memory for spoken language under the challenges of everyday listening could benefit from a framework that includes a larger understanding of differences in attentional resources, cognitive capabilities, self-efficacy and control beliefs.

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