CONFIDENTIAL - FOR PEER-REVIEW ONLY

Symlit_Rep_Study2: orientation&position (#100735)

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1) Have any data been collected for this study already?
No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?
We investigate young children's ability to spontaneously identify relations between a graphical symbol and one of two possible referents in a symbolic object-choice-task. Our main aim is to determine the age at which children's group-level performance surpasses chance-level when presenting them with stimuli exemplifying different symbol-referent-relationships, such as:

- Orientation of Object (orob): the graphical cue and referent have different shapes but share the same orientation (e.g. horizontal/vertical)
- Orientation of Feature (orfe): the graphical cue and referent but both have a salient feature and are pointing in the same direction
- Absolut Position (abpo): the graphical cue and referent appear in the same position on the hiding place (target) or the paper (cue) respectively
- Relative Position (repo): the graphical cue and referent consist of two shapes that are either close or apart, or align horizontally or vertically

We hypothesize that children will succeed earlier with orob than orfe and earlier with apbo than with repo.

3) Describe the key dependent variable(s) specifying how they will be measured.
The key dependent variable is children's choice behavior in the object-choice-task. Two choice items (target and distractor) serving as possible referents are presented on the left and right side of the screen. Children respond by touching the item of their choice on a touchscreen. Children's choices are coded as correct when choosing the target (1) or incorrect when choosing the distractor (0).

4) How many and which conditions will participants be assigned to?
In a blocked (4 trials per task) and counterbalanced within-subjects design, children will be presented with the four types of symbol-referent-relationships described above serving as experimental tasks.

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
All analyses will be computed in R (R Core Team, 2018). Bayesian models will be run in Stan (http://mc-stan.org/) and implemented via the function brm of the package brms (Bürkner, 2017). We will use logistic Bayesian generalized linear mixed models (GLMM) to fit children's responses (0/1) as a function of their absolute age in days, task (orob, orfe, abpo, repo) and an interaction between trial and task. We use default priors and include trial and sex as fixed effects to be controlled for. Trial number will be added as a random slope within subject.

Model: correct ~ task*z.age +z.trial +z.sex +(z.trial|id)

- correct: correct choice (0/1)
- z.age: age in days, centered to a mean of 0
- z.trial: trial number, scaled
- z.sex: participants' sex (male/female), scaled

The analysis will model participants binary choices to predict the probability of children interpreting the cues correctly and model how this probability will change as a function of their absolute age in days. In order to evaluate the relevance of age and task type for children's performance, we will compare a full model as specified above with a reduced model lacking the interaction of age and task by using WAIC scores and weights (McElreath, 2016). Furthermore, we will inspect the model estimates for the different predictors (including their 95% Credible Interval (CrI)). In addition, we use the model to predict the developmental trajectory (with 95% CrI) for each task type. The criterion for settling when children perform above chance with either type of stimuli is the point at which the 95% CrI for a particular trajectory does no longer overlap with a midline demarcating the 50% chance level.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.
To familiarize children with the hiding game and the touch interface, they first complete a set of four to eight familiarization trials with feedback in which a desired item is hidden in plain sight. In order to enter the main study phase, children should have a success rate of 75% in the familiarization. The experimental script provides at least four trials. If three in four are correct, the child proceeds to the main phase. If not, four additional familiarization trials are run. If the child is correct in six out of eight trials, she is included in the main sample. If children do not fulfill the criterion in a maximum of eight trials, they are excluded and replaced.
Participants will be excluded and replaced if they contribute less than eight valid out of sixteen possible test trials. Exclusions may be due to participants not making a choice, due to being fussy or shy, or when wanting to quit early.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

Starting at 36 months, we will test two children per month over a range of four years (48 months) for a sample of 96 children. While using age as a continuous predictor is less common in developmental studies, this design yields sample of at least 24 children per year of age which is in line with conventions in the field. Due to the possibility of children quitting early or not contributing enough valid trials, individual participants may not provide data in all four tasks. In that case, data collection will continue until there are at least two participants per month of age in every task.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

An additional exploratory analysis will include a random effect for item level effects (Model: correct ~ task*z.age +z.trial +z.sex +(z.trial|id) +(z.age|item)). Results will help to evaluate the equivalence of items within a task and be reported in the supplements. Due to the low number of individual items within a task we expect this model to be less diagnostic with regard to our main research question and, therefore, will not include the term in the main analysis.