reviewer 1 review

score 5/5

Type of Submission

Cognitive Science

The Review

This paper makes an interesting contribution to the question of how knowledge of

problem-solving is accumulated in human cultures. I think it would be of general

interest to Cogsci participants. It is clearly written and promises to be an

interesting presentation.

I have a few comments. It is clear that verbal instruction itself is not a

strategy that really benefits humans in terms of their learning new skills or

learning to solve problems. Humans do not learn better through verbal instruction,

and the ethnographic literature clearly indicates that in modern societies of all

kinds, life skills are not generally learned via verbal instruction, but by

watching, paying attention and being good at imitation. (Which chimps and other

apes are not as good at.) This applies to all sorts of life skills, from farming

techniques and hunting to dentistry and surgery! Humans excel in the biological

propensity to learn in a social setting, sometimes termed docility. Other species

may indeed benefit from social learning, but none has the ramped-up specialization

of docility that humans have. This in and of itself may be responsible for the

cumulative cultural evolution that we find.

It is also worth noting that the ‘ancestors’ in this experiment were of the same

cognitive capacity as the inheritors of the problems. This may well not be the

case in the real evolution of humans. A time of rapid change (punctuated

equilibrium) might have meant that very fast evolution of intelligence occurred

during some periods. In other words, an inheritor might just have been a lot

smarter than her ancestor a few short generations ago, and this might have led to

her ability to solve problems better.

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reviewer 2 review

score 5/5

Type of Submission

Cognitive Science

The Review

Review of Cumulative improvements in iterated problem solving

This paper presents experimental work investigating the cumulative cultural

evolution of problem solving. In a paradigm called "the Totem game", participants

build artefacts by finding specific combinations of materials over five

generations in an iterated learning chain. After each individual session the

'recipe' for artefacts are passed on to the next generation. The authors observe

accumulation of solutions making later generations produce more and more complex

tools.

I warmly welcome this interesting piece of work. The majority of studies on

cultural evolution have focused on diffusion and transmission and have thus tended

to leave innovation and emergence of new variants to the domain of unintentional

mutation, drift and cognitive biases (with some important exceptions). This study

show that human innovation can be an intentional process involving active search

for intelligent solutions. I consider this research both very timely, original,

and important.

The paper is well written and clear. Methods and analyses are appropriate.

However, there are a few issues that require authors' attention.

1) It is not clear what is transferred between generations in this study. It

seems to be a kind of recipe for artefacts (maybe a list of things to combine)

while new generations do not inherit the artefact itself. I.e. this is not really

emulation learning, but it is also not clear which kind of social learning it is?

It fact, the transmission/learning process either falls ambiguously in between

observation learning and teaching? Or - it could be argued to involve very

advanced and evolutionarily young processes of producing a kind of written

instructions? It would be great if authors could share their thoughts on how they

see transmission in this paradigm in relation to existing theories.

2) Following the previous comment: The authors talk about the transfer of

solutions. However, it is not clear whether the cumulative process in this study

is only an accumulation of solutions or also problem-solving strategies? The

authors notice that participants "must use tacit knowledge to help form

combinations that are most likely to yield new tools".

3) The authors themselves point to the fact that some of their findings -

especially the observation that the rate of innovation decreases over generation -

could possibly be an artifact of the experimental design. I very much agree. Cross

sectional data (e.g. from archeology) definitely do not support this finding.

4) Minor things: last sentence of the abstract: "We discuss the limitations

of thiswork, and motivate future directions" -> devide "thiswork" in two words

Page 4: "This rate was not found to vary based on the number of inherited tools,

as revealed by comparing a model predicting unique innovations from playing time

alone to one predicting unique innovations from the interaction between playing

time and inheritance size, ." -> delete last comma+white space.

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reviewer 3 review

score 5/5

Type of Submission

Anthropology, Cognitive Science, Psychology

The Review

This is a beautiful paper which experimentally explored the accumulation of

innovations (i.e., creating new tools) over consecutive generations. The authors

used a transmission chain game, where participants create new tools and pass their

innovations on to the next generation of participants. They find that participants

in later generations build up on their ancestors tools, improving performance over

time. The authors also show that inheriting more tools leads participants to make

less redundant guesses in the process of discovering new tools – suggesting that

richer input benefited participants’ learning strategies.

I highly recommend accepting it as a talk, and I think it will be of great

interest to the wide CogSci community. This paper presents novel results and novel

ideas in a well-written manner, has clear and nice visualizations, and was

altogether very interesting and thought-provoking to read.

A few minor things that should be addressed in the revised version:

1. The authors switch back and forth between the phrases “solving problems”

to “discovering tools”, which I found to be confusing. “Problem solving” triggers

slightly different associations (e.g., complex reasoning), while in this case

we’re mostly talking about simple combinations and educated guesses. For clarity,

consistency and accuracy, I would simply stick to the tool-making theme

throughout, and get rid of the problem-solving theme.

jjj2. The part in the discussion about the restrictions of the design (i.e.,

only one possible path to each tool; new tools are more likely to be combined)

belong in the \*methods\* section. These two issues bugged me throughout the results

sections, and would have been much better to acknowledge them sooner.

3. The results section has a lot of different measures (overall no. of tool

discovered, no. of new tools discovered, learning rates, discovery rates, types of

guesses etc.). It would be good to prepare the reader in advance for what is going

to happen by explaining all measures that were collected in the methods section.

Additionally, there are a lot of different analyses for each measure, but it’s not

always clear what these are (regressions models? If so, what was their fixed and

random effects structure?). If the authors need more space for these details, they

can definitely cut out the first two paragraphs of discussion as they were really

redundant.

4. In the regression model reported in “performance by generation”, it seems

like Generation Number was coded as a categorical variable. This seems strange

given that it can be treated as continuous or ordered, which would be more

informative. I would run this model to examine linear and quadratic changes in the

number of tools created over generations (see also comment 7):

Total no. of tools discovered ~ poly(generation,2) + (1+poly(generation,2) |

chain)

5. The sentence “we measured complexity as the combinatorial complexity of

the number of items in the participants’ inventories at the time a discovery was

made” was not clear. Is it the likelihood of discovering that specific combination

given the participant’s current inventory (more complex = less chances to be

discovered)?

6. What exactly is “discovering a tool by chance alone”? Is “chance alone” a

single guess (e.g., 1/1544 in generation 1), or a series of random guesses that

could be made in 25 minutes? These are very different, and in fact the latter

makes more sense to me (though I suspect the authors measured this with a single

guess). It’s important to establish what exactly the chance-level of this measure

is (i.e., how many guesses can be made on average during 25 minutes, divided by

the number of possible combinations).

7. “Diminishing return” is a bit vague. I assume the idea is that the

increase in the number of tools levels off in later generations (i.e, the increase

in not linear). This could be written more specifically, and also attested for

using the model mentioned above.

8. In Fig. 2’s caption it’s mentioned that items can be “refined”. How is

this done? Refinement was not mentioned anywhere in the text.

9. In Fig. 3, some of the lines are shifted to the left.

10. The part out outliers marked with X belongs in the caption of Fig. 6 (not

in Fig. 5).

11. Fig. 8’s caption belongs in the main text (explaining what each guess

category means).

12. Better to avoid the term “problem solvers”: it’s leads to garden-path

sentences. Just use “participants” or “individuals”.

13. In the sentence “… other forms of problem solving that do not involve

vertical transmission” – Is the idea to compare these findings with one emerging

in purely communication scenarios?

14. There was a typo in “building tours of spaghetti” - should be “towers”.

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reviewer 4 review

score 4/5

Type of Submission

Cognitive Science

The Review

This contribution presents an experimental study looking the cumulative evolution

of problem solving. It is theoretically justified and technically sound, and a

nice little experiment! However, I think the paper can do more to justify why this

is different from previous studies and what gap it is filling in the literature.

The 2nd paragraph of the conclusion say that the study "examined the likelihood

that problem solving knowledge would accumulate given that problem solving

knowledge could be effectively transferred to the next generation" - This is

presented as being different from the ability to have verbal instructions, or the

ability to just watch people doing the task before you, but I'm not sure how

different these things are different. Is it the cumulative aspect of it? I think

this needs to be really clarified and sign-posted.

The writing is mostly excellent, but there were a few points I had:

I think the paper would have benefitted from outlining your research questions

more specifically in the introduction. At the minute the beginning of each results

sections (“Next we asked…”) comes as a surprise.

{{{I think you need to acknowledge at the end of the “performance by generation”

section that later generations might have made fewer discoveries because more of

their time was spent completing the recipes of those before, I know you go on to

address this in the rate of discovery section but it feels like a bit of a hole at

the minute.

“ Data was collected for a total of 42 teams (N=168 participants).”

- this confused me because the word “teams” made me think it was a group activity

and i’d missed something so I went back and read the methods again. I see that you

mean chains, which is perhaps a better word to use here.

“ found evidence that the number of tools discovered within each chain increased

over generations Page’s L = 1193, c2 = 234, p < 0.001”

- you at least need a comma before the stats here.

“interaction between playing time and inheritance size, .”

- weird comma+full stop combo at the end of this sentence

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