## Introduction

This study examined the effects of external versus internal foci of attention on motor control and learning. It has been found that the focus of attention during a motor task is a critical variable in understanding performance enhancement[1]. An internal focus (on bodily movements, e.g., an arm swing in golf) is less effective than an external focus of attention (on the object/outcome, e.g. a golf club) in a variety of limb control tasks[2,3]. No studies have explored the role of attentional focus in oral-motor control and learning. Study of attentional focus during oral-facial motor learning is a logical step to understanding its role during speech treatment of people with apraxia of speech (AOS).

## The constrained-action hypothesis and speech production

The performance and learning of motor skills are enhanced when performers employ an external focus relative to an internal focus of attention[3-5]. Wulf et al. (2001) explained this benefit of an external focus of attention by postulating the "constrained action hypothesis". According to this view, individuals who utilize an internal focus constrain or "freeze" their motor system by consciously attempting to control it. This also seems to occur when individuals are not given attentional focus instructions[2]. In contrast, an external focus promotes the use of more automatic control processes, thereby enhancing performance and learning[3,5].

The potential benefits of an external focus have not yet been examined for the speech production mechanism, let alone been considered for treatment of persons with motor speech disorders. The current study represents our first step in applying these principles to the oral-motor system and eventually to the treatment of speech. Our hypothesis is that participants who are trained with an external focus during oral-motor tasks will have enhanced task performance (increased accuracy, less variation, greater retention), compared to those participants trained with an internal focus of attention. As has been our long-term strategy, comparison between oral-facial movements and limb movements were included in the design of this study. Importantly, attentional focus during treatment of speech disorders may be a critical, yet never studied variable in AOS. This study examined performance of young typical subjects to determine if we could replicate findings from the limb literature using the oral-motor system.

## Methods

*Participants*

Forty-six (44 female, 2 male) undergraduate student participants with no known health conditions or cognitive impairments were randomly selected from the population and randomly assigned to one of two conditions: an internal or external focus of attention.

*Tasks and Procedures*

An isometric task was administered in which participants practiced generating rapid pressure bursts (with the hand and tongue) to a target level of 20% of their maximal strength. Tongue and hand strength were assessed utilizing the Iowa Oral Performance Instrument (IOPI) [6]. The IOPI uses an air-filled rubber bulb attached to a pressure transducer. The amount of pressure generated by squeezing the bulb is displayed on a digital readout calibrated in kiloPascals (kPa).

To obtain maximal strengths, a standard clinical protocol was used in which each participant squeezed the rubber bulb against the roof of their mouth or in their palm as hard as possible. The greatest pressure obtained from three trials for each structure was noted as participants' maximal strengths and used to calculate 20% target levels.

Each participant practiced both manual and oral-motor performance in a single session; order of structure (hand-tongue, tongue-hand) was counterbalanced across participants. Participants were instructed to apply only enough pressure in one rapid exertion to see their pressure burst appear in a 20% target window slot. Visual feedback was present for each trial on a computer screen. A digitally recorded metronome generated a chime every 5 seconds which signaled participants to exert one pressure burst. Internal focus group participants were instructed to focus on the pressure they exerted with their hand/tongue, whereas external focus group participants were instructed to focus on the pressure they exerted on the bulb. In all other respects, instructions were the same for both groups. Reminders of participants' assigned focus of attention were provided once a minute by the examiner. The exact same instructions were read by the same examiner to all subjects (please see Table 1 below).

Practice trials for both hand and tongue were run in 40 bursts (4 blocks of 10 bursts) per structure (hand/tongue) per participant. Retention and transfer tests (without focus instructions) were administered after 5 days. For the retention test, the practice target level (20%) was used, while for the transfer test a novel target level of 30% of participants' maximal strengths was used to examine the generalizability of the effects.

*Analysis and Predictions*

Focus of attention (internal, external) was the between-subjects factor while Structure (hand, tongue) was the within-subject factor. The main dependent variable for practice and retention was absolute error; for retention, an additional dependent variable was the first trial number on which three consecutive target level bursts were produced. Results were analyzed using 2 (Focus) x 2 (Structure) x 4 (Block) repeated measures ANOVAs.

Based on the constrained-action hypothesis, we predicted enhanced task performance (smaller error values) in practice, retention, and transfer trials for the external focus group compared to the internal focus group, consistent with findings in the limb performance literature.

*Results*

Findings indicated smaller absolute errors for the external focus group relative to the internal focus group during hand and tongue practice trials (please see Figure 1). Regarding retention and transfer trials (please see Figure 2), the differences between the two focus groups was smaller, especially for the hand. However, for the tongue, the external focus group still showed smaller absolute errors than the internal focus group.

## Discussion

The present study is the first to extend the constrained action hypothesis to the oral-motor system. The constrained action hypothesis predicts that an external focus of attention leads to improved (more accurate) motor control and learning, and has been supported using various limb-motor control tasks[2]. The results from the above experiment confirm this prediction for the oral-motor system using a nonspeech oral-motor control task. Specifically, the external focus group demonstrated smaller absolute error values than the internal group, both during practice as

well as during retention and transfer trials, suggesting that effects of attentional focus also affect oral-motor learning. In fact, retention and transfer data suggest that the effect of attentional focus may even be greater for oral-motor control than for limb-motor control.

While this study employed a nonspeech task, the findings suggest that attentional focus may also be an important variable to consider in treatment for speech disorders. If a similar advantageous external focus is found during a speech task, it may change speech treatment for persons with speech and/or voice disorders since such therapy traditionally uses an internal attentional focus. For example, many treatment methods for AOS (e.g. "Sound Production Treatment"[7]) incorporate phonetic placement instruction where typically an internal attentional focus is utilized (e.g., a focus on tongue placement). An external focus of attention (e.g., a focus on the acoustic or perceptual goal) may prove to be more effective for target acquisition and response generalization in AOS. Future studies will explore how an external focus of attention may be further implemented for speech treatment, as well as how attentional disorders affect motor learning.

**References**

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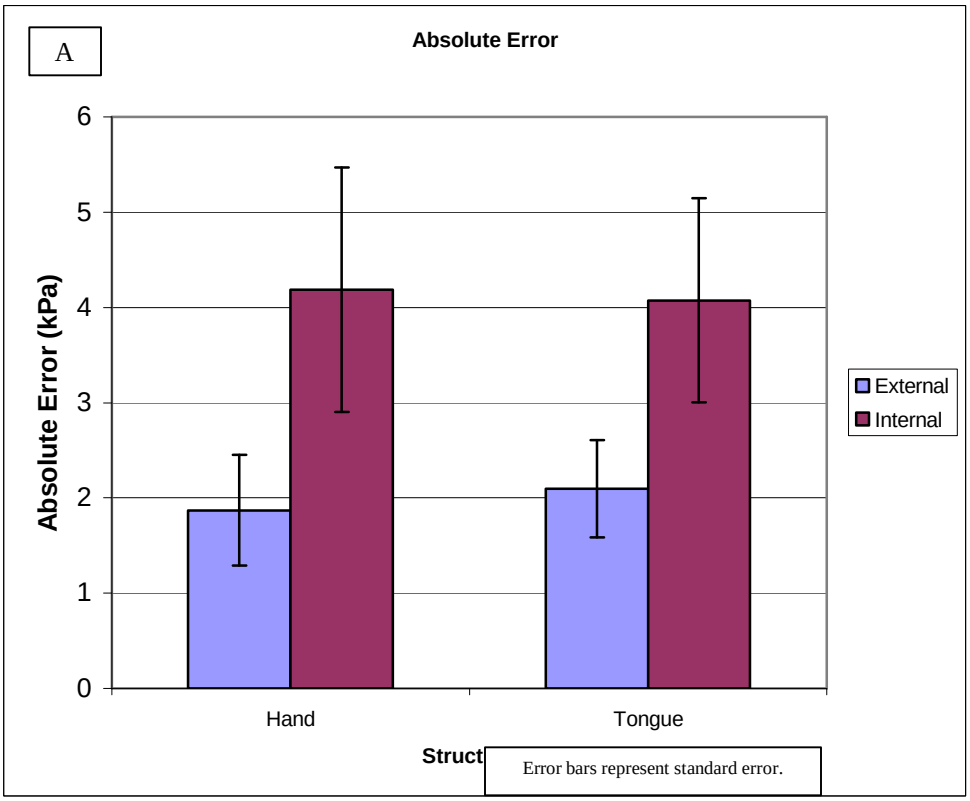
Figure 1. Absolute error for practice collapsed (A) across blocks and (B) by block.



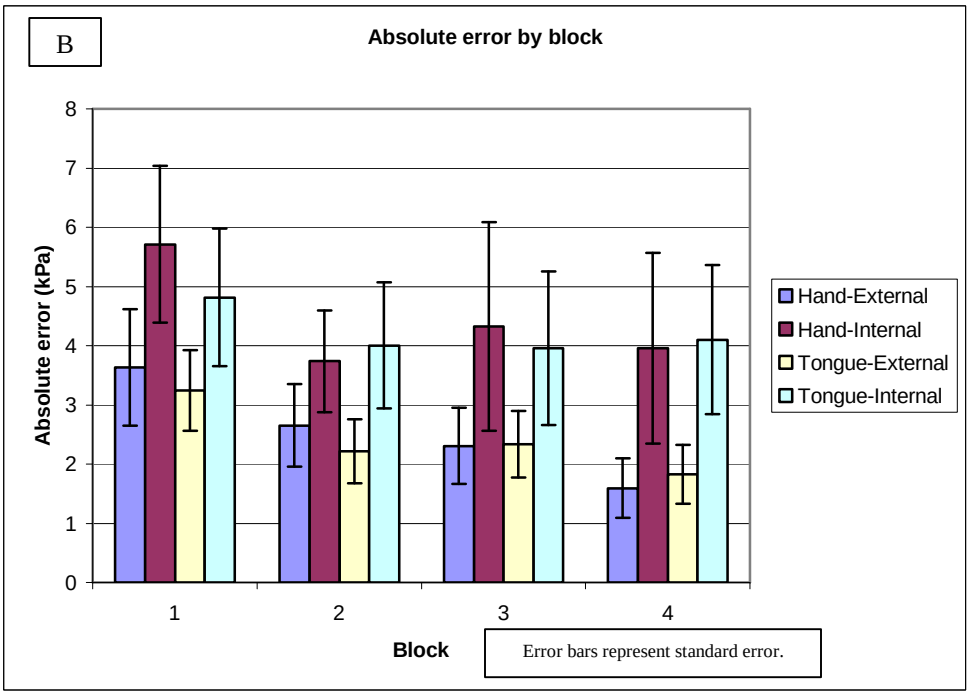



Figure 2. Absolute error for (A) retention and (B) transfer.

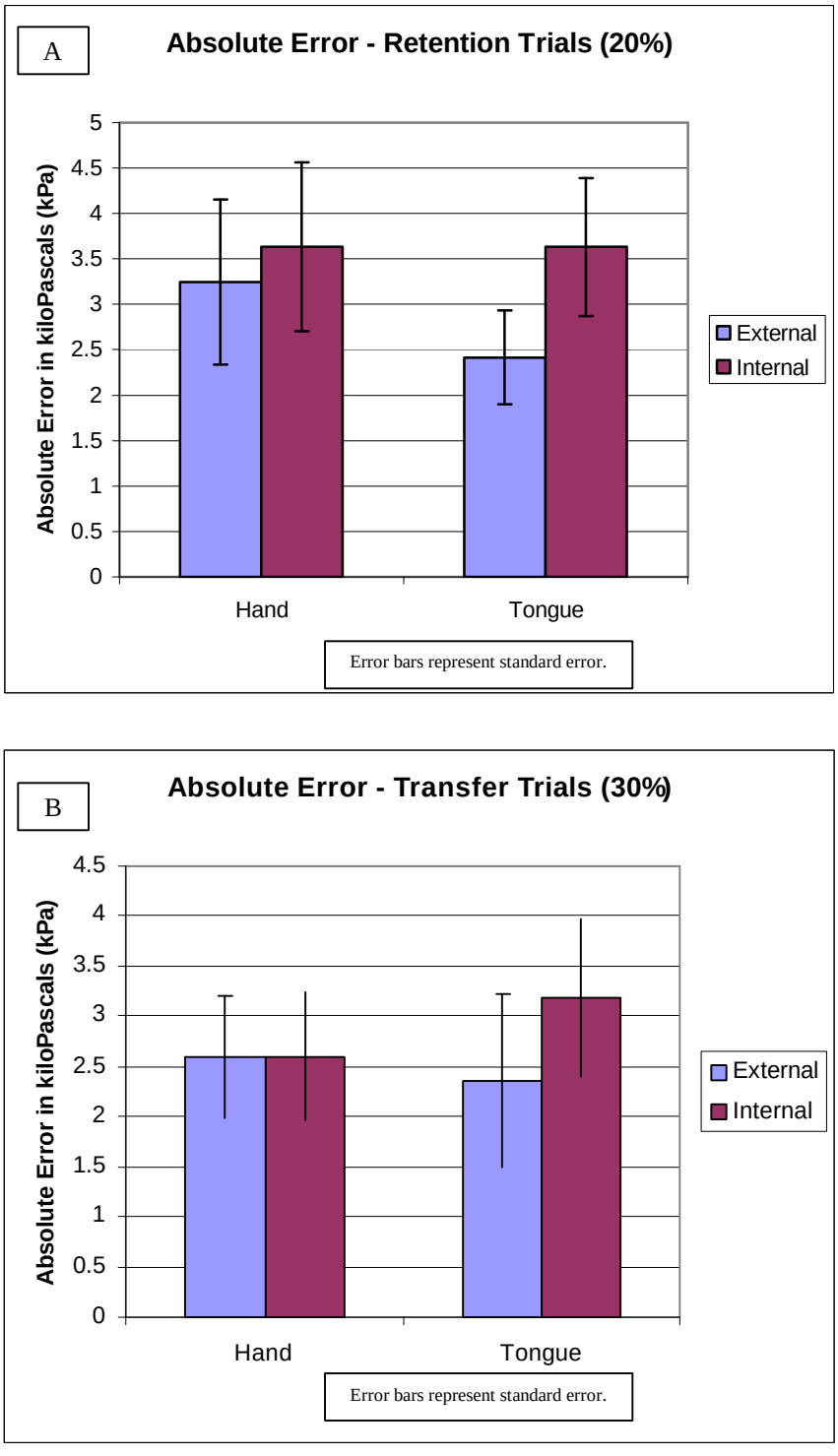


Table 1. Instructions for each focus group during practice trials.

| FOCUS | INSTRUCTIONS |
|---|---|
| Internal | "Keep focusing on your tongue/hand, focus on your tongue/hand. Push with your tongue/hand." |
| External | "Keep focusing on the bulb, focus on the bulb. Push on the bulb." |