Cognitive and Manual Dual-Task Effects on Phases of the Timed Up and Go in Aging

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Background

- Research on dual-task gait is heavily based on straight-ahead walking, yet most daily activities require transition movements, such as turning or sit-to-stand.
- It is unclear how older adults perform dual-task processing during functional mobility that includes not only straight-ahead walking, but also transitions (e.g. turning, sit-to-stand).
- The dual-task Timed Up-and-Go (TUG) may allow examination of attentional processing under changing postural demands inherent to the various phases of the TUG: straight-ahead walking (StrWalk), sit-to-stand (SitStand), turning (Turn), and turn-to-sit (TurnSit).
- Other studies on aging using dual-task TUG assessed general performance such as total duration[1,2], however time to completion does not always provide successful assessment of at-risk older adults. Indeed, Shumway-Cook et al. (2000) found no added utility in predicting falls in dual-task TUG in comparison to regular TUG.
- Assessing individual phases may allow targeted assessment on which specific phases are compromised in aging when subjected to dual-task challenge.

Research Aims and Hypotheses

Aims:

1. To examine age-related decrements in mobility during specific phases of the dual-task TUG.
2. To characterize the dual-task effect on phases of the TUG during simple and complex secondary tasks.

Hypotheses:

1. Older adults will demonstrate greater dual-task decrements than young adults during transition movements than straight-ahead walking.
2. Older adults will demonstrate greater dual-task decrements than young when performing secondary tasks with combined cognitive-manual modalities than simple cognitive or simple motor tasks.

Methods and Materials

Participants:

- Healthy, community-dwelling participants:
  - 12 young adults (26.13 ± 5.36y)
  - 12 older adults (74.18 ± 5.21y)

Procedures

- Instrument: 6 wireless inertial sensors (Opal system, APDM®, Portland, OR) on both wrists and ankles, and upper and lower trunk, which recorded kinematic data during TUG performance.
- Protocol: Performed the 7-meter instrumented TUG (iTUG) under the following dual-task conditions, counterbalanced by order, 3 trials each:
  1. Serial-3 **subtractions (COG)**
  2. Carrying full cup of **water (MAN)** — Simple
  3. **Combined subtractions with carrying water (CM)**
  4. **Dialing cellphone (PHONE)** — Complex (3–4)
- Phases of the iTUG and associated outcome measure:
  1. ***StrWalk***: duration (s) of straight-ahead walking; peak trunk velocity (deg/s) in the sagittal plane
  2. ***SitStand***: duration (s) to complete sit-to-stand transitions; peak angular velocity (deg/s) of trunk in sagittal plane
  3. ***Turn***: duration (s) to complete 360º turn; peak angular velocity (deg/s) of trunk
  4. ***TurnSit***: duration (s) to complete turning to sit; peak angular velocity (deg/s) of trunk
- Dual-task effect (DTE)*

$\%DTE_{duration} = -[(\text{Dual-task} - \text{Single-task}) / (\text{Single-task})] * 100$

$\%DTE_{peak\_vel} = [(\text{Dual-task} - \text{Single-task}) / (\text{Single-task})] * 100$

*Negative DTE value represents performance cost
Positive DTE value represents performance benefit

Statistical analyses

- To determine effect of age (young, old) and phase (StrWalk, SitStand, Turn, TurnSit) on DTE on the TUG, mixed design univariate ANOVA was used. Design included random-nested factor of subject, and fixed factors of age and phase. Analyses performed separately for each condition and outcome measure.
- To assess counting performance during COG and CM, similar mixed design univariate ANOVA was used for subtraction rate, and subtraction accuracy.

Age-related dual-task costs increased for the StrWalk and Turn durations when the cognitive task was combined with another task (complex)

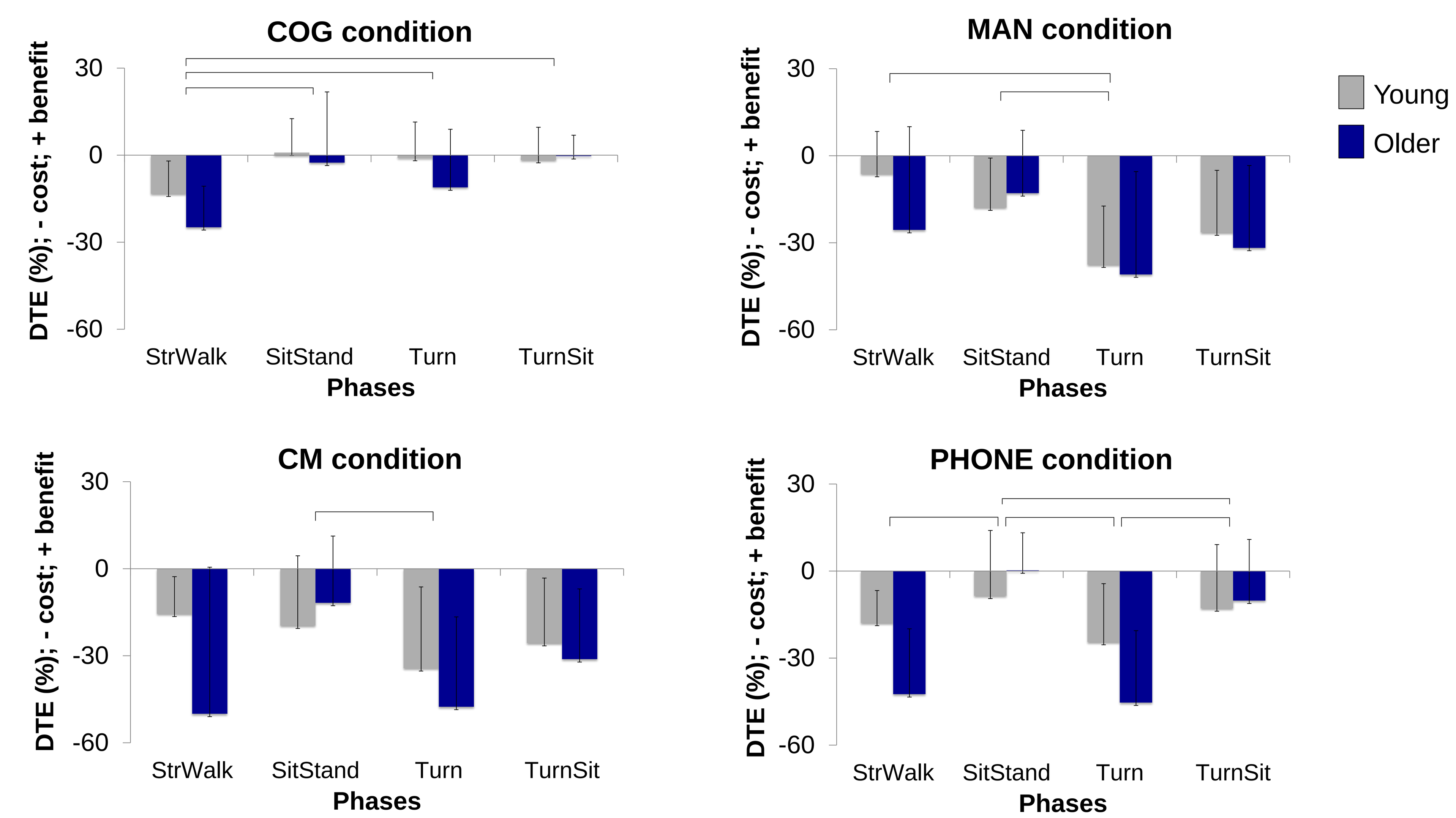

Figure 1. Dual-task effect (%DTE) on duration of each phase of the TUG. Individual plots represent type of secondary task concurrently performed during the TUG: subtractions (COG), carrying water (MAN), subtraction + carry water (CM), and dialing a cellphone (PHONE). The DTE varied by phase across all conditions (main effect of Phase for COG, MAN, PHONE, $p < .001$, and CM, $p = .004$). Age-related decrements were more evident during tasks that required cognitive modality in addition to another task (CM,PHONE) (significant interaction of Age by Phase on CM and PHONE, $p = .021$ and $p = .003$, respectively); while no interaction of Age by Phase during COG and MAN.

Age-related dual-task costs to peak trunk velocity appeared during StrWalk when performing one complex task (CM) but not the other (PHONE).

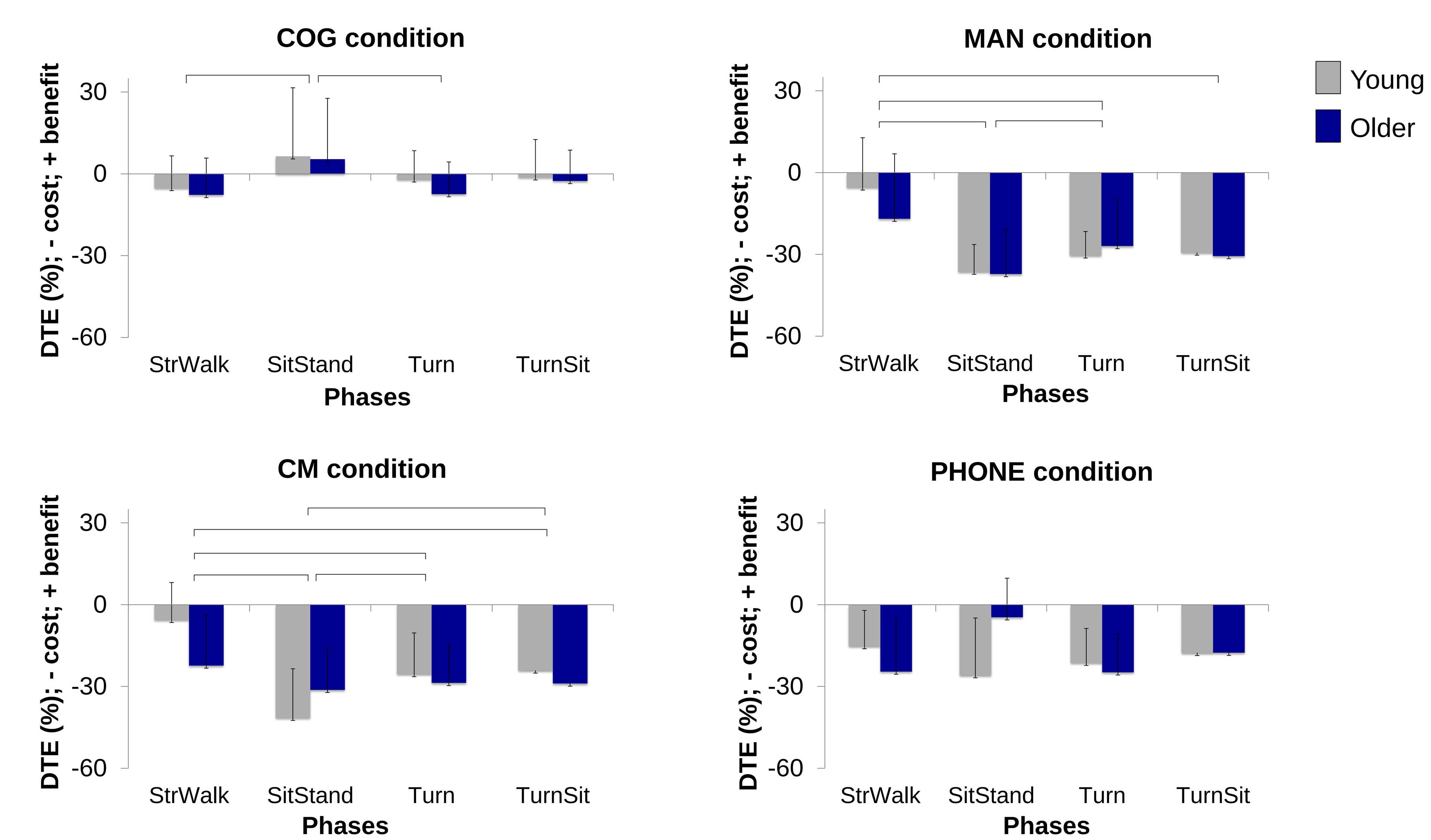

Figure 2. Dual-task effect (%DTE) on peak trunk velocity representative of each phase of the TUG. The DTE on peak velocity varied by phase across all conditions (main effect of Phase for COG, $p = .009$; MAN, CM, and Phone, $p < .001$). Age-related decrements were more emphasized during StrWalk only during CM (significant interaction of Age by Phase, $p = .002$), but not with other combined cognitive-motor tasks such as PHONE.

Cognitive task performance was similar for older and young adults. Subtracting was better during StrWalk and most compromised during SitStand.

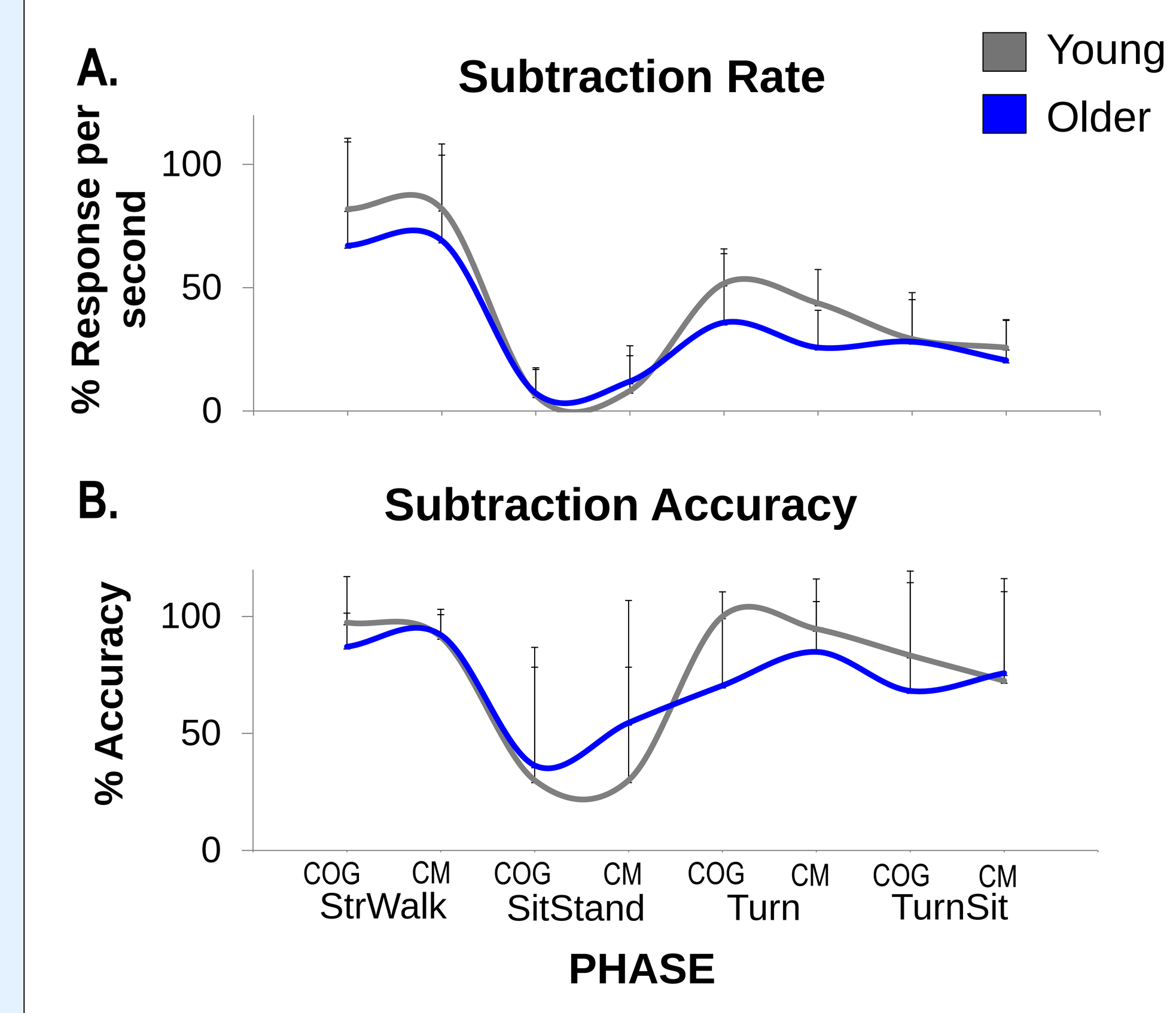

Figure 3. Cognitive performance as percent subtraction rate (response per second ; A) and accuracy (B) for COG and CM conditions. Separate univariate ANOVA performed per condition. Subtraction performance varied depending on phase of TUG (main effect of Phase for COG and CM, $p < .001$), for both young and older adults (no main effect of Age, $p > .05$). Subtraction was improved during StrWalk, likely due to more time available in this phase than others.

Conclusions

1. Dual-task processing differs by phases of the TUG for both age groups, regardless of secondary task complexity
2. Age-related dual-task costs to walking increase with complex secondary tasks:
   CM: subtractions + carry water
   PHONE: working memory + dialing phone
3. The complex cognitive-manual tasks differ in their impact on age-related dual-task costs to straight-ahead walking, possibly due to differences in demands specific to the manual task. Carrying water requires damping of arm movements in straight walking[3] and possibly greater vigilance to avoid spills.

References

1. Shumway-Cook A, Brauer SG, Woollacott MH. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go test. Phys Ther 2000;80:896-903.
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