# The Zone of Latent Solution (ZLS) Model: A Minimalist Account of Early Stone Tool Development

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The main new claims deducible from Stout et al. are: A) That core rotation vs. non-rotation was influenced by *some variant* of social learning ("rotation culture"); B) That action copying has to be the *specific* variant in such cases; C) That *A&B* together disprove Tennie et al.'s (2016, 2017) zone of latent solutions (ZLS) account for early stone tools (EST).

Only claim *A* ("rotation culture") finds initial support. Early Stone Age toolmakers thus join many species in showing variants of social learning. They also join non-human great apes (henceforth apes) in showing population level differences not readily traceable to genetic and/or environmental differences – i.e. culture (Whiten et al. 1999). But this leaves open which variant(s) of social learning, and it also does not exclude latent solutions – not least because the ZLS hypothesis is designed as a possible explanation for exactly such patterns (Tennie et al. 2009; opposing claims *B* and *C*).

Contra Stout et al., the latent solution founder effect (LSFE) does *not* consist of independent individual responses to environmental pressures[1]. As explained by Tennie et al. (2009; also Bandini and Tennie 2017), at the beginning of the LSFE, behaviors from within the ZLS are shown by one or more individuals in a population that does not yet express any latent solution to the particular problem. Which behavior is chosen can indeed depend on chance, e.g., the first individual(s) may stumble upon tool material A rather than B and thus express latent solution A (see the multiple independent similar innovations in Hobaiter et al. 2014). Next, others are socially biased towards developing a similar latent solution – for example as an individual consequence of attending more to A. Therefore, perhaps counterintuitively (and against claim *B*), cultural patterns do not require action copying (or action teaching)[2].

Stout et al.'s approach over-infers copying due to a focus on similarity. Consider an uncontroversial case: if you see me yawn, you might also yawn – *in a similar form* (using similar sounds/actions). Yet, typically you did not copy my "yawn form" at all. Stout et al.'s approach, however, judges your yawn a "behavior reproduction" – a phrase that connotes copying. The ZLS hypothesis instead clearly distinguishes between the *transmission of a form*[3] and *social influences on the frequency of a form*[4] (Bandini and Tennie 2017). While the former requires copying, the latter may or may not involve any copying – but can also produce cultures (Bandini and Tennie 2017 and references therein). Hence, data in support of claim *A* cannot – by itself – support claims *B* or *C*.

We can already infer that action copying is *not* necessary for rotation culture (contra claim *B*) because Stout et al. recreated the underlying actions without ever having observed the actions of the original makers. Instead, the social learning variant we should infer is "object movement

[1] This is notwithstanding that fact that, where environmental and/or genetic biases do exist, they can influence the *likely direction* of the LSFE.
[2] In the example I used here "stimulus enhancement" sufficed.
[3] Or "fidelity" – in yawning contagion = ~zero.
[4] In yawning contagion = high.

re-enactment"[5] (OMR; Custance et al. 1999). This inference is most parsimonious also because OMR underlies ape learning in so-called two-target tasks[6] where there is a similar requirement: to recreate one of two *object movements* (Tennie et al. 2006, OMR pinpointed in Hopper et al. 2008). Crucially, *all* recreations (here core movement vs. no-core-movement) can be latent solutions[7]. Our account indeed predicts that both variants of rotation culture will also be found in culturally unconnected populations (similar to the ape cultures so far examined; Tennie et al. 2016, 2017).

Because the cultural models they cite report stasis as an outcome of copying, Stout et al. conclude that any variant of copying can fit observed stasis. However, those models excluded the fine-grained copying used within the verbal cultural model of Stout et al. This copying variant has unavoidable copying error (see Eerkens and Lipo 2005). For tasks involving proportional error, even this copying can lead to stasis[8] (Hamilton and Buchanan 2009). But Stout et al.'s specific model (~based on action details) lacks proportional error and therefore fails to fit overall stasis (Tennie et al. 2016, 2017).

Stout et al. also claim that emulation *alone* can lead to cumulative culture, but when we tested this in children, it did not (Reindl and Tennie 2018). They also claim that the distinction between emulation and imitation is meaningless and should be collapsed, but then why do untrained apes emulate pure environmental results (Hopper et al. 2008) but fail to imitate pure actions (Clay and Tennie 2017)? Why do they not solve difficult tasks better after seeing both actions *and* results underlying the solution than when they merely see the underlying results (Tennie et al. 2010)? Why *is* training required for apes to enable action copying, and why does this lead to brain changes that are linked to action-copying (Pope et al. 2018)? The best answer is that apes are not good, natural imitators (action copiers). Instead, they are emulators. Humans emulate *and* imitate (Tennie et al. 2009[9]), and these simultaneous copying skills enable special forms of error-correction that can increase copying fidelity beyond the level required to escape the ZLS (Acerbi and Tennie 2016; compare Lewis and Laland 2012).

I am pleased that archaeologists examine when human-like culture first arose. However, for the reasons above and in Tennie et al. (2016, 2017), I am still of the opinion that the latent solutions account remains the most parsimonious hypothesis for ESTs: not least because it does not involve detailed copying – and thus *predicts* the observed stasis[10].

## References

Acerbi, A., and C. Tennie. 2016. "The role of redundant information in cultural transmission and cultural stabilization". *Journal of Comparative Psychology* 130,1: 62-70.

[5] The clue is in the name.
[6] Often erroneously called "two action" tasks.
[7] And so, not every case of copying escapes the ZLS (contra claim C).
[8] Because its mean and variance decrease across generations. Many thanks to Luke Premo who opened my eyes on this.
[9] In humans this is perhaps the outcome of another, continuing triple inheritance feedback loop; compare Heyes 2018.
[10] But also because it includes exaptations.

Bandini, E., and C. Tennie. 2017. “Spontaneous reoccurrence of “scooping”, a wild tool-use behaviour, in naïve chimpanzees”. *PeerJ* 5, e3814: 1-26.

Custance, D., A. Whiten, and T. Fredman. 1999. “Social learning of an artificial fruit task in capuchin monkeys (*Cebus apella*)”. *Journal of Comparative Psychology* 113,1,13: 988-996.

Clay, Z., and C. Tennie. 2017. “Is overimitation a uniquely human phenomenon? Insights from human children as compared to bonobos”. *Child Development*. 10.1111/cdev.12857

Eerkens, J. W., and C.P. Lipo. 2005. “Cultural transmission, copying errors, and the generation of variation in material culture and the archaeological record”. *Journal of Anthropological Archaeology* 24,4: 316-334.

Hamilton, M. J., and B. Buchanan. 2009. “The accumulation of stochastic copying errors causes drift in culturally transmitted technologies: quantifying Clovis evolutionary dynamics”. *Journal of Anthropological Archaeology* 28,1: 55-69.

Heyes, C. 2018. *Cognitive gadgets: the cultural evolution of thinking*. New York: Harvard University Press.

Hobaiter, C., T. Poisot, K. Zuberbühler, W. Hoppitt, and T. Gruber. 2014. “Social network analysis shows direct evidence for social transmission of tool use in wild chimpanzees”. *PLoS Biology* 12, 9: e1001960.

Hopper, L. M., S.P. Lambeth, S.J. Schapiro, and A. Whiten. 2008. “Observational learning in chimpanzees and children studied through ‘ghost’ conditions”. *Proceedings of the Royal Society of London B: Biological Sciences* 275,1636: 835-840.

Lewis, H. M., and K.N. Laland. 2012. “Transmission fidelity is the key to the build-up of cumulative culture”. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 367, 1599: 2171-2180.

Morgan, T.J.H. 2016. “Testing the cognitive and cultural niche theories of human evolution”. *Current Anthropology* 57,3,370-377.

Pope, S. M., J.P. Taglialatela, S.A. Skiba, and W.D. Hopkins. 2018. “Changes in frontoparietotemporal connectivity following do-as-I-do imitation training in chimpanzees (*Pan troglodytes*)”. *Journal of Cognitive Neuroscience* 30,3: 421-431.

Reindl, E., and C. Tennie. 2018. “Young children fail to generate an additive ratchet effect in an open-ended construction task”. *PloS ONE 13*,6: e0197828.

Tennie, C., J. Call, and M. Tomasello. 2006. “Push or pull: Imitation vs. emulation in great apes and human children”. *Ethology* 112,12: 1159-1169.

Tennie, C., J. Call, and M. Tomasello. 2009. “Ratcheting up the ratchet: on the evolution of cumulative culture”. *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 364,1528: 2405-2415.

Tennie, C., J. Call, and M. Tomasello. 2010. “Evidence for emulation in chimpanzees in social settings using the floating peanut task”. *PLoS ONE* 5,5: e10544.

Tennie, C., D.R. Braun, L.S. Premo, and S.P. McPherron. 2016. “The Island test for cumulative culture in the Paleolithic”. In: *The Nature of Culture*. *Series: Vertebrate Paleobiology and Paleoanthropology*, edited by: M.N. Haidle, N.J. Conard, and M. Bolus, 121-133. Dordrecht: Springer

Tennie, C., L.S. Premo, D.R. Braun, and S.P. McPherron. 2017. “Early stone tools and cultural transmission: Resetting the null hypothesis”. *Current Anthropology* 5: 652-672.

Whiten, A., J. Goodall, W.C. McGrew, T. Nishida, V. Reynolds, Y. Sugiyama ... and C. Boesch. 1999. “Cultures in chimpanzees”. *Nature* 399,6737: 682.