Assessing Automatization Using a Dual-Task Paradigm: Application to Speech Motor Automaticity in Parkinson’s Disease

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INTRODUCTION

Accuracy is the ability to complete a task with little-to-no attentional resources, allowing the behavior to become an automatic response, pattern, or habit. Basic aspects of speech production must rely, to some extent on automatic processes as a variety of communicative environments encountered in daily life require online monitoring of cognitive-linguistic processes and prioritization multiple attentional demands. Examining performance of a motor skill while concurrently performing a second task, (i.e., the dual-task paradigm) has been used to examine automatization (Logan, 1979). Few papers have examined disorder speech under dual-task conditions (Bunton & Keight, 2008), and even fewer have examined speech motor learning under such paradigms (Smits-Engelsman & de Ni, 2009; Whitfield & Goberman, 2016). The current investigation examines the durability of speech motor learning using a dual-task paradigm.

STUDY 1: Performance of a Novel Speech Task with a Concurrent Task

Twenty-five younger adult speakers were assigned to two groups, an extended practice group (YA) that included 15 participants (9 females, 6 males) and a limited practice (YA-LP) group that included 10 participants (7 females, 3 males).

All participants performed a sequential nonword repetition task during which they repeated a novel speech motor sequence, 6 syllables in length (“bob gite paw paw kay keys”). For the nonword task, participants were asked to read a sequence of nonwords that were presented on the computer screen. Participants were instructed to say the nonword sequence aloud as quickly and accurately as possible. The sequences consisted of 6 syllables in length, and each syllable was embellished with a consonant and vowel. The nonword sequences were presented in a random order, and the sequences were presented continuously. Participants were asked to perform the nonword sequence and to track the target track in red. The dual-task condition was a combination of the nonword sequence and a dual-task condition. The dual-task condition consisted of a speech motor task and a nonword task.

Nonword sequence durations were measured using a spectrographic and wave form display. The average sequence duration for each trial block was calculated from sequences that were produced correctly. Sequences produced in error were excluded from the analysis. For Study 1, sequence durations of the first nine trials were compared between the two groups younger adult groups using a linear mixed model analysis.

STUDY 2: Effect of Practice on Dual-Task Costs

The data from the same twenty-five younger adult speakers were examined for Study 2. Participants in the YA group performed the same experiment described in Study 1, with the addition of a second task. The YA-LP group performed the same experiment described in Study 1, with the addition of a second task. Participants were trained to perform the dual-task task concurrently with the digital visuomotor task.

Dual-task costs were calculated as the percent change in each measure between the single- and dual-task conditions. Dual-task costs for all four groups were compared.

STUDY 3: Application to Normal Aging and Parkinson disease

A group of 15 older adults and 15 participants with and without Parkinson disease (PD) performed the two dual-task paradigms. As in the YA group, each participant completed 12 single-task blocks of the sequential nonword repetition task on day one that was repeated under single- and dual-task conditions on day two. As with the previous study, all participants were trained on the visuomotor task prior to completing the dual-task condition.

Dual-task costs were calculated as the percent change in each measure between the single- and dual-task blocks (DT Cost = (DT - ST)/ST). Dual-task costs for all four groups were compared.

REFERENCES


CONCLUSIONS

Summary of the Findings:

- Study 1: Concurrent performance of the visuomotor task and nonword nonword repetition task resulted in slower performance of the nonword sequence
- Study 2: Participants who completed more practice trials of the nonword sequence experienced less dual-task interference on both the speech and non-speech task (i.e., bidirectional interference) than participants who completed less practice.
- Study 3: Following one day of practice, participants with PD exhibited a greater degree of bidirectional dual-task interference than all control groups, including younger adults who received limited practice.

Conclusions:
- Participants with PD may exhibit an overall deficit in speech motor automaticity that might impair performance of habitual speech acts as well as the developing a greater degree of automaticity during the later stages of learning and clinical change.
- While the current results suggest that the dual-task paradigm may provide a window into speech motor automaticity in clinical populations, automaticity is a complex construct and other paradigms to examine speech motor automaticity should be explored.

Figure 1. Average sequence duration for the single-task (DT) and dual-task (DT) conditions performed by the younger adults in the extended practice group (YA) and the limited practice group (YA-LP) for the nine trial blocks of the sequential nonword repetition task

Figure 2. Means (SE) for the extended practice younger adult group (YA) and the limited practice younger adult group (YA-LP) for sequence duration (top) for the nonword repetition task and percent time-on-target (middle) and average deviation from target (bottom) for the visuomotor task for the single-task and dual-task conditions.

Figure 3. Mean (SE) accuracy (left) and sequence duration (right) on Day 1 for the younger adult group (YA, black); older adult group (OA, red) and the Parkinson disease group (PD, black).

Figure 4. Example mouse trajectory (a) and deviation from target (b) in the single-task condition in the Parkinson disease (PD), older adult (OA), younger adult (YA), and limited practice (YA-LP) groups.

Table 1. Linear mixed model effects for sequence duration. The younger adult, extended practice group in the single-task condition was mapped to the intercept.

Table 2. Linear mixed model effects for percent time-on-target for the visuomotor task. The younger adult, extended practice group in the single-task condition was mapped to the intercept.

Table 3. Linear mixed model effects for average deviation from target for the visuomotor task. The younger adult, extended practice group in the single-task condition was mapped to the intercept.

Figure 5. Dual-task costs for sequence duration (Dur) and accuracy of the speech task and time-on-target (TOT) and average deviation from the target (DEV) of the visuomotor task (Non-speech) for the Parkinson disease (PD), older adult (OA), younger adult (YA), and limited practice (YA-LP) groups.