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Abstract:

Young and older adults provided language samples in response to elicitation questions while concurrently performing different tasks including walking, , finger tapping, and ignoring speech or noise. The language samples were scored on three dimensions: fluency, grammatical complexity, and content. The hypothesis that working memory limitations affect speech production by older adults was tested by comparing language samples collected during a baseline condition with those produced while the participants were performing the concurrent tasks. There were baseline differences: older adults' speech was less fluent and less complex than young adults' speech. Young adults adopted a different strategy in response to the dual task demands than older adults; they reduced sentence length and grammatical complexity while performing the concurrent tasks. In contrast, older adults shifted to a reduced speech rate in the dual task conditions.

Text of paper:

The Costs of Doing Two Things at Once for Young and Older Adults: Talking while Walking, Finger Tapping, and Ignoring Speech or Noise

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The Costs of Doing Two Things at Once for Young and Older Adults: Walking, Finger Tapping, and Ignoring Speech or Noise

Language sample methodology has been used previously to examine age-related changes to language and age-differences in performance on referential communication tasks. Previous studies (Cheung & Kemper, 1992; Kemper, Kynette, Rash, Sprott, & O'Brien, 1989; Kemper, Thompson, Marquis, 2001) using this methodology have compared cross-sectional and longitudinal oral speech samples on a variety of different measures of fluency, grammatical complexity, and content. These studies indicate that both the grammatical complexity and propositional content of older adults' spontaneous speech decline in late life. Kemper and Sumner (2001) investigated the relationship between select language sample measures and traditional measures of verbal ability, working memory, and verbal fluency. They report that grammatical complexity is associated with span measures of working memory; hence, the age-related decline in grammatical complexity is attributable to a loss of working memory capacity affecting the ability of older adults to manage the concurrent linguistic rules associated with the production of multiple grammatical clauses simultaneously. Kemper and Sumner found that propositional content is closely associated with verbal fluency suggesting that the age-related decline in propositional content is due to an age-related decline in processing efficiency, affecting the ability to rapidly access and retrieve propositional information from long-term memory.

The present study was designed to more systematically investigate the relationship between cognitive abilities and language sample measures of linguistic ability. Language samples were elicited while young and older adults performed a variety of different concurrent tasks. The use of concurrent tasks to study the allocation of attention and/or working memory has a rich history in psychology and neuropsychology (Baddeley, 1986; 1996; Baddeley, Lewis, Eldridge, & Thomson, 1984; Camicioli, Howieson, Lehman, & Kaye, 1997; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996; Gupta & MacWhinney, 1995; Leonard, Milner, Jones, 1988; Kinsbourne & Hicks, 1978; Kinsbourne & Hiscock, 1983; Kyllonen & Christal, 1990; McFarland, & Ashton, 1978; Murray, Holland, & Beeson, 1998; Navon & Gopher, 1979; Salthouse, Michell, Skovronek, & Babcock, 1989; Turner & Engle, 1989; Rosen & Engle, 1997; Towell, Burton, & Burton, 1994; see also, Verhaeghen, Steitz, Sliwinski, & Cerella, 2001).

Two recent series of studies of aging and dual task demands are notable. Lindenberger, Marsiske, and Baltes (2000) and Li, Lindenberger, Freund, and Baltes (2001) have investigated walking while memorizing within the context of the Baltes and Baltes (1990) *selection, optimization, and compensation* model. This model emphasizes the adaptability of aging individuals to select goals, optimize means to attain those goals, and utilize alternative means to compensate for losses or deficits. Lindenberger et al. examined balance and gait as individuals memorized lists of words. Dual task costs, measured in terms of memory accuracy, walking rate, and walking accuracy, increased with age. Li et al. extended this paradigm to investigate the use of compensatory walking or memory aids. Participants could grasp a handrail to assist with balance or use a control box to slow the presentation of to-be-remembered words. They found that older adults prioritized walking at the expense of memory performance and utilized the handrail to compensate for walking difficulties. Young adults optimized memory performance, utilizing the memory aid to delay presentation of the words.

Postural stability, like walking, is affected by concurrent cognitive demands. Maylor and Wing (1996) examined dual task costs to postural stability while participants performed a number of different cognitive tasks. Dual-task costs were significantly greater for the older adults when they were performing spatial tasks, such as remembering the location of digits assigned to a 4-by-4 grid, than when engaged in non-spatial tasks, such as random number generation. Using closely matched spatial and nonspatial tasks, Maylor, Allison, and Wing (2001) replicated these results, showing that the older adults experienced greater costs due to the spatial tasks.

These studies of dual tasks costs confirm a linkage between cognition and sensory-motor control of behavior (Lindenberger et al., 2000; Welford, 1958) and suggest that simple tasks such as walking and maintaining balance become increasingly dependent on cognitive control in order to compensate for sensory losses, attentional lapses, slowing of response times, and other age-related deficits. If so, we might expect that other cognitive tasks that are dependent on working memory resources should show deficits when combined with simple motor or sensory tasks. Although talking has commonly been used as a secondary task in many studies, the talking tasks have been limited to simple ones such as repeating a word or familiar phrase, or counting aloud (cf., Gupta & MacWhinney, 1995). In the present series of tasks, young and older adults were asked to provide language samples in response to elicitation questions while concurrently carrying out a variety of different tasks. The language samples were scored on three dimensions: fluency, grammatical complexity, and content. Fluency, grammatical complexity, and content were hypothesized to vary with concurrent task demands, reflecting dual tasks costs involved in selecting, coordinating, sequencing, and executing the complex demands of conversational speech while performing the concurrent tasks.

A primary goal of the current study was to assess whether concurrent task demands have differential effects on young and older adults' speech; however, age differences in speech fluency, grammatical complexity, and propositional content were expected based on past research (Kemper et al., 1989; Kemper et al., 2001). Thus, the hypothesis that working memory limitations affect the fluency, complexity, and content of speech was tested by comparing language samples collected during a baseline condition with those produced while the participants were performing a series of concurrent tasks that varied in difficulty. In the present study, baseline differences on the language sample measures were expected on the basis of previous research. Of interest were the effects of the concurrent tasks on the fluency, complexity, and content of young and older adults' speech.

Two types of concurrent tasks were used. In the first series, three motor tasks were compared: walking, complex finger tapping, and simple finger tapping. In the second series of tasks, two selective attention tasks were compared: the participants talked while ignoring speech or noise presented through headphones. These tasks were selected from among those used in prior studies of neuropsychology because they afforded participants the opportunity to talk while engaging in the concurrent task. Of interest, therefore, was the age equivalency of the dual tasks costs associated with the different tasks. Older adults were expected to show greater dual tasks costs, particularly for the more demanding concurrent tasks, than young adults, reflecting age-related declines in working memory and processing efficiency.

Method

Participants

Seventy-seven young adults, 18 to 28 years of age, and 91 older adults, 70 to 80 years of age, were tested. The young adults were recruited by posted signs and other announcements. The older adults were recruited from a registry of previous research participants; all were living at home alone or with family. The participants were paid a modest honorarium of $10/hr; for the older adults, this honorarium also included compensation for their travel to campus to participate in this research. Two young adults and 16 older adults were excluded from full participation based on the screening tasks described below, leaving 75 young adults (M_Y = 21.9, *SD* = 2.1) and 75 older adults (M_O = 73.0, *SD* = 6.4) who completed all tasks.

Screening

All participants were screened for hearing acuity and those who had experienced clinically significant hearing loss were excluded from participation in this study. A hearing loss was defined as (i) a greater than 40 dB hearing loss at 250, 500, 1000, or 2000 using pure tone audiometrics or (ii) self-report of 6 or more problems on the Hearing Handicap Inventory (Ventry & Weinstein, 1982). Among participants who met these screening criteria, average pure tone hearing level, in dB, was 22.8 (*SD* = 4.1) for young adults and 31.2 (*SD* = 3.33) for the older adults for the 4 thresholds tested, *t*(148) = 13.790. The young adults (M_Y = 1.44, *SD* = 3.3) reported fewer problems on the Hearing Handicap Inventory than the older adults (M_O = 4.48, *SD* = 5.8), *t*(148) = 3.962. An alpha level of .05 was set for these and all subsequent *t* and *F* tests.

The participants were also screened for a variety of health conditions that might limit their performance on the walking and finger tapping tests. These exclusionary conditions included: failing 4 or more questions on the Short Portable Cognitive Status Questionnaire (Pfeiffer, 1975), any health condition that interfered "a great deal" with daily activities such as arthritis, high blood pressure, heart trouble, or diabetes; self-report of a history of stroke, polio, cerebral palsy, emphysema, or other disabling condition; or a history of taking any medication for angina, pain, seizure, vertigo, or any neurological or psychotropic medication.

Cognitive Tests

The 150 participants who passed the screening tests were given a battery of cognitive tests designed to assess individual and age-group differences in verbal ability, working memory, inhibition, and processing speed. The young adults had completed slightly more years of formal education than the older group (M_Y = 15.6 years, *SD* = 1.8 years; M_O = 14.8 years, *SD* = 2.5), *t*(148) = 4.887. The older adults scored somewhat higher on the Shipley (1940) vocabulary test (M_O = 34.1 of 40 correct, *SD* = 3.4) than the young adults (M_Y = 32.1, *SD* = 4.3), *t*(148) = 9.423. The young adults had higher scores on the Digits Forward and Digits Backwards tests (Wechsler, 1958) (M_Y = 9.6, *SD* = 2.2 and 7.6, *SD*= 2.3, respectively) than the older adults (M_O = 6.7*,* *SD* = 2.4 and 5.8, *SD* = 2.0, respectively), *t*(148) = 57.684 and 28.638, respectively. The young adults had slightly higher scores on the Daneman and Carpenter (1980) Reading Span test, (M_Y = 4.3, *SD* = 6.0; M_O = 3.0, *SD* = 2.2), *t*(148) = 2.838. The young adults also scored higher on the Digit Symbol test (Wechsler, 1958), *(*M_Y = 34.1, *SD* = 4.8; M_O = 23.0, *SD* = 2.1), *t*(148) = 217.518. The Stroop test required participants to name the color of blocks of X's printed in colored inks or to name the ink color of color words printed in contrasting colored inks, e.g., RED printed in blue ink; participants were given 45 s to complete the tasks. The participant's score is the number of colors correctly named in 45 s. A measure of interference was computed by applying the formula:

Interference – (# blocks X's - # color words) / # blocks X's * 100 (1)

Young adults experienced less interference (M_Y = -.26, *SD* = .10) than older adults (M_O = -.46, *SD* = .15), *t*(148) = 8.881.

Tasks

Each participant completed nine tasks: talking alone, walking alone and while talking, complex finger tapping alone and while talking, and simple finger tapping alone and while talking, talking while ignoring concurrent speech, and talking while ignoring concurrent noise. All tasks were administered in a fixed order and interspersed with the cognitive tests. Following cognitive, health, and hearing screening, the participants were given the digit span tests and a baseline language sample was collected. The talking while ignoring noise task was next administered, followed by the vocabulary test and the baseline simple finger tapping, baseline walking tasks, and baseline complex finger tapping task. Following a break, participants were given the Stroop baseline color naming task, and the talking while ignoring speech task. Simple tapping while talking, the Digit Symbol, and Stroop color word naming tasks were administered followed by the reading span test and the complex tapping while talking and walking while talking tasks. The entire testing session lasted approximately 2 hr.

The Noldus Video Observer (Noldus, 1991) system was used to analyze all walking and tapping tasks. Participants were digitally video- and audio-recorded as they performed these tasks. The Noldus system enables the researcher to play back these recordings while inserting behavioral codes to mark critical behavioral events such as each foot step or tap of a finger. These codes are automatically time-locked to the recording. A hierarchical system of codes can be used so that critical events may be nested within larger behavioral segments. The Noldus system then computes rates, intervals, and durations for coded events based on the time-locked codes. Multiple coders can analyze each recording to establish reliability and reliability can be defined with ms accuracy if desired.

Walking. Walking has been previously shown to be related to higher cognitive functions, including performance on the Stroop task (Camicioli, Howieson, Lehman, & Kaye, 1997; Chen, Ashton-Miller, Alexander, Schultz, 1994; Chen, Schultz, Ashton-Miller, Giordani, Alexander, & Guire, 1996; Lajoie, Teasdale, Bard, Fleury, 1996; Lundin-Olsson, Nyberg, & Gustafson, 1998; Persad, Giordani, Chen, et al., 1995; Nutt, Marsden, & Thompson, 1993; Teasdale, Bard, LaRue, & Fleury, 1993; Wright & Kemp, 1992). Participants were asked to walk at a *brisk but comfortable* pace around an irregular elliptical pathway, approximately 18 ft in diameter, for 3 to 5 min. The participants were permitted to walk clockwise or counter-clockwise, as preferred. At the start of the concurrent walking and talking segment, the participants were handed a prompt card with an elicitation question printed on the reverse and instructed to complete 1 "lap" or about 30 s of walking before turning over the card, reading the question, and responding orally.

The walking or walking and talking segments were coded using the Noldus system and then analyzed to determine the average walking rate, in steps per s, starting 30 s after the participant began walking. Stumbles, mis-steps, and footsteps outside of or inside of the boundaries of the path were coded separately. The walking "errors" were of extremely low frequency and were not analyzed further.

During the concurrent walking and talking task, codes were inserted to mark the onset of speech and all discernable speech interruptions or pauses greater than 10 ms; additional codes marked the onset of walking and all pauses or interruptions of walking greater than 10 ms. Speech interruptions and pauses while walking were rare and were not analyzed further. The percentage of time each participant was actually walking or walking while talking simultaneously was computed as a measure of *time-on-task*. Two coders independently coded video recordings from 10 young and 10 older participants; they agreed at better than 90% accuracy on all walking measures. The two coders had better than 95% agreement on coding all pauses and walking mis-steps or other errors; they were required to agree within ± 5 ms on the onset and offset of all speech or walking pauses.

The total duration of the walking segment varied unsystematically across participants. Young adults walked for an average of 4 min 20 s (range: 200 - 320 s) in the walking baseline segment and for an average of 4 min 10 s (range: 180 - 380 s) in the walking and talking segment, $t(74) < 1.0$. Older adults walked for an average of 4 min 18 s (range: 200 - 360 s) in the baseline segment and for an average of 3 min 50 s (range: 200 - 340 s) in the walking + talking segment, $t(74) < 1.0$. There were no significant age differences in the duration of the walking or walking and tapping segments. The first minute and last minute of each walking segment were compared; there was no indication that tapping rate or time-on-task declined across these segments for young or older adults in either baseline or dual task conditions.

Finger Tapping. Finger tapping has been widely used to examine the effects of task concurrency and laterality of neuropsychological functions (Chaves, Trautt, Brandon, & Steyaert, 1983; Friedman, Polson, & Dafoe, 1988; Gill, Reddon, Stefnyk, & Hans, 1986; Gupta & MacWhinney, 1995; Hellige & Longstreth, 1981; Hicks, 1975; Hiscock, Kinsbourne, Samuels, & Krause, 1985; Kinsbourne & Hicks, 1978; Kee & Cherry, 1990; Leonard et al., 1988; McFarland & Ashton, 1978; Summers & Sharpe, 1979; Towell, Burton, & Burton, 1994). Two tapping tasks were used. Complex tapping required the participants to tap "as rapidly as possible" a four-finger sequence (if the fingers are numbered beginning with the index finger, the sequence is 1-3-2-4) for 3 to 5 min. Simple tapping required participants to tap "as rapidly as possible" with the index finger of the preferred hand for 3 to 5 min. During the concurrent tapping and talking tasks, participants were asked to tap for 30 s; then they were shown a prompt card with an elicitation question and asked to respond orally.

The participants were video- and audio-recorded while tapping and the Noldus system was used to computed tapping rates and time-on-task. Complex tapping was analyzed to determine complete 4-tap sequences per min. Sequencing errors were also coded during the complex tapping task. Simple tapping was analyzed to determine taps per min; all pauses or interruptions > 10 ms were also coded. During the concurrent simple tapping and talking or complex tapping and talking tasks, codes were also inserted to mark the onset of speech and any speech pauses or interruptions greater than 10 ms; time-on-task was computed as the percentage of time the participants were simultaneously tapping accurately while talking. Speech interruptions and errors or pauses while tapping were rare and were not analyzed further. Two coders independently coded video recordings from 10 young and 10 older participants; they agreed at better than 90% accuracy on all rate measures. The two coders had better than 95% agreement on coding all pauses and complex tapping sequence errors; they were required to agree within ± 5 ms on the onset and offset of all speech or tapping pauses.

The total duration of the tapping segments varied unsystematically across participants. Young adults tapped for an average of 3 min 50 s (range: 200 -320 s) in the simple tapping baseline segment and for an average of 4 min 5 s (range: 180 - 380 s) in the simple tapping and talking segment, $t(74) < 1.0$. Older adults tapped for an average of 5 min 5 s (range: 200 - 360 s) in the simple tapping baseline segment and for an average of 4min 50 s (range: 200 - 360 s) in the simple tapping and talking segment, $t(74) < 1.0$. Young adults tapped for an average of 4 min 10 s (range: 180 - 320 s) in the complex tapping baseline segment and for an average of 4 min 30 s (range: 180 - 340 s) in the complex tapping and talking segment, $t(74) < 1.0$. Older adults tapped for an average of 4 min 5 s (range: 180 - 360 s) in the simple tapping baseline segment and for an average of 4 min 35 s (range: 200 - 340 s) in the simple tapping and talking segment, $t(74) < 1.0$. There were no significant age differences in the duration of these segments. The first minute and last minute of each simple and complex tapping segment were compared; there was no indication that tapping rate or time-on-task declined across these segments for either young or older adults in either baseline or dual task conditions.

Ignoring Concurrent Speech or Noise. Ignoring concurrent speech or noise has been shown to interfere with performance on a variety of short-term memory tasks; ignoring concurrent speech appears to disrupt concurrent phonological processing within a limited-capacity working memory as neither intensity nor meaningfulness affect the magnitude of the effect whereas rhyming stimuli increase the magnitude of the effect (Colle, 1980; Colle & Welch, 1976; Jones & Macken, 1993, 1995a; Jones, Madden, & Miles, 1992; Jones, Miles, & Page, 1990; LeCompte, 1994; Salame & Baddeley, 1982; 1989). Auditory "babble" composed of a mixture of voices reduces the magnitude of the irrelevant speech effect (Jones & Macken, 1995b, c) whereas concurrent sequences of tones, and office or cafeteria noise (e.g., recordings made in an office or cafeteria) produce comparable interference effects (Banbury & Berry, 1998; Ellermeier & Hellbreck, 1998) suggesting the effect is not simply due to a disruption of phonological processing. The concurrent speech effect is not diminished by aging (Rouleau & Belleville, 1996).

Two conditions were used: ignoring concurrent speech and ignoring cafeteria noise. Both correspond to common situations in which older adults report having difficulty maintaining conversations, such as congregate meal sites or public lounges Holland, 1980). In the ignoring concurrent speech condition, the participants listened through headphones with binaural presentation to a recording of a passage read in a monotone voice by a speaker of the same sex as the participant. The passage was semantically anomalous in that it was created by concatenating individual sentences taken from a variety of sources on different topics. In the ignoring concurrent noise condition, the participants listened to binaural presentation of a recording made in a public cafeteria. The AUDiTEC (AUDiTEC, 1998) recordings of concurrent speech or cafeteria noise were used. The presentation was first adjusted to a comfortable listening level between 40 dB – 60 dB and the same dB level was used for both concurrent speech and concurrent noise conditions. Individual levels were set approximately 20 dB louder than the participant's pure tone hearing threshold. Average dB level for young participants was 40 dB ($SD = 0$); average dB level for older participants was 50 db ($SD = 5.5$), $t(148) = 185.5$. The 10 dB difference in listening levels for young and older adults is similar to the 10 dB average difference in pure tone thresholds for the two groups. The participants first listened to 30 s of speech or noise and then they were then shown a prompt card with an elicitation question.

Language Sample Elicitation

A baseline sample was collected from each participant at the beginning of the testing session and additional language samples were collected while the participants were performing each of the five concurrent tasks. Each language sample was approximately 5 min in duration and included at least 50 utterances. Language samples were elicited using a variety of questions requiring participants to describe people or events that have influenced their lives, recent vacations, significant inventions of the 20th C, individuals they admire, and so forth. Six different elicitation questions were counter-balanced across conditions. Each elicitation question was printed on a card which was shown or given to the participant. Participants were instructed that they were to respond to the elicitation question without disrupting their performance on the current task. When a participant first paused or stopped responding, a standard prompt such as "can you tell me more about….?" or ""would you like to add anything?" was used to ensure that an adequate language sample of at least 50 utterances was obtained from each participant in each condition.

The samples were analyzed following the procedures described by Kemper et al. (1989). The samples were transcribed and coded by first segmenting each into utterances and then coding each utterance. Utterances were defined by pauses > 10 ms in the participant's flow of speech; therefore, utterances did not necessarily correspond to grammatically defined sentences but included interjections, fillers, and sentence fragments. "Fillers," defined as speech serving to fill gaps in the speech flow, included both lexical and non-lexical fillers. Although commonly considered to be disfluencies or speech errors, fillers may serve pragmatic and discourse functions (Fox Tree, 1995). Non-lexical fillers, such as "uh," "umm," "duh," etc., were excluded from the transcript as they are not reliably segmented and transcribed (Brennan & Schober, 2001; Ferber, 1991) and older adults have been observed to produce only slightly higher rates of non-lexical fillers than young adults (Bortfeld, Leon, Bloom, Schober, & Brennan, 2000). Lexical fillers, such as "and," "you know," "yeah," and "well," were retained in the transcript. Also excluded from the transcript were utterances that repeated or echoed those of the examiner.

Three dimensions of language were then assessed: fluency, grammatical complexity, and prepositional density. Fluency is commonly assumed to involve both word retrieval, sentence formulation, and articulation processes and to be subject to lapses of attention, memory limitations, and motor and articulatory control problems. There is no generally agreed upon measure of fluency; fluency is common assessed by examining utterance length and grammaticality, speech rate, and the occurrence of fillers. Four measures of fluency were computed: (i) Mean Length of Utterance (MLU) was obtained automatically using the Systematic Analysis of Language Transcripts (SALT) software (Chapman & Miller, 1984). (ii) A word-per-minute (WPM) speech rate was also computed by timing the duration of 10 different segments of 5 to 10 words and computing an average. (iii) All grammatical sentences were identified and the percentage of utterances that were grammatical sentences was computed for the entire language sample. (iv) The percentage of utterances containing lexical fillers was determined. These measures of fluency are not highly correlated (Cheung & Kemper, 1992), suggesting that they are differentially modifiable aspects of fluency.

Grammatical complexity reflects the syntactic operations involving the use of embedded and subordinate clauses. Two measures of grammatical complexity were obtained from each language sample: (i) Mean Clauses per Utterance (MCU) was obtained by identifying each main and embedded or subordinate clause in each utterance. (ii) Developmental Level (D-Level), an index of grammatical complexity, was scoring based on a scale originally developed by Rosenberg and Abbeduto (1987). Grammatical complexity ranged from simple one-clause sentences to complex sentences with multiple forms of embedding and subordination. Each complete sentence was scored and the average D-Level for each language sample was then calculated. MCU treats all forms of embedding and subordination alike. D-Level assumes a left-to-right processing model of language production such that embedded constructions that occur in the subject, such as relative clauses modifying the subject, impose more processing demands than those occurring in the predicate. Consequently, subject embeddings are worth more points than predicate embeddings. Both measures of grammatical complexity are highly correlated and both correlate highly with measures of working memory span (Kemper & Sumner, 2001).

Finally, the content of the language samples was assessed. Content can be measured by identifying and tallying individual idea units or by assessing lexical redundancy and repetition. Two measures of propositional content were obtained from each language sample: (i) Propositional Density (P-Density) was calculated according to the procedures described by Turner and Greene (1977). Each utterance was decomposed into its constituent propositions, which represent propositional elements and relations between them. The P-Density for each speaker was defined as the average number of propositions per 100 words. (ii) A Type-Token Ratio (TTR) was also computed for each language sample based on the ratio of the number of different words in the sample to the total number of words in the sample. TTR was automatically computed by the SALT program. P-Density can be considered a measure of processing efficiency whereas TTRs may reflect working memory limitations affecting lexical repetition (Kemper & Sumner, 2001).

Two trained coders independently scored 10% of the language samples to establish reliability. Agreement exceeded $\underline{r}$ (15) > .90 for all measures.

Results

The analysis was designed to compare baseline performance to performance during in the concurrent motor tasks and selective attention tasks. The initial analysis, summarized in Table 1, examined age group differences in baseline performance. Baseline age group differences were expected on the language sample measures and for the walking and tapping performance measures. Second, Dual Task Costs (DTCs) were computed for the language sample measures and for the performance measures (walking and tapping rates and time-on-task measures). These DTCs for the language sample measures are reported in Figures 1 – 5, organized by task; DTCs for the performance measures are reported in Figure 6. The initial analysis examined whether DTCs for the language sample and performance measures were significantly different than zero; these findings are indicated on Figures 1 – 6. Multivariate ANOVAs were used to examine age group and tasks differences in DTCs for the measures of fluency (MLU, WPM speech rate, the percentage of grammatical sentences, and the percentage of utterances without fillers), complexity (MCU and D-Level), and content (TTR and P-Density) and for the two performance measures, rate and time-on-task. Table 2 reports the results of these MANOVAs along with the univariate results. Table 3 presents task differences in DTCs for the language sample measures and performance measures.

Baseline Measures

Baseline language sample measures are presented in Table 1 along with the results of a one-way ANOVA comparing the age groups on these measures. Older adults were less fluent than young adults, on all four measures (MLU, WPM speech rate, the percentage of grammatical sentences, and the percentage of sentences without fillers). Older adults' speech was less complex than the young adults, differing in MCU and (marginally) in D-Level. Although TTRs did not differ, the older adults also reduced the propositional content of their speech, lowering the P-Density measure.

Baseline performance measures for the young and older adults are given in Table 1. Walking rates, complex tapping, and simple tapping rates were slower for older adults. Both young and older adults were able to sustain their performance on these baseline tasks as time-on-task was 100% during simple tapping and walking and 97% for complex tapping for both groups.

Dual Task Costs

Following Lindenberger et al. (2001), DTCs were computed for each language sample measure and the performance measures using the formula:

$$\text{DTCs} = (\text{Concurrent Task} - \text{Baseline}) / \text{Baseline} * 100. \qquad (2)$$

Figures 1 - 5 report age group differences in DTCs for each task (walking, complex tapping, simple tapping, ignoring speech, and ignoring noise) for the language sample measures of fluency, grammatical complexity, and content; Figure 6 reports age group differences in DTCs for the performance measures (rate and time-on-task).

The initial analysis tested whether DTCs for the language sample and performance measures were significantly different than zero, using a series of *t*-tests on the DTCs for young and older adults separately. These results are indicated on Figures 1 – 6. DTCs that were significantly different than zero are indicated by an asterisk (*). These tests indicated that young adults experienced DTCs significantly greater than zero for MLU, D-Level, MCU, and P-Density for all 5 tasks. Older adults experienced DTCs significantly greater than zero for WPM speech rates, D-Level, and P-Density on all 5 tasks. The other measures produced smaller DTCs across the 5 tasks and age groups.

Three 2 X 5 MANOVAs were conducted to compare DTCs for age groups and tasks (walking, complex tapping, simple tapping, ignoring speech, and ignoring noise). The 3 multivariate analyses examined: (i) fluency, measured by MLU, WPM speech rate, the percentage of grammatical sentences, and the percentage of sentences without fillers; (ii) complexity, measured by MCU and D-Level; and (iii) content, measured by TTR and P-Density. A 2 x 3 MANOVA was conducted to compare DTCs for age group and tasks (walking, complex tapping, and simple tapping) for the two performance measures, rate and time-on-task. The MANOVAs and the corresponding univariate ANOVAs are reported in Table 2.

Significant task effects and Age x Task interactions were further analyzed using *post hoc* Tukey HSD tests. Table 3 summarizes task differences in DTCs for the language sample measures and performance measures.

Fluency. Although there was a significant multivariate effect, age group differences in DTCs for fluency were limited to WPM speech rate (see Table 2). DTCs for WPM speech rate for young adults averaged 0.328 (*SE* = 2.54) across tasks whereas DTCs for older adults averaged –10.120 (*SE* = 2.53) across tasks.

Task differences resulted in significant differences in fluency, affecting all 4 fluency measures (see Table 3). DTCs for MLU were largest for the walking task; complex tapping and ignoring speech yielding somewhat smaller DTCs than walking; ignoring noise and simple tapping produced small, positive DTCs (indicating MLU increases) and DTCs for these two tasks did not differ. DTCs were small and positive for the WPM speech rate measure for the simple tapping and ignoring noise tasks, and larger and negative for the walking, complex tapping , ignoring speech tasks. DTCs for the percentage of grammatical sentences were largest for complex tapping, somewhat smaller for walking and ignoring speech, and small and positive for simple tapping and ignoring noise. DTCs for the percentage of sentences without fillers were negative for all tasks, indicating an increase in the use of fillers. DTCs for the percentage of utterances without fillers were similar for walking and complex tapping, whereas simple tapping, ignoring speech, and ignoring noise resulted in smaller increases in the use of fillers.

The multivariate Age x Task interaction was significant but the univariate interactions were significant only for DTCs for MLU and WPM speech rates. DTCs for MLU were smaller for older adults than for young adults on all tasks; the greatest age difference in DTCs for MLU occurred on the walking task ((M_O = -1.73, *SE* = 2.85; M_y = -12.131, *SE* = 2.87) (see Figure 1); age differences in DTCs for MLU were equivalent for the other four tasks (M_O = 0.942, *SE* = 2.80; M_Y = -3.831, *SE* = 2,92). The greatest age differences in DTCs for WPM speech rates occurred on the walking task (Figure 1) (M_O = -17.125, *SE* = 3.55; M_y = +0.668, *SE* = 3.57), and the complex tapping task (Figure 2) (M_O = -16.561, *SE* = 3.11; M_y = -2.784, *SE* = 3.14). DTCs for young and older adults were smaller and equivalent for simple tapping (Figure 3) (M_O = -4.541, *SE* = 3.36; M_y = -0.734, *SE* = 3.61), ignoring speech (Figure 4) (M_O = -8.715, *SE* = 3.51; M_y = -4.144, *SE* = 3.53), and ignoring noise (Figure 5) (M_O = -7.466, *SE* = 2.74; M_y = -4.029, *SE* = 2.75).

Complexity. The overall age effect for complexity was significant as were both univariate effects (see Table 2). DTCs for grammatical complexity were smaller for older adults than for young adults. In terms of MCU, average DTCs for older adults were +2.810 (*SE* = 3.01) whereas those for young adults were –14.864 (*SE* = 3.12); in terms of D-Level, average DTCs for older adults were –7.924 (*SE* = 2.33). and for young adults were –18.762 (*SE* = 2.34)

The multivariate main effect of task was significant but only the univariate main effect for MCU was significant (see Table 3). On this measure of complexity, walking and ignoring speech produced equivalent DTCs; complex tapping and ignoring noise produced smaller DTCs, and simple tapping produced the smallest DTCs.

The multivariate Age x Task interaction was marginally significant and attributable to the MCU measure. Young adults experienced greater DTCs for MCU than older adults for walking (Figure 1) (M_O = -0.926, *SE* = 3.42; M_y = -19.574, *SE* = 3.48), complex tapping (Figure 2) (M_O = +2.360, *SE* = 3.42; M_y = -13.461, *SE* = 3.44), simple tapping (Figure 3) (M_O = +4.884, *SE* = 3.91; M_y = -7.714, *SE* = 3.93), ignoring speech (Figure 4) (M_O = +4.838, *SE* = 3.40; M_y = -22.364, *SE* = 3.37) ; and ignoring noise (Figure 5) M_O = +2.893, *SE* = 3.73; M_y = -11.206, *SE* = 3.75) than the older adults.

Content. There were no overall age differences in DTCs for content. The multivariate effect of task was significant as were both univariate effects for TTR and P-Density (see Table 2). DTCs for TTR were equivalent for the simple tapping, ignoring noise, and ignoring speech tasks and larger for these three tasks than for the walking and complex tapping tasks (see Table 3). DTCs for P-Density were equivalent for the complex tapping and ignoring speech tasks, and smallest for the ignoring noise task (see Table 3). The Age x Task interactions for DTCs for content were nonsignificant.

Performance. There were no overall age differences in DTCs for walking or tapping rates or time-on-task for the three motor tasks, simple tapping, complex tapping, and walking tasks. The multivariate effect of task was significant as were both univariate effects (see Table 2). Task effects for the rate and time-on-task measures are reported in Table 3. DTCs for simple tapping and complex tapping were positive, indicating tapping rates increased while the participants were talking; DTCs for walking were negative, indicating that the participants slowed somewhat while talking. DTCs for the time-on-task measure were greatest for the complex tapping task, and smaller and equivalent for the simple tapping and walking tasks.

There was a significant multivariate Age X Task interaction; it was due to a significant interaction for the time-on-task measure (see Figure 6). DTCs for time-on-task for young and older adults were equivalent for walking (M_O = -7.415, *SE* = 1.39; M_Y = -10.253, *SE* = 1.30), and simple tapping, (M_O = -10.220, *SE* = 2.37; M_Y = -8.824, *SE* = 1.11). Older adults (M_O = -22.292, *SE* = 1.37) experienced greater DTCs for time-on-task during complex tapping than did the young adults (M_Y = -16.982, *SE* = 2.37).

Summary

This study was designed to assess whether concurrent task demands differentially affect young and older adults' speech. In general, both groups of participants were able to meet the demands of doing two things at once, simultaneously talking while walking, finger tapping, or ignoring speech or noise The exception appears to be complex finger tapping where both groups adopted a task-alternation strategy, as indicated by the increased DTCs for the time-on-task measure for this task.

The speech of young and older adults did change when they were talking while simultaneously performing a concurrent motor or selective attention tasks. DTCs varied with the concurrent tasks and, in general, were significantly greater than zero More critically, there were age differences in dual task costs for fluency and grammatical complexity. Young adults experienced larger dual task costs than older adults for the measures of sentence length (MLU) and grammatical complexity (MCU and D-Level) whereas older adults experienced larger dual task costs for WPM speech rate. Dual task costs for the content measures were similar for young and older adults suggesting both groups of participants were trying to maintain the content of their speech while adopting to the dual task demands by reducing rate or complexity.

Conclusion

Li et al. (2001) begin their report on walking while memorizing by posing the following puzzle :

> Consider the behavior of individuals participating in a group hike. On moderately difficult terrain, a lively conversation might ensue while the group walks in close formation. However, with more challenging terrain, the conversation is likely to wane. Imagine further that the group includes individuals who are less fit, such as older individuals. Are they likely to withhold conversation altogether as they navigate around roots and boulders? (p. 230)

The answer to this question appears to be "no." Older adults, like young adults, are likely to continue to talk as they navigate in a complex physical environment. However, the fluency of their conversation is likely to change. Older adults are likely to speak more slowly than they would if resting. Talking more slowly may enable older adults to manage the complex demands of coordinating the two tasks, relegating demanding aspects of language production to flat, obstacle-free stretches of the terrain. Speech rate can be modified without affecting other measures of fluency such as the use of fillers or the production of ungrammatical sentence fragments. Older adults are thus able to adapt to dual task demands while preserving the appearance of maintaining fluent speech by simply speaking more slowly.

Young adults respond to dual task demands differently. They continue to speak just as rapidly when walking as when resting; however, young adults adopt a further set of speech accommodations, reducing sentence length, grammatical complexity, and propositional density when they are walking and talking simultaneously. By reducing length, complexity, and propositional density, young adults may free up working memory resources that are needed to help monitor the environment in order to preserve their walking rate.

Only when the concurrent task becomes very challenging, as in the case of complex finger tapping, does it appear that individuals are likely to interrupt their hike from time to time in order to carry on their conversation. In the present study, time-on-task rates for the walking and simple finger tapping tasks were unaffected by simultaneous speech whereas complex finger tapping while talking resulted in significant reduction in time-on-task. Further, older adults were somewhat more like to adopt such a task-alternation strategy than young adults.

We might imagine another scenario in which we consider the behavior of a group of young and older adults at a family dinner. Here, the question is how background noise and on-going conversations affect the ability of the individuals to relate a personal observation or anecdote. Are older adults more likely to break off their conversation whenever the service carts rattle by or others at the table discuss the events of the day? Again, the answer appears to be "no." Ignoring noise imposed few DTC on older adults apart from the reduction of speech rate. Again, young adults were more affected by the selective attention demands of ignoring speech or ignoring noise, showing greater costs for sentence length and grammatical complexity. When required to ignore concurrent speech, the speech of young adults converges on the same style as that of older adults, with regards to grammatical complexity.

Kemper, S., Herman, R. E., & Lian, C. H. T. (2003). The Costs of Doing Two Things at Once for Young and Older Adults: Talking while Walking, Finger Tapping, and Ignoring Speech or Noise. *Psychology and Aging, 18,* 181-192.
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It is surprising that the young adults experienced greater costs due to the dual task demands as research has typically shown that costs to older adults are greater (Verhaeghen et al., 2000). Murray et al. (1998) have reported that healthy older participants experienced few changes to spoken language on a picture-description task when performed alone or in conjunction with a tone-detection tasks. This study as well as the present study suggest that language appears to be an exception to the general hypothesis that older adults experience greater dual task costs than young adults.

With the exception of the time-on-task measure for complex tapping, there was no indication that the young and older adults prioritized tasks differently. Both groups were able to maintain their walking and tapping rates while talking and both groups were able to continuously talk while continuously walking or simply tapping their finger. Complex tapping was somewhat more disruptive for older adults than for young adults, suggesting that older adults may experience greater dual task costs for very challenging tasks. Although there was little evidence for fatigue or practice effects when the first and last minute of each walking or tapping segment were compared, both young and older adults experienced positive DTCs for simple and complex tapping rates. This may reflect practice or it may reflect motor entrainment of speech and tapping (Turvey, 1990).

It appears that older adults, in response to age-related loss of processing speed and working memory capacity, have developed a restricted speech register, that is grammatically less complexity and propositionally less dense than that used normally by young adults. This restricted speech register is, however, buffered from many of the costs associated with doing two things at once. Whereas young adults' faster, more complex speech is affected by simultaneously performing simple motor tasks, older adults are able to combine these tasks by reducing their speech rate without suffering further declines in grammatical complexity or propositional density. Under dual task conditions, young adults will shift to a simpler speech register, reducing grammatical complexity in response to the demands of doing two things at once. Indeed, the speech register used by young adults under dual task conditions resembles that used by older adults in baseline in terms of sentence length and grammatical complexity. Both groups were successful in adapting to the dual task demands, abet by using different strategies, as they were able to modifying their speech without increasing their production of sentence fragments and lexical fillers. These types of disfluencies maybe so negatively stigmatized that speakers may sacrifice other aspects of speech, such as speech rate and grammatical complexity, in order to avoid producing disfluent speech marked by sentence fragments and fillers.

The simplified speech register used by older adults and young adults under dual-task conditions differs from two other simplified speech registers. Bernstein (1968, 1971) characterized the speech of individuals from lower socio-economic levels as a controlling, authoritarian, public language, that is vague, diffuse, dependent on non-verbal changes in volume, tone, gesture, facial expression. He also described it as involving "short, grammatically simple, often unfinished, sentences with a poor syntactical construction; simple and repetitive use of conjunctions …thus modifications, qualifications, and logical stress tend to be indicated by non-verbal means; frequent use of short commands and questions; rigid and limited use of adjectives and adverbs; infrequent use of the impersonal pronoun (*it, one*) as subject of a conditional sentence; statements formulated as questions….a statement of fact is often used as both a reason and a conclusion…traditional phrases…symbolism of a low order of generality…implicit meaning" (1968, p. 228). While the speech of older adults and young adults under dual task conditions share many of these properties, it differs from this *restricted* register in a number of ways, most significantly in terms of its varied vocabulary and expressive content, as reflected in the TTRs and P-Density measure. Sentence length exceeds that reported by Bernstein and a wide range of grammatical constructions are used, although complex forms with relative clauses, embedded infinitive and that-clauses, etc. are infrequent.

This simplified speech register also differs from another form of simplified speech, pidgin language. Pidgins are simplified languages formed when speakers of two or more languages come in contact in trade or maritime situations. Pidgins are typically lacking many features, including "consistent marking of tense, aspect, and modality; relative clauses; movement rules, embedded complements, in particularly infinitival constructions; articles, especially indefinite" (Bickerton, 1981). Pidgins are further characterized by their restricted vocabulary, dependence on contextual and pragmatic cues, and frequent use of ellipsis. Older adults' speech and that of young adults under dual tasks conditions resembles pidgin language only that complex, embedded constructions are rarely produced, reflecting the demands placed on working memory by these constructions.

The restricted speech registers described by Bernstein and Bickerton appear to arise from restricted access to a fully-developed language. In contrast, the simplified speech of older adults and of young adults under dual task conditions appears to arise from accommodations to working memory limitations. Older adults also accommodate to chronic working memory limitations by shifting to a simplified speech style and can further accommodate to dual task demands by reducing speech rate. It may be that this speech register cannot be further simplified without leading to a breakdown in communication.

There are two caveats that must be considered: First, it is important to consider what effects other tasks might have on older adults' ability to do two things at once. These tasks were chosen because they correspond to common, everyday activities or because they were familiar motor tasks. It may be that more demanding tasks or unfamiliar tasks will pose greater challenges, especially to older adults, affecting the complexity and content of their speech. Navigating an uneven terrain, stepping over and around obstacles, or tapping in response to complex or varying rhythms may affect their ability to maintain this simplified speech register. Further reductions in response to very demanding tasks may be achieved only at a great cost to fluency, complexity and content, leading to highly fragmented, vacuous or "empty" speech marked with many lexical and non-lexical fillers, such as that characteristic of individuals with dementia (Kemper, Thompson, & Marquis, 2001).

In addition, only a single ordering of tasks was used in the present study and DTCs for young and older adults may be affected differentially by fatigue or practice. The instructions emphasized the maintenance of the walking or tapping tasks and the issue of how task prioritization also must be addressed in future studies.

Second, the participants in this experiment were highly selected. They were carefully screened for a variety of physical and medical problems that might affect their walking, finger tapping, or selective attention abilities. One indication of their overall health is that their baseline walking rates were no different from those of the young adults and they were able to maintain this walking rate even while talking. Less healthy older adults may be more vulnerable to dual task demands that will affect their ability to maintain even a simplified speech style.

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Table 1.

Age Differences in Baseline Language Sample Measures, Walking and Tapping Rates, and the Time-on-task Measures; Means (SDs) are given along with Results of the Multivariate and Univariate ANOVAs.

Measure	Young Adults Mean	SD	Older Adults Mean	SD	F	df	*p*	η^2
Fluency MANOVA					6.523	4,145	.000	.153
MLU	7.44	(2.13)	5.98	(2.01	18.629	1,148	.000	.112
WPM	155.0	(40.98)	136.01	(32.87)	9.895	1,148	.002	.063
% Grammatical	42.34	(18.83)	34.97	(22.06)	4.844	1,148	.029	.032
% w/out Fillers	26.21	(15.14)	21.66	(10.60)	4.511	1,148	.035	.030
Complexity MANOVA					21.662	2,147	.000	.228
MCU	1.32	(0.39)	0.93	(0.33)	43.606	1,148	.000	.228
D-Level	3.21	(1.30)	0.83	(1.19)	3.562	1,148	.061	.024
Content MANOVA					3.484	2,147	.033	.045
TTR	0.55	(0.12)	0.57	(0.12)	<1.0	1,148	.327	.006
P-Density	4.70	(1.30)	4.33	(1.01)	5.011	1,148	.027	.033
Rate MANOVA					25.071	3,146	.000	.104
Simple Tapping	2.62	(0.79)	2.11	(0.71)	17.140	1,148	.000	.104
Complex Tapping	2.91	(0.79)	1.92	(0.58)	74.710	1,148	.000	.335
Walking	1.39	(0.19)	1.30	(0.23)	6.206	1,148	.014	.040
Time-on-Task MANOVA					<1.0	1,146	.714	.009
Simple Tapping	100%	(0)	100%	(0)	<1.0	1,148	.561	.002
Complex Tapping	97%	(2.85)	97%	(4.38)	<1.0	1,148	.976	.000
Walking	100%	(0)	100%	(0)	<1.0	1,148	.315	.007

Note. MLU = mean length of utterance; WPM = word per minute speech rate; % Grammatical = percentage of grammatical sentences; % w/out Fillers = percentage of sentences without fillers; MCU = mean clauses per utterance; D-Level = Developmental Level; TTR = type-token ratio; P-Density = propositional density.

Table 2.

Results of the Multivariate and Univariate ANOVAs for Dual Task Costs to the Language Sample Measures and Performance Measures.

	AGE				TASK				AGE x TASK			
Measure	***F***	df	*p*	η^2	***F***	df	*p*	η^2	***F***	df	*p*	η^2
MANOVA Fluency	3.525	4,145	.009	.089	3.649	16,133	.000	.307	4.278	16,133	.000	.341
MLU	2.702	1,148	.102	.018	5,653	4,599	.000	.037	5.208	4,599	.000	.034
WPM	8.468	1,148	.004	.054	7.594	4,599	.000	.049	3.431	4,599	.009	.023
% Grammatical	0.031	1,148	.861	.000	2.453	4,599	.045	.016	1.958	4,588	.099	.013
% w/out Fillers	1.165	1,148	.282	.008	2.694	4,599	.030	.018	0.114	4,588	.978	.001
MANOVA Complexity	14.945	2,147	.000	.170	3.371	8,141	.001	.162	1.995	8,141	.051	.102
MCU	16.167	1,148	.000	.099	6.061	4,599	.000	.040	4.060	4,599	.003	.027
D-Level	20.783	1,148	.001	.068	1.528	4,599	.194	.010	0.389	4,592	.816	.003
MANOVA Content	0.069	2,147	.934	.001	3,450	8,141	.001	.164	0.976	8,141	.458	.052
TTR	0.082	1,148	.776	.001	4.418	4,599	.002	.029	1.309	4,599	.265	.009
P-Density	0.056	1,148	.813	.000	3.845	4,599	.004	.025	1.395	8,141	.234	.009
MANOVA Performance	1.991	2,147	.140	.026	13.384	4,145	.000	.270	3.784	4,145	.006	.095
Rate	3.225	1,148	.075	.021	11.198	2,296	.000	.070	1.875	2,296	.155	.013
Time-on-Task	0.063	1,148	.802	.000	33.394	2,296	.000	.184	4.459	2,296	.012	.029

Note. MLU = mean length of utterance; WPM = word per minute speech rate; % Grammatical = percentage of grammatical sentences; % w/out Fillers = percentage of sentences without fillers; MCU = mean clauses per utterance; D-Level = Developmental Level; TTR = type-token ratio; P-Density = propositional density.

Table 3.

Task Differences in DTCs for the Language Sample Measures and Performance Measures.

Measure	WALKING		COMPLEX TAPPING		SIMPLE TAPPING		IGNORING SPEECH		IGNORING NOISE	
	DTCs	*SE*	DTCs	*SE*	DTCs	*SE*	DTCs	*SE*	DTCs	*SE*
Fluency										
MLU	-6.934_a	2.02	-3.520_b	2.11	$+1.932_c$	1.99	-2.655_b	1.91	$+0.529_c$	2.08
WPM	-8.228_a	2.52	-9.673_a	2.21	$+1.903_b$	2.56	-6.197_a	2.49	$+2.286_b$	1.94
% Grammatical	-3.209_b	3.01	-6.931_a	3.27	$+1.804_c$	3.27	-3.846_b	2.77	$+1.607_c$	3.01
% w/out Fillers	-5.791_a	7.05	-8.025_a	4.30	-2.245_b	2.87	-2.513_b	2.87	-3.600_b	3.31
Complexity										
MCU	-10.250_a	2.45	-5.551_b	2.42	-1.415_c	2.77	-8.763_a	2.39	-4.157_b	2.65
D-Level	-17.557_a	2.48	-12.750_a	2.36	-11.201_a	2.37	-14.475_a	2.262	-10.731_a	3.36
Content										
TTR	-0.391_b	1.67	$+1.009_b$	2.02	-4.421_a	1.57	-3.461_a	1.81	-2.543_a	1.58
P-Density	-4.966_b	0.98	-5.907_a	0.94	-3.669_b	1.00	-5.094_a	0.91	-2.883_c	0.74
Performance										
Rate	-4.526_a	1.93	$+5.743_b$	2.51	$+3.821_b$	2.50				
Time-on-task	-8.834_b	0.98	-19.737_a	1.67	-9.522_b	0.78				

Note. MLU = mean length of utterance; WPM = word per minute speech rate; % Grammatical = percentage of grammatical sentences;% w/out Fillers = percentage of sentences without fillers; MCU = mean clauses per utterance; D-Level = Developmental Level; TTR = type-token ratio;

P-Density = propositional density. Means in the same row that do not share subscripts differ at $p < .05$ in the Tukey honestly significant difference test.

Figure Captions

Figure 1. Dual Task Costs (DTCs) (and standard errors) for the Language Sample Measures comparing Walking Baseline and Walking and Talking. An asterisk (*) marks DTCs significantly greater than zero.

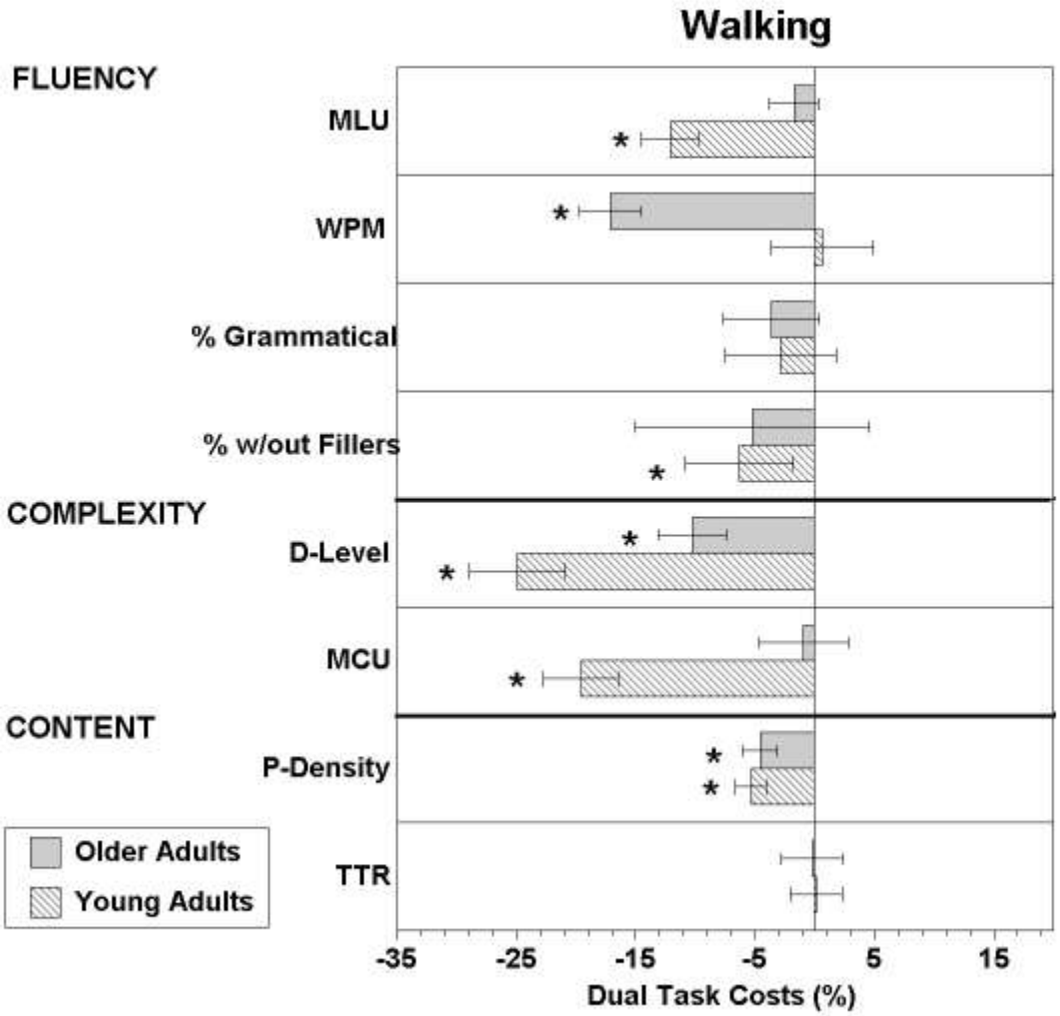
Figure 2. Dual Task Costs (DTCs) (and standard errors) for the Language Sample Measures comparing Complex Tapping Baseline and Complex Tapping and Talking. An asterisk (*) marks DTCs significantly greater than zero.

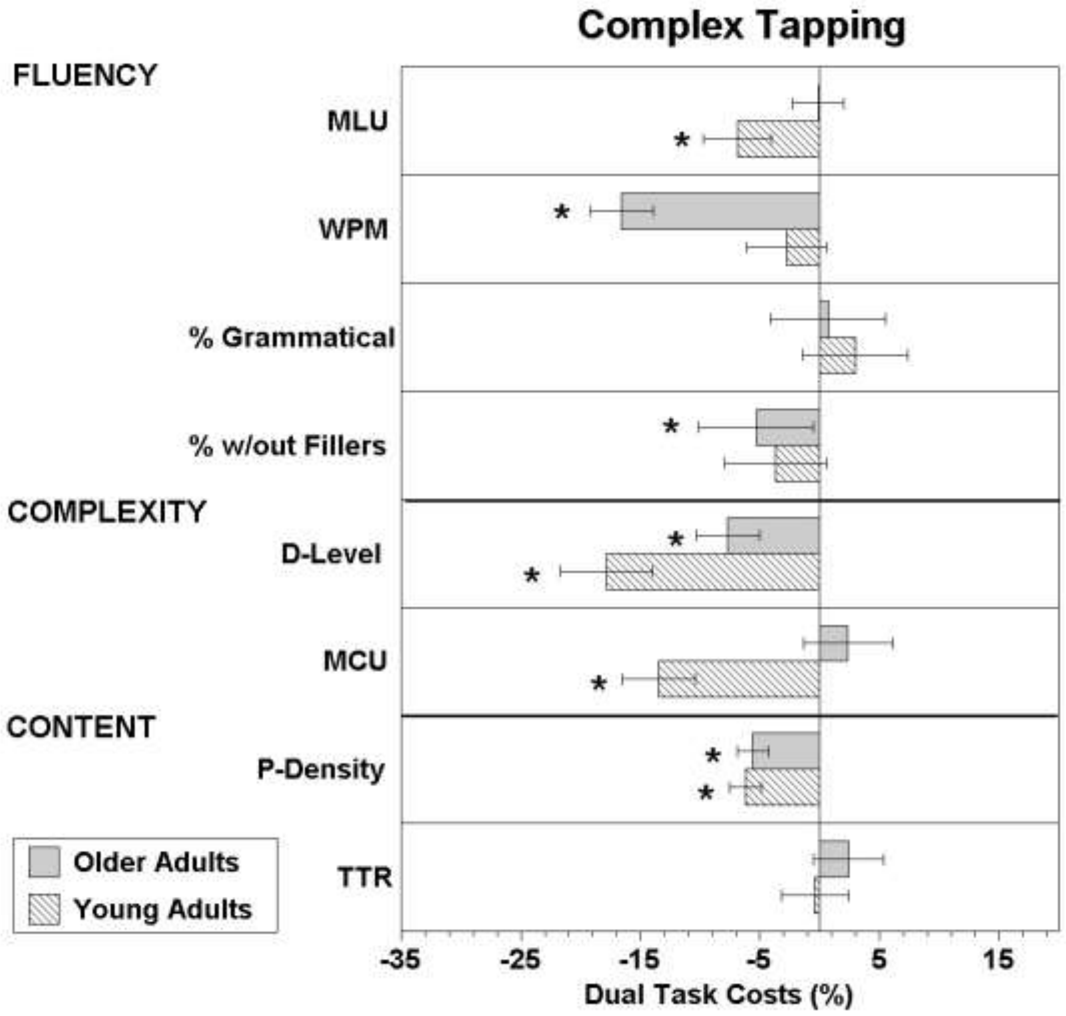
Figure 3. Dual Task Costs (DTCs) (and standard errors) for the Language Sample Measures comparing Simple Tapping Baseline and Simple Tapping and Talking. An asterisk (*) marks DTCs significantly greater than zero.

Figure 4. Dual Task Costs (DTCs) (and standard errors) for the Language Sample Measures comparing Ignoring Speech Baseline and Ignoring Speech and Talking. An asterisk (*) marks DTCs significantly greater than zero.

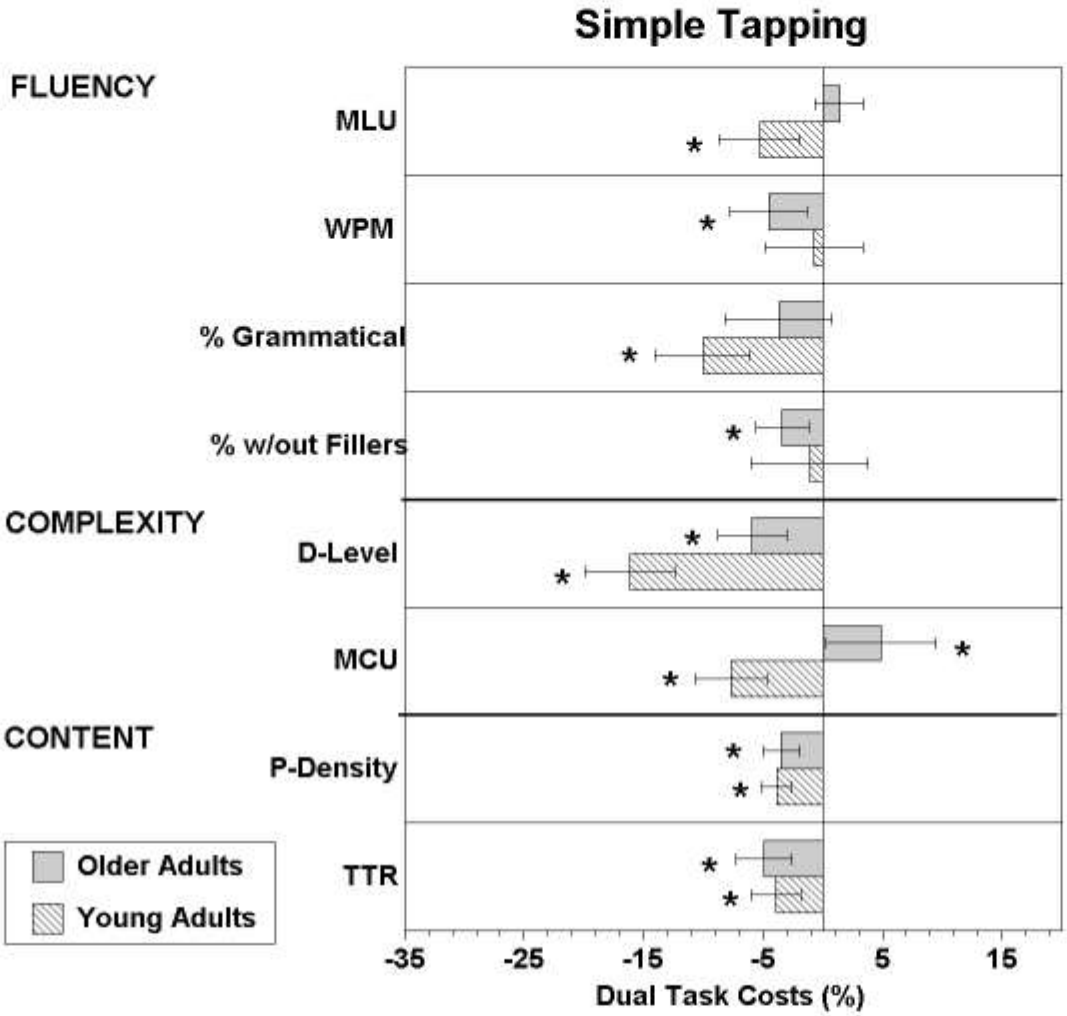
Figure 5. Dual Task Costs (DTCs) (and standard errors) for the Language Sample Measures comparing Ignoring Noise Baseline and Ignoring Noise and Talking. An asterisk (*) marks DTCs significantly greater than zero.

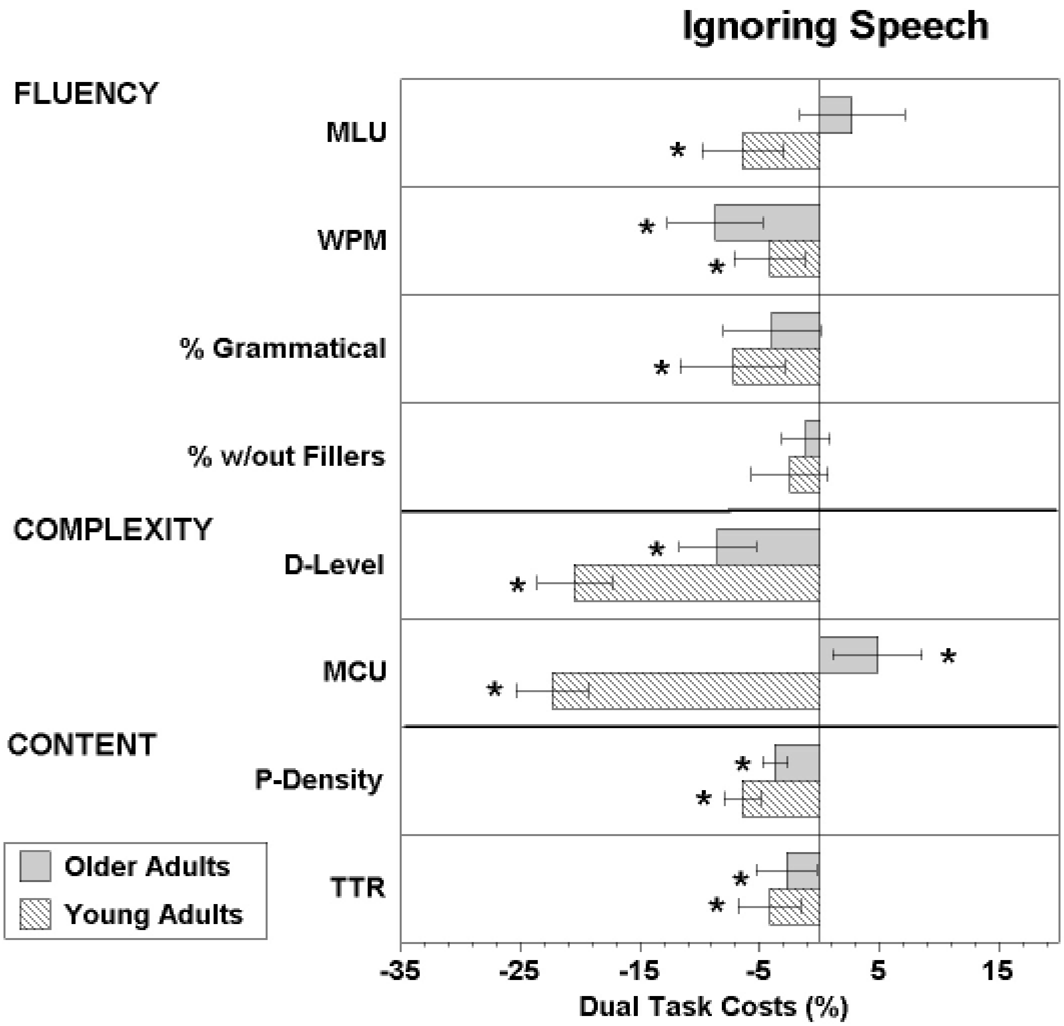
Figure 6. Dual Task Costs (DTCs) (and standard errors) on the Performance Measures for the Walking, Complex Tapping, and Simple Tapping Tasks. An asterisk (*) marks DTCs significantly greater than zero.

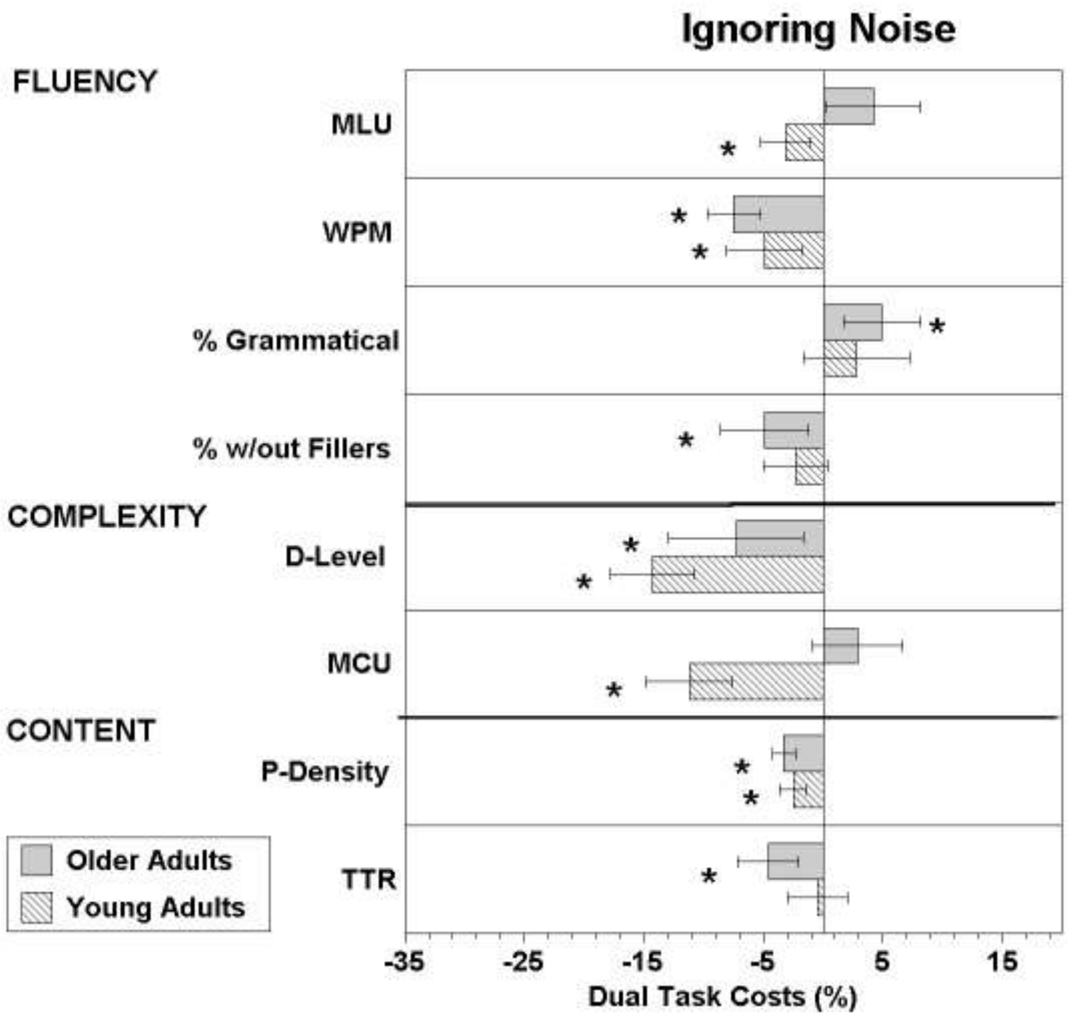

Walking
FLUENCY
MLU
WPM
% Grammatical
% w/out Fillers
COMPLEXITY
D-Level
MCU
CONTENT
P-Density
TTR
*
Older Adults
Young Adults
-35
-25
-15
-5
5
15
Dual Task Costs (%)

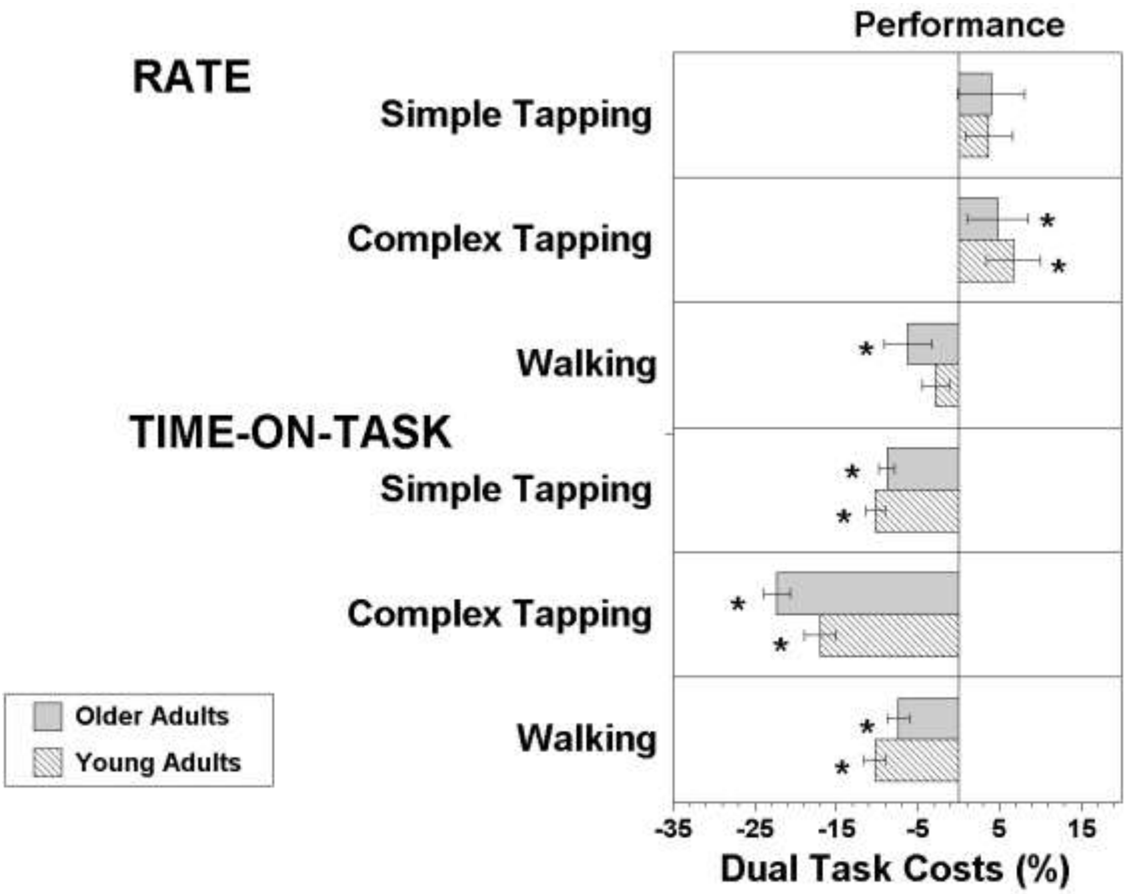

Complex Tapping
FLUENCY
MLU
WPM
% Grammatical
% w/out Fillers
COMPLEXITY
D-Level
MCU
CONTENT
P-Density
TTR
Older Adults
Young Adults
*
-35
-25
-15
-5
5
15
Dual Task Costs (%)

Kemper, S., Herman, R. E., & Lian, C. H. T. (2003). The Costs of Doing Two Things at Once for Young and Older Adults: Talking while Walking, Finger Tapping, and Ignoring Speech or Noise. *Psychology and Aging, 18,* 181-192. Publisher's official version: http://psycnet.apa.org/doi/10.1037/0882-7974.18.2.181. Open Access version: http://kuscholarworks.ku.edu/dspace/.




Ignoring Speech
FLUENCY
MLU
WPM
% Grammatical
% w/out Fillers
COMPLEXITY
D-Level
MCU
CONTENT
P-Density
TTR
Older Adults
Young Adults
*
-35
-25
-15
-5
5
15
Dual Task Costs (%)


Ignoring Noise
FLUENCY
MLU
WPM
% Grammatical
% w/out Fillers
COMPLEXITY
D-Level
MCU
CONTENT
P-Density
TTR
Older Adults
Young Adults
-35
-25
-15
-5
5
15
Dual Task Costs (%)


Performance
RATE
Simple Tapping
Complex Tapping
Walking
TIME-ON-TASK
Simple Tapping
Complex Tapping
Walking
*
Older Adults
Young Adults
-35
-25
-15
-5
5
15
Dual Task Costs (%)