

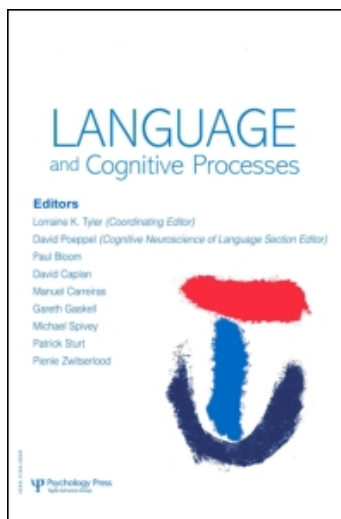
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### Age-related effects on speech production: A review

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## **Age-related effects on speech production: A review**

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In discourse, older adults tend to be more verbose and more disfluent than young adults, especially when the task is difficult and when it places few constraints on the content of the utterance. This may be due to (a) language-specific deficits in planning the content and syntactic structure of utterances or in selecting and retrieving words from the mental lexicon, (b) a general deficit in inhibiting irrelevant information, or (c) the selection of a specific speech style. The possibility that older adults have a deficit in lexical retrieval is supported by the results of picture naming studies, in which older adults have been found to name objects less accurately and more slowly than young adults, and by the results of definition naming studies, in which older adults have been found to experience more tip-of-the-tongue (TOT) states than young adults. The available evidence suggests that these age differences are largely due to weakening of the connections linking word lemmas to phonological word forms, though adults above 70 years of age may have an additional deficit in lemma selection.

### INTRODUCTION

For most people, speaking is a lifelong activity. Like the human body, speech changes with age: Adults speak differently from children, and older adults differently from young adults. Compared with changes in speech production during childhood, changes in adulthood are less dramatic and perhaps therefore less well researched. The present review of the literature focuses on effects of age on the production of object names in three different speech contexts: discourse, picture naming, and definition naming.

In discourse, young adults produce words, including object names, without much difficulty and only occasionally fail to retrieve a word. However, certain characteristics of older adults' discourse suggest that

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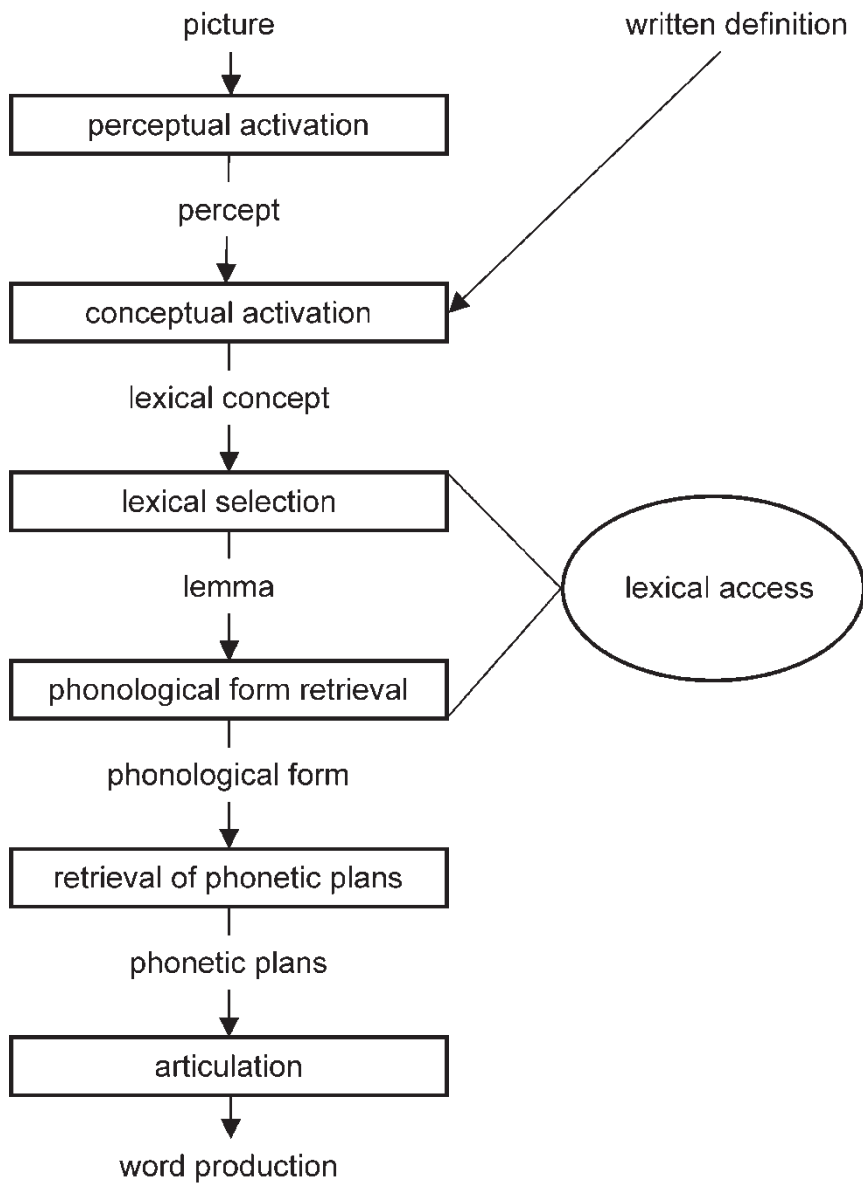
retrieval failures become more likely with age. Most notably, older adults are more verbose and more disfluent than young adults (Bortfeld, Leon, Bloom, Schober, & Brennan, 2001). The increase in number of words might reflect that older adults use 'filler' words (e.g., *well, you know*) or repeat words to compensate for difficulties in retrieving names of objects or persons. By producing filler words or repeating words, they might gain time to search for the name and to mask retrieval difficulties.

If older adults have word retrieval difficulties in discourse tasks but are able to conceal them by substituting difficult names with synonyms or circumscriptives, one would expect the retrieval problems to reveal themselves in picture naming tasks in which pictures with difficult names are presented. In such tasks, difficult words cannot be avoided, as the only correct word is the name of the presented picture. Similarly, one would expect lexical retrieval problems, if they exist, to appear in definition naming tasks in which definitions that elicit low-frequency words are presented. In addition, in discourse, the speech context provides potential sources of semantic and syntactic priming, which may facilitate lexical retrieval (McCall, Cox, Shelton, & Weinrich, 1997; Pashek & Tompkins, 2002). Since little or no speech context is available in picture naming and definition naming, name retrieval may be more difficult than in connected speech. Hence, performance in these tasks may serve as sensitive measures of the naming process across the life span.

Current models of lexical access in speech production (e.g., Caramazza, 1997; Dell, 1986; Levelt, Roelofs, & Meyer, 1999; MacKay, 1987) assume several sets of distinct processes intervening between the perception of a visual object/written definition and the articulation of the corresponding name, each of which could be affected by age. Picture naming requires the object to be recognised, i.e., perceptually activated, and the corresponding concept to be activated. Definition naming starts with conceptual activation. Concepts that are linked to entries in the mental lexicon are sometimes called lexical concepts. Given a lexical concept, both picture naming and definition naming require that a word which expresses this concept is selected and the phonological form of the selected word retrieved. Finally, a phonetic plan must be generated and executed during articulation of the word. The distinction between two stages of lexical access, lexical selection and word form retrieval, is important. During lexical selection, a word unit corresponding to the lexical concept is selected and its syntactic features (e.g., singular or plural, word class) are specified. During word form retrieval, the phonemic segments that make up the selected word are specified and its syllabic and prosodic structure is retrieved. Adopting the terminology from Levelt et al.'s (1999) model of speech production, we use the term *lemma* to refer to the selected word unit and its syntactic features, and the term *word form* to refer to the

phonologically encoded word. A framework consistent with this model is shown in Figure 1. Other models differ considerably from this model in the main processing units they assume and in the assumptions concerning the information flow between units. However, all current models distinguish between visual-conceptual and lexical processes, and they represent the semantic and syntactic properties of words separately from the phonological properties and therefore invoke separate retrieval steps for these properties.

Assuming that the processes involved in attending to a to-be-named object (i.e., covert orienting and visual filtering) are intact as long as the location of the object is predictable (Carlson, Hasher, Connelly, & Zacks, 1995; Kramer & Weber, 1999; for a review, see Plude, Enns, & Brodeur, 1994), older adults may need more time than young adults to recognise the object, to activate the corresponding lexical concept, to select the corresponding lemma, to retrieve the phonological form of the word, or to articulate the word. Similarly, older adults may need more time to activate the conceptual and lexical processes involved in the naming of definitions. It is important to explore age differences in these processes to determine whether they all become slower with age, or whether ageing has a disproportionate effect on one process, e.g., word form retrieval. Under general slowing theories (e.g., Salthouse, 1996, 2000; for a review, see Myerson & Hale, 1993), the speed of responding in cognitive tasks decreases with age regardless of the cognitive processes involved. Accordingly, the processes mediating picture naming and definition naming should all be affected by age. Another general theory of cognitive ageing is the Inhibition Deficit (ID) hypothesis (Hasher & Zacks, 1988, 1994, 1997). According to this theory, inhibitory processes decline with age, so that older adults activate more task-irrelevant information than young adults and are less able to suppress this information once activated. As a consequence, the theory predicts that irrelevant information should interfere with the retrieval of task-relevant information more in older than young adults. The ID hypothesis has not been directly applied to picture naming. However, as the hypothesis states that older adults suffer from a general inhibitory deficit that affects all cognitive processes, any components of picture naming that involve the inhibition of irrelevant information should be affected as well. For instance, if a particular process (e.g., the selection of words or segments) requires units to be inhibited, the process should take longer to complete (or be more error-prone) in older than young adults. It should be noted that inhibition as a mechanism involved in lexical access is proposed only by some models of speech production (e.g., Cutting & Ferreira, 1999; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; see Levelt et al., 1999, for a different proposal).



**Figure 1.** A framework of the stages involved in picture naming and definition naming, based on Levelt et al. (1999).

In contrast to general theories of cognitive ageing, the Transmission Deficit (TD) hypothesis (MacKay & Burke, 1990; Taylor & Burke, 2002) proposes that age-related slowing depends on the specific processes involved in a task. The TD hypothesis is the best articulated theory of how ageing affects language production. Unlike general slowing theories and the ID hypothesis, it makes specific predictions about the effect of age on picture naming. It focuses on the processes involved in language production and comprehension and states that the efficiency of these processes depends on how much and how fast priming<sup>1</sup> is transmitted across the connections linking concepts to word lemmas and lemmas to word forms. The TD hypothesis further states that the strength of these connections is weakened with age, thus reducing priming, particularly priming from lemmas to word forms, which is crucial for producing spoken words. Lemma-to-word-form priming diverges from one lemma (e.g., *ball*) along single connections to the corresponding phonemes (*b - a - l*). As successful word form retrieval requires that each phoneme in the word receives sufficient priming to enable activation, a deficit in transmitting priming across a single connection will prevent retrieval of the word form. In contrast, understanding spoken words involves priming from word forms to lemmas. Word-form-to-lemma priming converges from many phonemes (e.g., *b - a - l*) onto a single lemma (*ball*), and thus is more resistant to a transmission deficit. Similarly, the many connections linking lemmas and concepts can offset a transmission deficit. If a connection between a lemma (e.g., *ball*) and one conceptual feature (*is a toy*) is weakened, this feature will still be primed via connections from the lemma to other conceptual features at the same level (*is round*) and at a higher level (*is a round toy*). As an exception, proper names have no direct connections linking lemmas to conceptual features. The lemma of a proper name (e.g., *Pitt*) is connected to visual-conceptual features (*blonde, actor*) indirectly via a proper name phrase (*Brad Pitt*). As a result, the number of intervening connections that are vulnerable to a transmission deficit is increased. In addition, only a single connection links the lemma to the name phrase. A weakening of this single connection is more likely to result in a failure to retrieve the lemma or the corresponding word form than

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<sup>1</sup> Consistent with the TD hypothesis (MacKay & Burke, 1990), we use the term *priming* to refer to the excitation of a representational unit (i.e., a node) that prepares it for activation. The theoretical mechanism of node priming is different from the empirical process of priming which denotes an increase in the speed and accuracy of responding due to preactivation of the target response. Concerning the empirical process of priming, we distinguish between *semantic priming*, which refers to the preactivation of a target word's meaning, and *phonological priming*, which refers to the preactivation of its phonological form.

when multiple connections are available. This structure of connections can explain why proper names are particularly vulnerable to a transmission deficit (Burke, Locantore, Austin, & Chae, 2004; Burke, MacKay, Worthley, & Wade, 1991; Cohen & Burke, 1993; Maylor, 1990).

This review is divided into two sections. The first section summarises findings of studies looking at effects of age on discourse production. This section is divided into two subsections. The first focuses on the increase in verbosity with age and the second on the age-related increase in disfluencies. Possible origins of these age-related changes in discourse production are considered. The second section evaluates the findings of studies examining effects of age on accuracy and speed in naming pictures and definitions. This section is organized according to the experimental techniques used in the different studies.<sup>2</sup>

## DISCOURSE PRODUCTION

### Why do older adults produce more words than young adults?

Older adults produce more words than young adults in answers to autobiographical questions (Ceccaldi, Joanette, Tikhomirof, Macia, & Poncet, 1996; James, Burke, Austin, & Hulme, 1998) and in conversation (Arbuckle, Nohara-LeClair, & Pushkar, 2000; Bortfeld et al., 2001; Mackenzie, 2000). This age-related increase in the number of words produced in discourse has been associated with (a) language-specific processes involved in lexical access and in the conceptual and syntactic planning of an utterance (Bortfeld et al., 2001), (b) a more general cognitive deficit in inhibiting irrelevant information (Arbuckle et al., 2000), and (c) a voluntary change in speech style (Burke, 1997; James et al., 1998). We will review the evidence supporting each of these accounts.

There is some evidence suggesting that age-related increases in the number of words used in discourse reflect a language-specific deficit. Bortfeld et al. (2001) engaged pairs of young (mean age: 28 years), middle-

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<sup>2</sup> Some studies have shown that there are biases in how specific phonemes influence voice onsets and in how reliably voice onsets are detected by a voice key (Kessler, Treiman, & Mullennix, 2002; Rastle & Davis, 2002). These differences might contribute to the presence or absence of age differences in tasks in which utterance onset is the dependent measure. However, as long as young and older speakers produce the same words (i.e., their utterances are matched for onset syllable), the problems related to measuring voice onset do not arise (unless, of course, voice keys react differently to young and older speakers' voices. This may be true, but we do not know whether anyone has studied this). When young and older speakers produce different words, the problems may arise, along with many other problems (e.g., the words may not be matched for frequency, imageability, etc., either).

aged (mean age: 47 years), and older (mean age: 67 years) adults in a referential communication task. Pairs of participants were given identical sets of stimuli arranged in different sequences. They were separated by a screen preventing them from seeing each other's stimulus sequence. The task was to exchange information about the stimuli such that one participant, the matcher, could rearrange his or her stimuli to match the sequence of the other participant, the director. The stimuli were pictures of children (familiar stimuli) on one trial and pictures of abstract figures, known as tangrams (unfamiliar stimuli), on another trial. Bortfeld et al. counted the total number of words produced by each participant on each trial, including disfluencies, i.e., non-lexical fillers (e.g., *uh*, *um*), word repetitions (e.g., *just on the left left side*), and syntactic reformulations (e.g., *imme- just below the left side*) in the count. Older adults produced more words overall than young adults and more disfluencies than young and middle-aged adults. Both word counts and disfluency rates increased substantially with age when the stimuli were unfamiliar (conversation about tangrams) but only slightly when the stimuli were familiar (conversation about children). What exactly made conversation about tangrams difficult for older adults is unclear. The problem might have been in lexical access, i.e., in selecting specific word lemmas or retrieving specific word forms, or in planning the content and syntactic structure of the entire utterance. Considering lemma selection, the range of available labels is larger when talking about tangrams than about children. Perhaps the older adults found the process of selecting from a large range of labels more difficult than the young adults. Alternatively, the older adults may have found conversation about tangrams difficult because they had to determine an appropriate label for each tangram and consistently use that label to refer to it. Thus, talking about tangrams involved learning of new associations (i.e., between tangram figure and referential label). New learning has consistently been shown to be more problematic for older than young adults (Light & Burke, 1988; MacKay & Burke, 1990). Whatever the underlying difficulty, the interaction between age and stimulus familiarity suggests that older adults produce more words than young adults because they have a deficit of some sort (e.g., in language production or in learning of new associations), not because they select a different speech style.

In Bortfeld et al.'s (2001) study, a deficit specific to language is also suggested by the finding that the age-related increase in number of words co-occurred with an increase in the rates of non-lexical fillers, word repetitions, and reformulations. Assuming that these disfluencies reflect problems in lexical access or conceptual/syntactic planning, the increase in the number of words produced might reflect the same problems. This proposal is compatible with the finding that the middle-



aged participants, whilst producing fewer disfluencies than the older participants, still generated the same number of words as the older group. Having a milder problem than older adults, middle-aged adults might have managed to suppress some disfluencies, though at the cost of using extra words.

Rather than reflecting a language-specific deficit, the age-related increase in the number of words produced in discourse has been argued to reflect a general deficit in inhibiting irrelevant information. Within a group ranging in age from 63–95 years, Arbuckle et al. (2000) found that the older adults produced more irrelevant personal information than the younger adults in a life-history interview but not in referential communication about tangram figures. In the life-history interview, participants with high verbosity scores made up 5% of the participants from the youngest age group (aged 63–69 years) but 46% of the participants from the oldest group (aged 85–95 years). In the referential communication task, the amount of off-topic speech, i.e., speech which was irrelevant to the topic under discussion, was small for speakers of all ages. However, Arbuckle et al. observed that speakers who often strayed off topic in the life-history interview tended to describe the figures less efficiently, i.e., they needed more time, used more words and fewer referential labels, than speakers with lower levels of off-topic speech. The production of unnecessary descriptive information about the tangrams increased this inefficiency further. Thus, it appears that older verbose speakers produced more irrelevant speech than younger less verbose speakers regardless of the speech context (interview vs. referential communication), even though the content of the irrelevant speech varied across the different contexts: In the interview, personal information intruded, whereas descriptive information intruded in referential communication. Arbuckle et al. associated the age-related increase in verbose speech with a deficit in inhibiting irrelevant information. They suggested that the amount of irrelevant speech produced in a discourse task depends on the extent to which the task constrains speech. A life-history interview or a referential communication task places fewer constraints on speech production than a picture description task, which might explain why irrelevant information is more likely to intrude in the former than in the latter task context (James et al., 1998; Mackenzie, 2000).

Finally, it has been proposed that the age-related increase in the number of words produced in discourse does not reflect a deficit at all but rather a deliberate change in speech style. This proposal is based on two findings: First, the age-related increase in number of words co-occurs with an age-related increase in off-topic speech; second, this age-related increase in talkativeness and off-topic speech occurs only for topics directly related to personal experiences (Ceccaldi et al., 1996; Cooper, 1990; James et al.,

1998). In a picture description task, Cooper (1990) observed no difference between adults ranging in age from 20 to 78 years in the total number of words or the amount of irrelevant speech. On the other hand, Ceccaldi et al. found that older adults (aged 70+ years) produced three times as many morphemes as middle-aged adults (aged 45–55 years) in answers to autobiographical questions. This age-related increase in the number of morphemes produced was observed in both referential speech, i.e., speech conveying topic-related information, and modalising speech, i.e., the speaker's comments on this information. As the proportions of referential and modalising speech did not change with age, Ceccaldi et al. (1996) concluded that the amount of conversational speech increased with age without a concurrent change in the use of different speech components. They associated the age-related increase in the amount of speech in part to changes in the social situations of older adults. Because older adults in general tend to be more isolated than young adults, they may feel a greater need to talk, in particular about personal experiences. However, this interpretation of age-related increases in verbose speech as due to feelings of isolation is contradicted by the findings of Gold, Andres, Arbuckle, and Schwartzman (1988). They explicitly tested for an association between increased verbosity and psychosocial behaviour and found that older socially outgoing adults were more verbose than older socially more isolated adults (see also Arbuckle & Gold, 1993; Pushkar, Basevitz, Arbuckle, Nohara-LeClair, Lapidus, & Peled, 2000).

The findings of Cooper (1990) and Ceccaldi et al. (1996) are supported in a study by James et al. (1998). They examined age differences in the number of words and the amount of off-topic speech produced in conversation and picture description and found that older adults (mean age: 73 years) were more talkative and more often off topic than young adults (mean age: 19 years) when talking about personal subjects but not when describing pictures (see also Mackenzie, 2000). To account for this difference between tasks, James et al. pointed to the difference in speech topic and the extent to which personal experiences were relevant to a subject: In talking about personal topics, older adults select a different speech style than young adults because they have different communicative goals—they emphasise descriptions of personal experiences over descriptions of facts. Autobiographical experiences are irrelevant when describing pictures, which can explain why off-topic speech is not observed in picture description tasks.

These arguments highlight the difficulties arising when the number of words produced in discourse is used to determine whether older adults have problems in accessing lexical items. First, in discourse, problems arising during lexical access cannot easily be distinguished from problems arising during the generation of the syntactic frame of an utterance.

Second, increased verbosity in older adults might not reflect a language deficit but a cognitive deficit in suppressing irrelevant information. Finally, older adults might be more verbose because they have a different approach to the discourse task than young adults. In a discourse task with few constraints on speech production, older adults might emphasise the process of speaking and the opportunity it provides for social interaction more than speech efficiency.

### Why do older adults produce more disfluencies than young adults?

Older adults are more disfluent than young adults in picture description (Cooper, 1990; Le Dorze & Bédard, 1998; Schmitter-Edgecombe, Vesneski, & Jones, 2000) and in conversation (Bortfeld et al., 2001). Speech can be disfluent at different levels, e.g., in terms of prosody, lexical access, and syntactic production. The studies to be reviewed mainly considered disfluencies occurring at lexical and syntactic levels (for examples of prosodic disfluencies, such as errors in stress and intonation, see Lickley and Bard, 1998). However, within these two levels, there is considerable variation in the type of disfluencies examined. Whereas word repetitions and syntactic reformulations are included in most studies, non-lexical fillers (e.g., *uh*, *um*) and silent pauses are included in only a few. Non-lexical fillers are normally not included because they have various linguistic and communicative functions (Bortfeld et al., 2001), nor are pauses because their identification is highly subjective. Because of the different inclusion criteria used, the contrasting types of disfluencies are stated for each study separately.

There is some evidence that age-related increases in the number of disfluencies occur because older adults have more difficulties retrieving words than young adults. In a picture description study by Le Dorze and Bédard (1998), older adults (aged 65–85 years) retrieved the same amount of information as young (aged 25–44 years) and middle-aged (aged 45–64 years) adults, as reflected in the total number of different propositions and different content words. However, the older speakers needed more time to retrieve the information, as reflected in a lower number of different propositions and content words per minute and in their production of longer picture descriptions. Le Dorze and Bédard linked the reduced communication efficiency to the age-related increase in the frequency of word repetitions and to the comments on word-finding problems observed only in the older speakers' descriptions. They argued that the older speakers produced these disfluencies because of difficulties in accessing content words. Le Dorze and Bédard also noted that the older speakers were more likely than the young speakers to use the same rather than

synonymous words when expressing the same idea, which might also be due to word finding problems.

Also using a picture description task, Cooper (1990) found that adults between the ages of 20 and 78 years did not differ in processing efficiency, as measured by the number of relevant propositions per minute. However, the older adults tended to make longer pauses and to produce more filler words (e.g., *thing*) than the younger adults. Assuming that the use of filler words reflects word-retrieval difficulties, Cooper related the increased pause length in the older adults to slower lexical retrieval.

Like Le Dorze and Bédard (1998), Mackenzie (2000) found no age difference in picture description content, but observed differences in the efficiency of retrieving the content, with 'old-old' adults (aged 75–88 years) producing fewer relevant propositions relative to the number of words produced than middle-aged (aged 40–59 years) and 'young-old' (aged 60–74 years) adults. However, unlike Le Dorze and Bédard, Mackenzie attributed the reduced efficiency to slower visual perception and general cognitive slowing. She argued that if lexical retrieval had been slowed, the 'old-old' adults should have produced more words, but less content than the younger groups, but these measures were unaffected by age. It should be noted that Mackenzie used the cookie theft picture of a kitchen scene (Goodglass & Kaplan, 1983) to elicit speech. It contains a small number of easily labelled objects and actions which can be described with high-frequency words. This task might have been too easy to elicit word retrieval failures (see Cooper, 1990).

Consistent with Mackenzie (2000), Kemper and Sumner (2001) found no evidence that older adults suffer from lexical deficits. In answer to an autobiographical question, they found that, compared with young adults (aged 18–28 years), older adults (aged 63–88 years) produced utterances that were less dense in propositions (i.e., had lower numbers of propositions per 100 words), but were lexically more diverse, as reflected in higher type/token ratios (i.e., higher numbers of different words relative to the total number of words). Kemper and Sumner's failure to observe lexical access problems might reflect that they used an autobiographical question to elicit speech. Problems with lexical access might be less apparent in free discourse than in a more constrained task, such as picture description.

Evidence that age-related increases in disfluency rates reflect lexical access problems comes from a study by Schmitter-Edgecombe et al. (2000). Using a picture description task, they investigated effects of age on the proportion of main clauses containing disfluencies. They distinguished between a variety of disfluencies, including substitutions, word reformulations, repetitions, lexical fillers (e.g., *well, you know*), non-lexical fillers (e.g., *uh, um*), word-finding comments, and pauses. Based on previous

research reporting age-related increases in specific types of disfluencies, e.g., lexical fillers (Kemper, Rash, Kynette, & Norman, 1990) and lengthy pauses (Cooper, 1990), Schmitter-Edgecombe et al. predicted age-related increases only for certain disfluencies. The proportion of main clauses containing at least one disfluency was greater for older (aged 58–93 years) than young (aged 18–22 years) adults, but this held only for clauses containing word reformulations and word substitutions. They observed the opposite pattern within the old group, with the ‘old-old’ adults (aged 75–93 years) producing fewer reformulations and substitutions than the ‘young-old’ adults (aged 58–74 years). However, this decrease was accompanied by an increase in the number of lexical fillers. Schmitter-Edgecombe et al. associated the increase in the use of lexical fillers with word-finding problems. By producing more filler words, the ‘old-old’ adults gained time to access specific words, thus avoiding more serious disfluencies, i.e., reformulations and substitutions. Using the referential communication task described above, Bortfeld et al. (2001) found a similar age-related increase in disfluencies. They distinguished between disfluencies arising from difficulties in planning entire utterances, difficulties in retrieving individual words, and disfluencies serving a coordinative function. Disfluencies in general may reflect problems with planning what information to express and how to express it (Oviatt, 1995; Shriberg, 1996), while non-lexical fillers (e.g., *uh*, *um*) may either serve a coordinative function by warning the listener of the delays in speaking due to planning or retrieval problems (when occurring between syntactic phrases), or they may signal word-finding problems or repairs of them (when occurring within syntactic phrases) (Clark, 1994, 2002; Shriberg, 1996). Interestingly, the rate of non-lexical fillers does not increase with increasing utterance length in the way that the rates of other disfluencies do (Shriberg, 1996). As utterance length usually correlates with syntactic planning load (long utterances require more syntactic planning than short utterances), this suggests that non-lexical fillers do not signal syntactic planning difficulties. Now, if older adults have problems finding words in conversation, the incidence of fillers within phrases should increase more with age than the incidence of fillers between phrases. Overall, older adults (mean age: 67 years) produced slightly more disfluencies (i.e., repetitions, reformulations, and non-lexical fillers) than young (mean age: 28 years) and middle-aged (mean age: 47 years) adults. Crucially, the increase in the occurrence of fillers was larger for within- than between-phrase fillers, consistent with there being increased word-retrieval difficulties.

As shown above, disfluencies (e.g., word repetitions, fillers, and pauses) are indicative of problems arising during conceptual or linguistic planning but do not constitute clear indicators for specific types of problems. To discriminate between the various types of problems that might underlie

age differences in spoken discourse, it might be more useful to compare young and older adults' performance on a task that is specifically designed to tap one component of the speech, e.g., syntactic planning. If older adults perform poorly on such a task, it can be concluded that they are impaired in this specific component. Davidson, Zacks, and Ferreira (2003) tested this by presenting young (mean age: 22 years) and older (mean age: 74 years) adults with a sentence generation task. A subject-verb phrase (e.g., *I told*) was followed by content words of a simple sentence presented in a random order (e.g., *manager, story*). The task was to arrange the words into a sentence and produce it. Verbs were presented that allowed alternative arrangements of the words (e.g., *I told a story to the manager* or *I told the manager a story*). The older participants were as fast and as fluent in responding as the young participants, i.e., the proportion of sentences containing a hesitation, pause, or repair was the same for the two age groups. This suggests that, when the words are provided, older speakers can choose between and generate alternative utterance structures efficiently (at least the relatively simple structures used by Davidson et al.

However, evidence that older speakers have difficulties in producing more complex syntactic structures comes from a study by Kemper, Herman, and Lian (2003). They presented young (aged 18–28 years) and older (aged 70–80 years) participants with two, three, or four words and asked them to produce sentences that included the presented words. Sentences were scored as correct if they were fluent (i.e., without hesitations or repairs), grammatical, and included all stimulus words. The older participants performed as accurately as the young participants when two or three words were presented but less accurately when four words were presented. In addition, when the older participants did produce correct sentences, their sentences were shorter, grammatically less complex, and less informative than those produced by the young participants. An additional finding was that the older participants performed as accurately as the young participants when they produced sentences that included a verb with a simple argument structure (i.e., a verb that takes no object or a noun as object) but less accurately when they used a verb with a more complex argument structure (i.e., a verb that requires a sentence as object). Verbs with complex argument structures also reduced the length, grammatical complexity and content of the correct sentences produced by the older participants. Kemper et al. suggested that both manipulations, i.e., the number of words to be used in a sentence and verb complexity, increased the working memory load during sentence production. Apparently, age differences arise when the working memory load is relatively high. In Davidson et al.'s (2003) study, the age effect might have been absent because in that study, memory load was not varied.

Further evidence that verb complexity affects older adults' sentence production comes from a study by Altmann and Kemper (in press), in which participants had to generate simple grammatical sentences using prespecified words (a verb and two nouns, e.g., *eaten-cake-princess*). Altmann and Kemper compared the effect of verb complexity on young (mean age: 20 years) and older (mean age: 76 years) adults' sentence production. The older participants were less accurate than the young participants when using irregular past participles, which require that either a perfective sentence (*the princess had eaten the cake*) or a passive sentence (*the cake was eaten by the princess*) is produced, but were as accurate as the young group when using verbs which elicited simple active sentences regardless of the complexity of the argument structure of these verbs. No age differences were observed on response times. When using irregular past participles, speakers need to recognise that simple active sentences are inappropriate with this verb type. Because of this additional metalinguistic processing, irregular past participles put a heavier working memory load on speakers than other verb types. Consistent with the finding of Kemper et al. (2003), this increase in memory load might have been particularly detrimental for the older participants (see also Altmann, 2004; Altmann, Kempler, & Andersen, 2001).

## Conclusions

In sum, studies in which younger and older speakers were engaged in various discourse tasks confirm the general impression that older speakers 'talk more'. They use more words to express a given idea and their speech tends to be less fluent. These age-related differences are present in discourse tasks depending upon the task difficulty and the extent to which the task constrains the content of the utterance.

(1) Age-related increases in the number of words produced are more pronounced in difficult than in easy discourse tasks (e.g., referential communication about unfamiliar vs. familiar stimuli) (Bortfeld et al., 2001). Given the evidence that the ability to generate the syntactic structure of utterances is largely intact in old age (Altmann & Kemper, in press; Davidson et al., 2003; Kemper et al., 2003), this suggests that older adults produce more words to mask difficulties in conceptual planning or in selecting or retrieving individual words. The disfluent speech observed in older adults also seems in part to be due to lexical retrieval difficulties, as suggested by the evidence that the higher rate of non-lexical fillers within phrases was higher in older than younger speakers (Bortfeld et al., 2001).

(2) Picture description does not elicit verbose off-topic speech in older adults (James et al., 1998; Mackenzie, 2000), perhaps reflecting that it is

both a relatively easy and a highly constrained task (Arbuckle et al., 2000). In contrast, in conversational speech, older adults often digress from the speech topic (James et al., 1998). According to the inhibitory deficit account, older adults produce irrelevant speech in unconstrained tasks, independent of the speech topic, because they have a deficit in inhibiting irrelevant information (Arbuckle et al., 2000). According to the change-in-speech-style account, the amount of off-topic speech that older adults produce in discourse depends on the speech topic and its relevance to personal experiences. Because the increase in off-topic speech is observed only for topics that are relevant to personal experiences, it can be argued that verbose speech in older adults reflects selective changes in speech style as opposed to a cognitive deficit in inhibiting irrelevant speech (James et al., 1998). However, the finding that irrelevant speech increases with age even when the topic is unrelated to personal experiences is difficult to reconcile with this account (Arbuckle et al., 2000).

The reviewed studies suggest age-related changes in various processes involved in discourse production. Young and older speakers probably differ not only in their ability to retrieve words and generate (syntactically complex) sentences, but also in their ability to inhibit irrelevant information and in their speech style. For this reason, it is difficult to use young and older speakers' performance on discourse tasks as an indicator of their lexical retrieval abilities. Picture naming and naming to definition, to which we turn next, might be more sensitive tasks for determining if age differences in speech production are due, at least partly, to older adults having problems with lexical retrieval; first, because they are constrained tasks in which difficult words cannot be avoided and the communicative goals are well-defined; second, because the difficulty of syntactic processes is minimised.

## PICTURE AND DEFINITION NAMING

Two paradigms have been widely used to study lexical access to single words: picture naming and definition naming. A general finding of picture naming studies is that older adults are less accurate (Albert, Heller, & Milberg, 1988; Au, Joung, Nicholas, Obler, Kaas, & Albert, 1995; Barresi, Nicholas, Connor, Obler, & Albert, 2000; Hodgson & Ellis, 1998; Le Dorze & Durocher, 1992; Maylor, 1995; Nicholas, Obler, Albert, & Goodglass, 1985; Randolph, Lansing, Ivnik, Cullum, & Hermann, 1999) and slower than young adults (Bowles, 1994; Feyereisen, Demaeght, & Samson, 1998; Hodgson & Ellis, 1998; Maylor, 1995; Mitchell, 1989; Thomas, Fozard, & Waugh, 1977; but see Evrard, 2002; Poon & Fozard, 1978). It is less clear why this is the case. Within the framework of the speech production model proposed by Levelt et al. (1999, see Figure 1), older adults may need more



time than young adults to recognise the object and to activate the corresponding lexical concept. Alternatively, or in addition, they may need extra time to select a lemma for the object name, retrieve the phonological and phonetic form and, finally, articulate the name.

A consistent finding in naming-to-definition tasks is that older adults know and produce the name of more definitions than young adults, but for definitions they are unable to name, they are in a tip-of-the-tongue (TOT) state more often than young adults (Brown & Nix, 1996; Burke et al., 1991; Heine, Ober, & Shenaut, 1999; Maylor, 1990; but see Vitevitch & Sommers, 2003; for reviews, see Brown, 2000; Burke & Laver, 1990; Burke & Shafto, 2004; Schwartz, 2002). In a TOT state, a person knows the target name, but is unable to retrieve it. There is evidence from a variety of studies that TOTs occur when speakers can access word lemmas but not the corresponding word forms. In particular, research with Italian speakers (Badecker, Miozzo, & Zanuttini, 1995; Caramazza & Miozzo, 1997; Miozzo & Caramazza, 1997; Vigliocco, Antonini, & Garrett, 1997) and French speakers (Ferrand, 2001) have shown that persons experiencing TOT states are more likely to specify the grammatical gender of the target word correctly than would be expected on the basis of chance estimates. Research with English speakers (Vigliocco, Vinson, Martin, & Garrett, 1999) has shown that persons in a TOT state are able to correctly report whether the target word is a count noun or a mass noun. This demonstrates that they can often retrieve the target lemma, where grammatical gender and count/mass information are encoded, but are unable to retrieve the word form.<sup>3</sup> Thus, the high incidence of TOTs in older speakers suggests that they have a deficit in the lemma-to-word-form connections.

In our review of the picture naming and definition naming studies, we focus on age differences in lexical processes (i.e., lemma selection and phonological form retrieval), although age differences in object recognition are also considered. Because word and sentence comprehension appears to be largely intact in old age (for reviews, see Burke, MacKay, & James, 2000; Laver & Burke, 1993), we exclude from consideration the processes involved in understanding the written definitions.

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<sup>3</sup> Rather than reflecting a failure to retrieve the complete phonological form of a target word, it has been suggested that TOTs occur when speakers activate words associated with the target and these non-target words block or inhibit retrieval of the target (Brown, 1991; Jones, 1989). According to the ID hypothesis, the age-related increase in TOTs reflects that older adults activate more blockers and are more susceptible than young adults to inhibition of target retrieval from these blockers (Brown & Nix, 1996; Zacks & Hasher, 1994). However, because of compelling evidence against this account of TOTs (Brown, 2000; Burke, 1997; Burke et al., 1991; Cross & Burke, 2004; Heine et al., 1999; Maylor, 1990; Rastle & Burke, 1996; Vitevitch & Sommers, 2003), it has largely been abandoned and is not considered here.

In the following sections, we review experimental studies using a variety of paradigms to investigate (a) whether older persons have a specific lexical deficit, rather than being generally slower in all cognitive tasks than younger persons, and (b) whether such a deficit, should it exist, can be allocated to a specific stage of lexical retrieval. Tables 1 and 2 in the Appendix give an overview of the reviewed studies.

### Age and effects of phonemic cueing

Data based on the Boston Naming Test (BNT, Kaplan, Goodglass, & Weintraub, 1983) consistently show that any decrease in naming accuracy does not become significant until adults are in their 70s (Albert et al., 1988; Au et al., 1995; Barresi et al., 2000; Nicholas et al., 1985; see Feyereisen, 1997, for a meta-analysis). Investigating the cause of age-related naming failures, Nicholas et al. (1985) presented adults ranging in age from 30–79 years with objects to name spontaneously or following semantic and phonemic cueing. If an object was misperceived, as evidenced by a visual error (e.g., *snail* for *spiral*), a semantic cue was given. If an object was not named either spontaneously or following a semantic cue, a phonemic cue was given, which was the first phoneme or syllable of the target name. Nicholas et al. found that the number of occasions where a semantic cue was needed and the number of occasions where a phonemic cue was needed increased with age<sup>4</sup> but the benefit from cues was the same across the age range. They interpreted the age-related increase in the number of required semantic cues as evidence for perceptual difficulties in old age, whilst the benefits from phonemic cueing may reflect a major difficulty in retrieving the phonological form of a word in older adults. Consistent with this last proposal, the older adults also produced semantic errors, circumlocutions, and word-finding comments, where they were able to access the conceptual field of the targets (i.e., able to access the target's superordinate category, semantic associates, and semantic features) but remained unable to access the precise word (lemma or phonological form) within that field (see also Albert et al., 1988).

In a longitudinal study by Au et al. (1995), adults above 70 years of age benefited less from phonemic cues than younger adults. As there were no signs of semantic dementia, this age difference raises the possibility that naming failures in old age reflects more than impaired word form retrieval and that lexical selection at a semantic level might be

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<sup>4</sup> Nicholas et al. (1985) did not specify if these increases refer to the number of occasions where only one cue was needed (semantic or phonemic), or if there was an increase also in the need for double-cues.

implicated as well. However, from Au et al.'s study, it is not clear whether participants failed to name some pictures consistently or only in some sessions. Consistent failure to name a picture might indicate some degree of semantic degradation, whereas successful naming in some sessions may more likely indicate impaired word form retrieval (Shallice, 1987; Warrington & Shallice, 1979, though see Forde & Humphreys, 1997). To discriminate between semantic degradation and impaired word form retrieval, Barresi et al. (2000) investigated the consistency in naming individual items following phonemic cueing. Adults ranging in age from 50–79 years were tested in three sessions with 3 to 3½ years between test sessions. Successful naming or naming after cueing in an early test session with a failure to name an item following a phonemic cue in a later test session was taken as evidence for semantic degradation, whereas the opposite pattern, i.e., cueing failure in an early session with successful naming or cueing in a later session, was taken as evidence for impaired lexical access. Both types of naming failures were observed more often in adults above 70 years of age than in younger groups, though the impaired access type increased the most. Barresi et al. concluded that age-related decline in picture naming was in part due to semantic degradation and could not be wholly attributed to impaired lexical access.

In sum, the BNT studies show that naming failures do not become significant until adults reach their seventies, and that the underlying deficit is in selecting word lemmas and/or in the connections between word lemmas and word forms. The age-related increase in the proportion of semantic errors (i.e., semantic associates, circumlocutions, and word-finding comments) (Albert et al., 1988; Au et al., 1995; Nicholas et al., 1985) is also consistent with older adults understanding the underlying concept but having problems in selecting the target lemma or in using information about the lemma to retrieve the corresponding phonological word form. The interpretation of the results of phonemic cueing studies is complicated by the fact that phonemic cues might, via feedback, facilitate lemma selection (Howard & Orchard-Lisle, 1984; Lambon Ralph, Sage, & Roberts, 2000). Hence, positive effects of phonemic cuing (Albert et al., 1988; Nicholas et al., 1985) could reflect a deficit either in lemma selection or in lemma-to-word form connections. Failures to find phonemic cueing effects (Au et al., 1995; Barresi et al., 2000) might then indicate that word lemmas are degraded or the connections between lemmas and word forms are too weak to benefit from cueing. The absence of an age-related increase in phonological speech errors (Albert et al., 1988; Nicholas et al., 1985), though, suggests that the phonological forms of words are intact in old age, and that the deficit arises at a higher level.

## Age and effects of object name properties

A number of studies have observed overall age differences in picture naming latencies, with slower naming in older than younger adults (Mitchell, 1989; Morrison, Hirsh, Chappell, & Ellis, 2002; Poon & Fozard, 1978; Thomas et al., 1977; for a review, see Amrhein, 1995). In an attempt to determine where in the naming process this slowing arises, these studies investigated whether the effects of variables such as name frequency and age of acquisition, which are known to affect the time required for lexical retrieval in young adults, had comparable or stronger effects in older adults. If an interaction involving age is obtained, and if the effect of the independent variable can be clearly allocated to a specific level of processing, it can be concluded that older adults differ from younger ones in their processing at that specific level.

Thomas et al. (1977) presented adults ranging in age from 25 to 74 years with pictures of objects varying in name frequency. To determine whether age differences in picture naming latencies decreased with repeated naming of the objects and when the object names were primed, the same pictures were presented over eight blocks of trials. In each block, the first half of the trials presented pictures without a preceding word prime (unprimed condition), whereas the second half presented pictures preceded by a word prime (primed condition). On half of the primed trials, the prime named the target object, on the other half, it named a different object. On all trials, the task was to name the picture. A main effect of age was observed, with the older adults naming objects more slowly than the young adults. In the unprimed condition, high-frequency names were retrieved faster than low-frequency names. Age interacted with block order, with smaller age differences on later than earlier blocks for a given object. Age also interacted with prime condition, with age differences being smaller in the primed condition (where the object name preceded the object).<sup>5</sup> However, age did not interact with name frequency.

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<sup>5</sup> Thomas et al. (1977) only included the incorrect-prime condition to ensure that in the correct-prime condition, participants did not produce the picture name without recognising the picture, but simply translated the written form of the name into the corresponding phonological form. Thus, they did not analyse the difference in naming latency between the unprimed and the incorrect-prime condition. However, they presented a figure displaying the mean naming latencies in the unprimed, correct-prime, and incorrect-prime conditions for the different age groups. This figure shows that there was a slight increase in the latency in the incorrect-prime condition relative to the unprimed condition for both younger and older adults. This suggests that reading the name of a non-target object interfered with naming of the target object and that this interference was similar for the different age groups. The similarity of the interference for younger and older adults contradicts the ID hypothesis of cognitive ageing.

The finding that repeated naming of the objects and priming from the object names did not eliminate but only reduced the age difference led Thomas et al. to conclude that age-related slowing was not due to slower lexical access alone, but also to slowing in perceptual and motor processes.

Poon and Fozard (1978) drew the same conclusion. They presented young (mean age: 20 years), middle-aged (mean age: 50 years) and older adults (mean age: 65 years) with pictures of objects varying in familiarity. Unique aged objects (e.g., a bed pan) and unique contemporary objects (e.g., a calculator) were presented to determine whether familiarity with the object name affected naming latencies. Common aged objects (e.g., an old telephone) and common contemporary objects (a modern telephone) were presented to determine whether familiarity with the visual features of objects affected naming latencies, independently of familiarity with the object names. Overall, young, middle-aged, and older adults did not differ significantly in their naming latencies. However, age interacted with the agedness (aged vs. contemporary) and uniqueness (unique vs. common) of the objects. For pictures of unique objects, the young adults named contemporary objects faster than the older adults, whereas the reverse was true for aged objects. For pictures of common objects, the older adults named aged objects faster than the young adults, whereas no age difference was found for contemporary objects. Thus, familiarity with the object name and its visual features contributes to age differences in picture naming latency.<sup>6</sup>

Poon and Fozard (1978) also adopted the priming procedure used by Thomas et al. (1977). Following the presentation of the four sets of objects in the unprimed condition (described above), the same objects were presented in a primed condition, i.e., preceded by word primes that named the target object or a different object. Since the primed condition should minimise lexical access, the latency difference between this condition and the unprimed condition provides a measure of the time needed for lexical access. This difference was constant across age. From this, Poon and Fozard concluded that age-related slowing in picture naming arose during perception of the object and articulation of its name, whereas lexical access was unaffected by age.

The assumption on which this conclusion is based, i.e., that naming in the prime condition minimises lexical access, can be questioned. Reading

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<sup>6</sup> Rather than reflecting an effect of object name familiarity, the latency difference between unique aged and unique contemporary objects in Poon and Fozard's (1978) study might reflect a difference in the age of acquisition of the different object names. The older adults in this study will have learned the names of the aged objects earlier in life than the names of the contemporary objects, whereas the young adults will have learned the contemporary names earlier than the aged names (see Hodgson & Ellis, 1998).

the object name prior to presentation of an object should make the concept to be named and the phonological form to be retrieved more readily available. Indeed, assuming that word frequency effects arise during phonological retrieval, the finding of Thomas et al. (1977) that frequency effects disappeared in the prime condition is consistent with phonological retrieval being facilitated. In contrast, because word reading can be achieved using direct mappings between orthographic and phonological word forms (Roelofs, 1992), reading the object name should not prime the connection between the target lemma and target word form, as this is uniquely activated in picture naming. Consequently, the age difference observed in the correct-prime condition might be because older adults are slower than young adults in establishing the lemma-to-word-form connection, in addition to being slower in perceiving the object and articulating its name. The finding of Poon and Fozard (1978) that familiarity with the object name (assumed to affect the ease of lemma selection) interacted with age in the primed conditions is evidence that the primed conditions did involve lemma selection.

Even if we assume that the primed and unprimed conditions in the Thomas et al. (1977) and the Poon and Fozard (1978) studies differed in the amount of processing required, prime condition was confounded with the order in which the primed and unprimed conditions were presented. Consequently, the objects might have been easier to name in the (correctly) primed than the unprimed condition not only because of the prime, but also because the primed condition followed the unprimed condition.

Mitchell (1989) investigated age differences in lemma selection by contrasting naming times to pictures of objects with high or low name agreement, i.e., objects with only one plausible name (e.g., a chair) or several possible names (e.g., a sofa which could also be called a couch or settee). Older adults (aged 63–80 years) named the pictures more slowly than young adults (aged 19–32 years), but the advantage for objects with high name agreement was equal. Consequently, Mitchell concluded that age-related changes in overall naming latency reflected a general slowing of perceptual and motor processes, whereas access to lemmas was unaffected by age (see also Poon & Fozard, 1978).

However, an effect of age on lexical retrieval processes is suggested by the results of a study by Le Dorze and Durocher (1992). They compared French-speaking young (aged 25–44 years), middle-aged (aged 45–64 years), and older (aged 65–85 years) adults' naming of objects with one-, two-, and three-syllable names. The older adults named fewer objects correctly than the young and middle-aged adults, and the number of pictures named correctly decreased as the name length increased. Furthermore, there was an increase in the age difference as the name

length increased. However, as the objects in the three syllable groups were not matched on other stimulus variables, such as object familiarity and name frequency, the observed decrease in naming accuracy with age could reflect an increased sensitivity with age to variables other than name length. Indeed, Le Dorze and Durocher showed that name length correlated significantly with name frequency (with short words tending to be more common than long words) and that both variables correlated significantly with naming accuracy (with higher naming accuracy on objects with short and common names). However, no attempt was made to determine if name length and name frequency, if any, had independent influences on naming accuracy.

Such an attempt was made by Hodgson and Ellis (1998). Having established that older adults (aged 71–86 years) named fewer object pictures correctly than young adults (aged 22–33 years), they carried out a multiple regression analysis on the older adults' correct responses to determine which object properties influenced accuracy (visual complexity, object familiarity, imageability, name agreement, age of acquisition (AoA), name frequency, or name length). The analysis showed that name agreement, AoA, and name length predicted naming accuracy, with objects with many possible names, with late acquired names, and with long names being named less accurately. Assigning effects of these variables to processes involved in lexical access, Hodgson and Ellis concluded that lexical access was impaired in old age. However, the occurrence of visual errors in the elderly suggested an additional impairment in object recognition. Because Hodgson and Ellis found that name agreement, assumed to affect ease of lemma selection, as well as AoA and name length, assumed to affect ease of word form retrieval, predicted naming accuracy, the results of this study suggest that both lemma selection and word form retrieval are impaired in old age.

In Hodgson and Ellis' (1998) study, the young adults performed close to ceiling. To determine whether effects of AoA on picture naming latencies change with age, Morrison et al. (2002, Experiment 2) varied the age at which the names of the stimulus pictures were acquired, contrasting early acquired names (learned before the age of 26 months) with late acquired names (learned at the age of 50 months or later). The two sets of pictures were matched on a number of variables, including name frequency and name length, which have been found to correlate with AoA (short, high-frequency words tend to be acquired earlier in life than long, low-frequency words). If AoA effects are due to differences in the time a word has resided in memory (i.e., how long a word has been known), effects of AoA might decrease with age, as the proportional difference in residence time between early- and late-acquired words reduces over time. On the other hand, if AoA effects are due to differences in the age at which a

word is learned, the size of the effect should be the same in young and older adults. Morrison et al. found longer naming latencies in 'young-old' (aged 60–69 years) and 'old-old' (aged 80–93 years) adults than in young adults (aged 18–32 years) and longer latencies for late- than early-acquired names but no interaction between participant age and AoA. This result was taken as evidence that AoA effects reflect when words are learned rather than how long they have resided in memory. As AoA effects were also observed in word naming, which can be achieved using direct mappings between orthographic and phonological word forms, Morrison et al. located the AoA effect at the stage of phonological form retrieval. However, the additive effects of participant age and AoA are also compatible with the assumption that AoA effects reflect how long words have resided in memory and that the size of this effect decreases with age. The expected age-related decrease in the AoA effect might have been cancelled by an age-related deficit in lexical access. Thus, although the difference in the time early- and late-acquired words have spent in memory reduces with age, this reduction might have been cancelled by an age-related deficit in retrieving late-acquired words.

The finding of Morrison et al. (2002) that effects of participant age and AoA are additive is contradicted by a study by Lewis, Chadwick, and Ellis (2002). Using a face recognition task, they presented young (aged 18–25 years) and older (aged 41–80 years) participants with faces of current TV characters and asked them to indicate in which TV show each character appeared. By varying the age of the participants, while keeping the time the faces had been known the same for all participants, they were able to determine the independent effects of age of acquisition (young vs. middle and old age) and time known on recognition time. Lewis et al. entered the data into a multiple regression analysis and found that the length of time (in months) a face had been known predicted the speed of recognising that face for both the young and the older participants. However, the effect of time known was larger for the older than the young participants. One possible explanation of the increase in the effect with age is that the older participants had not encoded the newly learned faces as well as the young participants and thus needed more time to recognise them. New learning has been consistently shown to be more difficult for older than young adults (Light & Burke, 1988). Because of the different results of Morrison et al. and Lewis et al., it is difficult to determine if AoA effects reflect age of acquisition or time known, and if the effects differ for young and older participants or is independent of participant age.

In sum, latency studies of picture naming in which properties of the picture names were varied provide little evidence that a lexical deficit underlies older adults' slower picture naming. Rather, the effect of participant age has been shown to combine additively with factors that



affect the speed of lexical access (e.g., word frequency, object familiarity, name agreement, and AoA). Le Dorze and Durocher (1992) did report larger effects of name length on older than young adults' naming accuracy, but differences in name length may have been confounded with other differences known to affect picture naming (e.g., object familiarity); hence it is not certain that the observed age difference originated during word form retrieval.

### Age and effects of semantic priming and semantic interference

As we have noted, age-related slowing in picture naming might be due to the meaning of the picture name not being activated to the same level in older as in young adults. This possibility has been examined using a variety of priming and interference paradigms, in which the objects to be named are accompanied by spoken or written words (called primes when they precede the targets, and distractors when they co-occur with the targets).

Using a primed picture-naming paradigm, Bowles (1994) had young (aged 18–33 years) and older (aged 65–83 years) participants name pictures preceded by a masked, written word prime that was associatively related to the picture, by an unrelated prime, or by no prime (i.e., a blank screen). Stimulus onset asynchrony (i.e., the interval between onset of prime and onset of target, SOA) was manipulated by varying the duration of prime presentation from zero threshold, at which the prime could not be named, to full threshold, at which the prime could be named consistently. To control for age differences in the time needed to visually process the prime, presentation thresholds were individually determined, with mean thresholds of 13 ms (zero) and 22 ms (full) for young adults and 25 ms (zero) and 37 ms (full) for older adults. Bowles found longer naming latencies for the older than for the young participants, for the unrelated relative to the related prime condition (i.e., semantic priming), and for the primed relative to the unprimed condition (i.e., prime interference). Crucially, there was no interaction between age and prime type, or between age, prime type, and prime duration: In both age groups, semantic priming and prime interference were observed within the first 50 ms of prime duration (equivalent to SOAs of 90–150 ms for the young group and 103–165 ms for the old group). However, naming latencies in the primed conditions returned to the no-prime latency level at a later SOA in the older (350-ms SOA) than the young participants (200-ms SOA). Bowles concluded that semantic activation and interference from prime words did not take longer to accumulate in the older than the young participants, but that prime interference decayed more slowly. These results were simulated in a model

with three parameters: rate of excitation, rate of inhibition, and rate of decay of activation. Because the naming latencies observed in the older participants were best modelled by reducing the rate of all three parameters by a constant multiplicative factor, Bowles concluded that the delay in overcoming prime interference in the older participants reflected general slowing of cognitive processing (see also Tree & Hirsh, 2003).

The results of a study by Feyereisen et al. (1998) also suggest that age-related slowing in picture naming is a consequence of age-related slowing in overall speed of responding. Using a picture-word interference paradigm, Feyereisen et al. compared young (aged 16–31 years) and older (aged 60–77 years) adults' performance on picture and word naming. In both tasks, participants had to name the target stimuli, while ignoring simultaneous distractor words (or stars in a control condition) printed above or below the stimuli. In Experiment 1, the distractors were associatively related, phonologically related, or unrelated to the pictures. In Experiment 2, the associates were replaced with categorically related distractors. In both experiments, longer naming latencies were found for older than for young adults, for picture than word naming, and for the various distractor conditions compared with the control condition. Although there were numerical differences between the distractor conditions (relative to the unrelated condition, naming latencies were longer when a categorically related distractor was present and shorter when a phonologically related distractor was present), these differences were not statistically significant. The failure to obtain phonological facilitation and semantic interference effects might be due to the presentation of distractor words above or below the target pictures. Usually, visual distractors in picture-word interference tasks are superimposed on the pictures (e.g., Damian & Martin, 1999; Starrefeld & Heij, 1996). Age did not interact with interference effects, ruling out that an inhibitory deficit was responsible for the older adults' reduced naming speed. Likewise, there was no interaction between age and naming task, ruling out a task-specific deficit (e.g., in the lemma-to-word-form connections, which are critical for picture but not for word naming). Based on these results, Feyereisen et al. concluded that age-related slowing in picture naming reflected a general age-related slowing in cognitive processing.

Data from a study by Taylor and Burke (2002), however, can be interpreted as inconsistent with generalised slowing. In two experiments, they asked young (aged 18–29 years) and older (aged 62–85 years) participants to name object pictures while ignoring auditory distractor words presented immediately before (–150-ms SOA) or after (+150-ms SOA) picture onset. The distractor words were categorically related to the

target pictures (e.g., distractor: *turtle*, target: *frog*) or unrelated.<sup>7</sup> In Experiment 2, there was slower picture naming in the older than the young participants but age-equivalent levels of semantic interference. However, in Experiment 1, there was increased semantic interference in the older participants. This could reflect a specific deficit in selecting the appropriate semantic representation for the stimulus, or (possibly) even enhanced processing at a semantic level (see also Tree & Hirsh, 2003).

In sum, older adults name pictures more slowly than young adults. In some studies older adults show the same amount of lemma activation as young adults, as evidenced by age-equivalent effects of semantic priming and semantic interference (Bowles, 1994; Taylor & Burke, 2002; Tree & Hirsh, 2003), though in other studies semantic effects are larger in older than young adults (Taylor & Burke, 2002). The increased effect with age can be interpreted as consistent with general age-related slowing, with a specific deficit in lemma selection, or even with intact lemma selection. According to general slowing theories (e.g., Myerson, Ferraro, Hale, & Lima, 1992; for a review, see Myerson & Hale, 1993), older adults show greater effects of semantic priming and semantic interference than young adults because of their overall slower processing. The argument is that if the same proportion of processing is saved (or added) in young and older adults when they are given a semantic prime or distractor, but older adults are slower to process lexical information, then the absolute amount of time saved (or lost) when a semantic prime or distractor is available is greater in older than young adults. An age-related increase in the semantic priming effect is also consistent with the ID hypothesis which argues that unlike semantic inhibition processes, semantic activation processes, assumed to underlie the priming effect, are intact in old age (Zacks & Hasher, 1997). In contrast, the TD hypothesis (Burke et al., 1991; Laver & Burke, 1993; MacKay & Burke, 1990) proposes that older adults show larger semantic effects than young adults *despite* their slower overall processing. This is because semantic priming is aided by the many indirect connections that link conceptually related words. Priming from these indirect connections summates on the target, thereby overcoming the age-related slowing in transmitting activation over any one connection.

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<sup>7</sup> Conditions in which the relationship between distractor and picture was phonological, mediated phonological, and semantic/phonological were also included. We will return to these conditions in the next section.

## Age and effects of phonological and mediated priming

A number of studies have used phonological priming or cueing as a technique to locate the deficit underlying the age-related increase in TOTs (James & Burke, 2000; Rastle & Burke, 1996; White & Abrams, 2002). If an effect of phonological priming/cueing is observed in both young and older adults and the effect is of the same size in the different age groups, it can be concluded that older adults have intact phonological representations of words and that the increase in TOTs with age is due to a deficit in the connections linking word lemmas to word forms. On the other hand, a reduction in the phonological priming/cueing effect with age would suggest that older adults have impaired phonological representations rather than, or in addition to, impaired lemma-to-word-form connections.

Using a repetition priming paradigm, Rastle and Burke (1996) investigated effects of prior processing of target words on target word retrieval in young (aged 18–22 years) and older (aged 64–82 years) adults. They found that reading a word aloud in a pronunciation rating task increased correct retrieval of the word in answer to a question in a subsequent general knowledge task and reduced its vulnerability to a TOT state by almost 50%. Although the older participants produced more TOTs than the young participants, the effects of prior processing of the target names were age-equivalent (Experiment 1). Rating the pleasantness of a word (assumed to involve semantic processing) increased correct responding more than silent reading of the word in both the young and the older participants but reduced TOTs no more than silent reading in any of the age groups (Experiments 2 and 3). Based on the finding that prior phonological processing of a word was sufficient to resolve TOTs, Rastle and Burke concluded that TOTs occur because of a deficit in phonological retrieval. However, because prime words and target names were identical also at a lemma level, the priming effect may have occurred at this level rather than at the phonological level.

To control for repetition effects at a lemma level, James and Burke (2000) used phonologically related words as primes/cues. Young (mean age: 19 years) and older (mean age: 72 years) participants first read aloud and rated the pronunciation difficulty of words. Some words were phonologically related to the targets in a subsequent naming-to-definition task (e.g., primes: *indigent*, *abstract*, *truncate*, *tradition*, *locate*, target: *abdicate*). In the naming-to-definition task, the probability of TOTs decreased relative to when only unrelated words had been pronounced. In a second experiment, the order of the pronunciation and naming-to-definition task was reversed: Participants first named the definitions, and when a TOT occurred, they rated the pronunciation

difficulty of related and unrelated words. The production of a phonologically related word after the occurrence of a TOT increased the probability of resolving it when the definitions were presented again. Despite an age-related increase in the proportion of TOTs, the efficiency of phonological priming in reducing TOTs and of phonological cueing in resolving them were equivalent for the young and older participants. The finding that phonological similarity modulated naming performance is consistent with phonological retrieval rather than lemma selection being facilitated. Since the facilitatory effect was the same size in the young and the older participants, the data suggest that older adults have intact phonological representations of words, but are impaired in retrieving those representations.

A similar conclusion is invited by a study by White and Abrams (2002). They modified the phonological priming paradigm used by James and Burke (2000, Experiment 2). Instead of presenting prime words that cumulatively contained all of the syllables of the target word, White and Abrams presented prime words that all contained only one target syllable (the initial, middle, or final). This syllable was the same in all prime words (e.g., primes: *aberrant*, *abacus*, *abdomen*, target: *abdicate*). They found that producing a specific syllable of the target word embedded in a prime word was sufficient to resolve some TOTs, but only when the critical syllable was the first syllable of the word. Interestingly, this occurred only for the young (aged 18–26 years) and ‘young-old’ (aged 60–72 years) participants but not for the ‘old-old’ participants (aged 73–83 years). Again, there is no evidence from the young and ‘young-old’ age groups that word form retrieval was selectively affected by ageing. For the oldest group, however, the deficit in word form retrieval may be so extensive that it cannot be overcome by phonological priming, at least not when the prime-target overlap is reduced to the initial syllable (see also Bowles & Poon, 1985).

Thus, in naming definitions, older adults experience more TOTs than young adults, but they benefit as much as young adults from phonological priming. The age-equivalent effect of phonological priming indicates that word form retrieval, in the presence of a phonological prime, is unaffected by age, and that the age-related increase in the proportion of TOTs is not due to a deficit at the level of phonological representations. The finding that older adults produced more correct responses than young adults is inconsistent with a deficit in lemma selection. Rather, the deficit underlying TOTs seems to be in transmitting information from a word’s lemma to its phonological form. The failure to find larger effects of phonological priming on resolution of TOTs in older than young adults, despite the increase in TOTs with age, might suggest that older adults have more severe transmission failures than young adults. For a severe transmission failure, the strengthening of the lemma-to-word form

connection by a phonological prime might be insufficient to activate the word form, leaving the TOT unresolved. Indeed, the inefficiency of first-syllable primes in resolving TOTs in 'old-old' adults (White & Abrams, 2002) suggests that the severity of transmission failures continues to increase with age. Alternatively, the deficit in 'old-old' adults may be at a lemma level, with word lemmas being too weakly activated to sufficiently prime the corresponding word forms.

Because picture naming, like naming to definition, involves conceptually based word form retrieval, the deficit proposed to underlie TOTs might also contribute to the age-related slowing observed in picture naming. This was tested by Taylor and Burke (2002). Their picture-word interference study included conditions in which auditory distractor words were phonologically related to the target picture (e.g., distractor: *frost*, target: *frog*), semantically related to a homonym of the target (mediated distractors, e.g., distractor: *prom*, target: [toy] *ball*), and semantically and phonologically related to the target (S/P distractors, e.g., distractor: *skunk*, target: *squirrel*). The distractor words preceded (–150-ms SOA) or followed (+150-ms SOA) the target picture. Young and older participants showed the same facilitatory effect of phonological distractors at positive SOAs. In contrast, there were age differences in the mediated and S/P distractor conditions. The young participants were faster at naming pictures preceded by a mediated distractor than by an unrelated distractor (Experiment 1), presumably because the mediated distractor (*prom*) preactivated the phonological form of the target (*ball*). They named pictures preceded by an S/P distractor as fast as pictures preceded by an unrelated distractor (Experiment 2), presumably because in the S/P condition, a facilitatory phonological effect and an inhibitory semantic effect cancelled each other. In contrast, the older participants showed no latency difference between the mediated and the unrelated distractor conditions, but were slower with S/P than unrelated distractors. As Taylor and Burke explain, both of these differences can be accounted for by assuming that in the older speakers, access to the phonological representations of the targets was slowed. In contrast, the finding of age differences in some distractor conditions (mediated and S/P) but not in others (phonological) is incompatible with the idea of generalised slowing of cognitive processes as well as with the idea of a general deficit in inhibiting distracting information. The age difference in the S/P condition could be interpreted as evidence that in the older participants, the inhibitory semantic effect was too large to be cancelled by the facilitatory phonological effect, consistent with them having a deficit in inhibiting the meaning of the S/P distractors. However, this interpretation is unlikely as there was no age difference in the semantic distractor condition in the same experiment (see previous section).

## Age, naming of pictures of homophones, and effects of homophone priming

As noted, a number of studies suggest that in older persons, the lemma-to-form pathway is selectively impaired (e.g., Taylor & Burke, 2002). To explore this possibility further, Osborne and Burke (2002) examined age differences in the naming of homophone pictures. Assuming that homophones share phonological form representations (e.g., Jescheniak & Levelt, 1994; Jescheniak, Meyer, & Levelt, 2003; but see Caramazza, Bi, Costa, & Miozzo, 2004; Caramazza, Costa, Miozzo, & Bi, 2001; Caramazza & Miozzo, 1998), they predicted that the latency to name a homophone (e.g., *sail*) would reflect the cumulative frequency of the homophonous words. As a consequence, a low-frequency target word (*sail*) with a high-frequency homophone (*sale*) should be named as fast as its high-frequency twin and faster than a frequency-matched non-homophonous word. This has been referred to as the inherited frequency effect. In picture naming, objects with homophonous names may be more difficult to recognise and have lower name agreement than objects with non-homophonous names. Slow object recognition or slow lemma selection might delay naming of a low-frequency homophone to such an extent that the latency to name it exceeds the latency of the matching high-frequency homophone. As a result, the inherited frequency effect would be masked. If pictures with homophonous names are presented and named repeatedly, object identity and name agreement should be easier to establish and an inherited frequency effect observed, at least in young adults. If the effect depends on feedback from the shared phonological form to the lemma of the high-frequency homophone, which sends activations back to the shared form, the effect might be absent in older adults.

In two experiments, young (mean age: 19 years) and older (mean age: 73 years) participants named pictures of objects with (1) low-frequency homophonous names, (2) non-homophonous names matched to the specific frequency of the homophones (low-frequency (LF) controls), and (3) non-homophonous names matched to the cumulative frequency of the homophones (high-frequency (HF) controls). Each picture was presented in three separate blocks. In the first experiment, the young participants named homophones more slowly than LF and HF controls in the first block, probably due to differences in ease of recognition or lemma selection, but named them as fast as HF controls and faster than LF controls in the second and third blocks. In contrast, the older participants continued to name homophones more slowly than LF and HF controls. To reduce the homophone latencies, a second experiment was conducted in which pictures were presented and named prior to the experimental blocks. With pre-experimental naming, the young participants named

homophones as fast as LF controls in the first block but as fast as HF controls and faster than LF controls in the following blocks. In contrast, the older participants named homophones consistently more slowly than LF and HF controls. A name-picture matching experiment showed that the homophone pictures were more difficult to recognise than the LF and HF control pictures for both the young and the older participants. These results suggest that the young participants showed inherited frequency effects, once object recognition and name agreement had been resolved, whereas the older participants did not, not even after having named the homophone pictures. According to Osborne and Burke (2002), this is consistent with an age-related deficit in activating word forms from word lemmas.

The absence of the inherited frequency effect in older adults can be accounted for without postulating feedback from lemmas to word forms. Let us assume that homophones have separate phonological word forms and that the inherited frequency effect observed in young adults arises because of feedback from the phonological segments in the low-frequency target word to its own phonological form as well as to the phonological form of its high-frequency homophone, which raises the activation level of the phonological segments (Caramazza et al., 2001). According to this view, the absence of the effect in older adults might be due to impaired feedback from the phonological segments in a word to the word form. In contrast, the absence of the inherited frequency effect in the older adults is difficult to account for in a model which assumes that homophones have shared phonological word forms without allowing feedback from these word forms to the lemmas (Levelt et al., 1999). In such a model, the inherited frequency effect arises because the phonological form of a low-frequency homophone is easier to access due to greater frequency of production, as the same phonological form is produced for the high-frequency homophone (Jescheniak & Levelt, 1994). This model can only account for the absence of the effect in older adults by postulating that older adults have impaired word forms. However, the findings of the phonemic cueing and phonological priming studies reviewed here suggest that older adults have intact word forms.

Burke et al. (2004) and Chae, Burke, and Ketron (2002) investigated homophone priming effects on young and older adults' picture naming. Because homophone primes share the entire phonological form with the targets, they expected homophone priming effects at least as large as the priming effects observed in previous studies, where phonologically related prime-target pairs had been used (James & Burke, 2000; White & Abrams, 2002). Due to the increase in word retrieval failures with age, they also expected larger homophone priming effects in older than young adults. To increase retrieval difficulty, and thus the likelihood of finding a



homophone priming effect, Burke et al. used proper names as targets, and Chae et al. high- and low-frequency object names.

Burke et al. (2004) had participants name written word definitions and pictures of famous people on intermixed trials. On critical trials, the definition elicited a homophone for a subsequent picture. For instance, the definition *The hard stone, as of the plum or cherry, which contains the seed is called the p\_\_* primed naming of a picture of Brad Pitt. The older participants (mean age: 72 years) produced fewer correct names and more TOTs than the young (mean age: 19 years) participants. The young participants showed no homophone priming.<sup>8</sup> In contrast, homophone priming increased the proportion of correct responses and reduced the proportions of TOT and 'don't know' responses in the older participants. In a second experiment, the naming speed was recorded along with the proportion of correct responses, the length of the interval between prime and target was varied, and the number of primed pictures reduced in order to reduce the participants' awareness of the prime-target relationship. Production of a homophone increased the speed of correct naming for both age groups, but increased the proportion of correct responses only for the older participants. In both experiments, the proportion of TOTs was low in the young participants, which might explain why homophone priming did not reduce TOT responses in the young group. However, homophone priming also failed to reduce the proportion of 'don't know' responses in the young participants, although they produced this response to about half of the target pictures. In contrast, homophone priming reduced 'don't know' responses in the older participants.

In contrast to Burke et al. (2004), Chae et al. (2002) failed to obtain homophone priming in older adults. They used the same experimental procedure as Burke et al., except that participants named pictures of objects instead of pictures of famous people. For instance, the definition *One of the essential ingredients in bread is fl\_\_* primed naming of a picture of a flower. A main effect of age was found, with the older participants (mean age: 72 years) naming objects more slowly than the young participants (mean age: 19 years). Age interacted with name frequency, with the frequency effect increasing with age, and with priming, with homophone primes increasing naming speed for the young but not the

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<sup>8</sup> For the young participants, the homophone priming effect was absent only for participants who were unaware of the prime-target relationship. When data from aware participants were included in the analysis, a homophone priming effect was found. This suggests that effects of homophone priming in young adults arise because young adults are aware of the prime-target relationship and use this awareness to anticipate the target name.

older participants. In a second experiment, Chae et al. examined if the homophone priming effect in the young participants reflected that they were aware of the relationship between prime and target. To prevent awareness, they used masked priming, with written prime words presented too briefly for identification (29 ms for the young participants and 90 ms for the older participants). Again, the older participants named objects more slowly than the young participants and showed a larger frequency effect. Despite the brief prime presentation, homophone priming was still present in the young but absent in the older participants. However, in a third experiment in which the same paradigm was used, but homophone primes were replaced with identity primes, the age by priming interaction disappeared. Age-equivalent effects of identity priming have also been reported by Rastle and Burke (1996).

In sum, in naming of pictures with homophonous names, young but not older adults showed inherited frequency effects on the latency to retrieve low-frequency object names (Osborne & Burke, 2002). The production of homophones, elicited by word definitions, increased the likelihood of correct retrieval of celebrity names in older but not young adults, but speeded retrieval across the age range (Burke et al., 2004). In contrast, across two homophone priming paradigms (i.e., using primes elicited by definitions and masked word primes), priming increased the speed of object name retrieval for young but not older adults. This contrasted with age-equivalent effects of identity priming (Chae et al., 2002).

The age-equivalent effect of homophone priming on the speed of producing proper names seems to suggest that in both young and older persons, the production of a homophone strengthens the connections between the phonemes in the word form shared with the proper name. As a result, subsequent retrieval of the proper name is facilitated. In addition, the effect of homophone priming on the proportion of 'don't know' responses in older adults might suggest that the stronger phonological connections increase feedback to the lemma of the proper name, thereby increasing the probability that it is selected. This feedback appears to be absent in young adults. In older adults, homophone priming on the speed of naming has been found only for pictures of celebrities, not of objects. In young adults, larger effects have been found for pictures of celebrities than objects. These differences might be due to differences between object and proper names in their conceptual-semantic representations. It has been suggested that, unlike object names, proper names lack direct connections to conceptual-semantic information associated with the names. This can explain why proper names are particularly vulnerable to retrieval deficits (Cohen & Burke, 1993). The frequent failures to retrieve proper names might in turn explain why proper names are more susceptible than object names to homophone priming.

The inconsistent homophone priming effects in older adults mirror the inconsistent findings with young adults (Ferrand, Humphreys, & Segui, 1998; Wheeldon & Monsell, 1992), suggesting that homophone priming effects in word production are fragile and less predictable than effects of identity and phonological priming in both young and older adults. The weaker effects with homophone than identity primes most likely reflect differences between the two types of primes in the degree to which they overlap with the target picture. Unlike an identity prime, which is identical to the target picture in both meaning and word form, a homophone prime shares only the word form with the target.

The inconsistent results of studies of homophone priming may also be due to differences in the materials and/or methods used in the studies, which may interact with age-related effects. For instance, young and older adults might vary in their sensitivity to lexical factors such as the orthographic relatedness between primes and targets. Consistent with the ID hypothesis of cognitive ageing, older adults, in particular, may be susceptible to interference from homophone stimuli when they subsequently come to name targets. Such effects could arise from competing activated spellings (e.g., *flour-flower*) or from competing meanings being selected at the lemma level, prior to name retrieval. In Chae et al.'s (2002) study, the orthography of the homophone primes might have interfered with subsequent picture naming in the older adults, cancelling any facilitation from the phonological form of the homophones. Indeed, there was a tendency for the older adults to name homophone-primed pictures more slowly than unprimed pictures (see Wheeldon & Monsell, 1992, and Damian & Bowers, 2003, for effects of orthographic relatedness between primes and targets on the speed of word production). Support for the idea of age differences in sensitivity to lexical factors comes from a study by Vitevitch and Sommers (2003) who found different effects of neighbourhood density and frequency in young and older adults.

## Conclusions

On the basis of the reviewed picture naming and definition naming results, the following conclusions can be drawn about effects of age on accuracy and speed in naming pictures and definitions:

(1) Object recognition is largely intact in old age. However, adults above 70 years make some visual errors, suggesting that they have minor problems in recognising objects (Albert et al., 1988; Hodgson & Ellis, 1998; Nicholas et al., 1985).

(2) Lemma selection is largely preserved in old age, as evidenced by age-equivalent effects of semantic priming (Bowles, 1994) and semantic interference (Taylor & Burke, 2002) on picture naming speed (though see

Taylor and Burke, 2002, for some evidence of larger priming with older individuals). In naming definitions, older adults know and produce the name of more definitions than young adults (Burke et al., 1991; James & Burke, 2000; Rastle & Burke, 1996; White & Abrams, 2002), which is further evidence that their knowledge of word meanings is intact. However, the age-related increase in the proportion of semantic errors (Albert et al., 1988; Au et al., 1995; Nicholas et al., 1985) might suggest that older adults have some problems in selecting word lemmas. Alternatively, semantic errors may reflect problems in using information about a selected lemma to retrieve the corresponding phonological word form.

(3) The phonological representations of word forms are intact in old age. This is evidenced by two findings. First, in picture naming, older adults have more naming failures than younger adults, but are able to overcome these naming failures when given a phonemic cue (Au et al., 1995; Barresi et al., 2000; Nicholas et al., 1985). Second, in naming to definition, older adults produce more TOTs than young adults, but following identity or phonological primes, they are as efficient as young adults in reducing the occurrence of TOTs (James & Burke, 2000; Rastle & Burke, 1996). The age-equivalent effects of phonological cueing/priming suggest that older adults have intact phonological representations of word forms, and that the age-related increase in naming failures, including TOTs, is not due to these representations being impaired.

(4) The deficit underlying older adults' naming failures and reduced naming speed seems to be in transmitting information about a word's lemma onto its phonological form. A deficit in the lemma-to-word form connections is suggested by the absence of a semantically mediated phonological priming effect (from homonyms and from phonologically similar words) on older adults' picture naming speed (Taylor & Burke, 2002). In addition, in naming of pictures with homophone names, older adults show no inherited frequency effect (Osborne & Burke, 2002), which might depend on common lemma-to-word-form connections.

In contrast to the priming and homophone production studies, studies in which lexical properties of to-be-named objects are varied provide little evidence that a lexical access deficit underlies the slow picture naming in older adults (Mitchell, 1989; Morrison et al., 2002; Poon & Fozard, 1978; Thomas et al., 1977). As an exception, Chae et al. (2002) found larger word frequency effects on the time to name homophone pictures in older individuals. As frequency effects are assumed to occur at the level of the phonological word form (Jescheniak & Levelt, 1994), this suggests that older adults have a deficit in retrieving word forms from word lemmas, consistent with the mediated priming results.

A deficit in the lemma-to-word-form connections can explain the naming failures and reduced naming speed of 'young-old' adults, i.e.,

adults in their 60s. However, for 'old-old' adults, i.e., adults above 70 years of age, multiple deficits appear to contribute to the decline in naming performance. 'Old-old' adults benefit less from phonemic cueing than 'young-old' adults (Au et al., 1995; Barresi et al., 2000) and they do not benefit at all from phonological priming when primes share only the initial syllable with the targets (White & Abrams, 2002). This suggests that they have a deficit in word form retrieval that cannot be overcome by phonological priming. This deficit might be due to word lemmas being so degraded or so weakly connected to the corresponding word forms that naming is impossible, even following phonological priming.

## DISCUSSION

Overall, the literature on age differences in discourse production suggests that older adults are more verbose and more disfluent in their speech than young adults. These changes with age probably reflect, in part, difficulties in planning utterances at a conceptual level and in selecting and retrieving individual words. When the planning load is reduced, as in picture description, older adults are less verbose and less disfluent than when the planning load is high, as in conversation about a difficult topic (Bortfeld et al., 2001). Although there is some evidence suggesting that older adults produce higher rates of disfluencies than young adults, even on tasks as constrained as picture description (Cooper, 1990; Le Dorze & Bédard, 1998; Schmitter-Edgecombe et al., 2000), there is also evidence that older adults are as fluent and as fast in responding as young adults when they have to construct simple utterances using predetermined words (Davidson et al., 2003). This contrast between picture description tasks which require that participants generate the target words themselves, and sentence generation tasks where the words are given suggests that older speakers have problems in selecting or retrieving specific words rather than in putting the words together to form a sentence. However, the syntactic requirements in the sentence generation task used by Davidson et al. (2003) were limited, and older adults have been shown to have difficulties in planning and generating syntactically more complex sentences (Altmann & Kemper, *in press*; Kemper et al., 2003).

In addition to deficits in conceptual planning and in lexical access, an impairment in inhibiting irrelevant information can also contribute to the observed age differences in discourse production. In tasks in which speech production is limited and the target words are predetermined, as in picture description, there are no signs of increased verbosity or irrelevant speech in older adults. Finally, age changes in discourse production are in part a consequence of voluntary changes in speech style, reflecting different

communication goals in young and older adults. Collectively then, it appears that age-related differences in speech production in a discourse context are determined by multiple factors: linguistic, cognitive, and communicative.

When picture naming is considered, the evidence clearly indicates that older speakers are slower and less accurate than younger speakers. Similarly, the literature on age differences in definition naming shows that older speakers experience more TOTs than young ones. As argued above, these age differences are largely due to a weakening in the connections linking word lemmas to word forms (see Dell et al., 1997, for similar arguments applied to aphasic patients).

The weakened connections between lemmas and word forms appear to selectively impair older adults' speech production. Their comprehension of spoken and written words and sentences is largely intact. This has been demonstrated in semantic priming studies, in which a word or sentence prime that is semantically related to a following target word has been found to speed up recognition of the target (as indicated by correct lexical decision or naming) as much in older as in young adults (e.g., Burke, White, & Diaz, 1987; Madden, 1988, 1992; Madden, Pierce, & Allen, 1993; Paul, 1996; for reviews, see Burke et al., 2000; Laver & Burke, 1993). Similarly, when ambiguous words are embedded in a sentence context (e.g., *Some change was removed from her pockets*), older adults are as efficient as young adults in using the semantic context to disambiguate the meaning of the words (e.g., Hopkins, Kellas, & Paul, 1995; Paul, 1996; but see Wingfield, Alexander, & Cavigelli, 1994).

In contrast to the semantic processing involved in sentence comprehension, an age-related decline has been observed in the syntactic processing of sentences. It has been demonstrated that the presentation of sentence fragments (e.g., *the apple was*) which form a semantically incorrect sentence when combined with a following target (e.g., *read*) slows down lexical decisions to the target (relative to a neutral baseline) to the same degree in older and young adults. In contrast, sentence fragments which form a syntactically incorrect sentence when combined with the target (e.g., *the man was laughed*) slow down lexical decision more in older than young adults (Friederici, Schriefers, & Lindenberger, 1998).

According to the Transmission Deficit (TD) hypothesis (MacKay & Burke, 1990), word production and word comprehension are differentially affected by ageing because the impact of an age-related transmission deficit is different for the two types of task. This is because in production, single links diverge from the target lemma onto the individual phonemes in the target word form, whereas in comprehension, multiple links converge from the target phonemes onto a single lemma. This difference in

connectivity can explain why word production is more vulnerable than word comprehension to an age-related deficit in transmission of priming. In the same way as word forms have many connections to the corresponding lemmas when used for comprehension, lemmas and concepts are highly interconnected. As a result, a transmission deficit at this level can be offset when the target word is an object name. In contrast, when the target word is a proper name, e.g., the name of a person, the effect of a transmission deficit due to weakened connections is more detrimental. According to the TD hypothesis, this is because the lemma of a proper name is not directly connected to visual-conceptual information associated with the name, but connected only via a proper name phrase, which increases the number of connections vulnerable to a transmission deficit. In addition, there is only a single connection linking the lemma to the phrase. A weakening of this single connection is more likely to result in a transmission failure than when multiple connections are available (Burke et al., 2004; Cohen & Burke, 1993) (see the more detailed account in the Introduction).

The main reason for the age-related changes in picture naming appears to be a weakening of the connections between lemmas and word forms. Although the literature suggests that older adults may be more susceptible than young adults to interference from irrelevant stimuli (e.g., distractor words) and irrelevant aspects of stimuli (e.g., their spelling), there is little evidence that older adults have a general inhibitory deficit as predicted by the Inhibition Deficit (ID) hypothesis. Picture identification studies have shown that older adults are more susceptible to interference from perceptual alternatives than young adults suggesting a deficit in inhibiting perceptual alternatives (Lindfield & Wingfield, 1999; Lindfield, Wingfield, & Bowles, 1994), but word and picture naming studies have failed to find age differences in the ability to inhibit semantic and phonological alternatives (Taylor & Burke, 2002; White & Abrams, 2004).

## CONTRIBUTION TO MODELS OF SPEECH PRODUCTION

For this review we have adopted a working model of lexical access that distinguishes between lemmas and word forms (see Figure 1). As mentioned in the Introduction, not all models of lexical access make this distinction. Moreover, current models differ in their assumptions concerning the information flow between units and can accordingly be classified as serial stage, cascaded, or interactive models. The conclusion that with age the links towards word form units become less efficient is compatible with models that assume a lemma level, as well as with

models that do not postulate lemmas but view word form retrieval processes as separable from the retrieval of other types of information (syntactic, semantic) about words (e.g., Caramazza, 1997). In other words, this general conclusion is compatible with virtually all existing models of lexical access. However, specific patterns of results emerging from clusters of related studies might be more naturally accounted for within one theoretical framework than in others. For instance, the results concerning phonologically mediated and S/P priming effects reported above are perhaps most naturally accounted for within a cascaded model of lexical processing. If, as it has been argued, the phonological processing contributing to these effects depends on the links connecting word lemmas to word forms, then the pattern of effects in young persons suggests that word forms are activated prior to lemma selection, consistent with cascaded activation. The pattern of effects in older persons supports the conclusion that lemma-to-form connections are weakened with age. Another case that might contribute to differentiate between the different types of models is the research concerning inherited frequency effects. If the existence of such effects in young adults and their absence in older adults could be firmly established, one could either assume that (a) young, but not older speakers have shared form representations for homophonous words, (b) both young and older speakers have shared form representations for homophonous words, but that the feedback to the lemmas for the homophones is impaired in older speakers, or (c) the form representations for homophonous words are separate, but that the link between them is stronger in young than in older persons. Thus, further research concerning the precise nature of lexical processing differences between speakers differing in age should contribute both to our understanding of ageing as well as constrain models of speech production.

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## APPENDIX

TABLE 1  
Studies of age differences in picture naming

<i>Study</i>	<i>Age groups<sup>a</sup></i>	<i>Independent variables</i>	<i>Dependent variables</i>	<i>Age differences</i>		<i>Interactions with age</i>
				<i>uncued/unprimed condition</i>	<i>cued/primed condition</i>	
Nicholas et al. (1985)	y: 30–39 yrs m: 50–59 yrs y-o: 60–69 yrs o-o: 70–79 yrs	Cue type (semantic and phonemic)	Correct names:	y: 89% m: 89% y-o: 86% o-o: 80%	After phonemic cue (% of unnamed items): 81% 84% 76% 76%	
Au et al. (1995)	y: 30–39 yrs m: 50–59 yrs y-o: 60–69 yrs o-o: 70–79 yrs	Cue type (semantic and phonemic), session number	Correct names over time:	session: 1st 3rd y: 94% 92% m: 90% 87% y-o: 90% 87% o-o: 83% 75%	After phonemic cue (% of unnamed items): 1st 3rd 85% 90% 88% 68% 85% 80% 82% 65%	
Barresi et al. (2000)	m: 50–59 yrs y-o: 60–69 yrs o-o: 70–79 yrs	Cue type (semantic and phonemic)	Correct names over time:	Error type		
				m: 1.5% y-o: 1.5% o-o: 6.0%	knowl <sup>b</sup> access 7.6% 9.0% 15.2%	

*(Continued overleaf)*

Study	Age groups <sup>1</sup>	Independent variables	Dependent variables	Age differences		Interactions with age
				uncued/unprimed condition	cued/primed condition	
Thomas et al. (1977)	y: 25–45 yrs y-o: 46–65 yrs o-o: 66–74 yrs	Name frequency, presentation block, identity priming	Incorrect names:  Naming latency:	y: <1% y-o: <1% o-o: 2.8% y: 675 ms y-o: 725 ms o-o: 850 ms	550 ms 575 ms 675 ms	No Age × Name Frequency, Age × Block, Age × Prime Type
Poon & Fozard (1978)	y: M = 20 yrs m: M = 50 yrs o: M = 65 yrs	Object familiarity, identity priming	Correct names:  Naming latency:	Common contemporary objects		Age × Familiarity
				y: 80% m: 75 yrs o: 70 yrs y: 1200 ms m: 1300 ms o: 1500 ms	95% 90% 80% 750 ms 750 ms 800 ms	
Mitchell (1989)	y: 19–32 yrs o: 63–80 yrs	Name agreement (NA)	Incorrect names:  Naming latency:	y: 2.6% o: 2.3% y: 893 ms o: 954 ms		No Age × NA
Le Dorze & Durocher (1992)	y: 25–44 yrs m: 45–64 yrs o: 65–85 yrs	Name length	Correct names:	y: 92% m: 85% o: 78%		Age × Name Length



Hodgson & Ellis (1998)	y: 22–33 yrs o: 71–86 yrs	Visual complexity, object familiarity, imageability, name agreement (NA), age of acquisition (AoA), name frequency, name length	Correct names:	y: 96% o: 91%		Effects of NA, AoA, and name length on old adults' naming accuracy
Morrison et al. (2002, Exp 2)	y: 18–32 yrs y-o: 60–69 yrs o-o: 80–93 yrs	AoA	Naming latency:	y: 536 ms y-o: 689 ms o-o: 820 ms		No Age × AoA
Bowles (1994, Exp 1)	y: 18–33 yrs o: 65–83 yrs	Prime type (semantic and unrelated), SOA	Naming latency (across SOA):	y: 739 ms o: 830 ms	Onset of semantic priming and prime interference: 90–150-ms SOA 103–165-ms SOA	No Age × Prime Type, No Age × SOA
Bowles (1994, Exp 2)	y: 18–32 yrs o: 65–88 yrs	Prime type (semantic and unrelated), SOA	Naming latency (across SOA):	y: 769 ms o: 904 ms	Offset of prime interference: 200-ms SOA 350-ms SOA	No Age × Prime Type, Age × SOA
Feyereisen et al. (1998, Exp 1)	y: 16–31 yrs o: 60–77 yrs	Distractor type (phonological, semantic, and unrelated)	Incorrect names: Naming latency:	y: 3.8% o: 7.5% y: 821 ms o: 878 ms	Distractor interference: 6% 7% 869 ms 1010 ms	

(Continued overleaf)

Study	Age groups <sup>1</sup>	Independent variables	Dependent variables	Age differences		Interactions with age
				uncued/unprimed condition	cued/primed condition	
Feyereisen et al. (1998, Exp 2)	y: 18–22 yrs o: 65–80 yrs	Distractor type (phonological, semantic, and unrelated)	Incorrect names:  Naming latency:	y: 1.7% o: 4.2% y: 870 ms o: 998 ms	Distractor interference: 2.8% 6.8% 939 ms 1107 ms	
Taylor & Burke (2002, Exp 1)	y: 18–29 yrs o: 62–85 yrs	Distractor type ( <i>homophones</i> : semantic and sem. mediated <i>non-homophones</i> : semantic and phonological)	Incorrect names:  Naming latency:	y: 1.4% o: 2.3% <i>homophones</i> : y: 859 ms o: 970 ms  <i>non-homophones</i> : y: 810 ms o: 896 ms	semantic: y: 899 ms o: 1070 ms sem. mediated: y: 838 ms o: 989 ms semantic: y: 863 ms o: 988 ms phonological: y: 811 ms o: 899 ms	

Taylor & Burke (2002, Exp 2)

y: 18–22 yrs  
o: 60–89 yrs

Distractor type (semantic, phonological, and S/P) SOA (–150-ms, + 150-ms)

Incorrect names:  
Naming latency:

y: 2.7%  
o: 2.6%  
–150-ms SOA:  
y: 748 ms  
o: 880 ms  
+ 150-ms SOA:  
y: 715 ms  
o: 895 ms

semantic, –150-ms SOA:  
y: 813 ms  
o: 963 ms  
Phonological, across SOA:  
y: 704 ms  
o: 861 ms  
S/P, –150-ms SOA:  
y: 756 ms  
o: 929 ms  
S/P, + 150-ms SOA:  
y: 679 ms  
o: 881 ms

Osborne & Burke (2002, Exp 1A)

y: M = 19 yrs  
o: M = 73 yrs

Picture names (homophone, LF and HF controls), presentation block

Incorrect names:  
Naming latency:

y: 5%  
o: 11%  
block: 1st 2nd 3rd  
y:  
*homo*: 957 767 718 ms  
*LF*: 882 787 756 ms  
*HF*: 823 757 727 ms  
o:  
*homo*: 984 908 824 ms  
*LF*: 901 862 779 ms  
*HF*: 875 819 738 ms

Age × Inherited Frequency

(Continued overleaf)

Study	Age groups <sup>1</sup>	Independent variables	Dependent variables	Age differences			Interactions with age
				uncued/unprimed condition	cued/primed condition		
Osborne & Burke (2002, Exp 1B)	y: M = 21 yrs o: M = 73 yrs	Picture names (homophone, LF and HF controls), presentation block	Incorrect names: Naming latency:	y: 1% o: 3 % block: 1st 2nd 3rd y: <i>homo</i> : 734 672 664 ms <i>LF</i> : 744 696 680 ms <i>HF</i> : 700 673 664 ms o: <i>homo</i> : 908 838 800 ms <i>LF</i> : 842 807 775 ms <i>HF</i> : 808 766 740 ms			Age × Inherited Frequency
Burke et al. (2004, Exp 1)	y: M = 19 yrs o: M = 72 yrs	Homophone priming	Correct names: TOTs: Don't knows:	y: 42% o: 33% y: 12% o: 21% y: 45% o: 46%		47% 43% 10% 16% 44% 41%	
Burke et al. (2004, Exp 2)	y: M = 20 yrs o: M = 71 yrs	Homophone priming	Correct names: Naming latency:	y: 73% o: 59% y: 1626 ms o: 1817 ms		76% 78% 1480 ms 1618 ms	

Chae et al. (2002, Exp 1)	y: M = 19 yrs o: M = 72 yrs	Name frequency, homophone priming	Naming latency:	y: 921 ms o: 1189 ms	815 ms 1172 ms	Age × Name Frequency, Age × Priming
Chae et al. (2002, Exp 2)	y: M = 19 yrs o: M = 76 yrs	Name frequency, homophone priming	Naming latency:	y: 780 ms o: 966 ms	753 ms 985 ms	Age × Name Frequency, Age × Priming
Chae et al. (2002, Exp 3)	y: M = 20 yrs o: M = 74 yrs	Name frequency, identity priming	Naming latency:	y: 735 ms o: 950 ms	683 ms 905 ms	Age × Name Frequency, no Age × Priming

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<sup>a</sup> y = young, m = middle-aged, y-o = 'young-old', o-o = 'old-old'. <sup>b</sup> knowl = knowledge.

TABLE 2  
Studies of age differences in picture naming

Study	Age groups <sup>1</sup>	Independent variables	Dependent variables	Age differences		Interactions with age
				uncued/unprimed condition	cued/primed condition	
Rastle & Burke (1996, Exp 1)	y: 18–22 yrs	Identity priming	Correct names:	y: 32%	45%	No Age × Priming
	o: 64–82 yrs		TOTs/total – correct names:	o: 40%	54%	
James & Burke (2000, Exp 1)	y: M = 19 yrs	Phonological priming	Correct names:	y: 10.8%	6.8%	No Age × Priming
	o: M = 72 yrs		TOTs/total – correct names:	o: 26.1%	20.4%	
James & Burke (2000, Exp 2)	y: M = 19 yrs	Phonological cueing	Correct names after initial	y: 36.3%	40.9%	No Age × Priming
	o: M = 72 yrs		TOT:	o: 42.6%	47.4%	
White & Abrams (2002)	y: 18–26 yrs	Prime type (word containing initial, middle, or final target syllable)	Correct names after initial	y: 11.7%	10.3%	No Age × Priming
	y-o: 60–72 yrs		TOT:	o: 13.8%	11.3%	
	o-o: 73–83 yrs		TOT:	y: 47.5%	69.7%	Age × Priming
				o: 57.8%	73.6%	
				y: 24.9%	<i>Initial syllable:</i>	y vs. y-o:
				y-o: 22.8%	50.4%	No Age × Priming
				o-o: 35.6%	55.3%	y-o vs. o-o:
					39.6%	Age × Priming
					<i>Middle and final syllable:</i>	
					no effect	

<sup>1</sup> y = young, m = middle-aged, y-o = ‘young-old’, o-o = ‘old-old’.