# Replication of Study 4

# by Dessalegn & Landau (2008, *Psychological Science*)

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# Introduction

The interaction between language and cognition has been of interest to many. Dessalegn and Landau (2008) explored the hypothesis that language may help maintain visual feature conjunction, in particular the conjunction of color and location features. They studied this question with 4-year-old children, where failure to bind visual features may be more common than among adults due to weaker attentional control.

In four studies, children were presented with trials where they first saw a square split symmetrically into a green and a red part along the vertical, horizontal or diagonal axis. Then they had to identify the target in a set containing the target, its mirror image, and a foil. Of critical interest was the effect of the instructions children received during the initial target viewing. Study 2 showed that directional language (e.g., ‘the red is *to the left of* the green’) helps children remember the color-location features of the targets. Study 3 eliminated the possibility that the effect was simply due to increased attention to the targets. Study 4 further eliminates the possibility that the effect was due to the relational information in directional language (x *to the left of* y implies a relation between x and y). This is done by comparing children’s performance when exposed to directional language and when exposed to relational language (e.g., ‘the red is *touching* the green’). Study 4 is the target of this replication.

# Methods

## Power Analysis

The reported effect size of condition (directional vs. neutral/relational language) was d = .82. We calculated the observed power to be .62. Given that the effect size statistic reflects a t-test (rather than the ANOVA analysis that was carried out and included other variables), and that the effect of condition is of main interest, the power analysis was based on conducting a t-test. The power analysis also assumed a 2:1 ratio of the samples in the two conditions, which was a feature of the original study. The sample size required to detect an effect size of d = .82 with power of 80%, 90%, 95% was calculated to be 44, 60, and 74 children. Given the difficulty of accessing children, the target power of this replication is set at 80%.

## Planned Sample

45 4-year-old children (range 4;0 – 5;0, mean 4;6) will be recruited from a mid-size urban community in Southeast Ontario. All children will be native speakers of English. Following Dessalegn and Landau’s procedure, 30 children will be randomly assigned to the directional condition and 15 to the relational condition.

## Materials

The experimental stimuli were shared by the authors. They consisted of squares split in half by color (red, green) along one of three axes (vertical, horizontal, or diagonal). We re-recorded all sound instructions following the models we received. This was done because some files were missing, and we judged it desirable that all instructions be given by the same female voice. We constructed the practice trials following these trials’ description in the paper. The first two trials used two familiar animals as targets and the next four used novel shapes. (So we used 6 familiar items and 10 symmetrical shapes split into a black and a white half for the practice trials.)

## Procedure

Fig. 1a of the paper, reproduced below, illustrates the structure of experimental trials.

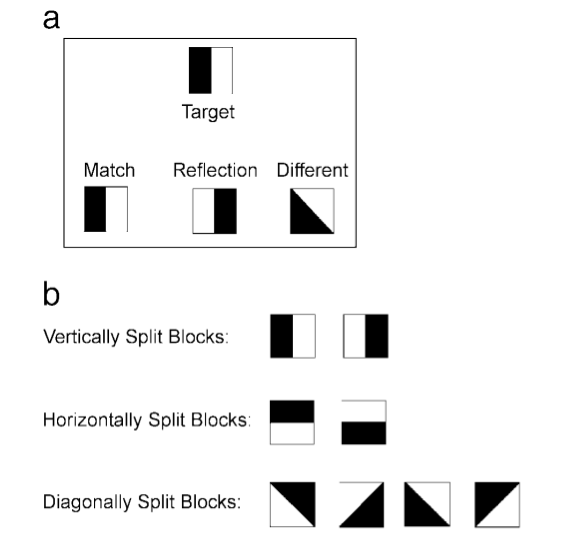


Figure 1a

On each trial, one of six different targets appears at the top center of a computer screen (see Fig.a). After it disappears, the three shapes in the bottom appear and children have to identify the one they have just seen.

The following description joins relevant text that appears on p. 190-193 of the paper:

On each trial, one of [six] different targets appeared at the top center of a computer screen. [This included 2 vertically split, 2 horizontally split, and 2 diagonally split squares.] After the children looked at the square, the experimenter said, ‘‘Let’s ask where the red is. Where is the red?’’ She then said,‘‘The red is . . .,’’ and after a click with the mouse an audio file played a voice that completed the sentence appropriately. In the neutral condition, the completion used relational but nondirectional terms: ‘‘… touching/connected to/next to/up against the green.’’ For children in the directional condition the continuation included directional terms: ‘‘… to the left/right/top/bottom of the green.’’ (For the vertically split targets, the recorded voice said ‘‘left’’ or ‘‘right’’; for the horizontally split targets, the voice said ‘‘top’’ or ‘‘bottom.’’ For the diagonally split squares (which could be labeled either way), half of the children were told the red was on the ‘‘left’’ or ‘‘right,’’ and the other half were told it was on the ‘‘top’’ or ‘‘bottom.’’) The experimenter said, ‘‘I want you to help me find one that is exactly the same’’ and the target then disappeared. After a 1-s delay, three test objects appeared at the bottom of the screen: the target’s match, its reflection, and a differently partitioned square. The children were asked to select the square that ‘‘looks exactly the same as the one you just saw.’’

Before the experiment, the children received 6 practice trials, 2 using familiar targets (e.g., animals) and test items from different categories, and 4 using novel symmetric shapes split in half by color and test items that included the target, its reflection, and a second distractor.

The verbal instructions were shared by the authors. They also shared their exact trial composition. Following further information we received, the experimenter will control the presentation of the stimuli the entire time and children will not be allowed to do their own button pressing to advance through the study.

## Analysis Plan

The original analysis was a 2x3 ANOVA using condition as a between-subject variable and trial (horizontal vs. vertical vs. diagonal split of the target) as a within-subject variable. No exclusion rules are reported and no participants or trials are reported to be excluded.

We plan to use a t-test to test the effect of condition, which is of focal interest. We will exclude participants who 1) fail to complete the study, or 2) their average reaction time is 5SD above the sample mean.

## Differences from Original Study

1. Sample: The paper provides very little demographic information about the sample (e.g., no gender, SES, or language background). We believe, and the authors confirmed that the children were recruited in an urban area (Baltimore, USA) and were English speakers. The children in the replication will be Canadian, native English speakers, from varied SES. It is possible that language background would be different from the original sample (due to passive or active exposure to French).
2. Analyses: We plan to use a t-test to test the effect of condition rather than 2-way ANOVA (see above for rationale). We have also specified several exclusion criteria which are common in developmental practice.

We do not believe that any of these differences would impact our ability to detect the effect.

# (Post Data Collection) Methods Addendum

## Actual Sample

Forty-nine Canadian 4-year-olds participated in the study.

All participants completed the study (exclusion criterion 1). For one child, however, data were not available due to equipment failure.

Criterion 2 proved to be inappropriate. It was meant to capture lack of engagement with the task and lack of attention. However, no child performed 5SDs above the mean. Instead, one child was excluded because he failed the first two practice trials, even though the extensive explanation of the task was repeated after the first trial. Thus, it was not clear he understood the task. The child also appeared disinterested and uncooperative early into the activity.

The remaining sample consisted of 19 girls and 28 boys with mean age 4 years 6 months (range 48 to 59 months). All children were native English speakers but 15 had exposure to French as a native language or at school and 2 more to another language. Participants were randomly assigned to the directional (*n* = 31) and the relational condition (*n* = 16).

## Differences from pre-data collection methods plan

We used normal color vision as a participant selection criterion.

# Results

## Data preparation

The proportion of trials (out of 24) on which a child selected the match was used as a dependent variable in the analysis in a two independent group t-test.

## Confirmatory analysis

Consistent with the results of Dessalegn and Landau (2008), children in the directional condition selected the match more often than children in the relational condition (Mdir = .66, SDdir = .187; Mrel = .576, SDrel = .164). Performance in the directional condition, however, was not significantly different from performance in the relational condition, *t*(45) = 1.534, *p* = .132, Cohen’s *d* = .48.

## Exploratory analyses

Examination of the data revealed that two children chose the different split distractor option (see Fig. 1) 50% or more of the time (*p* = .06 with chance at 33%). Only trials with horizontally split targets were considered here because of the left/right instructions associated with the vertically split square trials. Left/right are potentially more challenging instructions (4-year-olds may not yet have solid knowledge of these terms) and could contribute to performance difficulties and the generation of arbitrary strategies. Given that these two children may not have followed the instructions but used a “choose the odd one” strategy, we conducted an exploratory analysis without them. Correspondence with the authors revealed that children performing 2SD below the mean were excluded from the original analyses (B. Dessalegn, Dec. 1, 2014). One of the two children under discussion fit this criterion as well.

Without the two children apparently using a ‘choose the odd one’ strategy, both of whom were in the directional condition, participants in the directional condition were significantly more likely to select the match than children in the relational condition, (Mdir = .685, SDdir = .163), *t*(43) = 2.161, *p* = .036, Cohen’s *d* = .67, observed power .56.

# Discussion

## Summary of Replication Attempt

Dessalegn and Landau (2008) presented a set of intriguing findings suggesting that directional information in language, contained in spatial terms such as “on top of” and “to the left of,” can contribute to feature binding of color and location information in memory. The present study provides a partial replication of their findings. Specifically, while replicating the direction of the effect, we failed to replicate its size and significance even though the present study had greater power.

## Commentary

We consider three issues that may relate to our failure to replicate the original result.

First, it is likely that sample differences exist between the studies. The two samples were matched on age and native language but they came from the US and Canada. As expected due to the status of French as a national language in Canada and educational practices promoting bilingualism, a third of our participants had exposure to French. Such prevalence of exposure to French is unlikely in a sample from Baltimore, MD (although exposure to Spanish is). Unfortunately, the demographic description of the original sample is lean. Thus, except for the global US vs. Canada difference, and the type of second language exposure, differences between the samples are unknown. Demographic factors, however, may be important for the effect under investigation. For instance, research has documented gender differences in spatial ability (esp. location encoding, Geary, 2010). With respect to language background, bilingualism has been associated with better executive functioning and spatial reasoning (Greenberg, Bellana, & Bialystok, 2013).

Second, transient nature of the effect under investigation. Dessalegn and Landau (2013) provide a replication of their 2008 study while also showing that 3-year-olds’ markedly worse performance and 6-year-olds’ markedly better performance are not modulated by language. Thus, it appears that the effect of language on feature binding documented in the study targeted by this replication is transient. If so, then the effect may be particularly difficult to capture and replicate across samples, languages, and cultures. For example, characteristics such as education and SES background affect both language and memory development and could ‘move’ up and down the effect on the developmental timeline. Given this transiency of the effect, the fact that the present study found differences in the same direction (and of about the same absolute size – 10%) is quite remarkable. That said, this transiency also suggests that the true effect size associated with the role of language on 4-year-olds’ feature memory is likely below the original, large, effect size of .82.

Third, our exploratory analyses suggested that some children may employ strategies such as ‘choose the odd one’ at test. Such patterns of responding were not observed in the original study (B. Dessalegn, p.c., Dec. 1, 2014) and could contribute to greater variability in the data. This particular strategy is easily accessible to children, as seen in its widespread use as a research tool (Blom, Kuntay, Messera, Verhagen, Meserman, 2014; Ceci, Fitneva, & Williams, 2010). One reasons it may not have been observed before is the use of small samples. Another reason could be sought in the transiency of the effect of language on feature binding in memory and the potential sensitivity of this effect to individual and context variables. Overall, the children in our study performed worse than the children in the original study, in between the levels of performance observed for 3- and 4-year-olds by Dessalegn and Landau (2013). If the participants in the present study found the task more challenging the participants in the original study, they clearly would be more likely to show strategic behavior.

In conclusion, the present study was not able replicate the results of Study 4 of Dessalegn and Landau (2008). Nevertheless, the patterns in the data, together with other information that has emerged about the effect (Dessalegn and Landau, 2013) support the possibility that language may play a role in feature binding and object representation in memory. Ascertaining the size of this effect, its generality, and timing would require, however, larger and well characterized samples.

# References

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