TESTING THE LANGUAGE-THROWING HYPOTHESIS

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1. Introduction

Language and tool use – including object throwing – have long been considered important in human evolution (e.g. Darwin, 1871). Calvin (1982) made a novel proposal for the origin of language capacity in hominins: Morphological adaptations for arboreal living in ancient apes were exapted for object throwing and led to the emergence of hominins as an action-at-a-distance predator. Throwing accurately, however, requires precise timing in the coordination of various effectors, placing a strong selective pressure for multiple morphological changes including more neurons and increased encephalisation. These timing requirements for the sequencing of muscle actions are similar to those required for speech. Calvin hypothesised that the neural mechanisms that supported this timing in throwing were then exapted for use in language. This is the language-throwing hypothesis (Calvin, 1982, 1983, 1993). There is some supporting evidence from comparative research with chimpanzees (Hopkins, Russell & Schaeffer, 2012), but there is a paucity of research in humans. This talk presents a novel experimental method and results testing this idea in humans.

2. Methodology

A Dual-Task (DT) interference paradigm was used in a series of three experiments. The logic of the DT method is that overloading two systems simultaneously creates interference in performance and provides a window into their functional architecture (Pashler, 1994). DT normally uses discrete outcome variables such as hits/misses. However, language and throwing are both highly evolved, massively redundant systems capable of compensating for both natural and experimental perturbations. Thus, performance was analysed not only in

terms of *outcome variables* but also in terms of *throwing dynamics*, i.e. how throwers shape their co-ordination. This co-ordination is mapped onto a solution manifold using two outcome variables as axes: velocity and angle of release. Moreover, variability was investigated by applying a Tolerance, Noise and Covariance (TNC) analysis. TNC is a statistical approach to quantify positive and negative variability in co-ordination by comparing actual data with optimal data (Cohen & Sternad, 2009). Finally, as there is a tendency for mouth-movements and hand-movements to synchronise (Vainio, 2019), possible disruption of this tendency was investigated by measuring the difference in milliseconds between maximum stress in vocalisation and the moment of ball release.

3. Experimental Design

In experiment 1, using a repeated measures design, expert throwers (N= 24) threw a tennis ball at a 1.5m target 10m distant while simultaneously vocalizing under four conditions: Complex word, Simple Word, Grunt, Silence (control), using a variation of the Word Complexity Measure (Stoel-Gammon, 2009). Time-stamped video (1000fps) and audio of the throws and vocalizations were recorded for later analysis. Experiment 2 (N=25) measured maximum distance under 2 conditions (Complex word and Silence).

4. Preliminary Results

A linear contrast analysis was conducted on three outcome variables: hits/misses, radial error (i.e. hit distance from the target centre) and maximum distance. A repeated measures ANOVA was conducted on the angular distribution of hits and on two throwing dynamics variables: Release Height and Release Velocity. All found no statistically significant difference ($p>.05$). Finally, a repeated measures ANOVA conducted on the Stress-Release difference (ms) found a small (Partial eta squared $\eta_p^2 =.008$), but statistically significant ($p<.05$) difference between the complex and simple word conditions. This indicates a possible interference effect. However, caution is warranted: multiple DV's were tested in line with the pre-registration statement and the exploratory nature of this research. Therefore, replication is required before assuming this effect is real and not a statistical artefact. Results for TNC analysis are ongoing and will be reported at conference. In conclusion, this novel paradigm found some evidence in favour of the language-throwing hypothesis and technical details (code etc.) will be made available to other researchers.

References

Calvin, W. H. (1982). Did throwing stones shape hominid brain evolution? *Ethology and Sociobiology*, *3*(3), 115–124.

Calvin, W. H. (1983). A stone's throw and its launch window: Timing precision and its implications for language and hominid brains. *Journal of Theoretical Biology*, *104*(1), 121–135.

Calvin, W. H. (1998). The Emergence of Intelligence. *Scientific American*, 7.

Cohen, R. G., & Sternad, D. (2009). Variability in motor learning: Relocating, channeling and reducing noise. *Experimental Brain Research*, *193*(1), 69–83.

Darwin, C. (1981). *The descent of man, and selection in relation to sex*. Princeton, N.J: Princeton University Press.

Hopkins, W. D., Russell, J. L., & Schaeffer, J. A. (2012). The neural and cognitive correlates of aimed throwing in chimpanzees: A magnetic resonance image and behavioural study on a unique form of social tool use. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *367*(1585),

Pashler, H. (n.d.). Dual-Task Interference in Simple Tasks: Data & Theory. *Psychological Bulletin*, *116*(2), 220–224.

Stoel-Gammon, C. (2010). The Word Complexity Measure: Description and application to developmental phonology and disorders. *Clinical Linguistics & Phonetics*, *24*(4–5),

Vainio, L. (2019). Connection between movements of mouth and hand: Perspectives on development and evolution of speech. *Neuroscience & Biobehavioral Reviews*, *100*, 211–223.