

## Ambiguity Resolution as a Function of Reading Skill, Age, Dementia, and Schizophrenia: The Role of Attentional Control

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At any given point in time, every stimulus affords multiple dimensions to be selected. Even a simple flash of light on a computer screen simultaneously offers duration, luminance, and location. The extent to which one dimension is selected over another is likely to reflect (a) the number of competing dimensions, (b) the relative strength of the selected dimension compared with the relative strength of the competing dimensions, and (c) the ability to maintain some attentional set or selection device across time. When one considers problems of attentional selection, words are likely to be the richest stimulus in terms of potential processing pathways. Visually presented words afford luminance, location, color, orthography, phonology, morphology, syntax, and semantics, among many others. Of course, in most language processing contexts, the language user directs attention to the meaning of the stimulus, but other components are clearly available and important.

In the case of ambiguity resolution, not only are there qualitatively distinct types of dimensions (e.g., location vs. syntax) engaged, but also there is within-level competition. Although within-level competition is likely to be stronger than between-levels competition, the basic problem for the language user is again quite simple: He or she is confronted with an attentional selection problem. In the present chapter, we review the evidence concerning ambiguity resolution and show the relevance of this process to more general aspects of attentional selection.

In this review, we focus on studies of ambiguity resolution across distinct populations and tasks. We emphasize cross-population and cross-task comparisons, because most studies of ambiguity resolution have focused on the types of information and processes that skilled readers use to comprehend sentences in specific measures, such as speeded word naming, lexical decision, and eye fixation patterns during reading. Although this work has been central to a number

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of critical findings in psycholinguistics, it has also led to controversies regarding the extent to which the activity of word identification is constrained by higher order semantic and contextual representations (e.g., Binder & Rayner, 1999; Kellas & Vu, 1999; Swinney, 1979; Tabossi, 1988a). We believe that some of these controversies may be due to the neglected role of attention and task demands in modulating the pattern of results. For example, in a direct comparison of distinct lexical processing tasks, Balota and Paul (1996) showed that one finds quite different patterns of priming effects with ambiguous stimuli when attention is directed to lexical-level representations (e.g., in naming and lexical decision tasks) compared with meaning-level representations (e.g., as in relatedness judgments). Thus, where in the processing system a task directs attention modulates the observed pattern of results.

In addition to cross-task comparisons, we attempt to provide leverage on understanding lexical ambiguity resolution by focusing on how these processes may differ across distinct participant populations, such as high- versus low-span individuals (e.g., Miyake, Just, & Carpenter, 1994), skilled versus unskilled readers (e.g., Gernsbacher, Varner, & Faust, 1990), young (around 20 years of age) versus old adults (around 70 years of age; e.g., Paul, 1996), healthy controls versus individuals with schizophrenia (e.g., Chapman, Chapman, & Miller, 1964), and healthy older adults versus individuals with dementia of the Alzheimer's type (DAT; e.g., Balota & Duchek, 1991; Faust, Balota, Duchek, Gernsbacher, & Smith, 1997). These populations have been targeted because of the converging evidence indicating that there are general attentional breakdowns in these groups. Finally, we evaluate specific interpretations of the data that concern the role of inhibitory processes in meaning selection and the maintenance of contextual representations.

### Individual Differences Among Healthy Young Adults

Recent studies indicate that the ability to use context to constrain the interpretation of ambiguous words depends on working memory capacity (Gernsbacher, 1997b; Gernsbacher & Faust, 1991a; Gernsbacher & Robertson, 1995; Gernsbacher et al., 1990; Long, Oppy, & Seely, 1994; Miyake et al., 1994). For example, Miyake et al. (1994) had low-span, mid-span, and high-span individuals (Daneman & Carpenter, 1980) read sentences containing either balanced homographs (words having two equally frequent meanings, as in *YARD*) or polarized homographs (words having a clear dominant meaning and one or more subordinate meanings, as in *BOXER*). Reading latencies were recorded with a moving window procedure, and the disambiguating context followed the homograph. For example, participants might be presented the polarized word *BOXER* in the following sentence, *Since Kelly really liked the boxer, he took a bus to the nearest sports arena to see the match*. Miyake et al. found that when subsequent context required the integration of the subordinate meaning of polarized homographs (e.g., the *dog* meaning of *boxer*), large group differences emerged in reading latencies. Specifically, high-span readers did not show ambiguity costs (i.e., longer latencies for words following the disambiguating context), whereas low-span and, to a lesser degree, mid-span readers did produce ambiguity costs.

This pattern may suggest that working memory capacity limits the ability to maintain subordinate meanings across time. Alternatively, it is possible that low-span participants are simply more impaired in integrating low-frequency interpretations of previously encountered homographs.

Reading skill is another factor related to processes involved with ambiguity resolution. At the onset, it should be noted that although the label *reading skill* is the variable that discriminates groups of participants in these studies, reading skill is not independent of memory span (see, e.g., Carpenter, Miyake, & Just, 1994, for evidence that these factors are highly correlated). In one study of reading skill, Long et al. (1994) presented passages via rapid serial visual presentation, with one of the sentences containing a balanced homograph as the final word (e.g., *The townspeople were amazed to find that all the buildings had collapsed except the mint.*). After a variable stimulus onset asynchrony (SOA), participants made lexical decisions to associates (e.g., *MONEY* vs. *CANDY*) or inference words (e.g., *EARTHQUAKE* vs. *BREATH*) that were related to alternative meanings of the homographs. Long et al. found that high-skill readers responded faster to context-appropriate inference words (e.g., *EARTHQUAKE*) than to inappropriate inference words (e.g., *BREATH*), whereas latencies did not differ between the two types of inference targets for low-reading skill participants. In addition, less-skilled readers even failed to show an appropriateness effect when they were asked comprehension questions after each passage (distributed presentation) instead of after each block of passages (blocked presentation). The inability for less-skilled readers to use message-level information may have occurred either because they failed to compute topical inferences on-line or because they were less able to generate inferences during target processing. Interestingly, Long et al. did not find any group differences with respect to homograph associates. Both groups were faster to respond to targets related to the appropriate meaning (e.g., *MONEY*) than to the inappropriate meaning (e.g., *CANDY*) at SOAs longer than 200 ms. Thus, both groups were able to use meaning-level sentence constraints to select the context-appropriate (lexically associated) meaning. However, it is possible that backward-checking mechanisms involved in lexical decision performance (i.e., a bias to respond "word" to contextually-appropriate information) may have contributed to the observed appropriateness effect (see Neely, 1991, for a review).

The research by Gernsbacher and colleagues (Gernsbacher, 1997b; Gernsbacher & Faust, 1991a; Gernsbacher & Robertson, 1995; Gernsbacher et al., 1990) suggests that the ability to inhibit partially activated but inappropriate information appears to be a general distinguishing characteristic of skilled versus less-skilled readers. Although they have presented converging evidence from a number of experimental paradigms, we focus here on the context-inappropriate meanings of ambiguous words. A reduced ability to suppress irrelevant information would lead to both an increased memory load (due to additional information entering working memory) and a less-coherent contextual representation. Gernsbacher et al. (1990) tested this hypothesis using a relatedness judgment task (i.e., participants decided as quickly as possible if a target word is related in meaning to a preceding sentence). Sentences included a final (balanced) homograph or an unambiguous control word. Both groups of readers were slower to make relatedness judgments to context-inappropriate

target words following homographs (e.g., *ACE* given the sentence *He dug with the spade*) than to targets following control sentences (e.g., *ACE* given the sentence *He dug with the shovel*) after a short (100-ms) delay. However, at the longer (1,000-ms) delay, only less-skilled readers were slowed by the inappropriate relation between *ACE* and *spade*. Gernsbacher et al. interpreted these results as suggesting that less-skilled readers are not as efficient as more-skilled readers in suppressing context-inappropriate homograph meanings. Furthermore, Gernsbacher and Faust (1991a) demonstrated that this result was not likely due to poorer comprehension or poorer maintenance of context per se. When asked to judge the relatedness of context-appropriate targets (e.g., *GARDEN*), both skilled and less-skilled readers showed similar benefits for biased sentences (e.g., *He dug with the spade*) compared with unbiased sentences (e.g., *He picked up the spade*).

A more recent study (Gernsbacher et al., chapter 8, this volume; as discussed in Gernsbacher & St. John, chapter 4, this volume) has extended these findings to investigate the consequences of selection on the nonselected interpretation. This study used the context-repetition task, similar to a study by Simpson and Kang (1994; also see Gorfein, chapter 10, this volume; Simpson & Adamopoulos, chapter 7, this volume), in which balanced homographs were repeated in successive sentences, and participants judged whether each sentence made sense. Skilled readers' responses were faster for sentences that repeated meanings (e.g., *She blew out the match* following *She lit the match*) and slower for sentences that changed meanings (e.g., *She won the match*) than for nonsense sentences (e.g., *She prosecuted the match*). In contrast, less-skilled readers' responses were faster for sentences that repeated meanings, but no costs were found for sentences that changed meanings. These results are again consistent with the view that less-skilled readers have inefficient inhibition mechanisms. Thus, after processing the initial sentence, the context-inappropriate meaning remained accessible when the subsequent sentence required its selection. However, it should be noted that less-skilled readers are not more likely to accept context-inappropriate associates to homographs following biasing sentences. This was nicely demonstrated by Gernsbacher et al. (chapter 8, this volume). In this study, participants indicated whether the target was related to the sentence-final word but not to the sentence as a whole. In other words, participants were to respond "yes" to *ACE* following *He dug with the spade* because *ACE* and *SPADE* are associatively related. Interestingly, "yes" responses produced more slowing in this condition for less-skilled readers than for more-skilled readers. This might be viewed as consistent with the notion that less-skilled readers have difficulty selecting a unique interpretation of the sentence-homograph sentence. We address the implications of this result in more detail after discussing age differences in lexical ambiguity resolution.

Taken together, the studies reviewed in this section suggest that working memory limitations influence a reader's ability to maintain the subordinate interpretation of a polarized homograph or to use disambiguating cues to integrate the subordinate meaning into the sentence representation (Miyake et al., 1994). The results by Long et al. (1994) suggest that with balanced homographs differences in reading skill lead to differences in making inferences (either online or backward at target presentation), whereas the studies by Gernsbacher



indicate that less-skilled readers are less efficient in deactivating the contextually inappropriate meanings of balanced homographs.

### Age-Related Differences in Ambiguity Resolution

There is clear evidence that older adults, on average, have smaller working memory spans than younger adults (see Balota, Dolan, & Ducheck, 2000, for a review). In addition, there is some evidence that older adults exhibit some breakdowns in comprehension performance compared with younger adults (see Kemper, Jackson, Cheung, & Adamopoulos, 1993). In contrast to these age-related deficits, there is also considerable evidence that the automatic aspects of semantic priming are relatively constant across young and older adults (Balota & Ducheck, 1991; for a review, see Ducheck & Balota, 1993).

Overall, this age-related profile appears consistent with some aspects of the general cognitive landscape of skilled versus less-skilled readers reported by Gernsbacher, Varner, and Faust (1990). Indeed, Hasher and Zacks (1988; see also Stoltzfus, Hasher, & Zacks, 1996) proposed that older adults' reduced language comprehension abilities are due to inefficient inhibitory mechanisms. Specifically, Hasher and Zacks proposed that older adults are (a) less efficient in blocking irrelevant information from entering working memory and (b) are less able to discard irrelevant information that has already gained access to working memory. These characteristics lead to difficulties in comprehension for older adults. Of course, this theoretical perspective is very similar to the one advanced by Gernsbacher, Varner, and Faust (1990) concerning high- and low-skilled readers.

If the inhibition breakdown account is correct, and if older adults suffer from less-efficient inhibitory mechanisms, older adults should be less able to use context to restrict access of the appropriate meaning and to inhibit or deactivate context-inappropriate meanings. Overall, the literature does not support this prediction. For example, in a study conducted by Hopkins, Kellas, and Paul (1995), younger and older participants silently read contextually biased homograph-ending sentences (e.g., *She received the letter* vs. *The boy learned a new letter*) and named target words that followed. Targets were either related or unrelated to the homograph. If related to the homograph, the target was either consistent or inconsistent with the sentence context, and either strongly or weakly implied by the sentence (e.g., *NOTE* vs. *ADDRESS*). Two findings from this study are noteworthy. First, with the exception of longer reading times and slower naming latencies, the pattern of results did not differ between younger and older adults. Second, both groups showed selective access for the context-appropriate meaning. Specifically, at a 200-ms homograph-target SOA, both younger and older adults showed facilitation for targets related to the context-appropriate meaning, regardless of meaning dominance. In addition, latencies to targets related to the homograph but inconsistent with the sentence context were no different than latencies to unrelated targets. Thus, aging does not seem to limit one's ability to use context to activate the context-appropriate meaning. Moreover, these results appear to be inconsistent with the deactivation hypoth-

esis proposed by Stoltzfus et al. (1996). Specifically, aging does not seem to affect one's ability to use context to restrict initial access of meanings.

In an attempt to further test the inhibition-deficit hypothesis, Paul (1996) extended Hopkins et al.'s (1995) paradigm to a situation in which disambiguating sentence cues appeared after the polarized homograph (e.g., the word *COUNT* in the sentence *The count was determined correctly*). In this situation, multiple access was expected to occur when the homograph was read, and inhibition-deactivation of the context-inappropriate meaning was expected to occur after the disambiguating context was read. Again, the target was presented immediately after the sentence-final word for a speeded naming response, and it was related to the dominant or subordinate meaning of the homograph (e.g., *MATH*, *ROYALTY*) or it was unrelated (e.g., *GROWL*). The only age-related difference found in this study was a main effect of age, with older adults being slower overall to read the sentences and to name the targets; both groups responded faster to targets related to the context-appropriate meaning than to unrelated targets, regardless of meaning dominance.

In a cross-experiment comparison, Balota and Duchek (1991) and Balota, Boland, and Shields (1989) used an identical speeded naming paradigm with young and older adults. There were four primary conditions of interest: concordant (e.g., *MUSIC-ORGAN-PIANO*), discordant (e.g., *KIDNEY-ORGAN-PIANO*), neutral (e.g., *CEILING-ORGAN-PIANO*), and unrelated (e.g., *KIDNEY-CEILING-PIANO*). Although participants named all three words aloud on each trial, the response latencies to name the third word (e.g., *PIANO*) was the primary dependent measure. These studies indicated that response latencies to the third word were reliably faster in the concordant condition compared with the remaining three conditions, with both young adults (see Balota, Boland, & Shields, 1989) and older adults (Balota & Duchek, 1991) showing the same pattern. These results suggest that both young and older adults equally selected the congruent interpretation and that, in the discordant condition, there was actually inhibition of the inappropriate interpretation, thereby eliminating any priming from the second word to the third target word.

More recently, Brady, Balota, & Faust (1996) investigated age-related inhibitory control using a relatedness judgment task, similar to the task originally reported by Simpson and Kellas (1989). In this study, participants made relatedness judgments to word pairs consisting of homograph primes followed by related or unrelated targets. Each homograph was presented on two separate trials at varying lags. On the second presentation, targets were congruent (e.g., *BANK-MONEY* vs. *BANK-SAVE*), incongruent (e.g., *BANK-MONEY* vs. *BANK-RIVER*), unrelated-related (e.g., *BANK-CACTUS* vs. *BANK-SAVE*), or unrelated-unrelated (*BANK-CACTUS* vs. *BANK-CHEESE*). In Brady et al.'s study, targets followed homograph primes that were presented for 500 ms, and participants made relatedness judgments to the word pairs. Latencies were transformed to control for age-related cognitive slowing (e.g., Faust, Balota, Spieler, & Feraro, 1999). The interesting finding was that for the young and healthy older adults, meaning selection on the first presentation led to an active inhibition of the unselected meaning. Specifically, significant costs for incongruent trials were observed (i.e., increases in latencies and error rates on the second presentation in relation to the unrelated-related condition), and there was no

evidence of a difference in the size of the costs across young and healthy older adults.

In summary, the studies of age-related changes in homograph disambiguation appear to be somewhat different from the studies of young adults that vary in comprehension skill, reading skill, or working memory. One simple explanation for this discrepancy is that older adults are relatively less impaired in language processing tasks because of the additional 50 years of practice in language processing. Thus, although there may be working memory deficits in older adults, there is a compensatory increase in language processing efficiency because of the additional practice. However, it may be that age-related differences are more likely to occur when tasks require meaning-level backward integration of the target with previously encountered information. To more fully illustrate this point, we first describe two studies that reveal age-related impairments in homograph disambiguation, and then we highlight task characteristics that may or may not tap older adults' breakdowns in lexical ambiguity resolution.

Both studies that appear to support the notion of an age-related (inhibitory) breakdown (Faust et al., 1997; Johnson, McDowd, & MacDonald, 1993, cited in McDowd, Oseas-Kreger, & Filion, 1995) used Gernsbacher's (Gernsbacher & Faust, 1991a; Gernsbacher et al., 1990) original homograph relatedness paradigm to investigate the inhibition-deficit hypothesis (e.g., *He dug with the spade* vs. *He dug with the shovel*, with *ACE* serving as the target for a relatedness judgment). Johnson et al. (1993) directly compared younger and older adults and found that, after a long delay, older adults experienced more interference than younger adults when required to reject context-inappropriate meaning targets. In contrast, both younger and older adults showed comparable SOA-independent facilitation effects for context-appropriate targets. This is the same pattern that Gernsbacher et al. reported for skilled and less-skilled young adult comprehenders. Faust et al. also found that older adults produced large interference effects of 145 ms and 123 ms at both the short and long SOAs, respectively. Thus, older adults in both Faust et al.'s study and Johnson et al.'s study exhibited considerable interference at the long SOAs, which is the same pattern reported for the less-skilled readers in Gernsbacher et al.'s (1990) study, reviewed above.

Now consider what may be regarded as maximally adaptive behavior with respect to Gernsbacher's homograph relatedness task. First, judging whether the target fits the meaning of the sentence requires meaning-level backward integration of the target to the sentence. In particular, attention needs to be focused on semantic-level representations to achieve the goals of the task. Second, on spade-ace type trials, successful integration is particularly demanding because it requires attentional selection on sentence-level constraints (*something to dig with*), while the system must inhibit or ignore lexical-level associations between the target (*ACE*) and the homograph (*SPADE*).<sup>1</sup> Therefore, a tentative account of adult age differences in the Gernsbacher task is that older adults may be impaired when the task requires meaning-level backward integration of the target, especially when controlled attention between conflicting

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<sup>1</sup>This account does not deny the possibility that active inhibition is involved in selecting the optimal pathway, especially when selection among conflicting constraints is required.

pathways is involved, and there is a conflict between currently active interpretations.

In contrast to Gernsbacher et al.'s (1990) task, consider the task demands of the tasks used by Balota and Duchek (1991), Balota et al. (1989), Hopkins et al. (1995), and Paul (1996). All four studies used naming latencies for targets presented after a sentence embedded homograph as an indicator for the degree of meaning activation. It has been argued (Balota & Lorch, 1986; Neely, 1991) that in this type of task, participants do not necessarily engage in backward integration of the target meaning into the preceding context. Rather, contextual influences on target naming may reflect forward spreading activation or attentionally mediated expectancy effects (for a review, see Neely, 1991). Assuming that, in Hopkins et al.'s (1995) and Paul's (1996) studies, participants did not engage in backward integration, the context effects may reflect relatively automatic sentence-level and lexical-level forward influences. In the consistent-target condition, these two constraints work in the same direction, whereas on inconsistent trials, they are in opposition (for a similar account, see Paul, 1996). Because successfully naming the target in these studies did not require backward integration or pathway selection, age-related differences in performance were less likely to be observed than in tasks that require these demands. In some sense, less integrative load is being placed on the system in the naming task compared with the relatedness judgment tasks. On the basis of this account, one might predict that if reading time for words following the homograph had been measured in Paul's (1996) study, as in Miyake et al. (1994), impairments in older adults might have been detected.

In summary, the appearance of age-related differences in ambiguity resolution appear to depend in part on the task demands. Skill and age-related breakdowns are more likely to occur when pathway selection and backward integration are required for successful responding. At this level, one might argue that deficits in ambiguity resolution are due mainly to attentional deficits, and these lead to less than optimal adaptation to task demands (Balota, Paul, & Spieler, 1999).

This account, however, does not fully explain all the data. For example, it is unclear why less-skilled readers in Gernsbacher et al.'s (chapter 8, this volume) study showed reduced costs on trials repeating the homograph whereas older and younger adults in Brady, Balota, and Faust's (1996) repetition context study incurred equivalent costs. Both tasks appear to require meaning-level processing and integration on each trial. One possible explanation is that it is more attention demanding to integrate information at the sentence level (as in Gernsbacher & Robertson's study) compared with the word-pair level (as in Brady et al.'s study). Older adults' impairments may be restricted to the more demanding sentence-level integration, leading to a lack of observable age-related declines when word-pair relatedness judgments are required, as in Brady et al.'s study. This possibility needs to be directly tested.

### **Ambiguity Resolution in Dementia of the Alzheimer's Type**

A number of studies have provided evidence of problems in attentional selection and an inhibitory control deficit in DAT (see Balota & Faust, in press, for a

review). For example, individuals with DAT show relatively large increases in the Stroop effect (i.e., the increase in latency to name the ink color of a word when the word corresponds to an incompatible color name, e.g., the word *red* printed in blue ink; Spieler, Balota, & Faust, 1996). In addition, DAT individuals do not exhibit negative priming (i.e., slower responses to previously ignored stimuli), and they make more intrusion errors in a negative priming paradigm than controls when distractor information is semantically related to the target (e.g., *DOG-CAT*) but not when the distractor is semantically unrelated (e.g., *DOG-TABLE*, Sullivan, Faust, & Balota, 1995). Finally, in studies of reading aloud, DAT individuals show an increase in regularization errors (pronouncing *PINT* as rhyming with *MINT*), indicating a difficulty in suppressing codes generated by sublexical spelling-to-sound mechanisms (Balota & Ferraro, 1993; Patterson, Graham, & Hodges, 1994). Similar to the arguments made by Gernsbacher et al. (1990) regarding skilled and less-skilled readers and by Hasher and Zacks (1988) regarding young and older adults, it is possible that the comprehension difficulties observed in DAT individuals may be related to a more generalized deficit in inhibiting irrelevant or distracting information.

Interestingly, in situations in which attentional demands are minimized, DAT individuals show relatively normal levels of semantic priming (e.g., Balota & Duchek, 1991, Ober & Shenaut, 1995). These results indicate that representations and connections within the semantic network are relatively preserved, at least in early-stage DAT. In this light, homograph disambiguation has been a useful tool in the investigation of inhibitory control deficits in DAT because semantic representations seem to be intact whereas the ability to control activation within the network through attention may be disrupted. In general, these studies show that individuals with DAT exhibit intact facilitatory processes and deficient inhibitory control processes when reading homographs.

Studies using balanced homographs have focused on the availability of alternative meanings of ambiguous words in various contexts. For example, in Balota and Duchek's (1991) study, described earlier, the first word in the sequence (e.g., *KIDNEY*) constrained the interpretation of the following homograph (e.g., *ORGAN*) for both young adults and healthy older adults. As noted earlier, this led to facilitation in the concordant condition and equivalent performance in the discordant and unrelated conditions in healthy older adults. However, DAT individuals produced facilitation in both the concordant and discordant conditions. This pattern was taken as evidence that DAT individuals did not suppress the inappropriate meaning of the ambiguous word from the first word to the second (e.g., *KIDNEY* to *ORGAN*), thereby yielding reliable facilitation for the inappropriate target word (*PIANO*).

The results of Balota and Duchek's (1991) study converged with those of Faust et al. (1997), who used Gernsbacher et al.'s (1990) relatedness judgment task reviewed above (e.g., *He dug the whole with a spade-ACE*). In Faust et al.'s study, context constrained meaning selection more for the healthy control individuals than for the DAT individuals. Specifically, DAT individuals produced more errors (i.e., made more "yes" responses on the relatedness judgment task) and had disproportionately longer latencies for ambiguous words than for unambiguous words. The results of a second experiment indicated that DAT individuals were able to use sentences to enhance processing in appropriate contexts. Criti-



cal sentences were either congruent (e.g., *He dug with the spade-shovel*) or neutral (e.g., *He picked up the spade-shovel*), and facilitation was measured by subtracting the mean latencies of the congruent sentences from the neutral sentences. Both DAT individuals and healthy older adults showed strong facilitation for congruent sentences. These results eliminated the possibility that DAT individuals could not use sentence context to comprehend text. Thus, overall, the results of Faust et al.'s study are consistent with the notion that DAT individuals have difficulty controlling or inhibiting partially activated information.

In the homograph cross-trial repetition study by Brady et al. (1996) described above, meaning selection on the first presentation led to an active inhibition of the unselected meaning for healthy young and older adults. Specifically, after latencies were transformed to control for age-related slowing, significant costs for incongruent trials were observed (i.e., increases in latencies and error rates on the second presentation in relation to the unrelated-related condition). In contrast, DAT participants showed equivalent facilitation for congruent trials, a small increase in latencies for incongruent trials compared with controls, and a decrease in error rates for incongruent trials. These results are consistent with the aforementioned studies that suggest an inhibitory control deficit in DAT. Moreover, the error rate results are particularly interesting because this is a rare situation in which DAT individuals perform comparably (in fact, slightly better) than healthy control individuals.

It is interesting to note that a recent study by Balota, Watson, Ducheck, and Ferraro (1999) has shown a selective deficit in DAT in the ability to access subordinate meanings of polarized homographs, which does not appear to be simply due to the strength of the relationship. This study used a cross-modal priming paradigm (auditory words and visual targets) and measured speeded naming response latencies. The primes were either unambiguous words that varied with respect to the strength of the relationship to the target or polarized homographs that varied with respect to the dominance of the interpretation. DAT participants showed an increase in facilitation to both high-dominant (e.g., *FURNITURE-SOFA*) and low-dominant unambiguous prime-target pairs (*FURNITURE-RUG*) compared with healthy control individuals. However, a much different pattern was observed for ambiguous prime-target pairs. Specifically, there was again more facilitation for high-dominant polarized pairs (e.g., *BANK-MONEY*) in the DAT individuals compared with the healthy control individuals; however, the reliable facilitation for low-dominant polarized pairs that occurred in the healthy control individuals (e.g., *BANK-RIVER*) was totally eliminated in the DAT individuals. This pattern suggests either that DAT individuals are unable to suppress the dominant meaning once it becomes activated or that semantic representations of subordinate meanings are particularly sensitive to degradation in early-stage DAT.

In summary, homograph disambiguation has been used to investigate inhibitory control deficits in DAT. There are a number of studies that have provided evidence of breakdowns in processing homographs for individuals with DAT. When homographs are balanced (e.g., Balota & Ducheck, 1991; Brady et al., 1996; Faust et al., 1997), context-inappropriate meanings remain active in DAT. In contrast, when homographs are polarized (e.g., Balota, Watson, et al., 1999), subordinate meanings appear to be unavailable or difficult to access. It is

worth noting that these effects have been found in both speeded naming tasks and relatedness judgment tasks. In this light, these results converge with the observed breakdowns in inhibitory mechanisms across other tasks in DAT and suggest that inhibitory processes play a role in the control of inappropriate but partially activated interpretations of ambiguous words.

### **Ambiguity Resolution in Schizophrenia**

Interestingly, the topic of ambiguity resolution in schizophrenia has actually predated most of the contemporary work on this topic in even healthy young adults. In a classic study by Chapman et al. (1964), individuals with schizophrenia were more likely to interpret the dominant interpretation of an ambiguous word independent of the sentence context. For example, when presented with the sentence context *The farmer needed a new pen for his cattle*, individuals with schizophrenia were much more likely to interpret the word *pen* as a writing implement compared with control individuals (also see Benjamin & Watt, 1969; Blaney, 1974).

More recently, Cohen, Targ, Kristoffersen, and Spiegel (1988) extended this paradigm to investigate the temporal range of context on ambiguity resolution. In the critical conditions of this study, participants were presented contextual information that biased the subordinate interpretation of an ambiguous word (e.g., *PEN*) either before the ambiguous word (e.g., *You can't keep chickens without a PEN*) or after the ambiguous word (e.g., *Without a PEN you can't keep chickens*). The results of this study indicated that when the disambiguating information came before the ambiguous word, schizophrenic individuals were very poor at selecting the appropriately biased interpretation (e.g., *a fenced enclosure*). However, when the disambiguating information came after the ambiguous word, there was no difference between the schizophrenic individuals and the healthy control individuals. These results nicely point out the importance of contextual representations that are critical in modulating the relevant interpretation (also see Dick & McFarland, 1978, for a similar finding).

It is noteworthy that Cohen and Servan-Schreiber (1992), like Balota and Faust (2002), and Gernsbacher et al. (1990), suggest that the problems in ambiguity resolution in people with schizophrenia is symptomatic of a generalized problem in attentional selection. For example, Cohen et al. reported evidence from the Stroop color naming task that produces exaggerated interference effects, just as found in DAT individuals, reviewed above. More recently, Cohen, Barch, Carter, and Servan-Schreiber (1999) showed reliable correlations across a set of attentional selection tasks (e.g., Stroop, continuous performance) and language disambiguation tasks in people with schizophrenia.

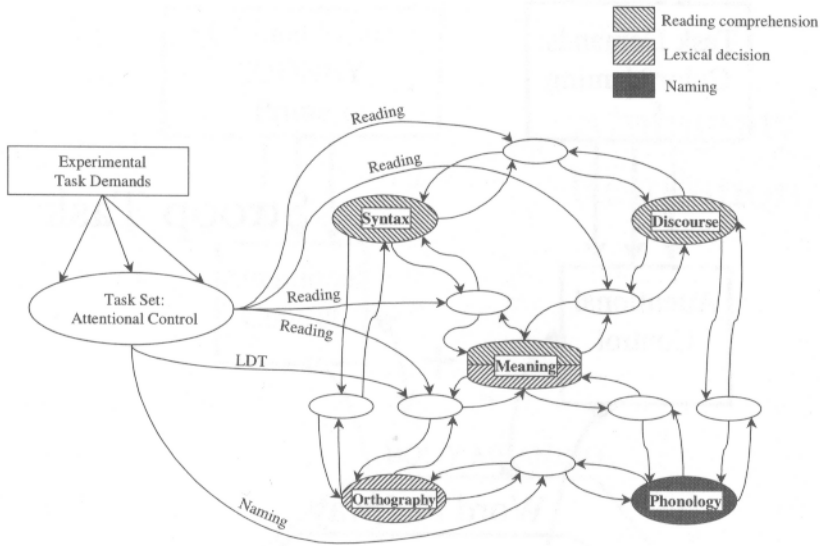
### **Ambiguity Resolution Across Groups and Tasks: A Theoretical Perspective**

At the beginning of this chapter, we suggested that individuals are constantly engaged in solving attentional selection problems. We also suggested that the

ability to solve such problems depends on (a) the number of competing pathways, (b) the relative strength of the competing pathway compared with the relevant pathway, and (c) the maintenance and quality of the task goals. First, consider the role of task goals. Here, we suggest that the processing system must engage different processing pathways depending on the goals of a specific task, and this will have consequences on later performance. Figure 6.1 (taken from Balota, Paul, & Spieler, 1999) attempts to capture the manner in which distinct tasks modulate different processing pathways. For example, speeded naming (a task that emphasizes the speed of the onset of articulation) maximizes the orthography-to-phonology pathway, whereas lexical decision (a task that forces participants to discriminate familiar and meaningful words from unfamiliar and less-meaningful nonwords) maximizes familiarity and meaning information. However, semantic relatedness decisions should be more dependent on meaning-level representations, and, when comprehension is strongly encouraged, on-line reading measures should be most sensitive to discourse-level representations. This view suggests that one may find different influences of ambiguity resolution depending on the task demands. In particular, tasks that emphasize phonological, lexical-level representations will be less likely to engage the inhibitory influences of context on alternative meaning-level representations because this is not necessary to accomplish the goals of the task. Hence, for these items, simple associative influences may play the strongest role.

We have already presented a number of pieces of evidence consistent with the importance of task goals in detecting consequences of ambiguity resolution. For example, Balota and Paul (1996) found simple additive effects of multiple primes (e.g., *INCH-PIANO*) on lexical decisions and naming latencies to homographic targets (e.g., *ORGAN*); however, when participants were required to decide if an ambiguous target word was related to either or both of the primes, there was a clear underadditive pattern. In addition, Brady and Balota (1997) investigated the consequences of ambiguity resolution in a cross-trial speeded naming task, similar to the procedure of Simpson and Kellas described above. Specifically, on Trial N, participants might receive *ORGAN-PIANO*, and then later on Trial N + 10, participants might receive *ORGAN-LIVER*. Under conditions of speeded naming, there was little evidence of inhibitory influences; however, as described above (Brady et al., 1996), when participants were making relatedness decisions, there were large cross-trial inhibitory effects. Thus, again, when attention is directed to the orthographic-to-phonological connections, by means of the naming task, there was less need to select an interpretation compared with making relatedness decisions. Finally, as noted earlier, the only place where there is clear evidence of age-related changes in the inhibition of unrelated meanings of ambiguous words is under conditions in which participants are asked to make relatedness decisions.

Now, let us adjust the microscope of analysis a bit, and zoom in on what sorts of selection devices might be involved when participants actually do need to resolve ambiguity in a task that demands semantic analyses (e.g., relatedness decisions). We believe that it is useful to consider ambiguity resolution as a form of attentional selection in which contextually relevant pathways are accentuated, and partially activated but inappropriate pathways are inhibited.

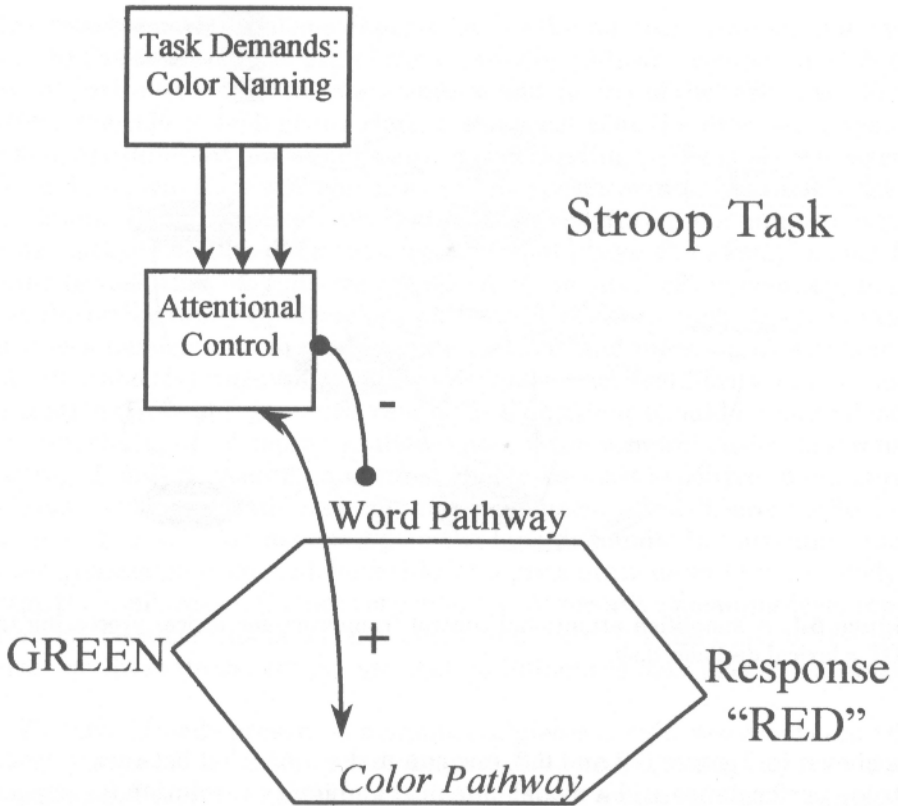


**Figure 6.1.** A simplified attentional control framework for lexical processing tasks. LDT = lexical decision task.

As shown in Figures 6.2 and 6.3, one can make a parallel between a model of Stroop performance and a model of lexical ambiguity resolution (as suggested by Cohen & Servan-Schreiber, 1992). The notion here is that, to select either the color code of a Stroop stimulus or the contextually relevant meaning of an ambiguous word, one is forced to accentuate the relevant pathway and attenuate the irrelevant pathway. The intriguing aspect of this framework is that ambiguity resolution is simply an aspect of general attentional selection processes, instead of specific characteristic of a linguistic processing module (see Neill, 1989, for a similar argument regarding the parallel between attentional selection in the Stroop task and ambiguity resolution).

Given this framework, one might ask where in this system do the group-related changes in ambiguity resolution occur? One must be cautious here because of the differences across studies and tasks and the potential influence of subtle changes on the direction of attention to different levels within the processing system, as shown in Figure 6.1. However, with this in mind, a few suggestions may be made. First, consider the changes across groups with differing memory spans. The results of Miyake et al. (1994) appear to suggest that low-span participants are relatively poor at maintaining a low-dominant interpretation of a polarized homograph across time. Turning to the results from participants with varying levels of reading skill, these results could be viewed as supportive of a breakdown in maintaining an adequate task module or possibly maintaining the contextual representations across time that disambiguates the ambiguous word. It is noteworthy that in neither case is there any necessity to suggest that there is a breakdown in inhibitory processing per se. A similar argument might be made regarding aging, Alzheimer's disease, and schizophre-



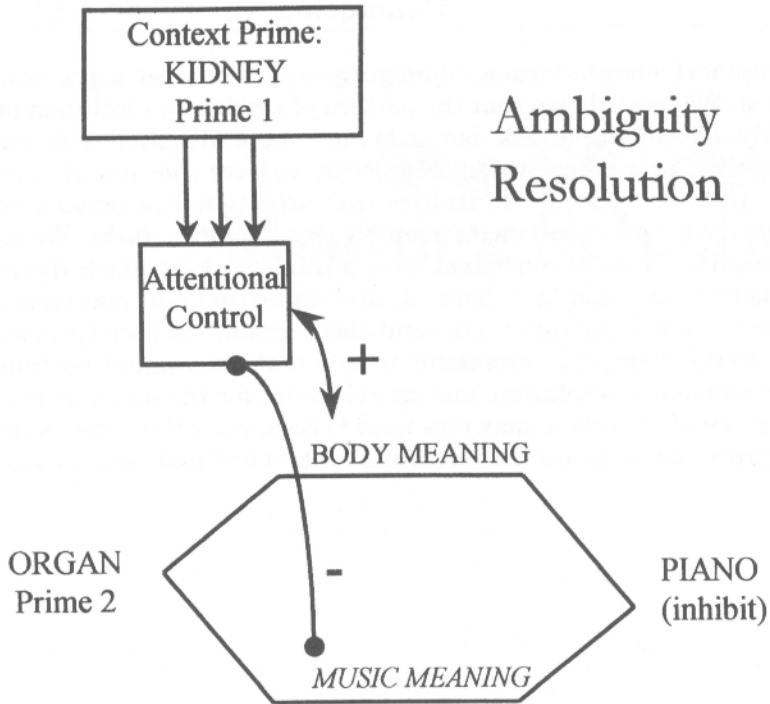


**Figure 6.2.** An attentional control framework for interpreting performance in the Stroop paradigm. Deficits as a function of aging, dementia of the Alzheimer's type, and schizophrenia could reflect breakdowns in the integrity of the attentional control module.

nia. Specifically, the breakdowns that one observes in ambiguity resolution (or the aftereffects of ambiguity resolution) may reflect the integrity of the maintaining context across time, as opposed to a breakdown in inhibition per se. Of course, the consistent breakdowns across these populations in other standard tasks that demand attentional selection (e.g., Stroop performance) also suggest that these problems reflect a generalized problem as opposed to a specific problem in ambiguity resolution.

Why might maintaining context be particularly sensitive to individual differences in memory span or susceptibility to disease processes? A few speculations are in order here: One might argue that the neural structures involved in either maintaining context or maintaining task demands (frontal lobe involvement) are the most recently evolved structures. These systems need to involve considerable flexibility, such that, to paraphrase James (1890), an individual can select one out of what seem several simultaneously possible objects or trains of thought. At any given moment, there is a multitude of codes that the processing system could attend to, and the task demands must be used to determine which of these codes are most relevant to accomplish the current goals of a





**Figure 6.3.** An attentional control framework for ambiguity resolution. Deficits as a function of aging, dementia of the Alzheimer's type, and schizophrenia could reflect breakdowns in the integrity of the attentional control module.

given task. In contrast to more dedicated systems that develop from consistent stimulus to response mappings, these control systems must be maximally flexible to engage task-relevant representations that are often changing on a moment-by-moment basis. Because of the variability in the demands placed on these structures, they will be less well-practiced and hence more susceptible to degeneration.

It is noteworthy that this view suggests that there are considerable differences across individuals in the ability to "understand the goals of the task" or maintain such a representation across time. Cognitive psychologists assume that instructions to participants naturally engage the appropriate representation to accomplish the goals of the task. However, it is quite possible that there are considerable differences in the quality of the representation that maintains the instructional set across time. Even in healthy young adults, there are slips in the task goals in the Stroop task, wherein participants name the word instead of the color of the stimulus on some trials. Such slips may not simply reflect random errors but rather may reflect fluctuations in the ability to maintain an adequate task representation across time, which must be occasionally refreshed.

## Conclusion

The present chapter has framed ambiguity resolution as an aspect of attentional selection. We have shown that the pattern of ambiguity resolution one obtains is highly dependent on task demands and where attention is directed within the linguistic processing system. Moreover, we have shown that groups of individuals that have specific difficulties with attentional selection across a wide variety of tasks produce deficits in ambiguity resolution tasks. We believe that these results are most consistent with a framework in which the integrity of systems that maintain task demands and contextual information may be most sensitive to individual differences and also degradation because of disease processes. In this light, it is interesting to note that the original excitement in the area of ambiguity resolution, and its relevance for the modularity of the language processing system, may now need to reconsider the importance of generalized processing systems that maintain context and task demands across time.