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

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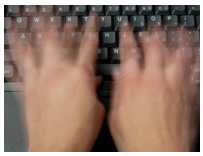
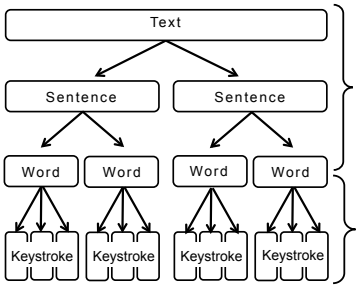
Introduction

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

Two-loop theory of hierarchical control
Logan & Crump, 2011; Yamaguchi, Crump, & Logan, 2013



Outer-loop representations

Relies on language comprehension processes to produce ideas and through lexical retrieval transform them into sentences and words.

Inner-loop representations

Receives words as input and relies on response scheduling in the motor system to fluidly order keystrokes for letters in the word.

A critical implication of the two-loop theory is that typists should rely on word-level verbal processes to control serial-ordering between finger movements.

Some early evidence suggests however, that dual-tasks *do not* disrupt typists:
- Conversing while typing (Dvorak, et al. 1936)
- Reciting nursery rhymes or shadowing prose while typing (Shaffer, 1975)
- Non-verbal dual-tasks (Salthouse and Salts, 1987)

Goals of the current study

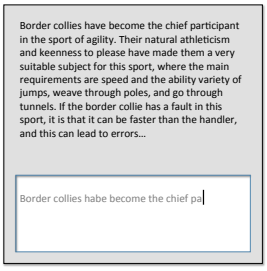
1. Determine whether typists use and benefit from word-level verbal processing (Exp. 1)
2. Determine whether typists rely on verbal processing to control serial-ordering (Exp. 2 & 3)

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.

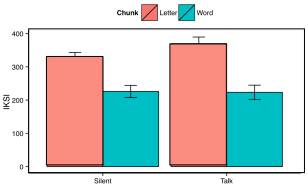


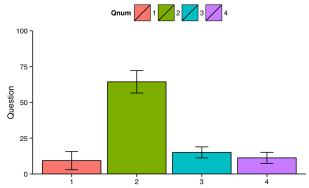
Experiment 1: Typists benefit from word-level verbal processing

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…"
1. Is **silent** while typing
2. Speaks **words** that you are typing
3. Speaks the **letters** that you are typing
4. Speaks other words or letters that you are ***not*** typing

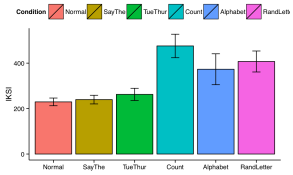


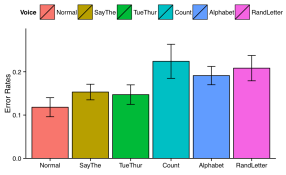


Experiment 2: Suppressing verbal processing disrupts typing

Subjects typed six paragraphs while performing articulatory suppression tasks

1. No suppression task
2. Repeating the word "the"
3. Repeating the words "Tuesday, Thursday"
4. Repeating the alphabet
5. Counting backwards by 2's from 100
6. Saying randomly chosen letters

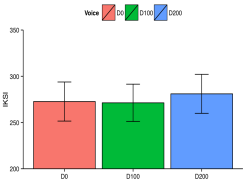


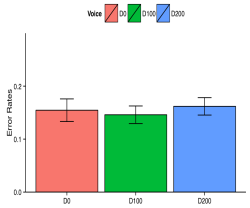


Experiment 3: Delayed auditory feedback disrupts typing

Subjects typed six paragraphs while reading the text out loud

1. With normal feedback through headphones
2. With auditory feedback delayed by 100 ms
3. With auditory feedback delayed by 200 ms





Conclusions

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

1. People report using word-level representations while typing and benefit from using word- as compared to letter-level verbal representations (Exp. 1)
2. Typists rely on word-level verbal processing to sequence actions fluently
   a. Suppressing verbal processing disrupts typing (Exp. 2)
   b. Disrupting verbal processing disrupts typing (Exp. 3)

Dvorak, A., Merrick, N. L., Dealey, W. L., & Ford, G. C. (1936). *Typewriting behavior: psychology applied to teaching and learning typewriting*. American book company.
Logan, G. D., & Crump, M. J. C. (2011). Hierarchical control of cognitive processes: The case for skilled typewriting. In *Psychology of Learning and Motivation* (Vol. 54, pp. 1–27). Elsevier. Retrieved from http://linkinghub.elsevier.com/retrieve/pii/B9780123855275000012
Salthouse, T. A., & Saults, J. S. (1987). Multiple spans in transcription typing. *Journal of Applied Psychology*, *72*(2), 187–196.
Shaffer, L. H. (1975). Control processes in typing. *The Quarterly Journal of Experimental Psychology*, *27*(3), 419–432.
Yamaguchi, M., Crump, M. J. C., & Logan, G. D. (2013). Speed–accuracy trade-off in skilled typewriting: Decomposing the contributions of hierarchical control loops. *Journal of Experimental Psychology: Human Perception and Performance*, *39*(3), 678–699. http://doi.org/10.1037/a0030512