**Description of the experiments**

A detailed description of the experiments based on these data can be found in: Reindl, E., Apperly, I. A., Beck, S. R., & Tennie, C. (2017). Young children copy cumulative technological design in the absence of action information. *Scientific Reports*

# Pilot study

2 conditions:

* baseline condition (run first, in order to establish children’s baseline performance)
* full demonstration condition (run after data collection for baseline was completed. This was because we used children’s baseline performance in order to create a tower that no baseline child had invented and which we could demonstrate to the children in the full demonstration condition as a culture-dependent trait)

## *Participants*

We tested 34 children (15 boys) between 4 and 6 years (Mage = 4 years 10 months (4;10), SD = 5.14 months, range: 4;1 to 5;9) from a metropolitan area in the UK.
Ethnic composition was 53% Caucasian, 29% Black, and 18% Asian.
Baseline children were tested first, in nursery schools. Children in the full demonstration condition were tested once the data collection for the baseline was completed and were recruited via advertisements on a local parenting website and on the website of the science museum where the testing for this condition took place.
Parents willing for their child to participate gave written informed consent.
Seventeen children (six boys) were assigned to the baseline, the other half to the full demonstration condition. There were no differences in age (*t*(32) = 0.662, *p* = .513, Cohen’s *d* = 0.228) or sex (χ2(1) = 0.477, *p* = .490) between conditions. Participants were rewarded with a sticker regardless of success.

## *Material*

Warm-up game

We used a day-night Stroop task consisting of 24 cards showing a picture of either daytime or nighttime (Gerstadt, Hong, & Diamond, 1994). Children should say “night” when shown the day card and “day” when shown the night card. We chose this game as pilot work showed that children were motivated to play this game, it required little space and material, and could be adapted to children’s skill level. The task was used to familiarize children with the experimenter (E); responses were not recorded.

Construction task

Each participant was provided with 30 white solid plastic lollipop sticks (length = 15 cm, diameter = 4.5 mm) and 70 g of green plasticine, first presented as one ball and then formed into three separate balls during a short demonstration of the materials (see procedure). Children sat on the floor and had access to a low grey table (40 x 35 x 15 cm). Constructions were built on a wooden board (25 x 25 x 2 cm) attached on top of the table with a bar clamp. At the end of each session, the clamp was opened and the board together with the construction transferred to another section of the testing area where photos were taken. Further materials were a folding rule to measure the height of the constructions, a stopwatch, a video and a still photo camera as well as a white sheet as the photo background.

## *Procedure*

Children were tested individually by E. Both were sitting on the floor, at the low table. After the warm-up, E told children that she had a special game for them which would be played at the table. She explained that the game was “to build something that is very high, as high as you can make it”. E showed children the plastic sticks and the plasticine and said: “You can use these things to help you build it. You can do anything you like with these things to try to make something very tall. You can use all of these [E pointed to lollipop sticks] and all of this [pointed to plasticine]. Also, with this [E took plasticine] you can do things like this [E tore one third off of the ball] or this [E tore another third off, then rolled it].”

Participants in the baseline condition were told that they did “not have much time to build something that is as high as possible”, so they needed to be quick. E placed the three plasticine balls on the table next to the board and the sticks on the floor in front of the children. Children were then encouraged to start building.

Participants in the full demonstration condition were told that the game involved turn-taking, so that E would start first and that the child’s task was to watch her. When the time was over, it would be the child’s turn to “build something that it as high as possible”. E then put the child’s materials out of reach and fetched a new set to build a tripod. The construction was chosen to be 46 cm tall in order to be substantially greater than the maximum height achieved by the baseline group (33.5 cm). After building her tower (50 - 60 sec), E announced that it was the child’s turn now. She put the board with the tripod on the floor to the left of the table and removed the rest of her building materials. Children were given a new board, three plasticine balls (lying next to the board), and 30 sticks (on the floor in front of the children). As in the baseline condition, children were told that they did “not have much time to build something that is as high as possible”, so they needed to be quick. They were then encouraged to start building.

Building time in both conditions was 6 min. While children were building, E sat next to the table making notes and did not intervene. If participants did not begin building, E encouraged them by saying “Try to make something very high with these things!” If children asked for help, E replied “Let’s see what you can do – see how high you can make it!” In cases where children said they were finished before the time was over, E encouraged them to continue by saying “You still have some time left! Try to make it even higher!”

When time was up, children were not allowed to touch the construction anymore. Children who held their construction in their hands were asked to place it on the table and those who stabilized it with their hands were told to let go. Towers that could not stand on their own had to be placed horizontally on the table. Tower height was measured at the tallest point of the construction (note that for towers that were lying horizontally, we measured the actual height, not the potential one when held upright). Once the participant had left the room, E took pictures of the construction (one from each side, one from above). The constructions were destroyed before the next child arrived at the testing area; also, every participant received a new set of sticks and plasticine. Total testing duration was 10 to 15 min.

## *Coding and analysis*

With regard to the baseline condition, we were interested in the design and height of the towers that children were able to make on their own. Based on these data, we created the cumulative technological product for our study: a tripod. With regard to the full demonstration condition, we were interested in whether children would be able to copy the tripod from a full demonstration. In addition, we investigated whether children would build taller towers than children in the baseline condition.

For this, we measured tower height (measured at the end of the trial) and tower shape.

Tower height

Tower height represented the height of the construction at the end of the trial. Therefore, tower height did not necessarily reflect the maximum height achieved by the child, as in some cases towers crashed and could only partly be rebuilt in the remaining time. This was especially the case for the full demonstration condition: For 9 out of 17 children, the towers with the maximum height crashed or were disassembled and rebuilt. Thus, at the end of the trial, towers with a smaller height than the maximum height achieved were measured, which potentially underestimated children’s performance. In the baseline, there were only four children for whom the final tower did not represent the tower with the maximum height. Although we were not able to establish the exact height of towers that did not “survive” until the end of the trial, we were able to determine their height in “stick levels” from the videos.

Tower shape

The shape of the tallest tower was coded offline by E based on photos and video stills. For children for whom the final towers were also the tallest towers, we based this classification on the photos taken at the end of the trial. For children for which the tallest tower was built throughout the session but did not “survive” until its end (because it crashed or because children disassembled it; baseline: n = 4, full demonstration: n = 9) we coded both the final tower (using the photos taken at the end of the trial) and the tower with the maximum height (using stills from the video).

First, we determined tower height in what we labelled stick levels: We counted how many sticks were vertically combined on top of each other (“combining” meaning two sticks joined vertically with a piece of plasticine, while an overlap of up to half the length of a stick was allowed). This allowed us to group the towers into four categories: Level-0-constructions (towers that were smaller than the height of one stick, e.g., towers lying on their side or constructions consisting only of plasticine); level-1-constructions (constructions with one (or more) sticks placed vertically into a plasticine base); level-2-constructions (comprising any constructions in which two sticks were combined on top of each other); and – applying the same logic – level-3- and level-4-constructions (note that the tripod falls into the level-3-constructions group). We further grouped the towers within each stick level category based on their shape, resulting in one to three shape categories per stick level.

# Main study

## *Participants*

We tested 73 children (34 boys) between 4 years 2 months and 5 years 8 months (Mage = 5 years 0 months, SD = 4.31 months) in nurseries and a science museum in a metropolitan area in the UK.
The ethnic composition was 59% Caucasian, 27% Asian, and 14% Black. Written informed consent was obtained by participants’ parents or guardians prior to the study. Children were randomly assigned to the baseline (n = 23, 43.5% male), full demonstration (n = 23, 56.5% male) or endstate demonstration condition (n = 27, 40.7% male); comparable numbers of children from each testing site were represented in each condition.
There were no differences in the distribution of age (Kruskal-Wallis-test, χ2(2) = 0.963, *p* = .618) between conditions.

## *Material*

For the warm-up, E placed five plastic spinning tops (diameter 3.5 cm) on the table and invited children to play together.
To investigate whether participants understood the meaning of “taller”, we included a control question after the warm-up game. E presented children with two Playmobil® giraffes of differing sizes (adult giraffe and calf, height 15.5 and 8 cm) and asked them to show her the taller animal.
For the construction task, the materials were the same as in the pilot study, with the following additions: In the demonstration conditions, a box with the same height as the table at which children were building was placed around 20 cm behind the table. This was where E moved the tripod to after presenting it to the children on the table (rather than placing it on the floor). In addition, in order to measure tower height throughout the trial, we used an expendable folding rule attached to the table, opposite of where E was sitting. The measurement was done by visual judgement, a procedure shown to be sufficiently reliable. Tower height at the end of the trial was measured with a loose folding rule held right next to the construction.

## *Procedure*

The procedure was largely the same as in the pilot study. After the warm-up, we tested children’s understanding of the concept “taller” with a control question for which children were shown two Playmobil® giraffes of differing sizes and asked to indicate which animal was taller. Children who did not answer correctly also proceeded to the construction task but their data were excluded from the analysis. For the construction task, E said: “The game is to build something that is very tall, as tall as you can make it”. She presented children with the material as she did in the pilot study.

In the demonstration conditions, E said: “Before you start, let me show you what I did earlier!” In the full demonstration condition E built the tripod (~50 - 60 sec). Upon completion, she said “Finished!” and looked at the tripod for 5 sec. She then placed the tripod on the box behind the table, where it was available for inspection throughout the trial. In the endstate demonstration condition, E fetched a board with a ready-made tripod from behind a barrier standing next to her and placed it on the table. She looked at it for 5 sec and moved it to the box. The rest of the instructions in the demonstration conditions was the same as the instruction children in the baseline were given: E said: “You don’t have much time to build something that is as tall as possible”; this was to induce them to be quick as their building time was only 6 min. E then encouraged children to start building.

During the building phase, E took measurements of children’s towers using a folding rule attached to the table, each time participants made an addition to their construction which increased its height and if the construction was standing on its own (i.e., children did not stabilize it with their hands). When the time was up, children were not allowed to touch the construction anymore. Children who held their construction in their hands were asked to place it on the table and those who stabilized it with their hands were told to let go. Towers that could not stand on their own had to be placed horizontally on the table. Tower height was measured again with a loose folding rule held right next to the construction. Once each participant had left the room, E took pictures of the construction (one from each side).

## *Coding and analysis*

We were interested in whether children in the demonstration conditions would be able to copy the demonstration tripod. In addition, we investigated whether children in the demonstration conditions would build taller towers than children in the baseline. We measured tower height (height of the tallest construction a participant built) and tower shape of the tower with the maximum height.

Tower height

Tower height was measured several times: throughout and at the end of the trial. This allowed us to identify each participant’s tallest construction, even if the construction did not “survive” until the trial end, e.g., because children disassembled it or because it collapsed due to being too instable or because children tried to further modify their construction. Since instances of tower collapses often resulted from the fact that we encouraged children to use the full building time (i.e., even when children announced they were finished we encouraged them to continue building in order to ensure equal construction time among participants), we measured tower height continuously to ensure that we made a fair evaluation of children’s performance. Consequently, for some children tower height represented the height of the tower which stood on the table at the end of the trial, whereas for other children tower height represented the height of a tower that they had built during the trial, but that did not survive until the end.

We analyzed whether maximum tower height differed between conditions, using a multiple regression including condition (baseline, full demonstration, endstate demonstration) as the predictor, sex (dummy-coded), and age (covariate) as control variables, but no interaction as we did not predict one. Prior to fitting the model, we confirmed that tower height and age had symmetrical distributions. We z-transformed age to a mean of zero and a standard deviation of 1 in order to facilitate the interpretation of the coefficients. We checked the following model diagnostics: normal distribution and residuals plotted against fitted values (to check for homoscedasticity of residuals), DFFits and DFBetas, Leverage, Cook’s distance, Generalized Variance Inflation Factor, and Levène’s test of equal error variances. There were no obvious deviations from the model assumptions. To determine the effect of condition, we compared the fit of the full model with the fit of a model lacking condition as a predictor. The model and the diagnostics were run in R (version 3.2.3, R Core Team, 2013), the Generalized Variance Inflation Factor was calculated with the function “vif” of the R package “car” (Fox & Weisberg, 2011). Sample size for the analysis was 73; the alpha level for all analyses was .05.

Tower shape

The shape of children’s tallest tower was coded offline based on photos and video stills in the same manner as in the pilot study.

# References

Fox, J., & Weisberg, S. (2011). An R companion to applied regression (2nd ed.). Thousand Oaks, CA: Sage.

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 3½-7 years old on a Stroop-like day-night test. Cognition, 53(2), 129-153.

R Core Team (2013). R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from: https://www.R-project.org