Simple and complex tool use improve language syntax comprehension

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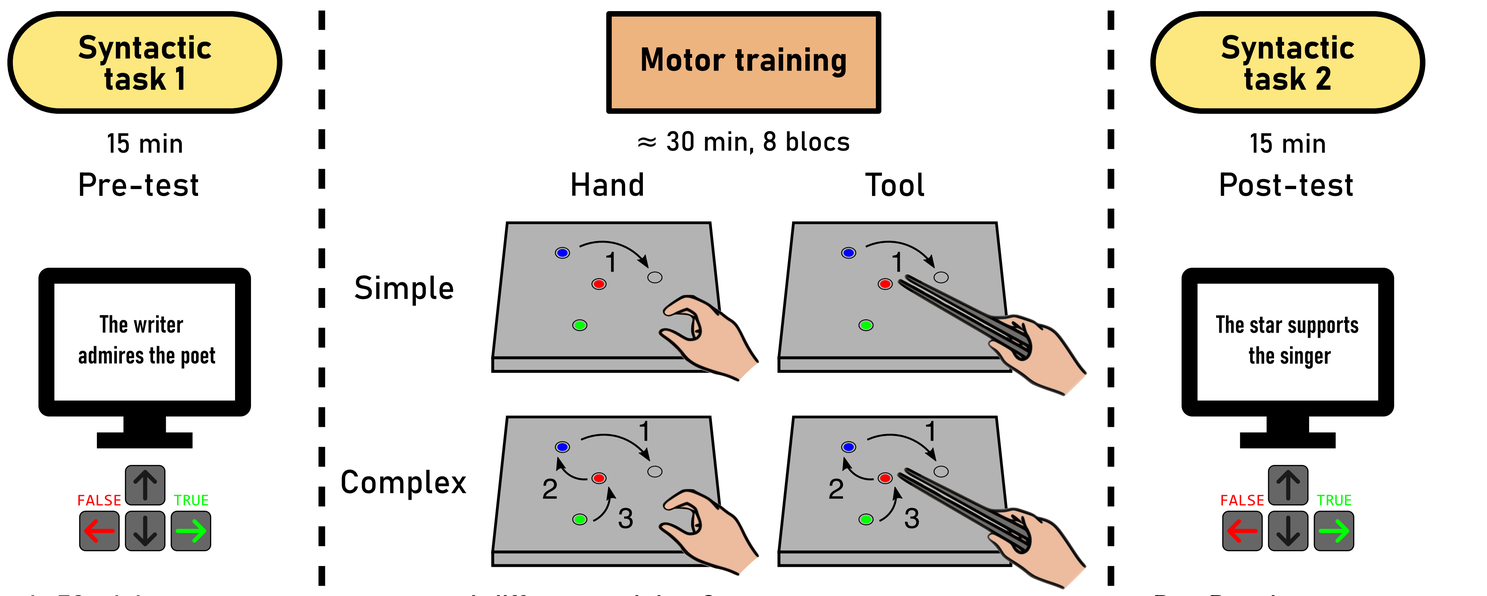
Context and Goal :

Do language and motor skills share cognitive processes? It has recently been suggested that a form of hierarchical nesting processing may operate in both skills: motor syntax in manual actions and language syntax in sentence comprehension.

We manipulated the effector (Hand vs Tool) and embedding sequence complexity (Simple vs Complex) of the motor training task. If the same syntactic processes are involved in our motor and language tasks, we should observe a learning transfer.

Protocol :



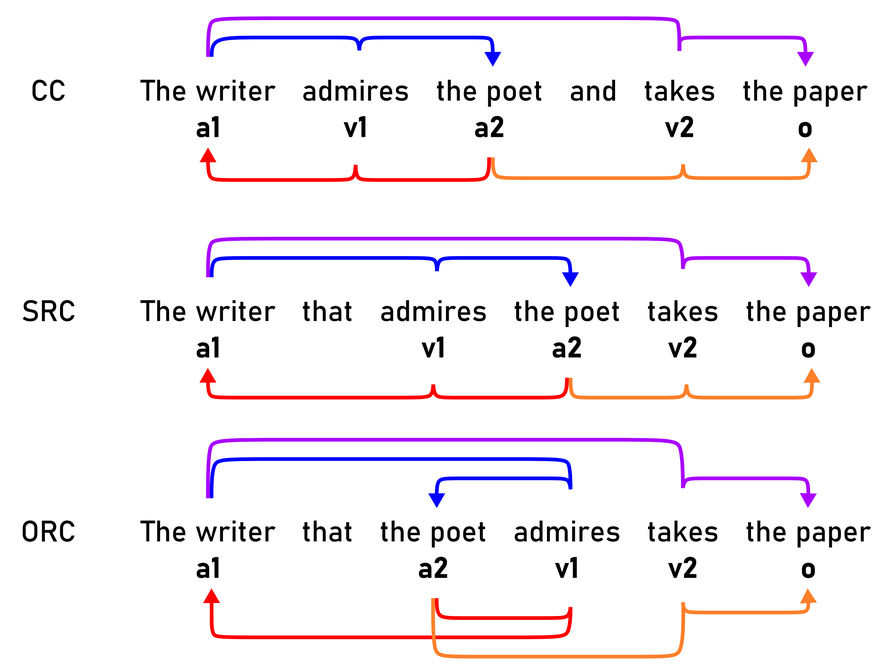
2AFC task, 72 trials
2 independent variables :
- 3 × Sentence Type
- 4 × Affirmation Type

4 different training Groups :
▸ Complexity (2) × Effector (2)
- S. : 1 movement × 300 trials
- C. : 1, 2 and 3 movements × 150 trials

Pre-Post improvement (accuracy, dprime)
▸ Between groups analysis

Sentence type

CC : coordinated clause ; SRC : subject relative clause ; ORC : object relative clause
a : actor ; v : verb ; o : object

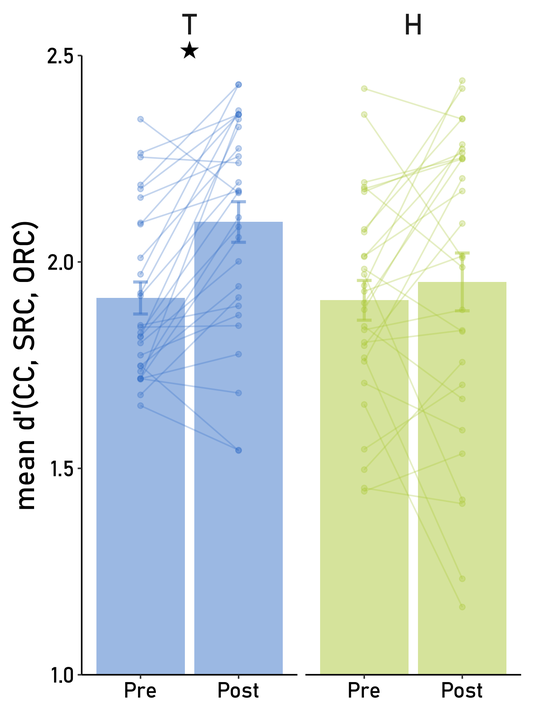


Affirmation type

		True/False
T1	The writer admires the poet (a1 v1 a2)	CC ✓ SRC ✓ ORC ✗
T2	The writer takes the paper (a1 v2 o)	CC ✓ SRC ✓ ORC ✓
T3	The poet admires the writer (a2 v1 a1)	CC ✗ SRC ✗ ORC ✓
T4	The poet takes the paper (a2 v2 o)	CC ✗ SRC ✗ ORC ✗

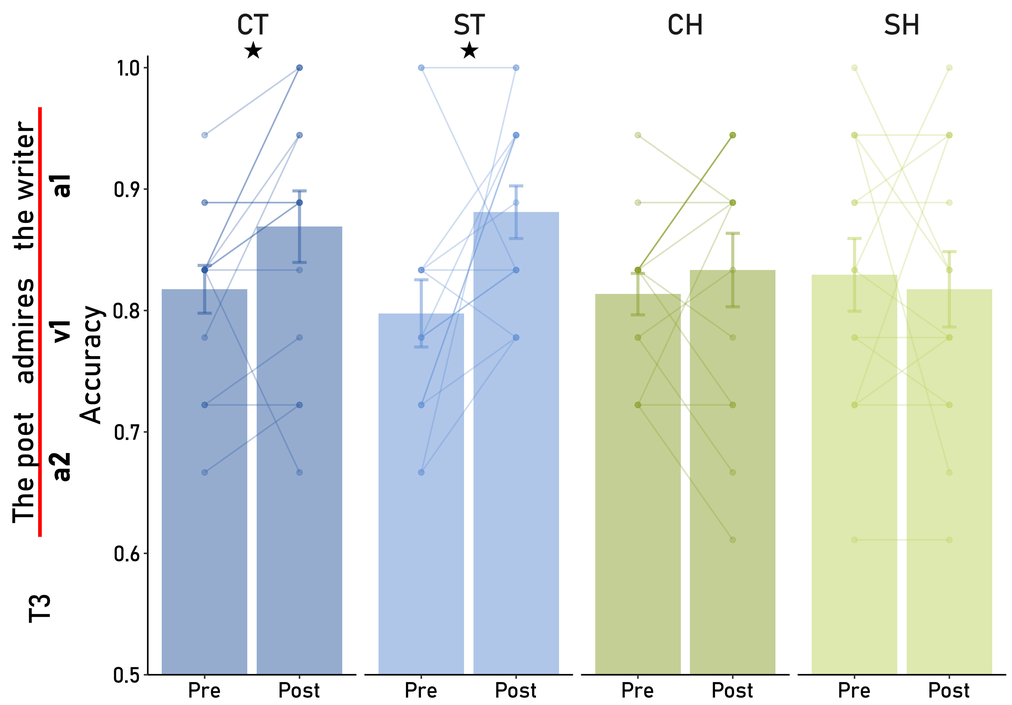
Results :

▸ Effector effect (Syntactic task)

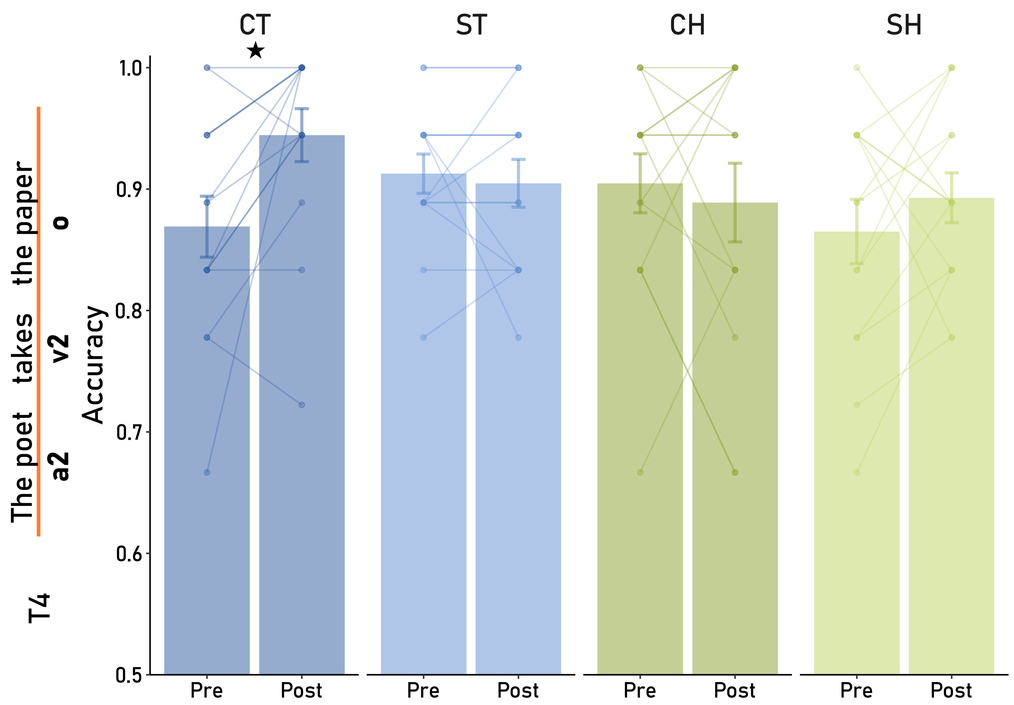


Whole model : [Complexity × Effector × Timepoint × Sentence type]
▸ Interaction [Effector × Timepoint] is significant [$\chi^2_{(1)}$ = 4.80, P = 0.03]
- Hand [Pre, mean d' = 1.91 ± 0.04; Post, d' = 2.10 ± 0.05; P < 0.001, Tukey's post hoc test]

▸ Group effect, specific for T3 and T4 (Syntactic task)

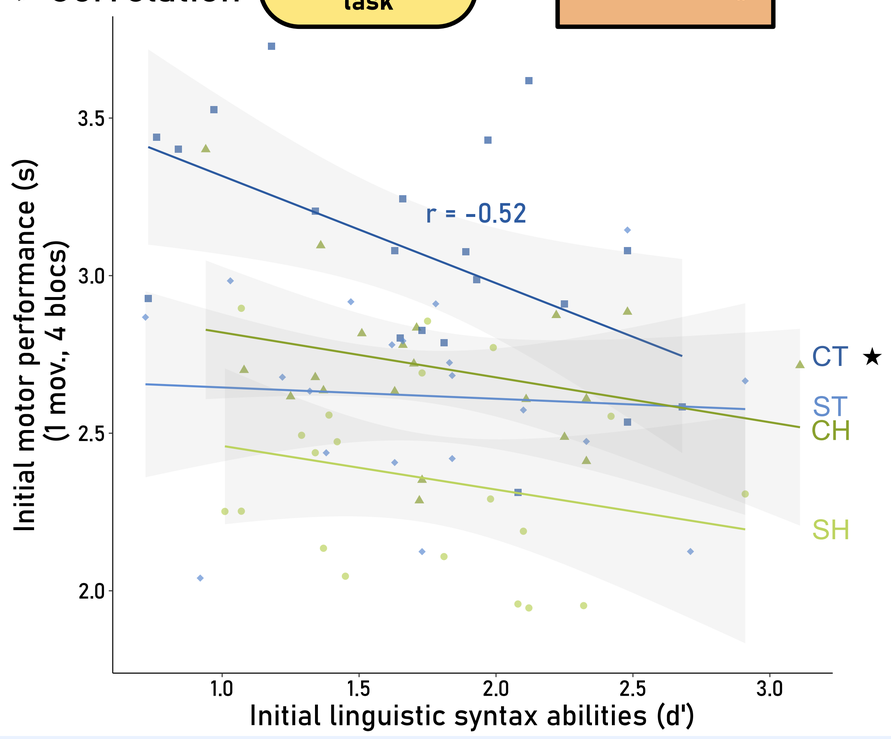


Whole model : [Complexity × Effector × Timepoint × Affirmation type]
▸ Interaction [Complexity × Effector × Timepoint × Affirmation type] is significant [$\chi^2_{(3)}$ = 10.2, P = 0.02]
- CT [Pre, Accuracy = 0.82 ± 0.02; Post, Accuracy = 0.87 ± 0.03; P = 0.02, Tukey's post hoc test]
- ST [Pre, Accuracy = 0.80 ± 0.03; Post, Accuracy = 0.88 ± 0.02; P < 0.001, Tukey's post hoc test]



- CT [Pre, Accuracy = 0.87 ± 0.02; Post, Accuracy = 0.94 ± 0.02; P = 0.001, Tukey's post hoc test]

▸ Correlation (Syntactic task ~ Motor training)



Discussion :

- Following tool-use training participants improved their overall performance in the language syntax comprehension task, no matter the complexity of the action trained.
- We observed a better comprehension of complex syntactic constructions in the CT group (Affirmation type 3 and 4).
- Importantly, we did not observe an effect for SH nor CH groups, meaning that motor embedding complexity alone is not sufficient to produce learning transfer.
- We found a positive correlation between initial motor and language performances in the CT group, suggesting that language syntax abilities can predict motor proficiency for complex tool use.

➢ In sum, we obtained a learning transfer from the motor to the language tasks in the tool-use conditions. This transfer was greater when the training involved embedded actions (complex motor sequences).
Altogether, our results are in line with the idea that motor and language skills share **common domain-general syntactic processes**.

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