Intentional gesturing at encoding facilitates retrieval, but not as much as mental imagery: Implications for representation of gestured information

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Background

Incidental **gesturing during encoding** of new information often facilitates later recall of that information.

- Following incidental encoding, surprise memory for events benefitted from gestures produced during verbal narrations compared to verbal description alone. Gestures produced spontaneously or by instruction were both effective (Cook, Yip, & Goldin-Meadow, 2010; see also Broaders, Cook, Mitchell, & Goldin-Meadow, 2007; Frick-Horbury, 2002).
- Gesturing is associated with generating internal visual imagery (Alibali et al., 1999; de Ruiter, 2008; McNeill, 1992; Melinger & Levelt, 2004).

Very little research has examined whether **intentional use of gestures** as an encoding device or memory mnemonic is effective.

- Kelly and Lee (2012) found that viewing semantically-matched gestures helped second-language word acquisition when the difference between word pairs was easy to differentiate, but the gestures actually decreased memory for semantic information for words that were hard to differentiate. Participants *did not generate gestures* themselves, though, but viewed scripted iconic gestures.

Critically, no research to our knowledge has compared the effectiveness of **mental imagery** vs. **gesturing** as memory mnemonics.

What mechanisms might underlie intentional gesture's benefit?

Gesture-as-Action-Simulation: internal mental simulation of information gives rise to externalized gestures (Hostetter & Alibali, 2008, 2010)

- **Prediction**: better internal mental imagery → more/more effective external gesture → better memory encoding and later recall
- Higher fluid intelligence supports better internal mental imagery (e.g., Poltrock & Brown, 1984)
- Those with higher fluid intelligence produce more kinematic, movement gestures (Sassenburg et al., 2011; Wartenburger et al., 2010)

Gesture-as-Catalyst: gesturing helps organize and create internal representations and new knowledge (e.g., Goldin-Meadow, Cook, & Mitchell, 2009; Goldin-Meadow, 2014)

- **Prediction**: more external gesture → more effective internal mental imagery → better memory encoding and later recall
- Those who naturally gesture more may produce more effective gestures on demand.
  - spontaneous gesture rate may be a stronger predictor for those assigned to gesture encoding

Method

Experiments 1 & 2:

Materials: 30 unassociated word pairs, concrete nouns that could be imagined or gestured
- normed associative rating, mean = 1.30 (1-7 scale)
- e.g., cat-hose, door-kite, statue-zipper, lava-carrot, jar-sock

Learning phase: word pair learning task (e.g., Schnorr & Atkinson, 1969)
- **Repetition** [Expt 1 only]: "repeat the words over and over in your mind to connect them together"
- **Imagery**: "repeat the words over and over in your mind and ***form an image*** in your mind of those two things in some relationship"
- **Gesturing**: "repeat the words over and over in your mind and ***illustrate or act out*** each of the words in some relationship with your hands and body, like in charades"
- 20 secs to encode each pair   2 practice trials, with modeling

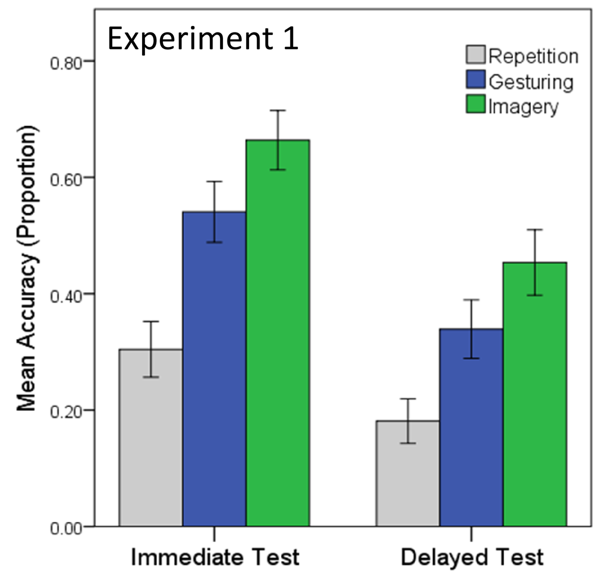
Test phase: cued recall – they were provided the first word (cat-) and had to type in the learned associate
- Immediate (minutes later) & Delayed (2 days later)   no instruction at recall, no time deadline

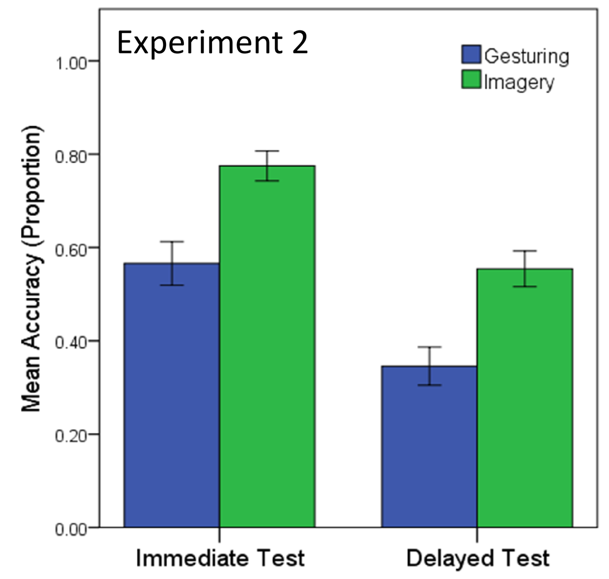
Experiment 2 added:

Gesture Rate: spontaneous gesture rate was first measured independently – done first on day 1 for all participants
- subjects described how to wrap a gift
- iconic gestures were coded from videotape; inter-rater reliability: $\rho(72) = .84$; primary coder's counts were used in analyses
- calculated gestures per minute
- Analyses using gesture rate calculated from a cartoon narration (SpongeBob Square pants) produced similar results.

Fluid Intelligence: measured independently with Ravens Progressive Matrices – done last on day 3 for all participants
- Calculated percent correct/number attempted
- Analyses using raw number correct produced similar results.
- Measures ability to solve novel visual pattern problems

Results





Experiment 1: $N = 69$, 23 Repetition, 23 Imagery, 23 Gesture
- Linear mixed effects regression; best fit model with maximal fixed effects factor structure: random intercepts, and random slopes per subject

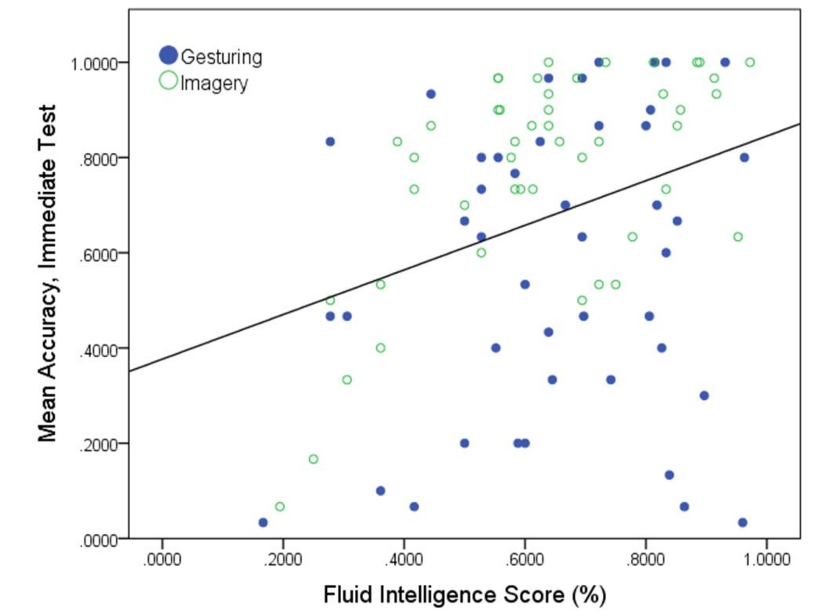
Higher memory accuracy for:
- Immediate vs. Delayed test, $p < .001$
- Imagery vs. Repetition, $p < .001$; Gesturing vs. Repetition, $p = .005$; Imagery vs. Gesturing, $p = .086$

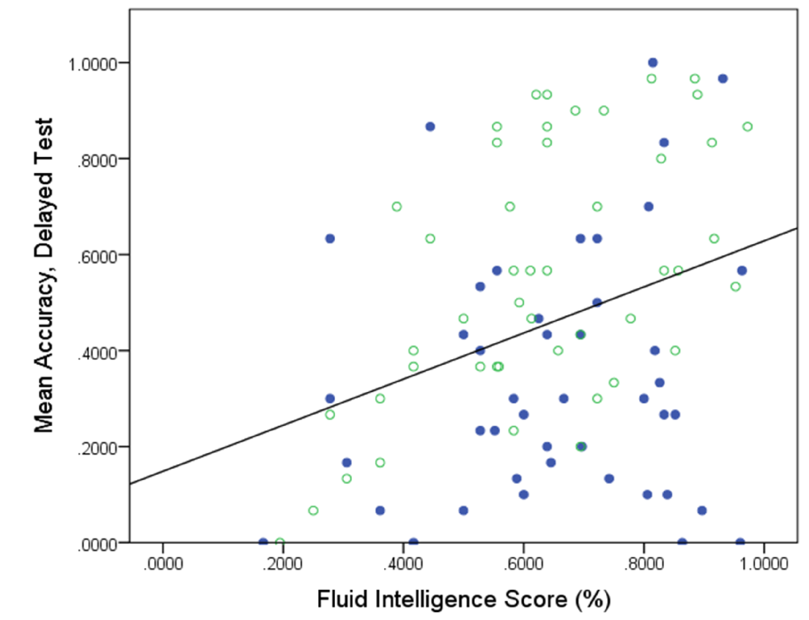
Experiment 2: $N = 91$, 47 Imagery, 44 Gesture
- Linear mixed effects regression; best fit model with maximal fixed effects factor structure: random intercepts, and random slopes per subject for Time and Strategy

Higher memory accuracy for:
- Immediate vs. Delayed test, $p < .001$
- Imagery vs. Gesturing, $p < .001$

Individual differences measures:
- Fluid Intelligence did not differ for Gesture (.65, $SE = .19$) vs. Imagery (.63, $SE = .19$) groups, $p = .59$.
- Gesture Rate did not differ for Gesture (.44, $SE = .16$) vs. Imagery (.39, $SE = .19$) groups, $p = .19$.

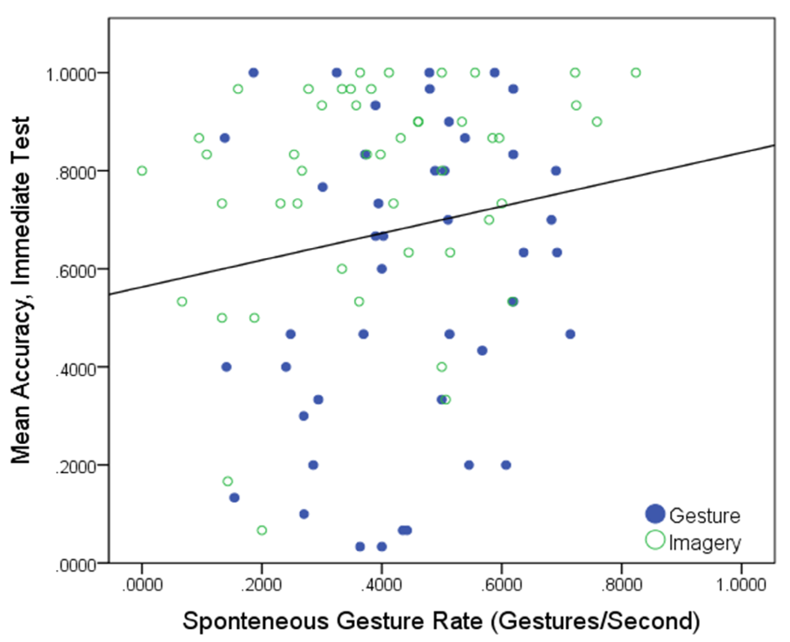
Strong Support for Gesture-as-Action-Simulation:
Higher **fluid intelligence** predicted better memory accuracy overall, $p = .009$. This held for both the gesturing and imagery groups, showing the mental imagery and/or simulation was in common.

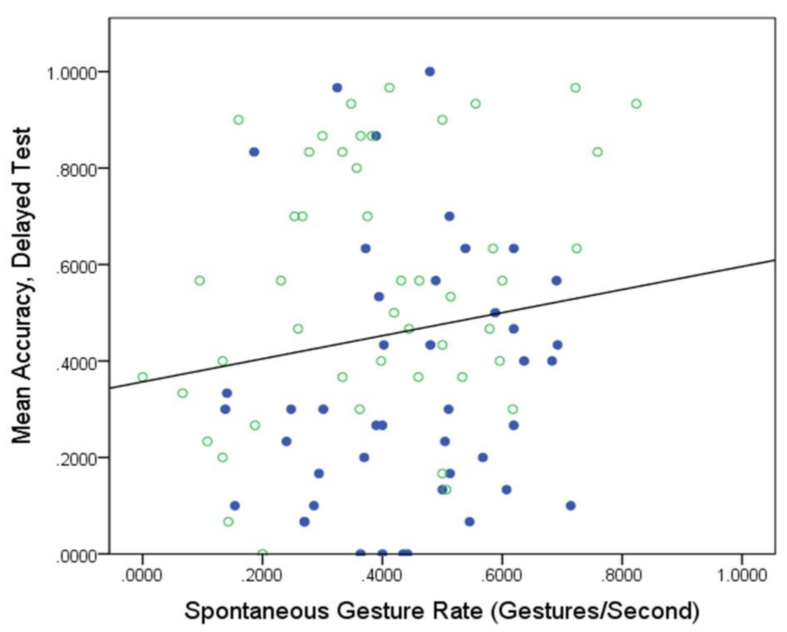




Experiment 2: lme regression model	β	*SE*	*df*	*t*-value
Intercept	.58	.02	5361	24.09***
Time (Immediate -1, Delayed +1)	-.11	.01	5361	**-13.82*** **
Strategy (Imagery -1, Gesturing +1)	-.12	.02	83	**-4.96*** **
Fluid Intelligence	**.40**	.15	83	**2.68** **
Gesture Rate	.16	.14	83	1.10
Time X Strategy	.002	.008	5361	.21
Time X Fluid Intelligence	.03	.04	5361	.83
Time X Gesture Rate	-.10	.05	5361	**-2.03***
Strategy X Fluid Intelligence	-.17	.15	83	-1.16
Strategy X Gesture Rate	.07	.14	83	.50
Gesture Rate X Fluid Intelligence	.33	.95	83	.34
Time X Strategy X Fluid Intelligence	-.05	.04	5361	-1.24
Time X Strategy X Gesture Rate	-.03	.05	5361	-.63
Time X Gesture Rate X Fluid Intelligence	.16	.27	5361	.60
Strategy X Gesture Rate X Fluid Intelligence	.38	.95	5361	.40
4-way interaction	.04	.27	5361	.17

Weak Support for Gesture-as-Catalyst:
- The interaction of **spontaneous gesture rate** with test time, $p = .042$, indicates that higher gesture rates led to higher memory accuracy, but this relation held only for the *immediate* test. No facilitation overall, $p = .274$.
- A gesture rate benefit was not specific to the group assigned the gesture encoding strategy, $p = .620$.
- Gesturing spontaneously may prime gesture production components, but any benefit of this is short-lived, and in common to both encoding strategies.





Discussion

1. In both experiments, those assigned to **Imagery** encoding showed **better memory accuracy** at both test times than those assigned to Gesture encoding. Gesturing and Imagery were both superior to verbal Repetition in the first experiment.
2. While intentional production of gestures at encoding can support better memory, it may not be as flexible or distinctive as visual imagery in discovering or representing relations that support associations between the concepts.
3. An individual's **Fluid Intelligence** score predicted better memory accuracy, for both test times, and for both encoding groups. Along with (1) above, this provides strong support for a Gesture-as-Action-Simulation approach to memory representations: greater fluency with internalized mental imagery of the objects and simulation of an association between the two concepts being memorized was the more critical element of forming and re-accessing a memory representation.
4. An individual's spontaneous **Gesture Rate** also predicted better memory accuracy, but the facilitation was a smaller effect, was limited to the immediate test, and it was not specific to those assigned to gesture encoding. This provides weak support for the Gesture-as-Catalyst approach to memory representations, where a propensity to gesture facilitated creating and producing gestures that supported an association between two concepts, but did not last or facilitate over the long-term.

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