Research Article

WALKING WHILE MEMORIZING: Age-Related Differences in Compensatory Behavior

Karen Z.H. Li, Ulman Lindenberger, Alexandra M. Freund, and Paul B. Baltes

Center for Lifespan Psychology, Max Planck Institute for Human Development, Berlin, Germany

Abstract—*This study investigated predictions of the life-span theory of selection, optimization, and compensation, focusing on different patterns of task priority during dual-task performance in younger and older adults. Cognitive (memorizing) and sensorimotor (walking a narrow track) performance were measured singly, concurrently, and when task difficulty was manipulated. Use of external aids was measured to provide another index of task priority. Before dual-task testing, participants received extensive training with each component task and external aid. Age differences in dual-task costs were greater in memory performance than in walking, suggesting that older adults prioritized walking over memory. Further, when given a choice of compensatory external aids to use, older adults optimized walking, whereas younger adults optimized memory performance. The results have broad implications for systemic theories of cognitive and sensorimotor aging, and the costs and benefits of assistive devices and environmental support for older populations.*

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 some people, such as older individuals, who are having particular trouble with the difficult terrain. Are they likely to withhold conversation altogether as they navigate around obstacles?

Inspired by such observations, we aimed to capture the dynamics of performance within the laboratory using tasks similar to those in this example. We focused on memorizing lists of words and walking on a narrow track. Our primary goal was to examine the possibility that within such a situation, older adults might exhibit different patterns of task emphasis than younger adults. Specifically, we expected that older adults, but not younger adults, would prioritize the sensorimotor over the memory task to avoid a loss of balance. This expectation was driven by the hypothesis that, on average, maintaining balance has a higher immediate "survival value" for older adults than does memorizing, as the potential consequences of falling are far greater for older than for younger adults.

There exists a large corpus of research documenting age-related declines in both cognitive and sensorimotor domains (Craik & Salthouse, 2000). However, fewer studies have focused on the interplay of age-related losses and subsequent responses to loss. It may well be that the estimated performance of older adults is the joint expression of age-related performance declines and the strategies developed to compensate for decline. For example, aging individuals might respond to declining abilities by selecting a smaller subset of goals to pursue (P.B. Baltes, Staudinger, & Lindenberger, 1999). In the hiking example, declining physical ability might result in a tendency to focus on walking safely and refrain from speaking, or to use a walking stick.

One approach that has addressed the dynamic interplay between losses and compensation is the theory of selection, optimization, and compensation (SOC; M.M. Baltes & Carstensen, 1996; P.B. Baltes, 1997; P.B. Baltes & Baltes, 1990; Freund, Li, & Baltes, 1999; Marsiske, Lang, Baltes, & Baltes, 1995). SOC theory posits that across the life span, individuals further their development adaptively by maximizing their potential gains and minimizing losses. They achieve this by the *selection* of goals and their subsequent pursuit, and *optimization* of means to attain the targeted goals. When losses or declines occur, SOC theory posits that individuals search for and utilize other means to *compensate* and maintain their goals. In old age, the interplay of these three processes becomes especially important. In particular, the emphasis of more important goals and the deemphasis of less important ones, termed *loss-based selection*, becomes more prevalent as abilities and resources decline.

Evidence of SOC-related processes already exists in the literature on cognitive aging. Older adults generally show a greater drop in performance levels than younger adults when instructed to carry out a concurrent task (see McDowd & Shaw, 2000; McDowd, Vercruyssen, & Birren, 1991, for reviews). Some researchers have noted that older adults appear less able to emphasize both tasks equally, or may even outperform younger adults on one of the tasks (e.g., Brébion, Smith, & Ehrlich, 1997; Hartley & Little, 1999), suggesting an age-related difference in dual-task priority. However, at least on simple tasks, older adults can become as flexible in their attentional allocation as younger adults, given sufficient training and feedback (Kramer, Larish, & Strayer, 1995). Thus, it appears that although older adults may be able to divide their attention accurately under certain conditions, they may not always do so under more difficult or less structured conditions. For example, in a study with four concurrent tasks, older adults tended to neglect the two most difficult tasks, even when task emphasis and difficulty were varied (Salthouse, Hambrick, Lukas, & Dell, 1996). In SOC terms, such shifts in task priority represent the process of loss-based selection.

A second area of research makes the case for SOC processes even more strongly: Several groups of investigators have proposed that with advancing age, balance and walking require growing amounts of cognitive and attentional processing (Brown, Shumway-Cook, & Woollacott, 1999; Chen et al., 1996; Lindenberger, Marsiske, & Baltes, 2000; Maylor, Allison, & Wing, in press; Maylor & Wing, 1996; Teasdale, Bard, LaRue, & Fleury, 1993). This argument is supported by the general finding that age differences in dual-task costs are greater for older

Karen Li is now at the Centre for Research in Human Development, Department of Psychology, Concordia University, Montreal, Quebec, Canada. Ulman Lindenberger is now at the Developmental Psychology Unit, Saarland University, Saarbrücken, Germany.

Address correspondence to Karen Z.H. Li, Centre for Research in Human Development, Department of Psychology, Concordia University, 7141 Sherbrooke St. West, Montreal, Quebec, Canada H4B 1R6, e-mail: kli@vax2.concordia.ca, or e-mail Ulman Lindenberger at lindenberger@mx.uni-saarland.de, Alexandra M. Freund at freund@mpib-berlin.mpg.de, or Paul B. Baltes at sekbaltes@mpib-berlin.mpg.de.

adults than for younger adults when a cognitive or attentional task is paired with balance or walking. In SOC terms, older adults compensate for declining balance control by applying more attention.

RESEARCH AIMS AND HYPOTHESES

We chose to investigate loss-based selection and compensation using concurrent walking and memorizing, in part because of its similarity to everyday dual-task activities (Tun & Wingfield, 1995). We extended the design of previous studies (e.g., Lindenberger et al., 2000) in several ways. First, we aimed to measure dual-task performance and costs only after extensive training on each task. Second, we obtained more direct measures of compensation by providing memory and walking aids, training participants to use them, and then measuring efficacy of aid use under dual-task conditions of varying difficulty. Third, when manipulating task difficulty in the dual-task conditions, we used individually estimated difficulty levels. In these ways, we attempted to reduce age and individual differences in task experience and sensitivity to task difficulty.

Our first hypothesis was that older adults allocate greater relative amounts of attention when performing a skilled walking task than do younger adults. We predicted that older adults would show greater dual-task costs overall, compared with younger adults. Second, because of the high costs of physical injury for older adults, we expected them to show greater relative costs in the memory domain compared with younger adults, whereas age differences would be smaller in the walking domain. Findings showing this pattern would suggest that older adults "protect" or prioritize their walking performance at the expense of the cognitive task (cf. Friedman, Polson, & Dafoe, 1988).

Our third hypothesis amplified the behavioral consequences of loss-based selection, as measured by use of external compensatory aids. If older adults prioritize the walking task, this should also be expressed in their compensatory behavior. That is, after loss-based selection or task prioritization occurs, compensatory behavior should focus on the prioritized task, not on the deemphasized task. We thus expected that relative to younger adults, older adults would (a) use the memory aid less frequently and (b) benefit more from the walking aid.

METHOD

Participants

Thirty-seven younger adults and 40 older adults were included in the study. Four older adults who failed to reach the memory training criterion and 1 older adult who failed to reach the walking criteria were discontinued from the study. Participants were drawn from the participant pool of the Max Planck Institute Center for Lifespan Psychology, and were paid 20 German Marks (approximately $10 U.S.) per hour. Characteristics of the participants are summarized in Table 1.

Table 1. *Descriptive statistics for the participants*

Statistic	Age group: Younger	Age group: Older
N	37	40
Males/females	13/24	21/19
Age range	20–30	60–75
Mean age (*SD*)	25.1 (2.7)	65.6 (3.9)

Materials

Component tasks

A detailed description of the memory materials and instrumentation of the walking track has been provided by Lindenberger et al. (2000). Briefly, participants were instructed to use the method of loci as a technique to encode and retrieve lists of words. The memory items were drawn from a digitized pool of 1,100 concrete German nouns. Words were presented at a standard rate of 10 s per word, or more quickly when difficulty was manipulated. To create enough lists, we reused words, with two constraints: When a word was reused, the two instances of the word had to be separated by at least three sessions and appeared in different serial positions.

The walking track was a conductive oval circuit (24 m long), capable of measuring the timing and accuracy of each footstep. Accuracy was assessed by measuring the frequency of contact with the boundaries of the track. For the manipulation of task difficulty, up to 16 wooden obstacles (58 × 29 × 27 cm for older adults, 58 × 29 × 34 cm for younger adults) were placed on the track. Younger adults were given obstacles that were 7 cm higher to impose walking decrements similar to those of the older adults.

Compensatory external aids

The *memory aid* delayed the presentation of words to enhance encoding. It consisted of a wireless, hand-held button box, which could be pressed to request an extra 3 s of encoding time (maximum of 16 requests per list of 16 words). The *walking aid* was designed to facilitate balance, and consisted of a handrail (94 cm high) surrounding the track. Participants wore a conductive glove so the duration of handrail contact could be measured.

Design and Procedure

The study took place in three phases (see Table 2) that included 19 to 22 sessions, depending on the participant's rate of training. A subset of the sample participated in a final test session for other purposes that are not described here. For safety reasons, a research assistant followed behind the participants when they were walking. Participants were habituated to the conductive glove and memory aid by wearing them during all walking trials. Each session in the experiment included six trials.

Training phase

Pretraining performance was assessed in each domain before participants had any exposure to the tasks. Participants then practiced the memory task while seated in front of a computer and practiced single-task walking on the track. We trained all participants to use the method of loci in this phase (see Kliegl, Smith, & Baltes, 1990; Lindenberger et al., 2000). The training criterion was to recall at least 12 of 16 words on a list at least once on Trials 1 through 3 and once on Trials 4 through 6 within the same session. It took all participants at least three sessions to meet this criterion.

The criteria for walking training were twofold: Participants (a) had to stay within a specific accuracy level, as indicated by the number of

Table 2. *Outline of the procedure*

Training (3–6 sessions)

- Single-task training to criterion for the memory (using method of loci) and walking tasks under standard difficulty levels
- Maximum of 6 sessions; 6 trials per session

Adaptive phase (10 sessions)

- Single-task training (5 sessions × 6 trials) with task difficulty varied adaptively to produce 25%, 50%, and 75% drops in performance relative to best performance under standard conditions
  —Memory task: presentation rate ranged from 10 to 1.5 s/word
  —Walking task: number of obstacles ranged from 0 to 16
- Training in use of the external aids under the same adaptive procedure (5 sessions × 6 trials)
  —Memory aid: 3 s extra time via button press
  —Walking aid: handrail

Dual-task phase (6 sessions)

- Concurrent walking while memorizing, memory recall while seated before the computer
- Increased difficulty of neither task, the memory or walking task alone, or both tasks
- Increase in difficulty individually determined from the adaptive phase (25% reduction in single-task performance)
- Aid(s) made available to address the domain(s) in which task difficulty increased (memory, walking, or both) in a given session

missteps on the outer bounds of the track, and (b) had to show a relative increase in walking distance on subsequent trials compared with the first two trials. The specific criteria were based on previous results (Lindenberger et al., 2000). In our study, younger adults had to increase their distance by 25% and make no more than 4 missteps within a trial; older participants had to increase their distance by at least 10% and make no more than 25 missteps within a trial. These requirements had to be met on at least two trials within a session.

The training phase ended and the adaptive phase began when a participant had met both the memory and the walking criteria. In both the training and the adaptive phases, feedback (words recalled, walking velocity and accuracy) was shown after every trial.

Adaptive phase

Trials began at standard levels of difficulty (10 s/word, no obstacles) and systematically increased or decreased in difficulty (5% faster presentation rate, one obstacle added) across trials to lower performance by 25%, 50%, and 75% of each person's best single-task performance. Best single-task performance was defined as mean performance in the final training session. Five sessions were conducted without the external aids, and an additional five sessions were conducted with the external aids, but using the same procedure otherwise.

The performance functions obtained in the no-aid sessions were used to estimate the difficulty levels suitable to lower each individual's single-task performance by 25%. These values were then used on designated trials in the dual-task phase.

Dual-task phase

Participants were instructed to perform both tasks together as well as possible. Within each session, an ABCCBA design was employed: A trials involved standard difficulty levels (i.e., neither task was made more difficult). On both B and C trials, the individualized difficulty levels were incorporated, either for the memory task, the walking task, or both tasks. On C trials, participants were allowed to use the relevant external aid (or aids) for the task (tasks) with increased difficulty. The difficulty manipulation (and consequently the aid or aids available) was constant within a session but differed between sessions.

RESULTS

We focus here on dual-task costs and the use and efficacy of compensatory aids in the dual-task phase. Therefore, we only briefly describe results from the training and adaptive phases to demonstrate that participants were adequately trained, and were sufficiently sensitive to the difficulty manipulations.

Training and Adaptive Phases

The descriptive statistics for pretraining and the final training session are shown in Table 3. As in previous research (Lindenberger et al., 2000), the younger and older groups improved across training, but differed in mean recall, walking speed, and walking accuracy by the end of training (all $ps < .001$). During the adaptive phase, both age groups demonstrated adequate sensitivity to the manipulations of difficulty: Performance levels decreased and the frequency with which aids were used increased as the tasks became more difficult.[1]

1. On a trial-by-trial basis for each age group, good recall performance was positively correlated with longer presentation times per word (Rs: .09 to .33, $ps <$ .01), and shorter presentation times were correlated with more frequent use of aids (Rs: $-.26$ to $-.29$, $ps < .001$). Similarly, in the walking domain, increasing the number of obstacles was associated with lowered velocity of walking (Rs: $-.54$ to $-.66$, $ps < .001$). Further, increased walking difficulty was positively associated with time spent in contact with the handrail (Rs: .11 to .18, $ps \leq .001$).

Table 3. *Mean task performance under single- and dual-task conditions*

Phase and condition	Age group: Younger	Older
Memory: Words recalled (maximum = 16)		
Single-task training		
Pretraining	6.2 (3.4)	3.5 (2.4)
End of training	13.5 (1.3)	11.2 (1.8)
Dual-task phase with difficulty increased in . . .		
Neither task	13.8 (1.5)	9.3 (2.7)
Walking task	13.2 (2.2)	8.1 (3.1)
Memory task	10.2 (2.1)	6.9 (2.1)
Both tasks	9.8 (2.0)	6.3 (2.3)
Walking: Velocity (m/s)		
Single-task training		
Pretraining	1.3 (0.2)	1.1 (0.2)
End of training	1.7 (0.2)	1.3 (0.2)
Dual-task phase with difficulty increased in . . .		
Neither task	1.4 (0.2)	1.1 (0.2)
Memory task	1.5 (0.2)	1.1 (0.2)
Walking task	1.1 (0.2)	0.8 (0.2)
Both tasks	1.1 (0.2)	0.9 (0.2)
Walking: Accuracy (maximum = 4)		
Single-task training		
Pretraining	3.4 (0.7)	2.5 (0.8)
End of training	3.2 (0.6)	2.6 (0.6)
Dual-task phase with difficulty increased in . . .		
Neither task	3.2 (0.6)	2.5 (0.8)
Memory task	3.6 (0.5)	2.8 (0.8)
Walking task	3.3 (0.7)	2.4 (0.9)
Both tasks	3.6 (0.4)	2.6 (0.9)

Note. Standard deviations are in parentheses.

Dual-Task Phase

The primary analyses were performed using proportional dual-task costs (DTCs; see Lindenberger et al., 2000).[2] For reference, mean performance levels for all dual-task conditions are shown in Table 3.

Dual-task memory costs

Mean DTCs were computed separately for trials in which task difficulty was increased in (a) neither task (i.e., standard difficulty levels), (b) memory, (c) walking, and (d) both tasks. These analyses excluded trials in which participants were allowed to use the aids. Figure 1 shows DTCs for each condition.

A repeated measures mixed factorial analysis of variance (ANOVA) using age group (two levels) and difficulty (four levels) was carried out using the DTC scores. Overall, DTCs in memory were significantly greater for the older group than the younger group across all conditions, $F(1, 75) = 22.31$, $p < .001$, $MSE = 1{,}082.99$; and difficulty had an overall effect on DTCs for both groups, $F(3, 73) = 43.80$, $p < .001$, $MSE = 253.86$. Post hoc contrasts indicated that all four difficulty conditions were different from each other (ps $\leq .01$). The two-way interaction was not significant ($p = .32$).

We also examined each difficulty condition separately to test whether both age groups produced nonzero memory DTCs in every condition. Younger adults produced nonzero DTCs only when the memory task was made more difficult (i.e., when only the memory task was more difficult or when both tasks were more difficult; ps $<$ .001). In contrast, older adults showed significant DTCs in memory for all four conditions (ps $< .01$). These findings replicate and extend those reported by Lindenberger et al. (2000).

Dual-task walking costs

Our primary analyses of walking costs are based on proportional DTCs in walking velocity (meters/second), or the relative slowdown in walking while memorizing, compared with walking alone. Figure 2 shows the DTCs in walking velocity for each difficulty condition.

2. DTCs represent differences from single-task performance at the end of the training phase. For conditions in which difficulty was increased, we also computed DTCs using as a baseline the mean single-task performance levels from the adaptive phase during the segments in which task difficulty was increased to produce a 25% drop in performance. Analyses of variance using these alternative DTCs produced the same results as the analyses using the standard single-task baselines in both the walking and the memory domains.

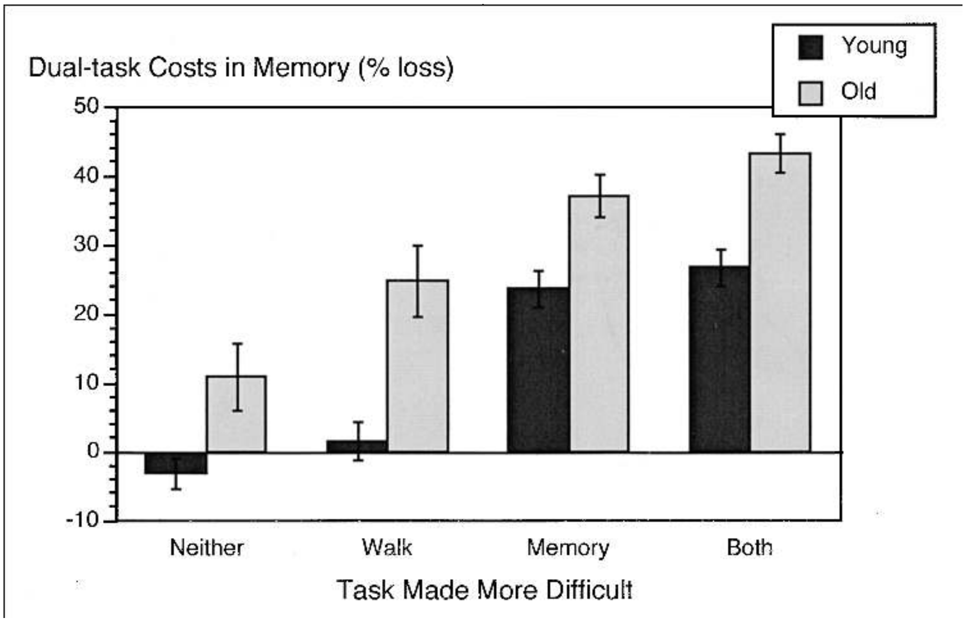

Fig. 1. Dual-task costs in memory recall as a function of age group and difficulty condition. Error bars represent ±1 *SEM*.

As with the memory data, we carried out a repeated measures mixed factorial ANOVA with age group (two levels) and difficulty (four levels) as between- and within-participants factors, respectively. Overall, the younger and older groups showed equivalent DTCs (p = .32). The main effect of difficulty condition was significant, $F(3, 73) = 191.39$, $p < .001$, $MSE = 11{,}129.11$, as was the two-way interaction, $F(3, 73) = 5.56$, $p = .002$, $MSE = 89.68$. Post hoc contrasts indicated that whereas all condition means for younger adults were significantly different from each other ($ps < .001$), for older adults, DTCs in velocity did not differ for the two conditions in which walking was made more difficult ($p = .08$).[3]

Walking accuracy was analyzed by transforming the frequency of missteps into a 4-point scale to correct for skewness, and then computing DTCs as the absolute difference between single- and dual-task accuracy (Lindenberger et al., 2000). A repeated measures ANOVA, similar to the one for walking velocity, was carried out on these measures of the accuracy cost. The results paralleled those for velocity in that younger and older adults showed comparable DTCs in walking accuracy across all four conditions ($p = .27$). For each age group, all condition means were significantly different from each other, $F(3, 73) = 17.82$, $p < .001$, $MSE = 1.92$ (all post hoc contrasts, $ps < .01$).

Together, the DTC results are in line with our first hypothesis in showing greater DTCs for older than for younger adults overall. In addition, the presence of age differences in DTCs for memory and the absence of age differences in DTCs for walking support our second hypothesis that older adults prioritize walking over memorizing. Because of the possibility of trade-offs between walking speed and walking accuracy, we combined these two measures when we analyzed the relationship between DTCs in the walking and memory tasks.

The relationship between domains

To explore the relationship between DTCs across domains, we standardized the DTCs for velocity and accuracy of walking separately, then averaged the standardized scores to form a composite walking measure. The memory DTCs were also standardized across all dual-task conditions. The two groups' mean standardized DTCs for each difficulty condition are plotted in Figure 3. This depiction reveals that age differences within each difficulty condition are more pronounced in the vertical dimension (memory DTCs) than in the horizontal (walking DTCs). This representation provides convergent evidence for our second hypothesis: that older adults behave in a way that reduces walking DTCs at the expense of memory DTCs.

Use and efficacy of compensatory aids

Our third hypothesis was that relative to younger adults, older adults should focus less on the memory aid if they are indeed prioritizing walking, and should also benefit more from the walking aid. To investigate this hypothesis, we calculated the performance gain resulting from use of each aid by comparing trials on which that aid was and was not available. We then correlated each group's performance gains with the group's frequency of aid use to determine how well younger and older adults optimized their use of the aids. Only nonzero frequencies of aid use were included in these correlations (see Table 4).

The first row of Table 4 shows correlations when the memory task was made more difficult. The positive correlation for each group suggests that those younger and older adults who utilized the memory aid most frequently also benefited the most. The second row of correla-

3. The younger adults showed significantly lower DTCs in walking velocity when both tasks were made more difficult than when only the walking task was increased in difficulty. It is possible that, like the older adults, younger adults favored the walking domain and applied more attention to it when both tasks became more difficult. The pattern of DTCs in memory for these two conditions is consistent with this interpretation.

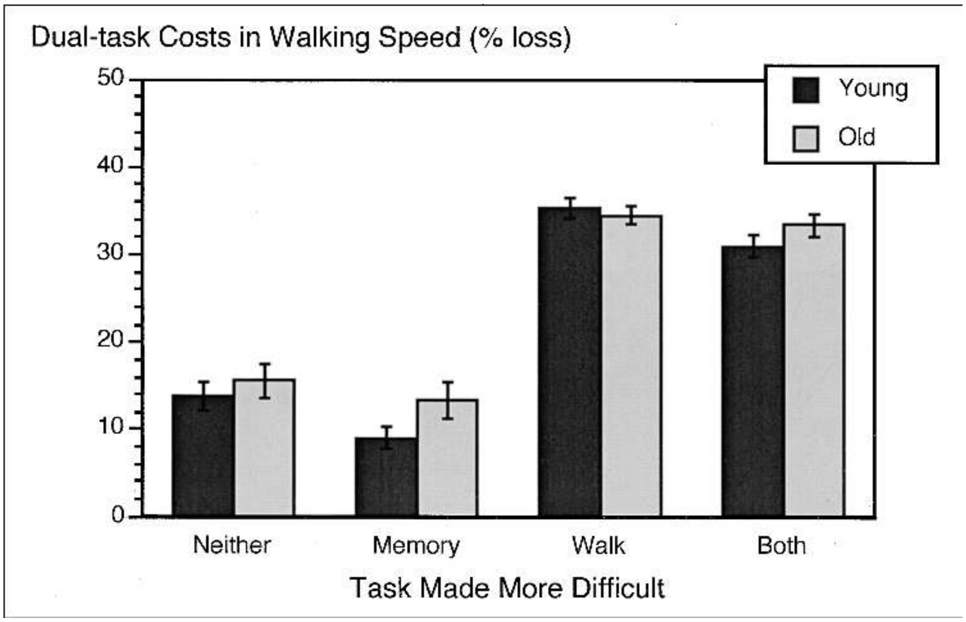

Fig. 2. Dual-task costs in walking velocity as a function of age group and difficulty condition. Error bars represent ±1 *SEM*.

tions, for the condition in which walking was made more difficult, shows a similar pattern. In both cases, efficacy of aid use was similar for the two age groups.

The final section of Table 4 shows correlations for the condition in which both tasks were made more difficult. In this condition, only the younger adults successfully compensated by using the memory aid, whereas only the older adults benefited from using the handrail.[4] The strong asymmetry in these results cannot be due to group differences in the efficacy of aid use, given the first two rows of correlations. Instead, we argue that these results provide an independent index of age-related selection or prioritization of walking over memorizing.

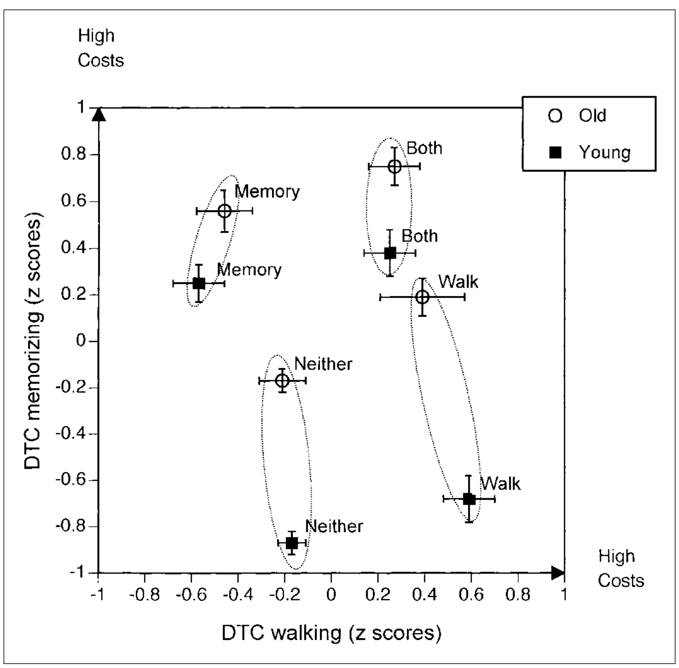

Fig. 3. Standardized dual-task costs (DTCs) for the memory task as a function of standardized DTCs for the walking task, for each age group and difficulty condition. Difficulty conditions are indicated by the labels near the data points; these labels specify the task (or tasks) made more difficult. Walking costs reflect both velocity and accuracy. Error bars represent ±1 *SEM*. Dotted ovals highlight the young-old pair for each experimental condition.

DISCUSSION

In this study, after participants received extensive training on both component tasks and use of the external aids, we assessed dual-task walking and memorizing under varying difficulty conditions. Whereas DTCs in the memory domain were significantly greater for older adults than younger adults, the DTCs for walking were comparable for the two age groups. Further, when both tasks were made more difficult, older adults optimized use of the handrail, whereas younger adults optimized use of the memory aid. Together, the results are in line with the view that in old age, walking and maintaining balance are prioritized at the expense of memory performance.

In SOC terms, our dual-task results indicate that older adults were selecting the task that was more important to them. In this way, our results echo theories of successful aging (e.g., M.M. Baltes & Carstensen, 1996; P.B. Baltes, 1997; Heckhausen & Schulz, 1995).

4. A similar pattern is evident in the mean frequencies of aid use when both tasks were increased in difficulty: Younger adults used the memory aid more frequently per trial (M = 5.4) than older adults did (M = 2.1). The age groups were comparable, however, in the percentage of total walking time in contact with the handrail (2.5% for both groups). We note that frequencies of aid use are less informative than efficacy measures, as judicious usage of an aid may be more effective than arbitrary but frequent usage.

Table 4. *Correlations between performance gains and frequency of aid use under dual-task conditions*

Correlation	Age group: Younger	Older
Difficult memory task		
Memory gain and use of memory aid	.49* (35)	.49* (32)
Difficult walking task		
Gain in walking accuracy and use of handrail	.54* (18)	.43† (21)
Both tasks difficult		
Memory gain and use of memory aid	.52* (34)	.14 (28)
Gain in walking accuracy and use of handrail	.18 (10)	.68* (20)

Note. Cell sizes, given in parentheses, represent the number of participants who produced nonzero mean frequencies of aid use in each condition.
†$p = .05$. *$p < .01$.

Determining whether the task selection we observed was deliberate or driven by the nature of the tasks requires further research. Both scenarios are possible within the SOC framework (e.g., Marsiske et al., 1995).

In addition to the DTC data, the results for efficacy of aid use provide evidence for loss-based selection. Interestingly, older adults also used the memory aid with some frequency, though less frequently on average than did younger adults. It is possible that the complexity of the dual-task and dual-aid situation was too great an attentional load for the older adults to show memory gains in this condition. It is possible that the younger adults also faced a limited-capacity situation in this condition and optimized memorizing as a result. Admittedly, the small number of younger participants who elected to use the handrail at all in this condition may have precluded a significant correlation ($n = 10$). Nevertheless, it is clear that whereas younger adults effectively utilized the memory aid when given a choice of external aids, older adults did not.

This pattern of results has broader implications for the study of assistive devices for older adults: It appears important to assess whether older adults elect to use such devices, and not simply to assess the basic efficacy of aids. Our findings indicate that even if older adults can demonstrate proficient use of an aid under some conditions, they may not benefit from using the same device when an alternative is offered, or when the resultant gains do not outweigh the costs of using the aid (Wright & Kemp, 1992). Indeed, a cost-benefit analysis seems an appropriate method for studying the utility of assistive devices, and for understanding aid use at a motivational level (e.g., Schönpflug, 1998).

The present results join others in demonstrating that in old age, attentional and cognitive processes are recruited in order to maintain a sufficient degree of balance control during locomotion. It is a compelling finding that when walking difficulty was imposed, younger adults showed zero dual-task memory costs whereas older adults showed significant cross-domain memory costs. In addition to supporting the attentional-recruitment view, these results speak to the relative differentiation of the sensorimotor and cognitive domains in young adulthood, and the dedifferentiation of these domains with advancing age (P.B. Baltes & Lindenberger, 1997; Lindenberger et al., 2000).

To summarize, the present study integrates the SOC-related concepts of loss-based selection and compensatory aid use. The findings illustrate how in old age, individuals address declining abilities by prioritizing what should be preserved, and then maintaining prior performance levels by using compensatory means. The findings have implications for theories of multiple-task performance (e.g., Damos, 1991), aging and brain activation during dual-task performance (Reuter-Lorenz, Stanczak, & Miller, 1999), cognitive and sensorimotor aging (e.g., Ferrandez & Teasdale, 1996; Lindenberger & Baltes, 1994), and falls in the elderly (e.g., Lundin-Olsson, Nyberg, & Gustafson, 1997).

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