

# How typists talk to their fingers: Evidence for word-level verbal control of skilled action sequencing

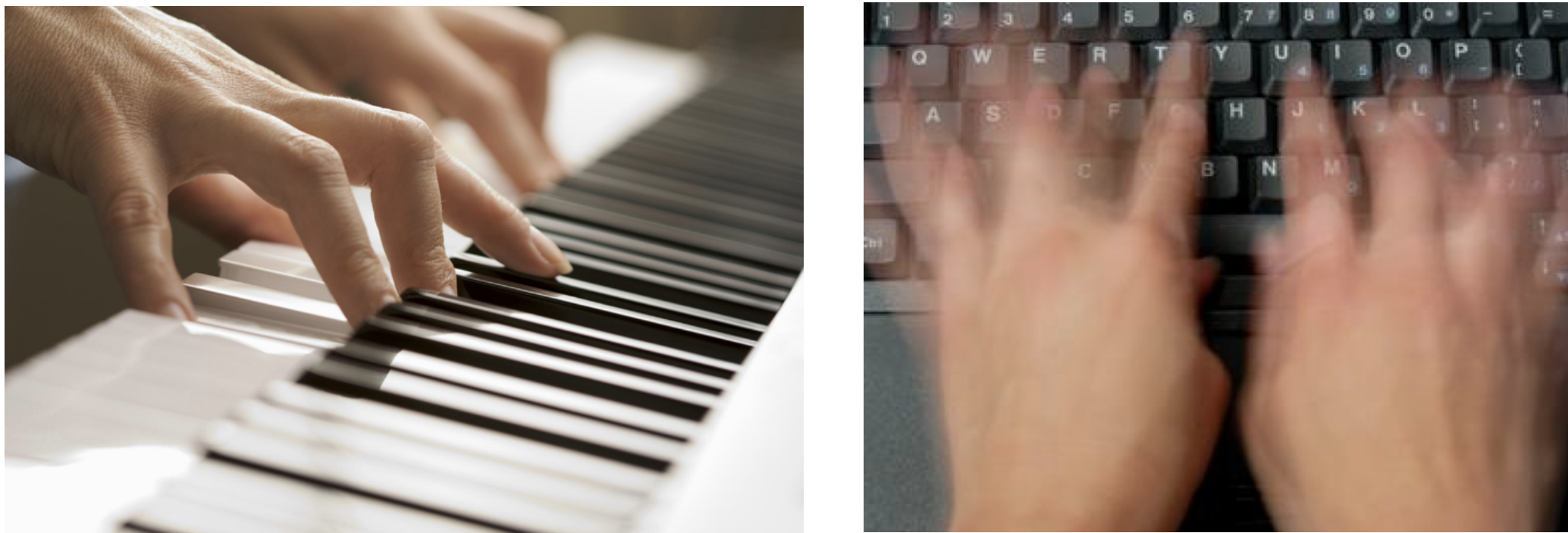
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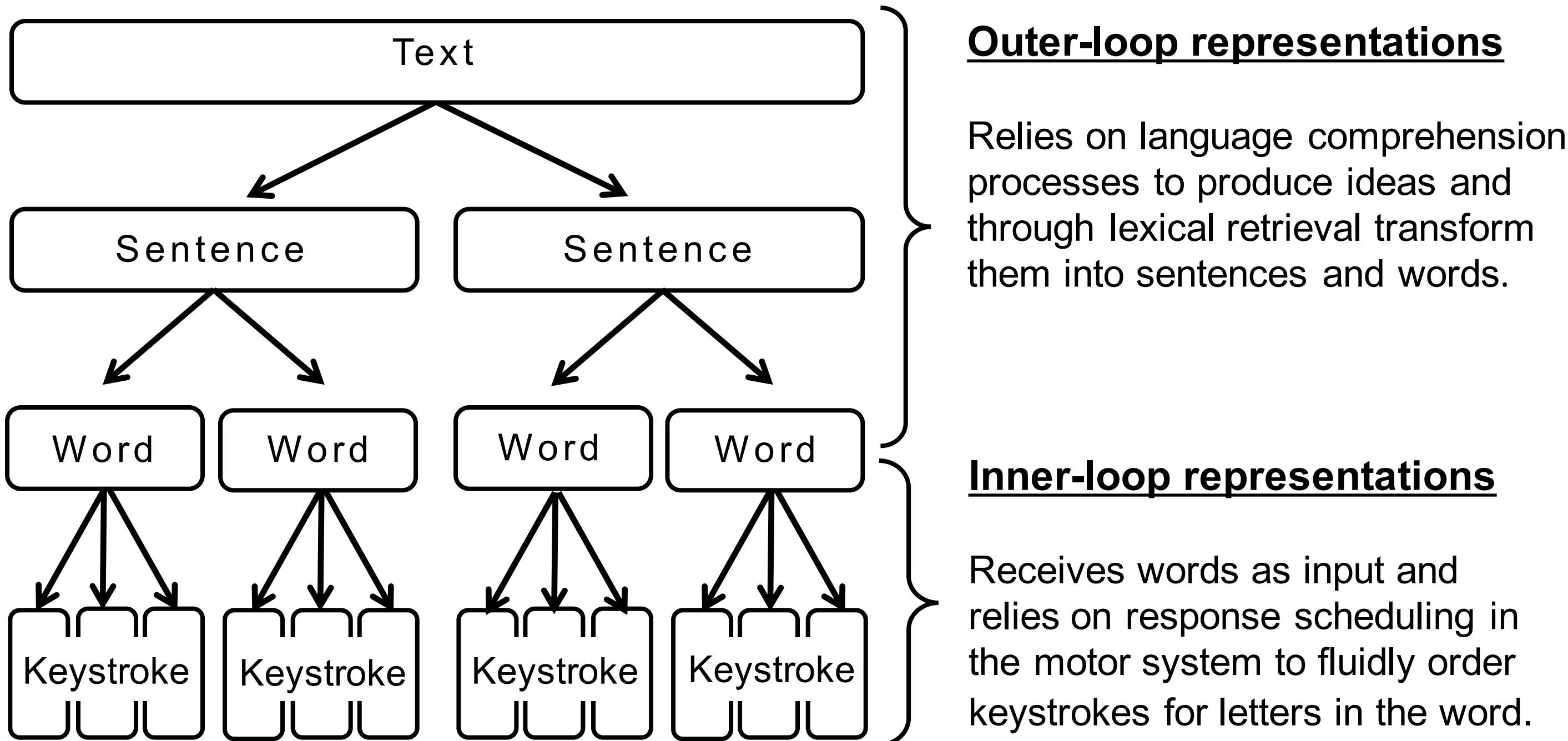
## Introduction

How do people represent and fluently execute complex sequences of actions?



### Two-loop theory of hierarchical control

Logan & Crump, 2011; Yamaguchi, Crump, & Logan, 2013



Typists can fluently execute complex motor sequences under this framework because letter sequences are automatized and triggered by word-level representations.

Consistent with the view that sequences are automated, Salthouse and Salts (1987) found that non-verbal dual-tasks do not interfere with typing.

However, a critical implication of the two-loop theory is that typing should rely on word-level representations to accurately trigger the automated letter sequences. This would suggest that disrupting the use of word-level representations should disrupt typing. Yet, some early studies have found that secondary verbal tasks (e.g., conversing, reciting nursery rhymes) did not disrupt typists (Dvorak et al., 1936; Shaffer, 1975).

The current study revisits this issue by assessing the relationship between word-level verbal representations and typing.

## Goals of the current study

1. Determine whether typists use and benefit from word-level verbal processing (Exp. 1)
2. Determine whether typists rely on verbal processing to control serial-ordering (Exp. 2 & 3)

## General Methods

In each experiment, subjects typed four to six paragraphs while performing a secondary verbal task.

All paragraphs were ~110 words and consisted of information related to Border Collies.

Typing performance was assessed by measuring inter-keystroke intervals (IKSI) for correctly typed words and word accuracy.

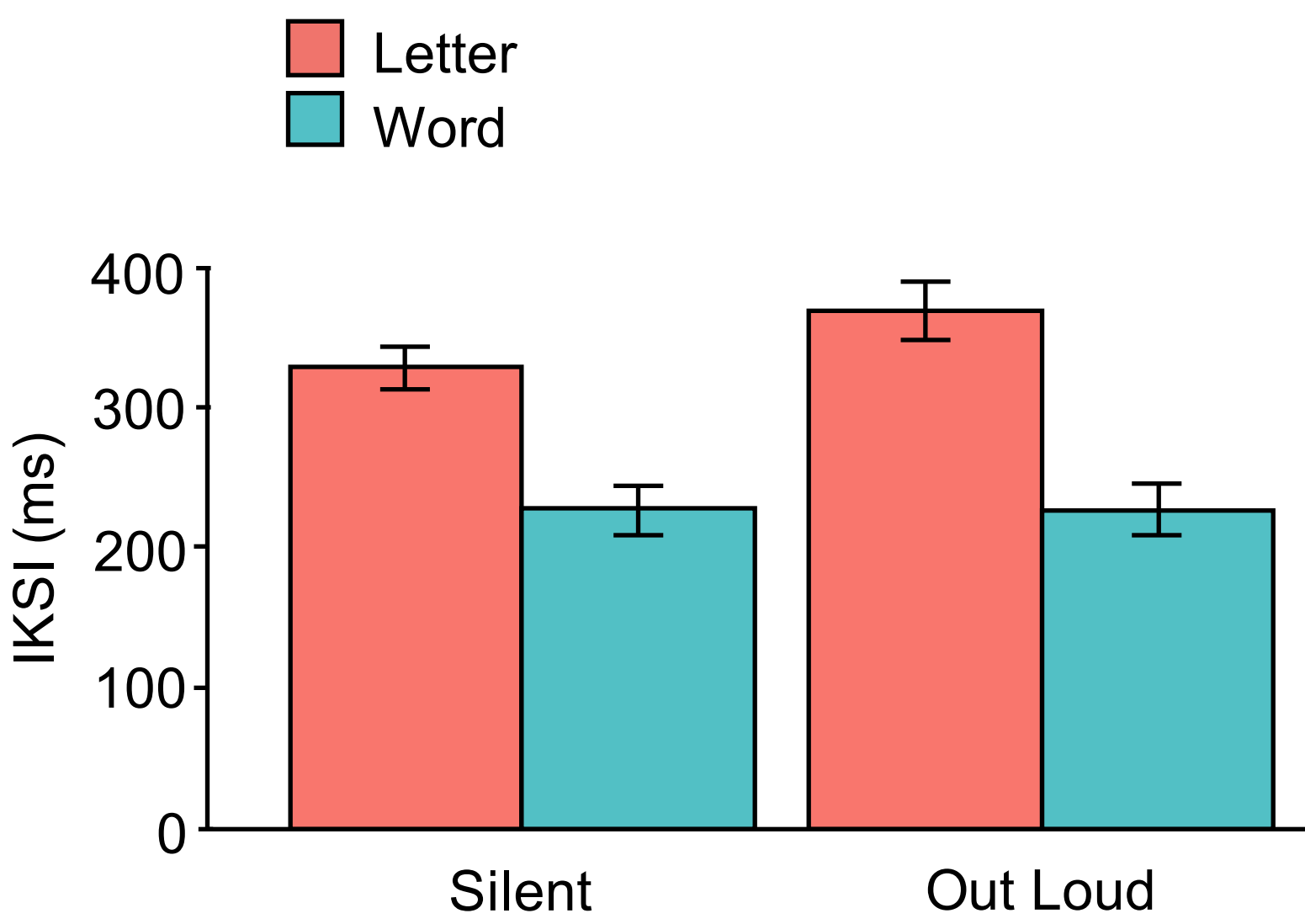
Border collies have become the chief participant in the sport of agility. Their natural athleticism and keenness to please have made them a very suitable subject for this sport, where the main requirements are speed and the ability variety of jumps, weave through poles, and go through tunnels. If the border collie has a fault in this sport, it is that it can be faster than the handler, and this can lead to errors...

Border collies have become the chief pa

## Experiment 1: Typists benefit from word-level verbal processing

Subjects typed four paragraphs

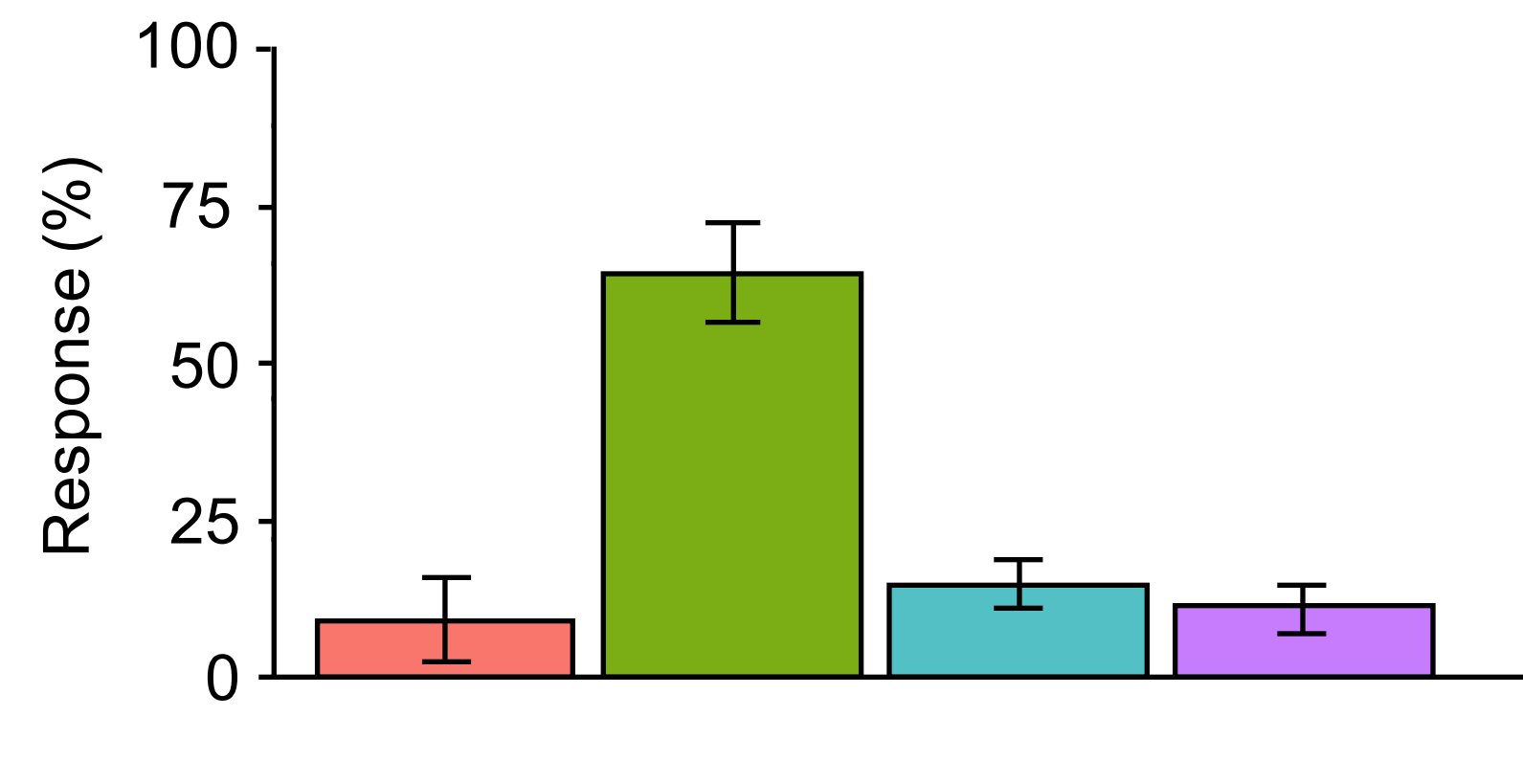
1. Reading either the letters or words
2. Reading silently or out loud



Subjects were asked to report:

“What percentage of time your inner voice...”

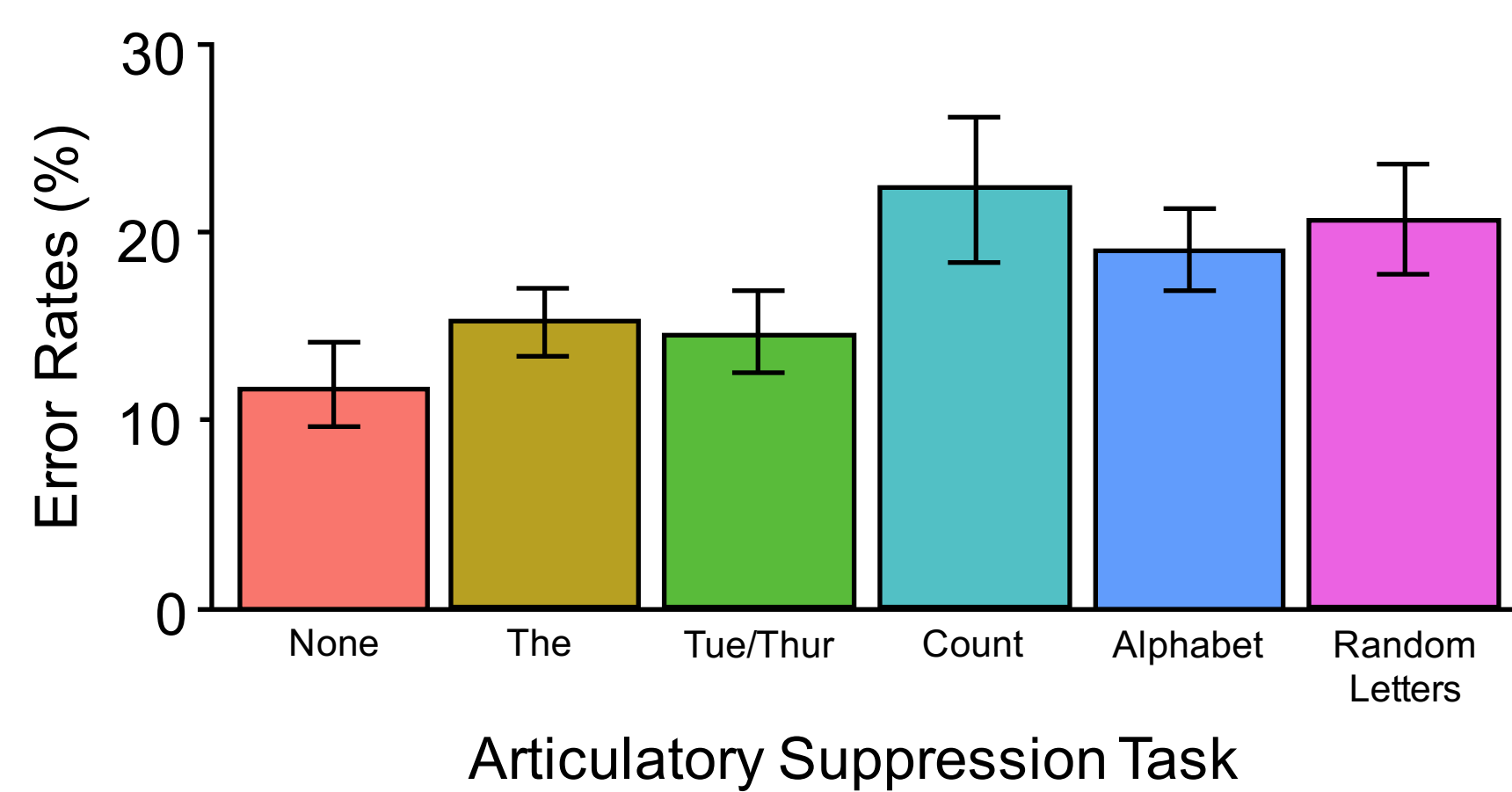
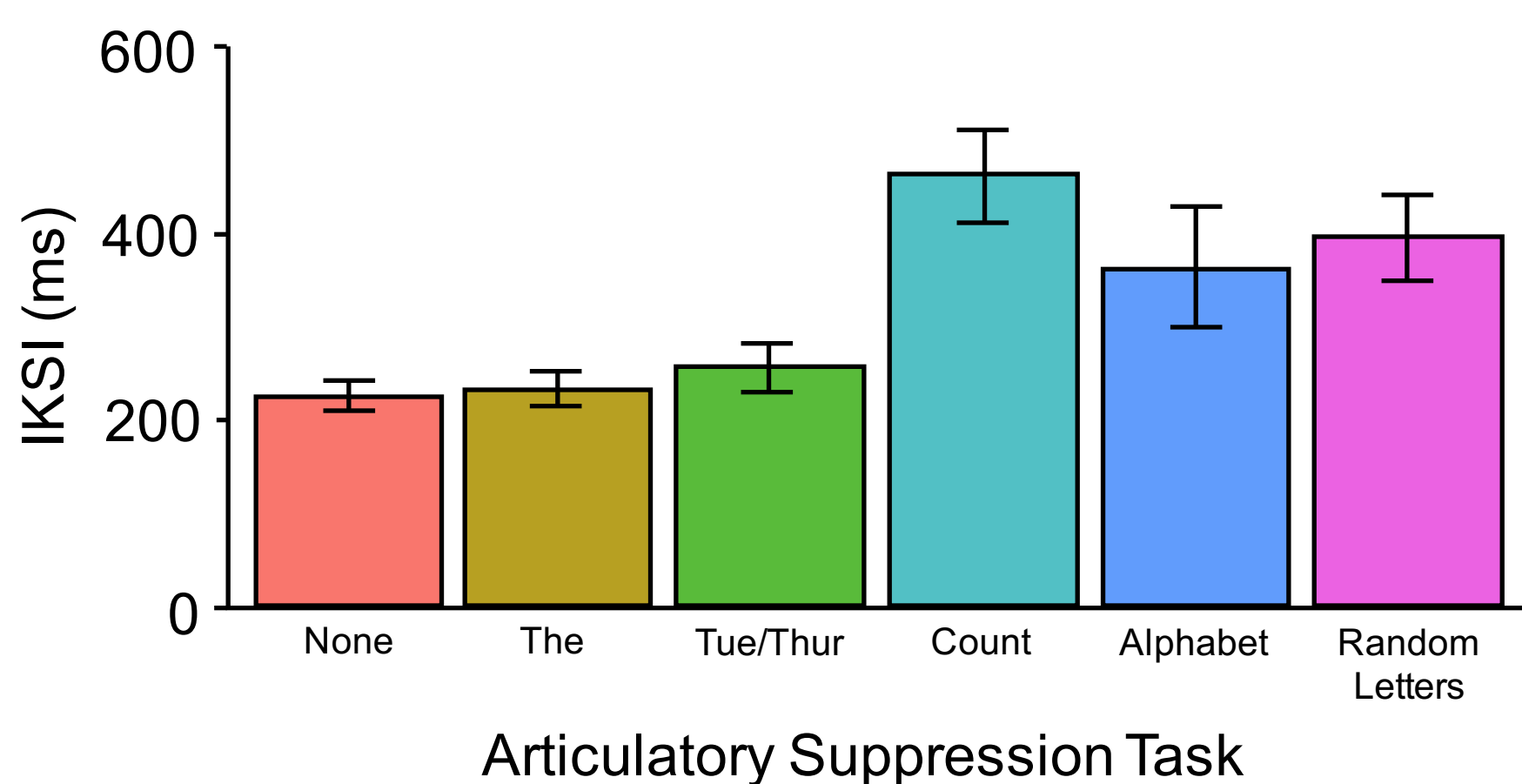
- Is silent while typing
- Speaks **words** that you are typing
- Speaks the **letters** that you are typing
- Speaks other words or letters that you are **not** typing



## Experiment 2: Suppressing verbal processing disrupts typing

Subjects typed six paragraphs while performing articulatory suppression tasks

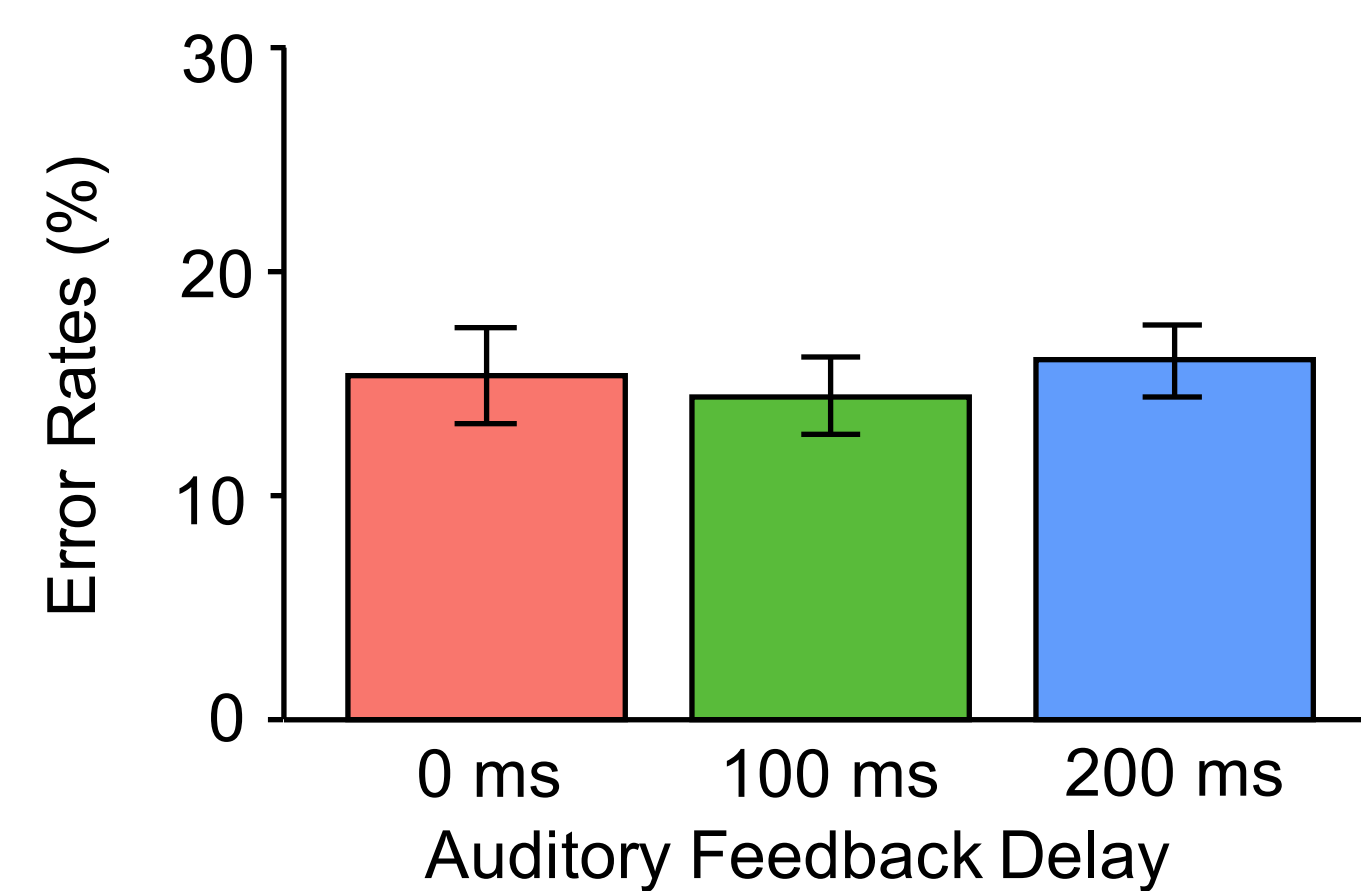
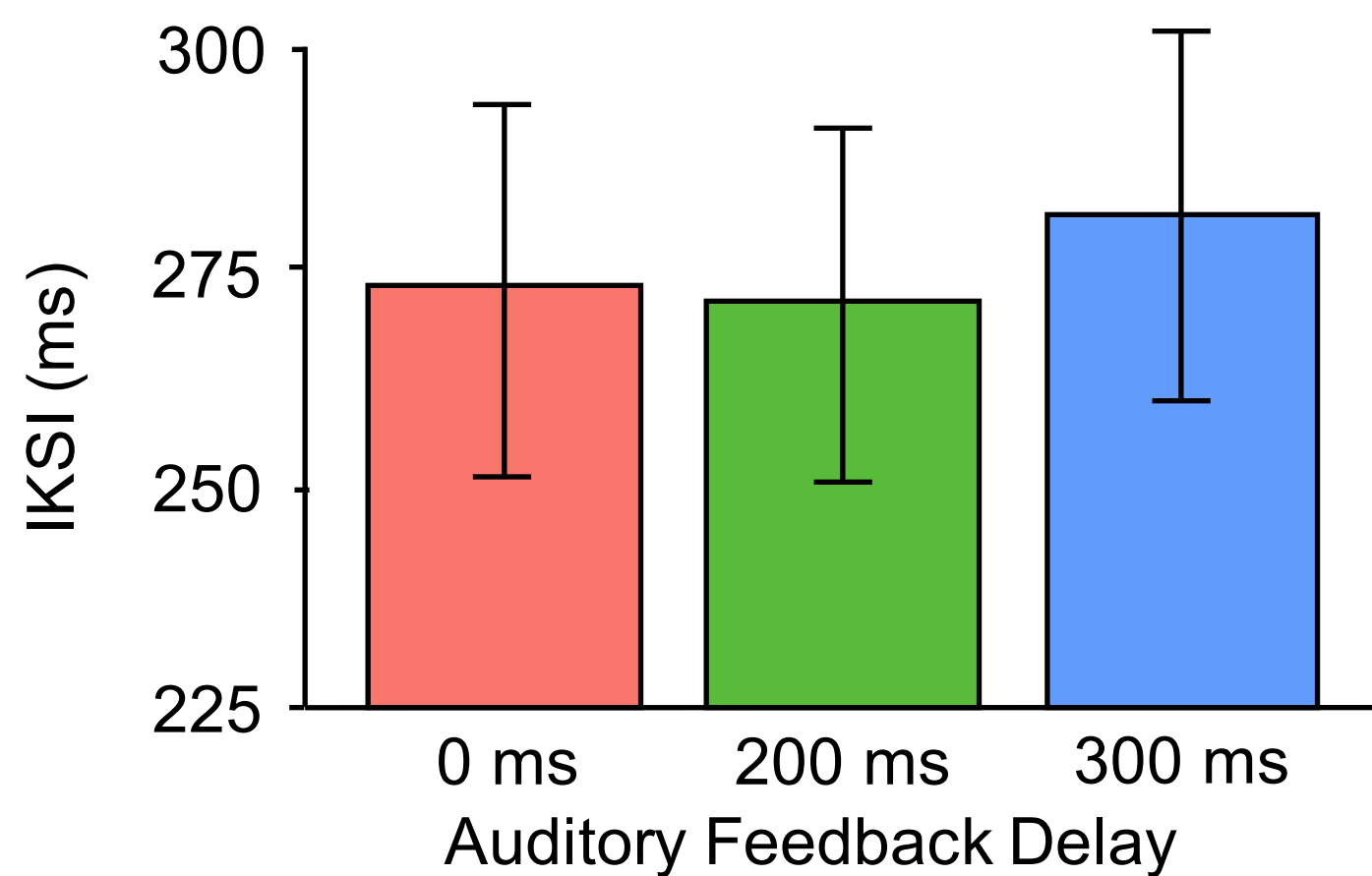
- No suppression task
- Repeating the word “the”
- Repeating the words “Tuesday, Thursday”
- Counting backwards by 2’s from 100
- Repeating the alphabet
- Saying randomly chosen letters



## Experiment 3: Delayed auditory feedback (barely) disrupts typing

Subjects typed six paragraphs while reading the text out loud

- With auditory feedback delayed by 0 ms
- With auditory feedback delayed by 100 ms
- With auditory feedback delayed by 200 ms



## Results & Conclusions

Consistent with the two-loop theory, we found that people report using word-level verbal representations and benefit from their use (Exp. 1).

Additionally, we found some verbal dual-tasks could disrupt typists (Exp. 2) and disrupting speech could create small disruptions in typing (Exp. 3)

However, not all of the verbal dual-tasks disrupted typists. The articulatory suppression tasks that failed to disrupt typists were also the most repetitive. One possibility is that verbal tasks do generally disrupt typing, but typists were able to automate our repetitive verbal tasks in order to maintain fluent control over typing.

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