Handedness does not modulate embodied numerical cognition, except when it does: An investigation of cross-cultural and individual differences in finger-counting habits.

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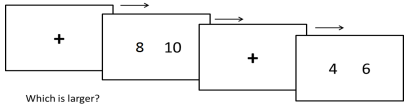
Introduction

- Cardinal/Finger-montring left-starters show greater cognitive effort when comparing numbers typically counted on two hands (Morrissey et al. (2016).
- Is this function of habitually counting on the hand one is not writing on?
- SNARC: the tendency to associate small quantities with the left and larger quantities with the right hand (Dehaene et al., 1993).
- Reminding participants of fingers reduces SNARC (Morrissey & Hallett, *in preparation*; Viarouge et al., 2014).
- Chinese participants show less cognitive impacts of finger-counting

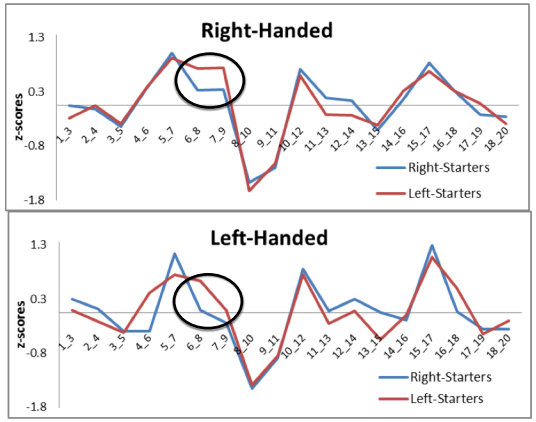
Participants

Participants included 207 right-handed Canadians, 39 left-handed Canadians, 97 right-handed Chinese, and 20 left-handed Chinese. Participants compared 18 pairs of numbers, ranging from 1 vs. 3 up to 18 vs. 20, in random order, 360 times. Each pair was separated by a numerical value of 2. This comparison would either follow, or be preceded by, a finger counting inventory.



Study 1

- Median reaction time score is taken for each participant, for each number pair.
- Participants take longer on average when comparing bigger numbers (Gobel, et al., 2011).
- A log fit line was subtracted from these from these median RT scores, separately for each participant (see figure below).
- Residuals were standardized to a mean of 0 and a SD of 1.



Results

A 2x2 univariate ANOVA evaluated predicted performance differences for number comparisons that would take two hands to count (Morrissey et al.). Handedness and starting hand were the two factors.

Left-starters showed a greater cognitive load than right starters

$F(1, 242) = 11.786$, $p = .001$, $\eta_p^2 = .046$, $d = .65$

Participants who were left handed showed less of a cognitive load overall

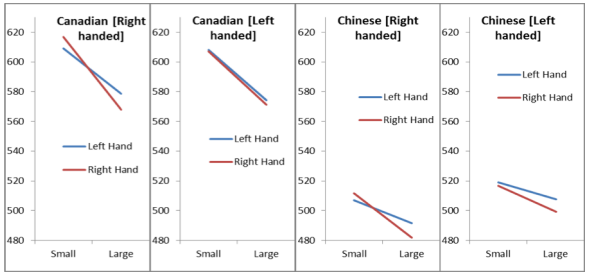
$F(1, 242) = 9.899$, $p = .002$, $\eta_p^2 = .039$, $d = .60$

There was no interaction between handedness and starting hand

$F(1, 242) = .006$, $p = .940$, $\eta_p^2 < .0005$

Study 2

- A median was taken for correct RT for each of the four combinations of response hand and response condition.
- SNARC congruent responses, were subtracted from SNARC incongruent responses, and averaged.
- This score indicates how much faster a particular answer was when congruent with SNARC.
  - Three right-handed Chinese participants, and one right-handed Canadian participant, were excluded due to a failure to have at least one correct response in all 72 response conditions.



Results

A 2(country)x2(handedness)x2(timing) univariate ANOVA evaluated SNARC residuals **[d_{ws} indicates a –like standardized within-subject effect]*

SNARC was significant overall

$F(1, 351) = 11.570$ $p = .001$, $\eta_p^2 = .032$

There was a decrease in SNARC among left-handed participants, such that this effect was not present among these participants.

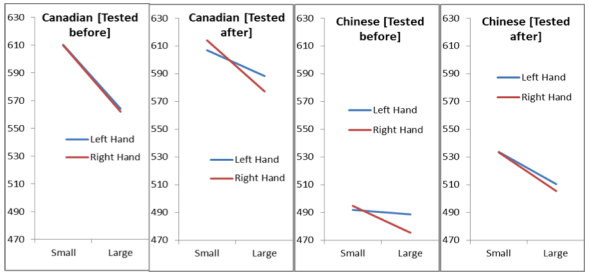
$F(1, 351) = 14.133$, $p = .043$, $\eta_p^2 = .012$

The effect of handedness was not moderated by country

$F(1, 351) = .431$, $p = .512$, $\eta_p^2 = .001$

Canadian: [Right handed SNARC: $d_{ws} = .39$; Left handed SNARC: $d_{ws} = .04$]*

Chinese [Right handed SNARC: $d_{ws} = .58$; Left handed SNARC: $d_{ws} = .15$]



However there was an interaction of procedural order and country

$F(1, 351) = 5.160$ $p = .024$, $\eta_p^2 = .014$

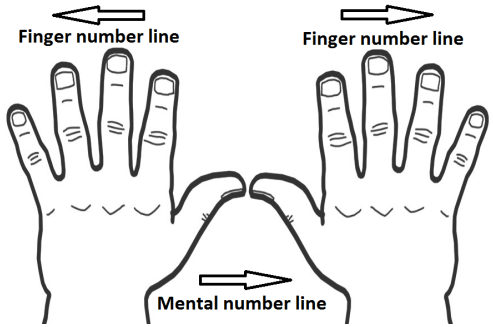
Follow-up tests indicate that being questioned about finger counting habits reduced Canadians' SNARC, but trended towards increasing it for Chinese:

Canadians: $F(1, 241) = 4.427$, $p = .036$, $\eta_p^2 = .018$

SNARC after finger counting: $d_{ws} = .19$; SNARC before: $d_{ws} = .51$

Chinese: $F(1, 110) = 2.635$, $p = .107$, $\eta_p^2 = .023$

SNARC after finger counting: $d_{ws} = .64$; SNARC before: $d_{ws} = .30$



Discussion/Future Directions

- Representational effect differences do not appear to be a function of whether one typically counts while writing.
- Being a left starter is associated with a greater cognitive load for numbers counted on both hands, regardless of handedness.
  - Average differences between left handed and right handed participants will require further investigation to verify/explain.
- SNARC effects vary, depending on the availability of finger counting habits.
- Cross-cultural differences are likely due to the dominant Chinese finger-counting system using only one hand to count.
- Left handedness was also associated with a smaller SNARC cross-culturally.
- We posit that this is a situated interaction of a global left-right reference frame interacting with how hands are placed down on a standard keyboard.
  - A separate study of right-handed participants confirms that finger counting reduces SNARC **far** more if one is an ordinal left-starter, a level of detail we have insufficient data to model here (Morrissey & Hallett, *in preparation*).
- Future work needs to examine possible separate reference frames for each hand (see Riello & Rusconi, 2011 for a nice first attempt).
- Timing of finger counting inventory should be more consistently reported in the literature.

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