CHAPTER 4

RESULTS

4.1 Participant Characteristics

Fifteen healthy young adults (HYA), 15 healthy older adults (HOA), and 15 older adults with balance impairment (OABI) were recruited into the study. The characteristics and clinical measurements of the three groups are summarized in Table 4. The number of female participants, the number of participants who had a history of falling while doing one task, the average number of imbalance events, the history of imbalance in the past year, the depression score on the Beck Depression Inventory (BDI), and the rate of spilling water were not significantly different between the three groups. However, healthy young adults had more years of education, walked faster, had better balance on the Berg Balance Scale (BBS), took fewer number of drugs, performed the counting backward by 1 tasks while sitting more quickly and accurately, and performed the counting backward by 3s tasks while sitting more quickly, compared to both older adults groups. In addition, HYA reported fewer number of falls, fewer numbers of participants who had history of falls while doing two tasks at once, greater number of participants who had no history of falls in the past year, and performed the counting backward by 3s tasks while sitting more accurately, compared to OABI. There were no significant differences between older adults groups in any baseline characteristics, except for the BBS and history of falls in the past year. Specifically, OABI had poorer balance on the BBS, greater number of falls in the past year, fewer number of participants who had no

history of fall, and greater number of participants who had history of falls while doing two tasks at once, compared to HOA.

At the end of the data collection process, all participants were asked to rate all of the secondary tasks (the counting backward by 1 and 3s tasks, and the tray carrying task) from the easiest, to the most difficult task. The results showed that most participants perceived that counting backward by 3s was the most difficult task (73.3% for HYA, 86.7% for HOA, and 93.3% for OABI) and counting backward by 1 was the easiest task (66.7% for HYA, 60% for HOA, and 60% for OABI).

4.2 Effect of secondary task on gait parameters during narrow walking

4.2.1 Gait speed

There was a significant walking task × group interaction effect for gait speed ($F_{3.66, 76.75} = 3.28$, $p < 0.05$, $ES = 0.135$; Figure 8, Table 5). HYA walked slower while counting backward by 3s, whereas HOA and OABI walked slower while counting backward both by 1 and by 3s, compared to walking without any secondary tasks. HYA walked with equivalent gait speed under the "walking while counting backward by 1" condition and the "single-task walking" condition. In addition, both HYA and HOA walked slower while performing tray carrying tasks, compared to single-task walking. However, there was no significant difference in gait speed between single-task walking and walking while performing tray carrying tasks for OABI.

Table 4 Characteristics and clinical measurements of participants

Characteristics	Healthy Young Adults	Healthy Older Adults	Older Adults With Balance Impairment
Age (year)[**]	24.27±2.66	72.53±5.49	74.93±5.31
Gender (women), n (%)	10 (66.67%)	10 (66.67%)	13 (86.7%)
Education (years)[**]	16.07±2.05	6.67±3.54	7.00±4.87
Number of drugs taken per day[**]	0.00±0.00	1.47±1.59	1.73±1.22
Number of falls in the past year[*]	0.60±1.68	0.53±0.74	2.27±1.49
History of falls in the past year			
- No history of fall, n (%)[**]	13 (86.7%)	9 (60%)	0 (0%)
- Fell under single-task condition, n (%)	1 (6.7%)	5 (33.3%)	5 (33.3%)
- Fell under dual-task condition, n (%)[**]	1 (6.7%)	1 (6.7%)	10 (66.7%)
Number of imbalance in the past year	2.40±1.99	2.80±2.81	14.07±35.88
History of imbalance in the past year			
- No history of imbalance, n (%)	3 (20%)	3 (20%)	2 (13.3%)
- Lost balance under single-task condition, n (%)	3 (20%)	9 (60%)	9 (60%)
- Lost balance under dual-task condition, n (%)	9 (60%)	3 (20%)	4 (26.7%)
Berg Balance Scale[**]	55.93±0.26	54.33±2.02	49.53±1.25
Gait speed (m/s)[**]	1.23±0.13	1.01±0.16	0.98±0.15
Beck Depression Inventory	7.00±1.65	11.53±7.39	10.40±5.29
Counting backward by 1 task while seated			
- The rate of response (responses/min)[**]	81.87±19.10	52.53±20.37	48.53±19.19
- The rate of accuracy response[**]	0.98±0.04	0.91±0.06	0.92±0.07
Counting backward by 3s task while seated			
- The rate of response (responses/min)[**]	30.31±8.67	21.64±7.67	18.84±5.35
- The rate of accuracy response[*]	0.92±0.06	0.77±0.18	0.71±0.24
Rate of spilling water while seated (responses/min)	0.00±0.00	0.00±0.00	0.00±0.00

NOTE. Values are mean ± standard deviation, [*] $p < 0.05$, [**] $p < 0.001$

4.2.2 The rate of missteps

Neither the interaction ($F_{6, 126} = 1.20$, $p > 0.05$, ES = 0.054) nor main effect of group ($F_{2, 42} = 2.77$, $p > 0.05$, ES = 0.117) were significant for the rate of missteps. However, there was a significant main effect of task ($F_{3, 126} = 14.92$, $p < 0.001$, ES = 0.262), indicating that participants stepped onto or outside each strip of tape more often when they walked while performing the tray carrying task, compared to other tasks.

4.2.3 Cadence

The task $\times$ group interaction ($F_{3.53, 74.21} = 1.92$, $p > 0.05$, ES = 0.084) was not significant for cadence. However, the significant main effect of task was found ($F_{1.77, 74.21}$ = 34.87, $p < 0.001$, ES = 0.454). Follow-up analyses revealed that the cadence under single-task walking condition was higher than all dual-task walking conditions. Moreover, the cadence under walking while performing the tray carrying task was higher than walking while counting backward by 1 ($p < 0.05$) and by 3s ($p < 0.001$). In addition, a significant main effect of group ($F_{2, 42} = 7.75$, $p < 0.01$, ES = 0.27) was also found, indicating that cadence of HYA was higher than those of HOA and OABI**.**

Table 5 Effects of secondary task on gait parameters during narrow walking

Variable	G	Single-task	Narrow walking + Counting backward by 1 task	Narrow walking + Counting backward by 3s task	Narrow walking + Tray carrying task	Interaction effect Task × G	Main effect G	Main effect Task
Gait speed (m/s)	HYA	1.09±0.23	1.01±0.28	0.82±0.29	0.86±0.23	.018	<.001	<.001
	HOA	0.81±0.15	0.59±0.22	0.49±0.22	0.67±0.16			
	OABI	0.71±0.18	0.47±0.21	0.42±0.19	0.62±0.22			
Rate of missteps (steps/min)	HYA	37.16±18.38	34.83±15.12	29.53±9.36	39.51±19.70	.31	.074	<.001
	HOA	21.84±9.21	23.57±14.88	21.84±14.82	35.27±17.32			
	OABI	40.07±22.63	38.82±22.37	32.35±19.96	46.69±27.04			
Cadence (steps/min)	HYA	106.08±14.87	101.16±18.37	84.25±24.17	97.88±16.76	.125	<.01	<.001
	HOA	92.91±12.18	71.18±19.87	59.20±23.33	85.25±12.10			
	OABI	94.10±15.68	74.25±25.86	58.66±28.15	89.63±22.44			

Note. Values are mean ± SD; P values are shown for main effect and interaction effect.

Abbreviations: G = group; HYA = healthy young adults, HOA = healthy older adults, OABI = older adults with balance impairment.
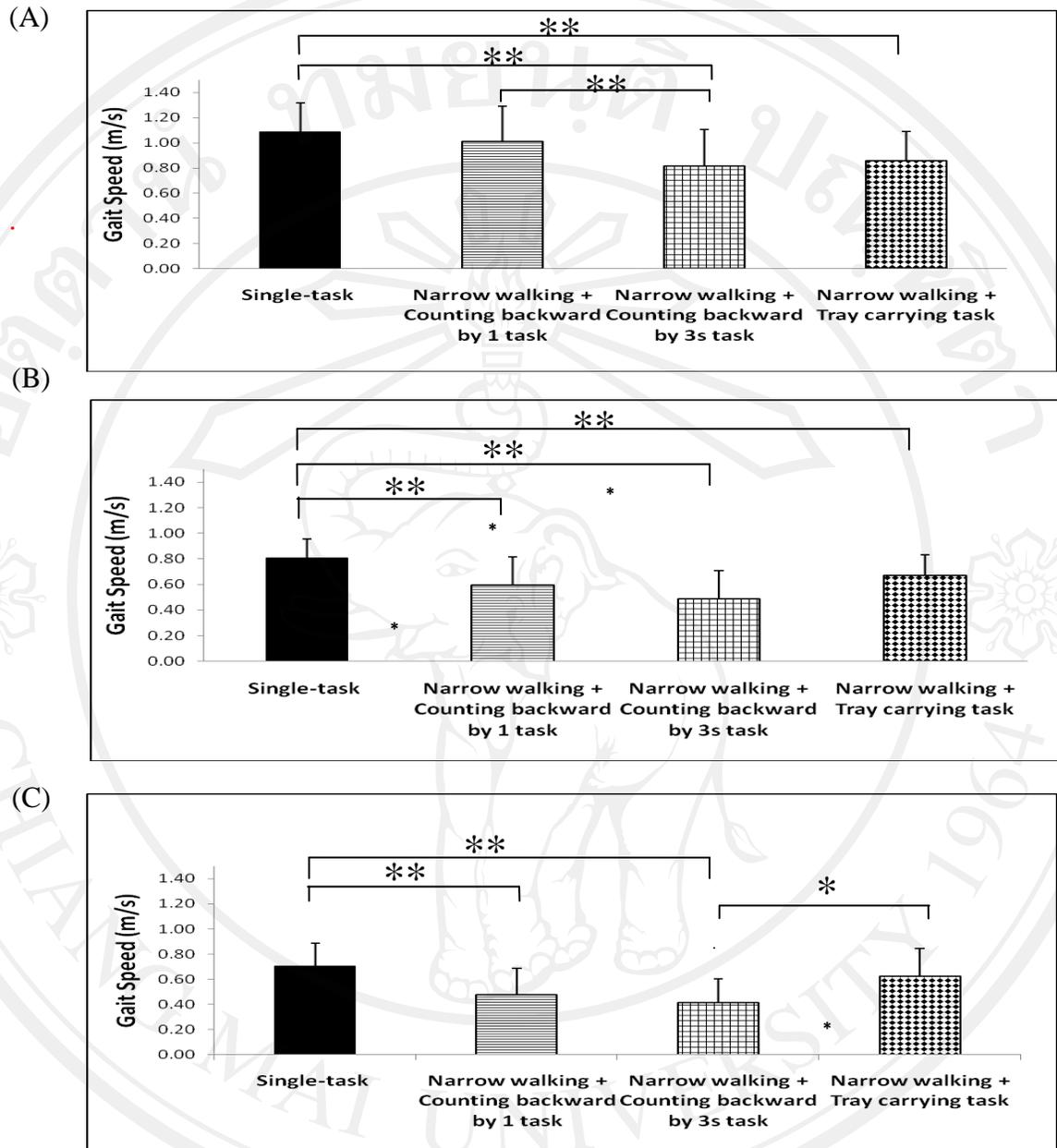
Figure 8 The effects of secondary task (counting backward by 1 task, counting

backward by 3s task, and tray carrying task) on gait speed during narrow walking across

3 groups: (A) healthy young adults; (B) healthy older adults; and (C) older adults with

balance impairment. Expressed as mean ± standard deviation (*p < 0.01, **p < 0.001)

4.3 Effect of task prioritization on gait parameters under the three dual-task walking conditions across groups

4.3.1 Gait speed

The results of the repeated-measures ANOVA showed that there was a significant task $\times$ prioritization $\times$ group interaction effect for gait speed ($F_{6.61, 138.83} = 2.94$, $p < 0.01$, ES $= 0.123$; Figure 9, Table 6). Under the "narrow walking while performing counting backward by 3s" task, only HYA decreased their gait speed in the "focus on narrow walking: FN" condition, compared to the "focus on secondary task: FS" condition. In addition, gait speed was similar in the "focus on both tasks equally: FB" and "FN" conditions. These prioritization effects were not found under other walking tasks.
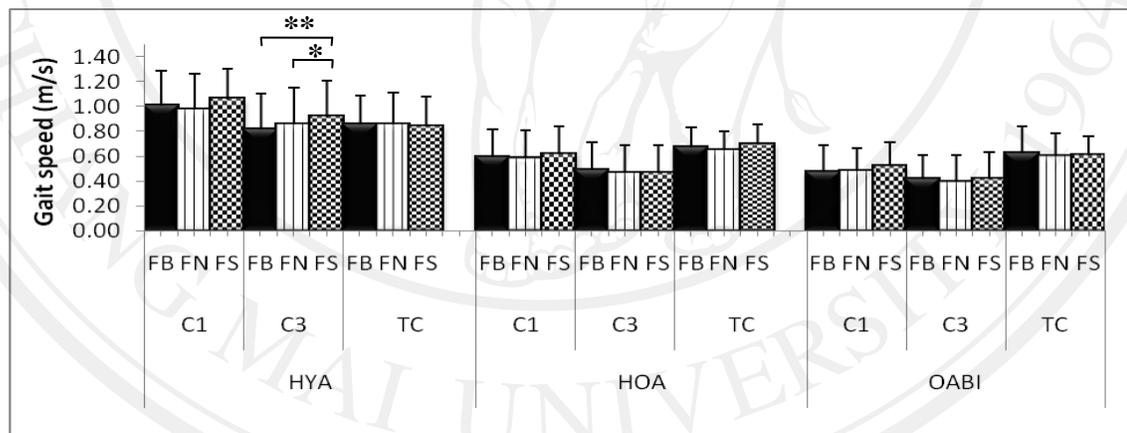

Figure 9 The effects of prioritization conditions (focus on both tasks equally; FB, focus on the narrow walking task; FN, focus on the secondary task; FS) on gait speed during dual-task walking while performing counting backward by 1 (C1), counting backward by 3s (C3), and tray carrying (TC) task across all groups (healthy young adults; HYA, healthy older adults; HOA, older adults with balance impairment; OABI). Expressed as mean ± standard deviation (* $p < 0.01$, ** $p < 0.001$)

4.3.2 Swing time

There was a significant task $\times$ prioritization $\times$ group interaction effects for swing time ($F_{5.08, 106.62}$ = 2.92, p < 0.05, ES = 0.122; Figure 10, Table 6). Under the "walking while performing counting backward by 1" task, only HYA increased their swing time in the "FN", compared to the "FS" condition. These prioritization effects were not found under other walking tasks.
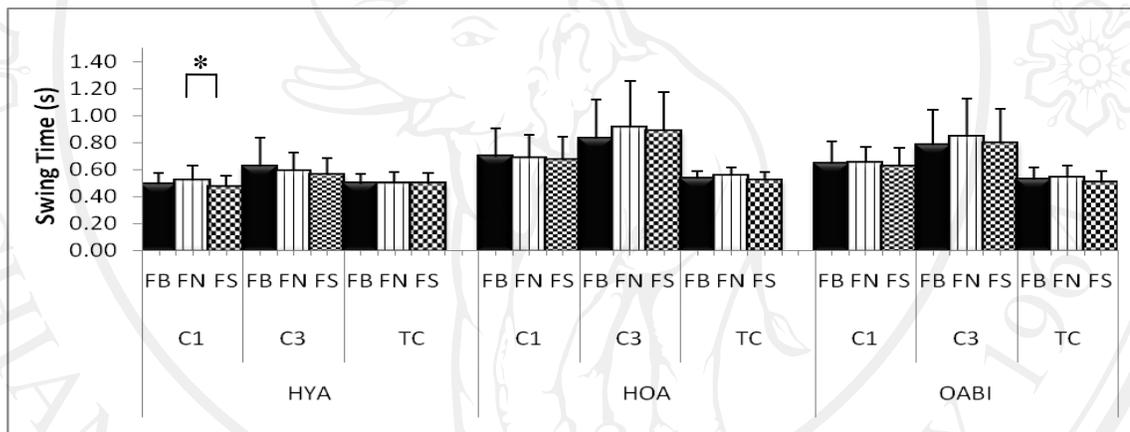

Figure 10 The effects of prioritization conditions (focus on both tasks equally; FB, focus

on the narrow walking task; FN, focus on the secondary task; FS) on swing time during

dual-task walking while performing counting backward by 1 (C1), counting backward by

3s (C3), and tray carrying (TC) task across all groups (healthy young adults; HYA,

healthy older adults; HOA, older adults with balance impairment; OABI). Expressed as

mean ± standard deviation (* p < 0.01)

4.3.3 Stride length

The 3-way interaction effect was not significant for stride length ($F_{6.43, 135.03} = 2.14$, $p > 0.05$, ES = 0.092). There was a significant task $\times$ prioritization interaction effect ($F_{3.22, 135.03} = 5.10$, $p < 0.01$, ES = 0.108). Under the "walking while counting backward by 3s" task, the stride length was longer in the "FS" condition, compared to the "FB" condition ($p < 0.01$). The task $\times$ group interaction effect was also significant ($F_{3.21, 67.51} = 3.39$, $p < 0.05$, ES = 0.139). HYA walked with a shorter stride under "walking while performing tray carrying" task, compared to both "walking while counting backward" tasks ($p < 0.001$ and $p < 0.01$, respectively).

4.3.4 Step width

The 3-way interaction effect was not significant ($F_{6.34, 133.06} = 1.91$, $p > 0.05$, ES = 0.083). There was a significant task $\times$ prioritization interaction effect for step width ($F_{3.17, 133.06} = 4.88$, $p < 0.01$, ES = 0.104). Under the "walking while counting backward by 3s" task, the step width was wider in the "FS" condition, compared to the "FB" condition ($p < 0.01$). In addition, there was a significant task $\times$ group interaction effect ($F_{3.28, 68.89} = 3.47$, $p < 0.05$, ES = 0.142); indicating that only OABI walked with narrower steps under the "walking while counting backward by 1" task, compared to the "walking while counting backward by 3s" task ($p < 0.01$). Moreover, HYA walked with narrower step under the "walking while performing tray carrying" task, compared to both the "walking while counting backward" tasks ($p < 0.001$ and $p < 0.01$, respectively).

4.3.5 The rate of missteps

The 3-way interaction effect was not found ($F_{6.44, 135.16} = 1.58$, $p > 0.05$, ES = 0.07). However, there was a significant task $\times$ prioritization interaction effect for the rate of missteps ($F_{3.22, 135.16} = 3.36$, $p < 0.05$, ES = 0.074). Across all dual-task walking, the rate of missteps was lower in the "FN" condition, compared to the "FB" and "FS" conditions ($p < 0.001$). In addition, a significant task $\times$ group interaction effect was also found ($F_{4, 84} = 2.88$, $p < 0.05$, ES = 0.12). Both HOA and OABI increased their rate of missteps under the "walking while performing tray carrying" task, compared to "walking while counting backward both by 1 and by 3s" tasks. Moreover, OABI also increased their rate of missteps under the "walking while counting backward by 1" task, compared to the "walking while counting backward by 3s"task.

4.4 Effect of task prioritization on the secondary task performance during dual-task walking across groups

4.4.1 The rate of verbal responses

A significant task $\times$ prioritization $\times$ group interaction effect was found for the rate of verbal response ($F_{4, 84} = 2.80$, $p < 0.05$, ES = 0.118; Figure 11, Table 6). Under the "walking while performing counting backward by 1" task, only HYA counted backward faster in the "FS" condition, compared to the "FB" and "FN" conditions. These prioritization effects were not found under the "walking while performing counting backward by 3s" task.
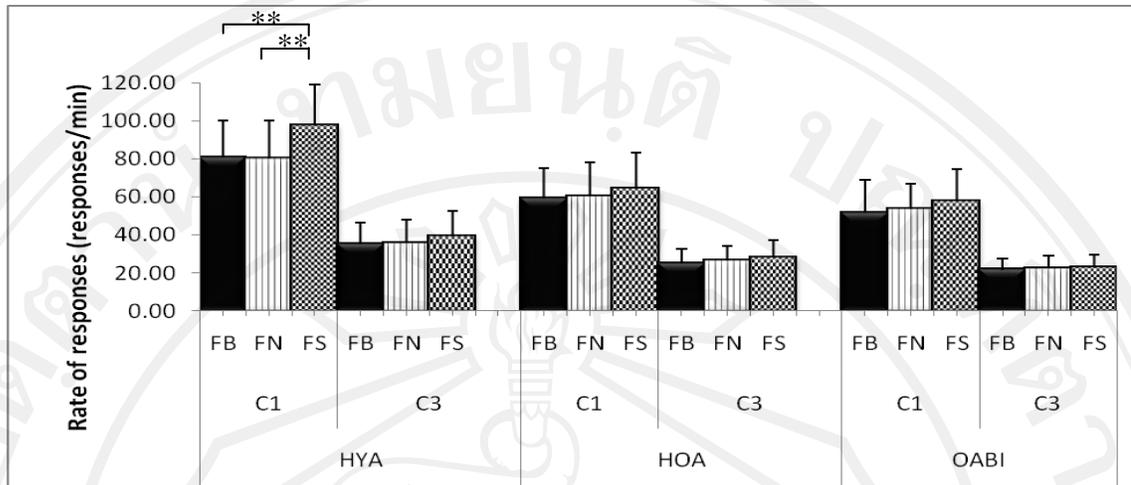
Figure 11 The effects of prioritization conditions (focus on both tasks equally; FB, focus
on the narrow walking task; FN, focus on the secondary task; FS) on rate of verbal
response during dual-task walking while performing counting backward by 1 (C1) and
counting backward by 3s (C3) task across all groups (healthy young adults; HYA, healthy
older adults; HOA, older adults with balance impairment; OABI). Expressed as mean ±
standard deviation (** p < 0.001)

4.4.2 The rate of accuracy responses

The significant 3-way interaction effect was not found ($F_{6, 126} = 1.93$, $p > 0.05$, ES =
0.084). The only significance found for the rate of accuracy response was the task ×
group interaction effect ($F_{2, 42} = 4.88$, $p < 0.05$, ES = 0.19). Both HOA and OABI
responded more accurate under the "walking while counting backward by 1" task,
compared to the "walking while counting backward by 3s" task ($p < 0.001$). The rate of
accuracy was equivalent between tasks for the HYA.

4.4.3 The rate of spilling water

The 2-way interaction effect was not significant. The only significance found for the rate of spilling water was the main effect of prioritization ($F_{2, 84} = 5.96$, $p < 0.01$, ES = 0.228). When participants were instructed to focus on the tray carrying task, the spilling rate was lower than when they were asked to focus on the narrow walking task ($p < 0.01$).

Table 6 Effect of prioritization during dual-task walking while performing secondary tasks across all groups

Variable	G	T	P			Main effect			Interaction effect			
			FB	FN	FS	T	P	G	T×P	P×G	T×G	T×P×G
Gait speed (m/s)	HYA	C1	1.01±0.28	0.97±0.29	1.06±0.24							
		C3	0.82±0.29	0.86±0.29	0.92±0.29	.005	.028	.000	.008			.008
		TC	0.86±0.23	0.86±0.25	0.84±0.24							
	HOA	C1	0.59±0.22	0.58±0.23	0.61±0.23							
		C3	0.49±0.22	0.46±0.23	0.47±0.22	.001	.043	.000	.48	.45	.001	
		TC	0.67±0.16	0.65±0.15	0.69±0.16							
	OABI	C1	0.47±0.21	0.48±0.18	0.52±0.19							
		C3	0.42±0.19	0.39±0.22	0.41±0.22	.002	.49	.000	.24			
		TC	0.62±0.22	0.60±0.18	0.61±0.15							
Swing time (s)	HYA	C1	0.49±0.08	0.52±0.11	0.47±0.08							
		C3	0.62±0.21	0.59±0.14	0.56±0.13	.017	.09	.000	.043			
		TC	0.50±0.07	0.50±0.08	0.50±0.08							
	HOA	C1	0.7±0.21	0.69±0.17	0.67±0.17							
		C3	0.83±0.29	0.91±0.34	0.89±0.29	.000	.15	.000	.08	.43	.019	.016
		TC	0.53±0.06	0.55±0.06	0.52±0.06							
	OABI	C1	0.64±0.17	0.65±0.12	0.62±0.14							
		C3	0.78±0.26	0.85±0.28	0.80±0.25	.000	.09	.000	.32			
		TC	0.53±0.09	0.54±0.09	0.51±0.08							
Rate of verbal response (responses/min)	HYA	C1	80.49±19.42	80.40±19.59	97.55±21.47							
		C3	35.26±11.33	35.50±12.69	39.17±13.37	.000	.000	.000	.000			
	HOA	C1	59.07±15.82	60.28±18.06	64.33±18.75							
		C3	25.18±7.48	26.32±8.04	27.84±9.52	.000	.055	.000	.627	.001	.004	.031
	OABI	C1	51.70±17.16	53.43±13.54	57.48±16.97							
		C3	21.69±5.98	22.59±6.64	22.98±6.38	.000	.009	.000	.14			

Note. Values are mean ± SD; P values are shown for main effect and interaction effect. Abbreviations: G = group; P = prioritization; T = task; HYA = healthy young adults; HOA = healthy older adults; OABI = older adults with balance impairment; FB = focus on both tasks equally; FN = focus on the narrow walking task; FS = focus on the secondary task; C1 = counting backward by 1 task; C3 = counting backward by 3s task; TC = tray carrying task.