Journal of Gerontology: PSYCHOLOGICAL SCIENCES
1997, Vol. 52B, No. 6, P274–P283

Cognitive Gerontology and Attentional Inhibition: A Reply to Burke and McDowd

Rose Zacks[1] and Lynn Hasher[2]

[1]Michigan State University.
[2]Duke University.

Our response to the Burke and McDowd critiques (in this issue) begins with a history of the origins of the inhibitory deficit view and of its development since 1988 as well as with an account of some particularly useful findings and of our preferred mode of theory building, which is nonformal and empirically driven. Against this background, we find many points of agreement with Burke and McDowd but also many points of disagreement. For example, we agree with Burke that many aspects of language comprehension and production are age invariant, but we disagree that all such findings count against our viewpoint. Likewise, we readily acknowledge the problems in measuring inhibition that McDowd so clearly documents, but do not feel that this is a fatal problem as long as the inhibitory deficit view continues to be viable within the basic attentional literature, continues to permit the integration of a large body of existing data, and continues to generate new predictions.

FOR the past 10 years, our work has been guided by a framework that is closely tied to "selection-for-action" theories of selective attention (e.g., Allport, 1989; Navon, 1989a, 1989b; Neill, 1989; Tipper, 1992). These theories propose that excitatory and inhibitory processes operate together to regulate attention. We have elaborated on these theories in order to extend them to memory and language processing situations, with a particular emphasis on the possibility that there are individual and group differences in basic inhibitory but not excitatory attentional mechanisms that may help to account for patterns of spared and impaired functioning among older adults.

A body of work has now accumulated, making it timely to consider the larger theoretical framework. Our own recent evaluations can be seen in three chapters: one by Hasher, Zacks, and May (in press), another by Stoltzfus, Hasher, and Zacks (1996), and one by Zacks and Hasher (1994). To a large degree, those publications and attendant empirical findings from our labs and those of other investigators who work within a similar view frame our responses to the critique made by Burke (1997) addressing language processing and the one made by McDowd (1997) addressing basic attentional issues. Before responding to these critiques directly, we place our theory development work in a historical context. We then discuss a series of theory-generated findings that highlight the potential value of a broad, integrative theoretical framework. We also make explicit several pretheoretical assumptions and general predispositions to research that will be used to clarify points of agreement and disagreement with the two critiques. With this overview of the the origin and development of our theory, and with a selection of recent empirical findings, we turn to the final section of this article, in which we address specific empirical and theoretical points that are raised in the critiques.

Historical and Intellectual Context

Hasher and Zacks (1979) proposed a theoretical framework that attempted to build on then current understandings of attentional limitations in order to explain differences in memory performance across tasks and groups of individuals. Building on the suggestion that there is limited capacity available for mental work (e.g., Kahneman, 1973), we initially proposed that memory encoding processes differ in the amount of capacity they require and that groups of people differ in the capacity they have available, such that currently depressed young adults, young children, and older adults have less capacity than do nondepressed young adults. Fundamental to this proposal was the idea that some attributes of information are so basic that they are encoded by most people as automatic by-products of attending to an input (see Hasher & Zacks, 1984). The result of the inevitable storage of information, such as the frequency of occurrence of elements and their combinations, is the creation of an implicit knowledge base that can then serve to streamline behavior wherever environmental regularities prevail and prediction is useful. Recent work suggests that such knowledge can be used to bootstrap even very early elements of language acquisition (Saffran, Aslin, & Newport, 1996).

Much of our research dealt with more effortful processes, particularly in the domain of human memory. There we became aware of the possibility of extending the general viewpoint of attentional capacity limits into the domain of language comprehension. We were particularly interested in the critical process of forming on-line inferences of the sort that enable immediate comprehension and that ultimately permit long-term recollection of discourse (see Hasher & Zacks, 1988; Zacks & Hasher, 1988; Zacks, Hasher, Doren, Hamm, & Attig, 1987). This work required a refinement of the notion of capacity limits and here again

we borrowed from and elaborated on the work of others (e.g., Baddeley, 1992; Daneman & Carpenter, 1980) to shift our focus to working memory capacity. We assumed that general limits on working memory capacity are differentially distributed between storage and processing functions such that as capacity diminishes (as it may with aging), processing components would be spared at the expense of storage components, at least in language comprehension tasks. We made this assumption because language processing has powerful stimulus-driven components and because the social circumstances in which language is used demand appropriate and timely responses.

Our findings were generally consistent with such views (see Hasher & Zacks, 1988, pp. 194–208; Zacks & Hasher, 1988; Zacks et al., 1987). Nonetheless, because our work on memory and language and increasingly in cognitive gerontology was grounded in theories originating in the domain of attention, the growing and quite profound criticisms of the basic assumptions of limited and general capacity notions made by mainstream attention theorists (e.g., Hirst & Kalmar, 1987; Navon, 1984) eventually became quite compelling to us (see Hasher & Zacks, 1988; McDowd, 1997). Coupled with preliminary findings in our inference formation work that suggested the possibility that older adults — despite their presumed reductions in capacity — actually had too much, not too little information stored in working memory (Hamm & Hasher, 1992), we sought an alternative way to interrelate attentional constraints on memory and language processing.

The initial formulation of this alternative view is seen in Hasher and Zacks (1988, pp. 212–220), where we adapted notions from selection-for-action attention theories that proposed that selection requires both excitatory and inhibitory processes (Neill, 1989; Tipper, 1992). Our reading of the then extant literature suggested that inhibitory attentional processes are impaired with aging, while excitatory processes are spared (see Appendix, Note 1). Excitatory processes seemed likely spared on the basis of the findings in semantic priming showing equal or greater priming for older adults even under largely automatic conditions. With respect to inhibition, we originally suggested that these processes might serve two major functions, controlling both *access* to and *deletion* from working memory (Hasher & Zacks, 1988) (see Appendix, Note 2). With respect to the access function, efficient inhibition limits entry into working memory to the subset of activated representations that are most directly relevant to the task at hand. This, of course, assumes that nonrelevant representations can be active, as might occur when a subsidiary goal activates information not relevant to the main goal. With respect to the deletion function, efficient inhibition operates to suppress from working memory any nonrelevant information or any information that becomes nonrelevant because of changes in topic, task demands, and so on. On the basis of new findings, we recently added a third function of inhibition mechanisms, *restraint* over strong responses (see Hasher et al., in press; May & Hasher, in press).

This theoretical framework has guided our research over the past 10 years and continues to do so. In the next section, we highlight selected examples of our work, focusing on studies we might not have otherwise undertaken without this guiding framework. In doing so, we highlight some strengths of an integrative theoretical approach, for example in seeing parallels in underlying mechanisms across dramatically different tasks, in explaining both disrupted and spared performance patterns, and in generating alternative explanations for old phenomena.

Recent Findings

There is a very rich literature in selective attention suggesting the problems older adults have in dealing with distraction. Our attempts to explore this phenomenon have included the use of a reading with distraction task in which the nature of the distraction was varied, from meaningless strings of Xs, to words, to phrases related to the content of the target passage. Not surprisingly, we found that older adults are differentially bothered by distraction, especially if the distraction bears a meaningful relationship to the target information (Connelly, Hasher, & Zacks, 1991). Perhaps more importantly, we also found that placing even otherwise highly disrupting, meaningfully related distracting information in predictable locations does no more damage for older adults than does having minimally disruptive strings of Xs present (see Carlson, Hasher, Connelly, & Zacks, 1995). Distraction in fixed locations limits the disruption ordinarily seen, especially for older adults. These findings join with those of others in a series of selective attention studies (e.g., Connelly & Hasher, 1993; Madden, 1983; Plude & Hoyer, 1985), to show that spatial predictability can reduce dramatically, and sometimes even eliminate, the usual disadvantage that older adults operate under in tasks requiring selective attention. (Together with other studies, this work suggests that inhibition related to location is not impaired with age.)

A major thread in our research has been the study of age differences in the susceptibility to interference effects at retrieval. In general, the dual process selective attention theory that guides our work leads to the prediction that older adults (and others with inhibitory deficits) will have substantial retrieval deficits. This is because, at encoding, the working memory of older adults will include more nonrelevant information from their relatively less effective access and deletion functions of inhibition. This sets the stage for more cluttered or richer memory bundles or "fans," to use the language of Anderson (e.g., 1983). It is a basic finding in the human memory literature that larger fans result in slower and less accurate retrieval (e.g., Anderson, 1983; Nelson, Schreiber, & McEvoy, 1992; Watkins & Watkins, 1975). Another source of retrieval deficits can stem from the failure to suppress irrelevant retrieval pathways at the time of testing.

Coupled with the large literature showing the deficits of older adults on retrieval tasks (including those underlying inference formation in text processing; e.g., Light & Capps, 1986), we began a line of work to demonstrate the predicted increase in fan effects with age. The results generally support this prediction (Gerard, Zacks, Hasher, & Radvansky, 1991; Radvansky, Zacks, & Hasher, 1996; see also Cohen, 1990). However, at least one circumstance eliminates fan effects for both younger and older adults and that

is the use of a spatial organizing device for relating otherwise unrelated facts (also called a situation or mental model). That is, having objects (e.g., a potted palm, a soda machine, and a welcome mat) all located in one plausible place (a hotel lobby) eliminates the disruption to retrieval usually seen with large sets of facts hooked to a single cue. (Such facts are prima facie evidence against a global binding deficit that some have suggested is associated with aging.)

Note the parallel here with our findings in the reading with distraction task (Carlson et al., 1995) described above and with those reported in the context of a negative priming task (Connelly & Hasher, 1993) and other selective attention tasks. The usual age-related disruption from the effects of marginally relevant distraction or no longer relevant information can be reduced if the location of that distraction is predictable or if factual information can be grounded in specific imagined locations (see Radvansky & Zacks, 1997). Space is special and thus may prove to be the basis for at least one route for remediation for aspects of impaired cognitive functioning for at least some older adults.

Of course, there are rough edges to this somewhat rosy picture of the value of an inhibitory viewpoint. For example, returning to situations in which the location of distraction is spatially uncertain, it seems reasonable to suggest that the differential slowing associated with the presence of distraction should result in the acquisition of more information about the irrelevant or distracting materials, knowledge that might be expected to be seen on a retention test. This is not generally found, at least when assessed by deliberate retrieval tests (e.g., Dywan & Murphy, 1996). Still, it should be noted that our work on directed forgetting has shown that irrelevant (or at least no longer relevant) information makes up a bigger proportion of what older adults do remember from a situation than is the case for younger adults (Zacks & Hasher, 1994; Zacks, Radvansky, & Hasher, 1996). And new work by May (1997) shows both differential age-related costs and benefits of greater knowledge of distraction acquired in the context of a language-based problem-solving task.

In the course of our work on age differences in inhibitory control, we have also found that very well-learned responses are particularly difficult to control, at least if they are wrong. For example, we (Butler, Zacks, & Henderson, 1996) have studied age differences on a task that requires participants to look in the opposite direction to a visual cue that abruptly comes on in the periphery, a task that requires suppressing the reflexive response of looking in the direction of the cue. On this "antisaccade" task, older adults are more likely than young adults to produce an incorrect reflexive response of looking toward the peripheral cue.

Another very different task also shows the difficulty older adults have in controlling strong responses. Here people are asked to make category decisions to familiar items from familiar categories. Older adults' performance is similar to that of younger adults on correct "yes" trials when, for example, the category "furniture" is followed by the word "chair." By contrast, when participants are signaled to withhold their decision about category membership, older adults are quite impaired (May & Hasher, in press). Such findings in category decision making confirm others reported in memory, language, and selective attention tasks: It is difficult to prevent strong responses from being produced, and this is particularly true for older adults. The poorer performance of older adults in such tasks is actually consistent with their spared performance shown on tasks that require strong responses. Such tasks include single-item associative tasks such as giving free word associations and generating the completion for sentences missing highly probable responses.

Our findings on age differences in control over strong responses were amplified when we pursued the suggestion of age differences in circadian arousal patterns. Of particular relevance to this article are findings suggesting that the three functions of inhibition — access, deletion, and restraint — may be particularly impaired when older adults are asked to perform at nonoptimal times (see Appendix, Note 3). These data can be contrasted with findings showing that strong responses and performance in domains of expertise are not impaired at nonoptimal times of day for either younger or older adults (Hasher et al., in press; May & Hasher, in press). That is, if the first response is highly probable and if it is correct, performance will not vary across the day even though circadian arousal does. However, if the strong response is incorrect, then control over that response, control enabled by the "restraint" function of inhibition, is far better at one's optimal time of day than at one's nonoptimal times.

Consider now working memory capacity. It is widely thought to be an index of the general capacity available for mental work. Older adults have often been shown to have smaller capacity than younger adults (e.g., Salthouse, 1990) and so are thought to be less able to hold onto stored information while simultaneously operating on current information. Any number of tasks have been devised to measure that capacity. Virtually all share three operations: (1) multiple lists or sets of items are presented; (2) each list or set is followed by a recall test; (3) the lists are arranged in ascending order of length, such that the longest and most difficult list comes last.

Based on the operations involved in span measurement, the inhibitory theory actually suggests a radically different explanation of span performance from the dominant capacity view. In the context of the multiple-list recall task that span tasks actually are, the efficient operation of the deletion function of inhibition will help a person to recall items only from the most recent list. By contrast, inefficient deletion enables recall of the current list of items to be disrupted by no longer relevant items from previous lists that were never suppressed. This phenomenon of heightened accessibility of previous lists will particularly impact on the longest lists, which are presented last in span tasks. Recall of items from the longest lists will be particularly impaired for older adults with their deficient deletion functions of inhibition. By this argument, standard span tasks such as those used to measure working memory capacity may reflect interference proneness as well as (or instead of) general mental capacity. It may well be that interference due to diminished inhibitory control results in the poorer working memory scores typically seen for older adults (see May, Hasher, & Kane, 1997).

We offer this as an example of the importance of process models of tasks and of the value of reconsidering old tasks from a new or different theoretical perspective, including from an inhibitory perspective. Finally, we note that the use of sophisticated computational models (e.g., Just & Carpenter, 1992), just like the use of more descriptive, general models, must rest solidly on good process models of tasks.

Research Themes

A number of general characteristics of our approach to research are implicit in the foregoing. Nonetheless, we think it useful to begin our substantive response to the Burke and McDowd articles by making explicit some of the central assumptions that have guided our collaborative theory building and empirical work over a 20-year period. Throughout this time frame our central concern has been to explore the relations among attention, memory, and language because we believe that many questions about cognition cannot be neatly packaged into the traditional subfields of cognitive research, but must be studied by approaches that bridge domains. Our central pretheoretical assumption is that attention, memory, and language are deeply interrelated and that the ultimate understanding of each may be fuller if an integrative approach is employed.

Our interest in cognitive functions that cross traditional areas guides our selection of specific questions to study and has permitted the observation of parallels that might have been missed had we taken a more domain-centered focus to our research. One example is our relatively early application of the notion of attentional and memory constraints to problems of inference generation and age differences therein (Zacks & Hasher, 1988; Zacks et al., 1987). Another example comes from the parallels that exist among the comprehension of garden-path paragraphs, the ability to respond to topic changes in text, and the ability to use deliberate directed forgetting instructions (see Zacks & Hasher, 1994). Our evidence suggests that in all cases, older adults show deficits because of inhibitory problems in suppressing previously relevant information. Earlier, we discussed an example in which spared location-based inhibitory processes integrate work from selective attention to retrieval.

We also have a commitment to a certain strategy of theory building, one that Baddeley (1992) has termed "pragmatic," in that the theory is modified on the basis of new findings while trying to maintain its central core of assumptions. Although all types of theories have their strengths, our preference has been and continues to be for general, nonreductionist, and verbally stated theories as contrasted to more formal computational models. In this preference, our approach is more similar to that used by Craik and Lockhart (1972) in developing their levels of processing view and by Baddeley (e.g., 1992) in developing his model of working memory than it is to theorists like McClelland and Rumelhart (1981) or MacKay (1987), to take two examples relevant to the current discussion. The modeling approach of the latter theorists has the benefits of requiring precise quantitative formulation of assumptions and of making precise predictions, but perhaps at the expense of considerably greater complexity and a narrower range of application than is true of more informal models. McDowd's theoretical predispositions seem closer to our own, while Burke's are much closer to the formal modeling approaches.

Given a pragmatic approach to theorizing, our theoretical concepts apply at a more global level than is the case for computational models that may incorporate nominally the same concepts. In the present instance, the important concept is inhibition. The concept of inhibition has been applied in many different contexts and at different levels of the cognitive architecture (cf. Klein & Taylor, 1994). Whether the same processing rules apply across these different theoretical uses of the concept of inhibition is debatable. As already noted, in our work the concept of inhibition is invoked in the context of a theory of selective attention that assumes two active processes of selection: excitation and inhibition. Such theories focus on the deliberate, although not necessarily strategic, control of the contents of working memory (see Hasher et al., in press). By contrast, the lateral inhibition mechanism of interactive activation models (e.g., McClelland & Rumelhart, 1981) operates automatically and subconsciously at primarily low levels of processing (e.g., the encoding of letters and letter features in visual word recognition). It is quite possible that the two types of inhibition follow different developmental trajectories just as the attentional inhibitory processes associated with identity versus location may.

Given that our interests are broad and cross traditional area boundaries, there will inevitably be instances in which we have not acknowledged or have misconstrued specific findings relevant to our view. Nonetheless, our goal is to minimize such errors and to ensure that our theoretical assumptions are consistent with relevant theories and empirical findings. This comment applies not only to our initial formulation of an idea, but as indicated earlier, we also try to be responsive to contradictory new findings and/or criticisms of our theoretical position in order to moderate our views appropriately. Evidence of such efforts can be seen in our reanalysis of the negative priming task, in our new understanding of the determinants of working memory capacity, and in our recognition of parallels between spatial selection and situation models.

These observations lead to a final point: Specific predictions about any independent or individual or group difference variable can only be made in the context of a process model of that task. As such, the validity of predictions from a theory is determined in part by the validity of the relevant process models, which in our case have mainly come from the work of others. Thus, we have tried to select tasks that have accepted process models while remaining alert to newer findings that may call those models into question. In a major instance described below (see the section "Unexpected Outcomes" on the processing of ambiguous words and the notion of "promiscuous activation"), newer views of the processing involved in an experimental situation suggest why it is that we and others have found results apparently inconsistent with a inhibition deficit view.

The Burke (1997) Article

We turn now to the Burke critique in which she reviews a large body of literature comparing younger and older adults

on language comprehension and production tasks and relates the findings in that literature to her interpretation of our viewpoint. Her main conclusions are as follows: (1) There is "remarkable age constancy in many aspects of language performance," a pattern of findings which she views as generally contrary to predictions derived from our inhibitory deficit theory. (2) In the less frequent cases where data from language tasks confirm the pattern of age differences predicted by our view, alternative, noninhibitory explanations are offered. (3) Because our theory is imprecise, specific predictions are not always possible, and there is a general confusion between inhibition at the behavioral and theoretical levels. (We will not have much more to say about this last criticism beyond the points already mentioned in connection with the presentation of our orientation to theorizing.)

At a general level, our response to the first two criticisms includes both points of agreement and points of disagreement. Among the former, for example, is Burke's conclusion that there are minimal age differences on many aspects of language processing. However, it should be pointed out that the conclusion of minimal age differences is actually more applicable to the language comprehension than to the language production research reviewed by Burke. Her own summary of language production findings indicates clear age deficits on measures of word finding (e.g., increased tip-of-the-tongue states, decreased fluency, slowing of association production) and perhaps in the maintenance of discourse focus. With respect to comprehension, although Burke is largely accurate with regard to the studies that are included, her review omits a large number of studies that do indicate age deficits on language comprehension and memory tasks, especially when these tasks involve conceptually and/or structurally complex inputs (e.g., Light & Capps, 1986; Zacks & Hasher, 1988; see Kemper, 1992). To be sure, these findings come primarily from off-line measures of language processing in contrast to the mainly online measures in the research that Burke focuses on. In such cases, it appears that Burke might invoke memory problems to account in part, at least, for older adults' poorer performance. But if older adults' comprehension of the inputs is as good as younger adults', why would memory problems appear after the brief delays that are generally used in these off-line tasks? Indeed, the major purpose of our framework is to demonstrate that online effects of selective attention have consequences for memory such that language comprehension itself can be compromised. (As an example, take our view that inferences are not always formed because the large fans created by inefficient inhibition will reduce the probability that the needed linking target will be retrieved in a timely manner.)

Another point of agreement that we share with Burke is that alternative explanations are available for many of the findings that we have interpreted as supporting our view. However, different alternative accounts are suggested on a finding-by-finding basis. As is elaborated below, the inhibitory deficit view is favored at least by its parsimony.

In an attempt to be systematic in our more detailed comments on the conclusions reached by Burke, we have divided the research she reviewed into three categories: (1) studies in which age differences were not found but for which we did not predict any; (2) studies in which age differences were not found but for which we expected them to occur; and (3) studies in which predicted age differences were found but for which Burke offers alternative explanations.

Disagreements over predictions: Age differences that were not found and that we also did not predict. — In the category of studies that found no age differences and where this pattern was anticipated, we include word association, semantic priming, and category instance and script generation studies. In general, these studies involve procedures that assess the overt retrieval or implicit activation of strong associative connections in semantic memory. For example, in single-word free-association tasks, participants respond to each cue word with the first word that comes to mind, or, the first word that achieves an above-threshold level of activation. Assuming that speed of activation of the different associates to a cue is a function of their relative associative strengths, the word produced can be assumed to be the momentarily strongest association to the cue. (Baseline associative strength is the primary determiner of momentary associative strength, but such factors as recent exposure and priming from previous items can also play a role.) This line of argument suggests that generating word associations is a task that taps mainly automatic activation processes with minimal involvement of conscious selection against strong distractors. If so, the inhibitory deficit view does not implicate age differences in the processes underlying the generation of word associations. Given also that it is widely accepted that the content and organization of semantic memory are similar in younger and older adults, the findings of age constancy in the breadth of word association responses and in their variability within and across individuals do not necessarily seem inconsistent with the inhibitory deficit view. Age differences are more likely to appear when procedures are adopted to ensure that the strongest response to a cue is either insufficient to meet task demands or does not meet them at all.

Similar arguments can be made in relation to findings from semantic priming and category and script generation studies. In general, our view does *not* predict age differences in situations in which the presented cues automatically activate potential responses that are primarily consistent with task demands. It is only when task-inappropriate responses are strongly activated that the benefits of efficient inhibitory attentional processes are likely to be seen. This last point suggests a possible partial explanation for why Burke arrived at a different prediction from our theory for this group of tasks: Burke seems to have started from a notion of inhibition similar to that used in interactive activation models of the McClelland and Rumelhart (1981) type. As previously mentioned, this form of inhibition may have very different underpinnings than does our notion of attentional inhibition. We take this opportunity to clarify our position.

One point is that we do not think it likely that deficient inhibition facilitates the activation of entirely unrelated or extremely improbable associates to a word, category, or script cue. Regardless of the efficiency of attentional inhibi-

tion mechanisms, a cue automatically activates only those items that have at least a moderate level of association with the cue, and certainly not completely unrelated items such as are used in the unrelated prime condition of semantic priming studies. We also assume that it is only strong potential competitors to target information or responses that are inhibited. Generally, such information will have a strong connection to the target information and/or to the cues that elicit the target information. Incidental background information (e.g., features of the video monitor on which experimental stimuli are displayed) and weekly activated information will not undergo inhibition (see Anderson, Bjork, & Bjork, 1994, for a related point in the context of a proposal about mechanisms of retrieval interference).

Our viewpoint does include the assumption that excitatory and inhibitory processes are under the control of currently active goals. Insofar as the goals of older adults may be different in any given situation than those of younger adults, it is possible that activation patterns might be different. Nonetheless, we would still not anticipate that totally nonrelevant information would become active.

We hope that, taken together, these points make it clear why it is that we do not accept a number of Burke's predictions from our theory. In particular, our theory does not suggest that deficient inhibition in older adults "would reduce the difference in activation levels between related and unrelated words, thereby reducing the semantic priming effect" (p. P255). Nor does it predict a reduced effect of dominance in script and category instance generation tasks as is also suggested by Burke.

Unexpected outcomes: Age differences expected but not found. — The experimental paradigms used in our second category of studies from Burke's article are ones that we expected to show age differences consistent with inhibitory deficits. Although this group of studies encompasses a variety of different goals and specific procedures, a common theme is the investigation of the processes by which the contextually appropriate meanings of words are selected. In many of the experiments, probe words associated with different senses of a word or with different meanings of a multiple-meaning word are presented for naming or lexical decision. Priming effects on the naming or lexical decision task (speed-up or slow-down of responding relative to a baseline) are used to provide information about the representation of the critical word's meaning at the time of probe presentation, and by varying the interval between the critical word and the probe, to study how that meaning changes over time.

In considering the results of the studies in this group, it is important to keep in mind that many of them were predicated on a nonselective, broadspread or "promiscuous" activation view of meaning activation and selection (e.g., Swinney, 1979). In the case of ambiguous words (where it is most easily described), such a view assumes the following processing sequence. When an ambiguous word such as "bank" occurs, all of its meanings are initially activated (if only preconsciously), even if the word occurs in a context that is strongly consistent with only one of its meanings (e.g., "money bank" vs "river bank"). The sentence context in conjunction with inhibitory processes functions to quickly suppress the context-irrelevant meaning(s) and to maintain the activation of the contextually appropriate meaning. In the case of nominally unambiguous words, similar processing mechanisms can operate on meaning features (e.g., the "roundness" vs the "juiciness" of oranges). Given that inhibitory mechanisms are presumed to be involved in selecting the context-appropriate meaning from among the array of meanings initially activated, this view suggests that older adults should show deficits in meaning selection, including prolonged activation of context-irrelevant meanings. As Burke indicates in her review, relevant studies have failed to show such effects. She concludes that a major prediction of our theory has failed.

In response to this conclusion, we raise two counterarguments. The first assumes, as we did when we wrote our initial papers on the inhibitory deficit view, that the promiscuous activation model is valid. If so, it might be argued that the type of inhibition involved in meaning resolution differs from that involved in the more controlled selective attention processes that are at the heart of our viewpoint. Absent evidence on this possibility, we turn to a second counterargument, this based on the possibility that the broadspread activation view itself is incorrect. If so, there is reason to reconsider the role of inhibitory processes in meaning resolution in context.

A reading of the current literature indicates that a variety of findings are leading some researchers to question the promiscuous meaning activation view outlined above. The relevant findings suggest that under many circumstances, the discourse context constrains the meanings that are initially activated. For example, a fairly large number of studies (e.g., Morris, 1994; Stoltzfus, Hasher, & Zacks, 1992; Tabossi, 1988) have failed to replicate the broadspread initial activation pattern reported in the earlier studies (see MacDonald, Pearlmutter, & Seidenberg, 1994, for a recent and compelling review). These newer findings and other considerations are offered by MacDonald et al. (1994) in support of an alternative view of the processing of meaning in context. This alternative argues that instead of automatic activation of all meanings associated with a word, "the pattern of semantic information that becomes available when a word is processed depends on the context in which it occurred" (p. 679). If, as this latter view suggests, initial meaning activation is not necessarily broad when words are processed in context, then perhaps inhibition may not be important for meaning selection. Should such a position continue to gain support, the absence of age differences in meaning selection would not be surprising from an inhibitory deficit point of view.

Interpretational disagreements: Expected age differences found but alternative explanations offered. — Burke reviews findings from a number of different language comprehension, memory, and production paradigms that have produced findings of age differences consistent with the notion of an inhibitory deficit in older adults. In the case of these studies, her main criticism is that each finding has an alternative, noninhibitory explanation. We first point out that in the case of the studies that we and our collaborators

carried out (e.g., Connelly et al., 1991; Hamm & Hasher, 1992; Hartman & Hasher, 1991), the findings corroborated a priori predictions from our viewpoint. Second, Burke does not offer a single alternative explanation for the relevant findings, but instead proposes several different explanations. For example, source monitoring difficulties on the part of older adults are invoked to account for the Hartman and Hasher (1991) findings; episodic memory deficits are suggested as a partial explanation of the Hamm and Hasher (1992) findings; and slowing is said to be a factor in the decreased fluency of older adults. Though each of these explanations may be reasonable, parsimony would suggest that a single explanation that encompasses these and other findings would be preferred (see Appendix, Note 4).

A final point. — An additional general issue is relevant to literatures reviewed by McDowd and Burke. This has to do with the characteristics of the participants in the majority of the cited studies. Many of the "older" adults in these studies are relatively young and fit into a young-old rather than an old-old category. As well, the older adults tend to be very well educated and to have high vocabulary scores. With respect to the latter, the many years of practice such people have with their formal language skills may well heighten the role of automatic processes involved in semantic memory utilization, diminishing the role that inhibition may play. It is possible that as a result of participant selection biases common in cognitive gerontology, we may all be underestimating the ultimate impact of developmental changes in inhibitory attentional mechanisms. Results of some recent studies that have tested for predicted effects of deficient inhibition in participants whose average age is above 75 and/or in individuals with beginning signs of Alzheimer's disease support this possibility (Simone & Baylis, 1997; Spieler, Balota, & Faust, 1996).

The McDowd (1997) Article

We turn now to a consideration of criticisms regarding the attentional side of the inhibitory framework. Much of McDowd's article focuses on the negative priming task and its limitations. We begin with the most central concern, which is the usefulness of the task as an index of attentional inhibition.

At the time that we and others began working with the identity version of the negative priming task, it seemed as if it might be a direct measure of inhibition. It is now clear that performance on negative priming tasks is multiply determined and that, in addition to any inhibition that may be present to slow responding to a target if that item had just served as the previous trial's distractor, there are also decision, checking, or retrieval processes that can also slow response times to such targets. Indeed, it now appears to be relatively easy to engage "post-identification" processes, for example, by making identification of the target difficult by overlapping targets and distractors (e.g., Sullivan & Faust, 1993; Sullivan, Faust, & Balota, 1995) or by perceptually degrading the targets themselves (see Kane, May, Hasher, Rahhal, & Stoltzfus, 1997). As well, the mix of conditions (e.g., whether or not the target word ever repeats from one trial to the next) in the list that includes negative priming trials can influence strategies (Kane et al., 1997), and this too can alter the pattern of negative priming. Under circumstances presumed to promote post-identification processing, older adults reliably show negative priming. However, when the negative priming task is arranged to minimize the contribution of such processes, there is still evidence that older adults either do not show negative priming (see May, Kane, & Hasher, 1995) or else show less negative priming than do younger adults (Earles, Connor, Frieske, Park, Smith, & Zwahr, 1997).

As well, we note recent findings of Intons-Peterson, Rocchi, West, McLellan, and Hackney (in press) showing that patterns of negative priming change across the day, with older adults failing to show the effect when tested at less optimal times, and showing the effect at optimal times. This recent work dovetails with other findings (e.g., May & Hasher, in press) to demonstrate substantial differences across the day in the efficiency of inhibitory control processes, differences that are tied to circadian arousal patterns. Because close to three-quarters of older adults are at peak arousal in the morning, and as there is mounting evidence that inhibitory but not excitatory processes vary with circadian arousal, a final understanding of age differences in inhibitory control will await the outcome of studies in which times of testing are configured so as to maximize performance. In current studies, time of testing is often free to vary in such a way as to differentially disadvantage older adults (see May, Hasher, & Stoltzfus, 1993).

Unfortunately, the multiple determinants of negative priming also make it difficult to address a second concern that McDowd raises, this about the relation between inhibition and selection. As we did initially, McDowd assumes that the inhibition measured in the negative priming task as a carry-over effect from one selection trial to the next one is critical to the distraction effect seen on a single selection trial. The assumption is that the more efficient inhibition is, the less distracted one will be by stimuli one needs to ignore. Thus, McDowd expects to see a negative correlation between negative priming and distraction effects measured by the difference between the time to select and name a target in the presence of a distractor and the time to simply name a target that appears alone.

This is not easily addressed, in part because correlations have been calculated in situations in which multiple determinants of negative priming can be operating. Setting that aside (and see May et al., 1995 for a detailed discussion of these issues), we note that we originally suggested that one function of inhibition is to slightly retard the reprocessing of recently rejected items (notably, the distractor from the previous trial). This still seems likely to us and in fact matches with suggestions made by Houghton and Tipper (1994). At the time we originally made this suggestion (Stoltzfus, Hasher, Zacks, Ulivi, & Goldstein, 1993), we drew an analogy between a phenomenon involving recently rejected identities and another phenomenon, inhibition of return, involving recently rejected locations which are harder to "reuse" than are other locations. The analogy still seems apt to us, but the fact that older adults show as substantial an inhibition of return effect as do younger adults is not troubling (as McDowd suggests it should be), since

research reviewed earlier suggests that spatial inhibitory processes are preserved with age.

Another aspect of the problem of knowing the relationship between attentional inhibition and distractor interference is the rich variety of tasks that carry the term "interference" as part of their name (Garner interference, Eriksen interference, Stroop interference, proactive interference, among others). The use of the same term to denote a negative impact of distraction does not necessarily mean that the mechanisms underlying the observed behavior are the same (see Appendix, Note 5).

We would note, however, that the connection between attentional inhibition and retrieval interference (examples of which include proactive interference and fan effects) is actually rather direct. This is because it is the failure to delete no longer relevant information from working memory that creates the larger memory fans that include currently relevant information along with some previously relevant information. Because larger fans were stored, a person with inefficient inhibitory skills will have greater difficulty retrieving than will another person with efficient inhibitory skills whose fans are more likely to include only relevant information. As mentioned before, such retrieval problems can show up as reduced working memory capacity, as failures to form inferences on line as well as failures to remember details rather than general descriptions, and potentially as increased reliance on easily accessed schematic knowledge. Insofar as retrieval is involved in both social and cognitive settings, this is probably a good example of the impact inhibition has on behavior.

Thus, although we accept the criticism that there is difficulty in measuring attentional inhibition, our own reading of the literature and of the second part of McDowd's article (as well as of her earlier overview of this area; see McDowd, Oseas-Kreger, & Filion, 1995) is that we are generally in agreement that the concept of attentional inhibition continues to be a useful one. McDowd does suggest some useful ways, involving Houghton and Tipper's (1994) formal model, in which the notion of attentional inhibition might be further developed. It is our reading of both the aging and the basic attention literatures that this concept still has a rich life.

Conclusions

In our 1988 article, we acknowledged a number of shortcomings of general and limited capacity theories of cognitive processing, many of which were raised within the basic attentional literature itself. In the 10 years we worked from a limited capacity framework, including our attempt to specify that framework using working memory capacity notions, these basic criticisms continued to increase, at the same time that the predictive power of the general view seemed to us to lessen substantially. This was a judgment call we made in 1988; by contrast others were not at all compelled by such criticisms and instead continue working in the limited-capacity view (e.g., Carpenter, Miyake, & Just, 1994; Just & Carpenter, 1992).

To our reading, the strong criticism that general capacity notions have received within the basic attention literature is not (yet) found in that same literature for the notion of inhibition. Nonetheless, we surely acknowledge the value of the criticisms raised by Burke and McDowd. Like McDowd, we have been deeply concerned with the measurement problem. Our take is, however, different. Negative priming is clearly not the precise inhibitory measurement tool that it seemed it might be in 1985 (Tipper, 1985; Tipper & Cranston, 1985). We do not, however, agree with the strong conclusion that "in the absence of a valid, reliable, and pure measure of inhibitory function, it is very difficult to properly assess the hypothesis that inhibitory function declines with age" (p. P270). At this point, inhibitory processes still seem to us to be a vibrant and useful hypothetical construct that can account for a wide range of spared and impaired patterns of cognitive functioning shown by older adults, our particular domain for testing what is in substance a general model of cognition. There is reason to believe that some of the inhibitory patterns seen in older adults are also seen in young children (Dempster, 1992; Harnishfeger & Bjorklund, 1993), children with attention deficit disorder or other learning disabilities (Lorsbach, Wilson, & Reimer, 1996; Schachar & Logan, 1990), adults with low verbal ability (Gernsbacher & Faust, 1995), and adults suffering from schizophrenia or depression (see Houghton & Tipper, 1995, for a review). As well, inhibitory control has potentially important ramifications for the social lives of all individuals (Macrae, Bodenhausen, & Milne, 1995). Our theoretical viewpoint is not fully specified and there are measurement and task problems. Nonetheless, it seems to us that the view we initially proposed in 1988 and that we have continued to develop and work with since then has considerable promise in helping to understand age differences, as well as age similarities in a broad range of cognitive tasks.

ACKNOWLEDGMENTS

The work reported here was supported by Grants AGO-4306 and AGO-2753 from the National Institute on Aging. We thank our collaborators for many conversations over the grounds covered here and Cynthia P. May, Michael Kane, and Kathleen Eberhardt for their assistance with various issues raised here.

Address correspondence and requests for reprints to Dr. Rose Zacks, Department of Psychology, Michigan State University, East Lansing, MI 48824. E-mail: zacksr@pilot.msu.edu

REFERENCES

Allport, A. (1989). Visual attention. In M. I. Posner (Ed.), *Foundations of cognitive science* (pp. 631–682). Cambridge, MA: MIT Press.

Anderson, J. R. (1983). Retrieval of information from long-term memory. *Science, 220,* 25–30.

Anderson, M. C., Bjork, R. A., & Bjork, E. L. (1994). Remembering can cause forgetting: Retrieval dynamics in long-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 1063–1087.

Arbuckle, T. Y., & Gold, D. P. (1993). Aging, inhibition, and verbosity. *Journal of Gerontology: Psychological Sciences, 48,* P225–P232.

Baddeley, A. (1992). Is working memory working? The fifteenth Bartlett lecture. *Quarterly Journal of Experimental Psychology, 44A,* 1–31.

Burke, D. M. (1997). Language, aging, and inhibitory deficits: Evaluation of a theory. *Journal of Gerontology: Psychological Sciences, 52B,* P254–P264.

Butler, K., Zacks, R. T., & Henderson, J. M. (1996, April). *Age comparisons on an antisaccade task.* Poster presented at the 1996 Cognitive Aging Conference, Atlanta.

Carlson, M. C., Hasher, L., Connelly, S. L., & Zacks, R. T. (1995). Aging,

distraction, and the benefits of predictable location. *Psychology and Aging, 10,* 427–436.

Carpenter, P. A., Miyake, A., & Just, M. A. (1994). Working memory constraints in comprehension: Evidence from individual differences, aphasia, and aging. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 1075–1122). San Diego, CA: Academic Press.

Cohen, G. (1990). Recognition and retrieval of proper names: Age differences in the fan effect. *European Journal of Cognitive Psychology, 2,* 193–204.

Connelly, S. L., & Hasher, L. (1993). Aging and the inhibition of spatial location. *Journal of Experimental Psychology: Human Perception and Performance, 19,* 1238–1250.

Connelly, S. L., Hasher, L., & Zacks, R. T. (1991). Age and reading: The impact of distraction. *Psychology and Aging, 6,* 533–541.

Cowan, N. (1988). Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human information processing system. *Psychological Bulletin, 104,* 163–191.

Cowan, N. (1993). Activation, attention, and short-term memory. *Memory & Cognition, 21,* 162–167.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11,* 671–684.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19,* 450–466.

Dempster, F. N. (1992). The rise and fall of the inhibitory mechanism: Toward a unified theory of cognitive development and aging. *Developmental Review, 12,* 45–75.

Dywan, J., & Murphy, W. E. (1996). Aging and inhibitory control in text comprehension. *Psychology and Aging, 11,* 199–206.

Earles, J. L., Connor, L. T., Frieske, D., Park, D. C., Smith, A. D., & Zwahr, M. (1997). Age differences in inhibition: Possible causes and consequences. *Aging, Neuropsychology, and Cognition, 4,* 45–57.

Gerard, L. D., Zacks, R. T., Hasher, L., & Radvansky, G. A. (1991). Age deficits in retrieval: The fan effect. *Journal of Gerontology: Psychological Sciences, 46,* P131–P136.

Gernsbacher, M. A., & Faust, M. E. (1995). Skilled suppression. In F. N. Dempster & C. J. Brainerd (Eds.), *Interference and inhibition in cognition* (pp. 295–327). San Diego, CA: Academic Press.

Hamm,V. P., & Hasher, L. (1992). Age and the availability of inferences. *Psychology and Aging, 7,* 56–64.

Harnishfeger, K. K., & Bjorklund, D. F. (1993). The ontogeny of inhibition mechanisms: A renewed approach to cognitive development. In M. L. Howe & R. Pasak (Eds.), *Emerging themes in cognitive development: Vol. 1. Foundations* (pp. 28–49). New York: Springer-Verlag.

Hartman, M., & Hasher, L. (1991). Aging and suppression: Memory for previously relevant information. *Psychology and Aging, 6,* 587–594.

Hasher, L. (1994, July). *Inhibition and cognition.* Paper presented at the annual meeting of the American Psychological Society, Washington, DC.

Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. *Journal of Experimental Psychology: General, 108,* 356–388.

Hasher, L., & Zacks, R. T. (1984). Automatic processing of fundamental information: The case of frequency of occurrence. *American Psychologist, 39,* 1372–1388.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 22, pp. 193–225). New York: Academic Press.

Hasher, L., Zacks, R. T., & May, C. P. (in press). Inhibitory control, circadian arousal, and age. In D. Gopher & A. Koriat (Eds.), *Attention and performance, XVII, Cognitive regulation of performance: Interaction of theory and application.* Cambridge, MA: MIT Press.

Hirst, W., & Kalmar, D. (1987). Characterizing attentional resources. *Journal of Experimental Psychology: General, 116,* 68–81.

Houghton, G., & Tipper, S. P. (1994). A model of inhibitory mechanisms in selective attention. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 53–112). San Diego, CA: Academic Press.

Intons-Peterson, M. J., Rocchi, P., West, T., McLellan, K., & Hackney, A. (In press). Aging, optimal testing times, and negative priming. *Journal of Experimental Psychology: Learning, Memory and Cognition.*

Just, M. A., & Carpenter, P. A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review, 99,* 122–149.

Kahneman, D. (1973). *Attention and effort.* Englewood Cliffs, NJ: Prentice-Hall.

Kane, M. J., May, C. P., Hasher, L., Rahhal, T., & Stoltzfus, E. R. (1997). Dual mechanisms of negative priming. *Journal of Experimental Psychology: Human Perception and Performance, 23,* 632–650.

Kemper, S. (1992). Language and aging. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (pp. 213–270). Hillsdale, NJ: Erlbaum.

Klein, R. M., & Taylor, T. L. (1994). Categories of inhibition with reference to attention. In D. Dagenbach and T. H. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 113–150). San Diego: Academic Press.

Light, L. L., & Capps, J. L. (1986). Comprehension of pronouns in younger and older adults. *Developmental Psychology, 22,* 580–585.

Lorsbach, T. C., Wilson, S., & Reimer, J. F. (1996). Memory for relevant and irrelevant information: Evidence for deficient inhibitory processes in language/learning disabled children. *Contemporary Educational Psychology, 21,* 447–466.

MacDonald, M. C., Pearlmutter, N. J., & Seidenberg, M. S. (1994). Lexical nature of syntactic ambiguity resolution. *Psychological Review, 101,* 676–703.

MacKay, D. G. (1987). *The organization of perception and action: A theory for language and other cognitive skills.* New York: Springer-Verlag.

Macrae, C. N., Bodenhausen, G. V., & Milne, A. B. (1995). The dissection of selection in person perception: Inhibitory processes in social stereotyping. *Journal of Personality and Social Psychology, 69,* 397–407.

Madden, D. J. (1983). Aging and distraction by highly familiar stimuli during visual search. *Developmental Psychology, 19,* 499–507.

May, C. P. (1997). *Age, inhibition, and the influence of distraction on a remote associates task.* Manuscript in preparation.

May, C. P., & Hasher, L. (In press). Synchrony effects in inhibitory control over thought and action. *Journal of Experimental Psychology: Human Perception and Performance.*

May, C. P., Hasher, L., & Kane, M. (1997). *The role of proactive interference in measures of working memory span.* Manuscript submitted for publication.

May, C. P., Hasher, L., & Stoltzfus, E. R. (1993). Optimal time of day and the magnitude of age differences in memory. *Psychological Science, 4,* 326–330.

May, C. P., Kane, M., & Hasher, L. (1995). Determinants of negative priming. *Psychological Bulletin, 118,* 35–54.

McClelland, J. L., & Rumelhart, D. E. (1981). An interactive model of context effects in letter perception: 1. An account of basic findings. *Psychological Review, 88,* 375–407.

McDowd, J. M. (1997). Inhibition in attention and aging. *Journal of Gerontology: Psychological Sciences, 52B,* P265–P273.

McDowd, J. M., Oseas-Kreger, D. M., & Filion, D. L. (1995). Inhibitory processes in cognition and aging. In F. N. Dempster & C. J. Brainerd (Eds.), *Interference and inhibition in cognition* (pp. 363–400). San Diego: Academic Press.

Morris, R. K. (1994). Lexical and message-level sentence context effects on fixation times in reading. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 92–103.

Navon, D. (1984). Resources — a theoretical soupstone? *Psychological Review, 91,* 216–234.

Navon, D. (1989a). The importance of being visible: On the role of attention in a mind viewed as an anarchic intelligence system. I. Basic tenets. *European Journal of Cognitive Psychology, 1,* 191–213.

Navon, D. (1989b). The importance of being visible: On the role of attention in a mind viewed as an anarchic intelligence system. II. Application to the field of attention. *European Journal of Cognitive Psychology, 1,* 215–238.

Neill, W. T. (1989). Lexical ambiguity and context: An activation-suppression model. In D. S. Gorfein (Ed.), *Resolving semantic ambiguity* (pp. 63–83). New York: Springer-Verlag.

Nelson, D. L., Schreiber, T. A., & McEvoy, C. L. (1992). Processing implicit and explicit representations. *Psychological Review, 92,* 322–348.

Plude, D. J., & Hoyer, W. J. (1985). Attention and performance: Identifying and localizing age deficits. In N. Charness (Ed.), *Aging and human performance* (pp. 47–99). New York: Wiley.

Radvansky, G. A., & Zacks, R. T. (1997). The retrieval of situation-specific information. In M. A. Conway (Ed.), *Cognitive models of memory* (pp. 173–213). Cambridge, MA: MIT Press.

Radvansky, G. A., Zacks, R. T., & Hasher, L. (1996). Fact retrieval in younger and older adults: The role of mental models. *Psychology and Aging, 11,* 258–271.

Saffran, J. R., Aslin, R. N., & Newport, E. L. (1996). Statistical learning by 8-month-old infants. *Science, 274,* 1926–1928.

Salthouse, T. A. (1990). Working memory as a processing resource in cognitive aging. *Developmental Review, 10,* 101–124.

Schachar, R. J., & Logan, G. D. (1990). Impulsivity and inhibitory control in normal development and childhood psychopathology. *Developmental Psychology, 26,* 710–720.

Simone, P. M., & Baylis, G. C. (1997). Selective attention in a reaching task: Effect of normal aging and Alzheimer's disease. *Journal of Experimental Psychology: Human Perception and Performance, 23,* 595–608.

Spieler, D. H., Balota, D. A., & Faust, M. A. (1996). Stroop performance in healthy younger and older adults and in individuals with dementia of the Alzheimer's type. *Journal of Experimental Psychology: Human Perception and Performance, 22,* 461–479.

Stoltzfus, E. R., Hasher, L., & Zacks, R. T. (1992). *Semantic priming during language processing: Several failures to replicate.* Poster presented at Psychonomic Society meeting. St. Louis, MO.

Stoltzfus, E. R., Hasher, L., & Zacks, R. T. (1996). Working memory and aging: Current status of the inhibitory view. In J. T. E. Richardson (Ed.), *Working memory and human cognition* (pp. 66–88). New York: Oxford University Press.

Stoltzfus, E. R., Hasher, L., Zacks, R. T., Ulivi, M. S., & Goldstein, D. (1993). Investigations of inhibition and interference in younger and older adults. *Journal of Gerontology: Psychological Sciences, 48,* P179–P188.

Sullivan, M. P., & Faust, M. E. (1993). Evidence for identity inhibition during selective attention in old adults. *Psychology and Aging, 8,* 589–598.

Sullivan, M. P., Faust, M. E., & Balota, D. (1995). Identity negative priming in old adults and individuals with dementia of the Alzheimer's type. *Neuropsychology, 9,* 537–555.

Swinney, D. A. (1979). Lexical access during sentence comprehension: (Re)consideration of context effects. *Journal of Verbal Learning and Verbal Behavior, 18,* 681–689.

Tabossi, P. (1988). Accessing lexical ambiguity in different types of sentential contexts. *Journal of Memory and Language, 27,* 324–340.

Tipper, S. P. (1985). The negative priming effect: Inhibitory priming by ignored objects. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 37*(A), 571–590.

Tipper, S. P. (1992). Selection for action: The role of inhibitory mechanisms. *Current Directions in Psychological Science, 1,* 105–109.

Tipper, S. P., & Cranston, M. (1985). Selective attention and priming: Inhibitory and facilitatory effects of ignored primes. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 37*(A), 591–611.

Watkins, O. J., & Watkins, M. J. (1975). Buildup of proactive inhibition as a cue-overload effect. *Journal of Experimental Psychology: Human Learning and Memory, 104,* 442–452.

Zacks, R. T. (1995, May). *Attending and remembering.* Paper presented at the annual meeting of the Midwestern Psychological Association, Chicago, IL.

Zacks, R. T., & Hasher, L. (1988). Capacity theory and the processing of inferences. In L. L. Light & D. M. Burke (Eds.), *Language, memory, and aging* (pp. 154–170). New York: Cambridge University Press.

Zacks, R., & Hasher, L. (1994). Directed ignoring: Inhibitory regulation of working memory. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory mechanisms in attention, memory, and language* (pp. 241–264). San Diego, CA: Academic Press.

Zacks, R. T., Hasher, L., Doren, B., Hamm, V., & Attig, M. S. (1987). Encoding and memory of explicit and implicit information. *Journal of Gerontology, 42,* 418–422.

Zacks, R. T., Radvansky, G. A., & Hasher, L. (1996). Studies of directed forgetting in older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22,* 143–156.

Received June 12, 1997
Accepted June 30, 1997

Appendix

Notes

1. In rereading several of our overview papers and presentations in preparation for this article, we found to our surprise that although we strongly implied in published articles that automatic excitatory processes were spared with aging, the explicit statement of this point was largely confined to various presentations (e.g., Hasher, 1994; Zacks, 1995).

2. The term "working memory" has been used in various ways. Our own view follows that of Cowan's (1988, 1993) in assuming that familiar stimuli automatically activate their representations in memory and that activation can spread automatically to associated representations. As with Cowan, our view is that working memory is co-extensive with the subset of mental representations that are at the focus of attention (see Hasher et al., in press, for further elaboration).

3. The failure to attend to age differences in circadian arousal and to the time of testing can impact on conclusions that might be drawn about processes and age differences, particularly if inhibitory control is an aspect of the clinical task (see May & Hasher, in press).

4. It seems to us that Burke's conceptualization of "off-target verbosity" differs from that of Arbuckle and Gold (1993). The latter authors defined this behavior largely on the basis of how people responded to focused questions, such as "How much education did you get?" Answers that were meandering or incoherent, and that included irrelevant information were scored as being verbose. Given the type of questions used and the type of answers scored as verbose, it is unlikely that Arbuckle and Gold's type of verbose speech would be rated positively by either younger or older adults.

5. Thus proactive interference is commonly attributed to competition among response candidates that a person retrieves, whereas Stroop interference is often attributed to the need to control strong responses.