Rooms Without Walls: Young Children Draw Objects But Not Layouts
Supplemental Material
Moira R. Dillon

Supplemental Materials and Methods

For practice trial picture and full experimental script, see the OSF: osf.io/5wng2

Supplemental Data

For the full set of children's drawings, original and coded (by the first coder), see the OSF: osf.io/5wng2

Supplemental Analyses and Results

Reliability analysis

The preregistered analysis specified a mixed-model ordinal logistic regression, predicting coder 1's coding by coder 2's coding, for both count and dimensionality data. After data collection was complete, it became clear that this model for reliability was misspecified. Count reliabilities were thus conducted with intraclass correlation coefficients (see main text). Dimensionality reliabilities were thus evaluated only by the separate analysis of naïve coder 1's dimensionality data (see below).

Naïve coding and analyses

As planned, two hypothesis-naïve coders used photographs of the fort and toy to recode the count and dimensionality of the spatial elements that children drew in Experiments 1 and 2. The first naïve coder for each experiment recoded all of the drawings, and the analyses of the main text were repeated with the naïve-coded data. The second naïve coder recoded 25% of the drawings. The same reliability analysis was conducted between the first and second naïve coders as in the main text. The coding reliability for both experiments was moderate (fort: ICC(1,1) = .76, 95% CI [.67, .82]; toy: ICC(1,1) = .73, 95% CI [.64, .80]).

Experiment 1: Fort

A mixed-model Poisson regression with spatial element (wall or object) and configuration included as predictor variables, and participant included as a random-effects intercept, revealed main effects of both spatial element (Wald Test, $\chi^2(1) = 35.35$, $p < .001$) and configuration (Wald Test, $\chi^2(3) = 14.48$, $p = .002$). As in the main text, children drew more objects than walls (**Figures S2-S3**) and the number of elements they drew varied based on the fort configuration. When examining the configurations with decals, a second mixed-model Poisson regression with spatial element (wall, object, wall decal, or object decal) included as a predictor variable and participant included as a random-effects intercept revealed a main effect of spatial element (Wald Test, $\chi^2(3) = 15.42$, $p = .001$). Planned Holm-corrected pairwise contrasts also revealed that children drew significantly more objects than walls (**Figures S2-S3**).

A mixed-model ordinal logistic regression with spatial element (wall or object) included as a predictor variable and participant included as a random-effects intercept revealed that children drew objects with greater dimensionality than walls, as in the main text. The odds of children's drawing objects with greater dimensionality were 962% more likely than the odds of children's drawing walls with greater dimensionality (95% CI = [466, 1894], $p < .001$). For the two configurations with decals, the naïve coder did not rate any spatial elements as 3D. For this reason, the ordinal logistic regression model was no longer appropriate; a mixed-model binomial logistic regression with spatial element (wall, object, wall decal, object decal) as a predictor variable and participant included as a random-effects intercept revealed that children drew objects with greater dimensionality than walls (Planned Holm-corrected pairwise contrast, $P = .89$, 95% CI = [.83, .93], $p < .001$).

Experiment 2: Toy

A mixed-model Poisson regression with spatial element (wall or object) and configuration included as predictor variables and participant included as a random-effects intercept revealed a main effect of configuration (Wald Test, $\chi^2(3) = 15.37$, $p = .002$) but no main effect of spatial element (Wald Test, $\chi^2(1) = 0.16$, $p = .693$; **Figures S2-S3**). A similar analysis for the configurations with decals did reveal a main effect of spatial element (Wald Test, $\chi^2(3) = 12.29$, $p = .006$). Planned Holm-corrected pairwise contrasts did not find that children drew more walls than objects (**Figures S2-S3**). These results vary somewhat compared to the main analysis since that analysis found significantly greater counts of walls compared to objects in both regressions.

As in the main text, a mixed-model ordinal logistic regression revealed that children drew objects with greater dimensionality than walls. The odds of children's drawing objects with greater dimensionality were 1185% more likely than the odds of children's drawing walls with greater dimensionality (95% CI = [622, 2187], $p < .001$). This effect persisted when just examining the two configurations with decals: The odds of children's drawing objects with greater dimensionality were 396% more likely than the odds of children's drawing walls with greater dimensionality (Planned Holm-corrected pairwise contrast, 95% CI = [185, 763], $p < .001$).

Experiment 2: Comparing the Fort and Toy

To directly examine the differences in children's drawings across the two experiments, the same mixed-model regressions were conducted as above, but with experiment as an additional predictor variable. First, for element count, including walls and objects across all four configurations, there were main effects of both spatial element (children drawing more objects than walls; Wald Test, $\chi^2(1) = 18.40$, $p < .001$) and experiment (children drawing more elements for the toy versus fort; Wald Test, $\chi^2(1) = 5.95$, $p = .015$). Critically, and as in the main analysis, these results were further characterized by a significant spatial element by experiment interaction (Wald Test, $\chi^2(1) = 17.02$, $p < .001$): Children drew significantly more walls than objects for the toy versus fort. As in the main analysis, planned Holm-corrected pairwise contrasts revealed that children did not draw significantly more objects for the toy versus fort ($p = .774$), but they did draw significantly more walls for the toy versus fort ($p < .001$). The second regression, examining element counts in the two configurations with four spatial elements also revealed a main effect of spatial element (Wald Test, $\chi^2(3) = 8.52$, $p = .036$), but no main effect of experiment (Wald Test, $\chi^2(1) = 1.31$, $p = .253$). There was again a significant element type by experiment interaction (Wald Test, $\chi^2(3) = 19.12$, $p < .001$). Moreover, planned Holm-corrected pairwise contrasts revealed that children did not draw significantly more objects for the toy versus fort ($p = 1.000$), but they did draw significantly more walls for the toy versus fort ($p = .014$).

Finally, a mixed-model ordinal logistic regression examining element dimensionality for walls and objects across all four configurations revealed that children drew objects with greater dimensionality than walls. The odds of children's drawing objects with greater dimensionality were 483% more likely than the odds of children's drawing walls with greater dimensionality

(95% CI = [273, 813], $p < .001$). Children also drew elements with greater dimensionality for the fort versus toy: The odds of children's drawing elements with greater dimensionality for the fort were 62% more likely than the odds of children's drawing elements with greater dimensionality for the toy (95% CI = [43, 75], $p < .001$). The model did not reveal a significant dimensionality by experiment interaction (odds ratio = 0.88, 95% CI = [0.50, 1.56], $p = .662$). The model including all four element types across two configurations revealed that children drew objects with greater dimensionality than walls: The odds of children's drawing objects with greater dimensionality were 302% more likely than the odds of children's drawing walls with greater dimensionality (95% CI = [113, 654], $p < .001$). Children also drew elements with greater dimensionality for the fort versus toy: The odds of children's drawing elements with greater dimensionality for the fort were 67% more likely than the odds of children's drawing elements with greater dimensionality for the toy (95% CI = [42, 81], $p < .001$). The model did not reveal a significant element type by condition interaction (Planned Holm-corrected pairwise contrast, odds ratio = 1.17, 95% CI = [0.52, 2.64], $p = .714$).

<u>Analysis of fort and toy configurations without decals</u>

As part of the planned analyses, the spatial element (wall or object) counts and the dimensionality were examined in configurations without decals (**Figure 1**, first two configurations). The results are convergent with the results of the more comprehensive analysis (including all four configurations) reported in the main text.

Experiment 1: Fort

A mixed-model Poisson regression with spatial element (wall or object) included as a predictor variable and participant included as a random-effects intercept revealed a main effect of spatial element (Wald Test, $\chi^2(1) = 24.35$, $p < .001$). As in the main text, children drew significantly more objects than walls.

A mixed-model ordinal logistic regression examining element dimensionality for walls and objects in configurations without decals revealed that children drew objects with greater dimensionality than walls: The odds of children's drawing objects with greater dimensionality were 488% more likely than the odds of children's drawing walls with greater dimensionality (95% CI [139, 1343], $p < .001$).

Experiment 2: Toy

A mixed-model Poisson regression with spatial element (wall or object) included as a predictor variable and participant included as a random-effects intercept revealed that there was no significant difference between the number of walls and objects that children drew (Wald Test, $\chi^2(1) = 0.02$, $p = .885$). While the main text analysis found that children drew more walls than objects for the toy, this present result (and the results from the naïve coding, see above) falls more in line with the prediction of no difference. As suggested in the main text, while children clearly drew more objects than walls for the fort, their drawing counts for the toy may have weakly reflected the relative real-world sizes of each of the different element types.

Finally, a mixed-model ordinal logistic regression examining element dimensionality for walls and objects revealed that the odds of children's drawing objects with greater dimensionality were 3048% more likely than the odds of children drawing walls with greater dimensionality (95% CI [1124, 7992], $p < .001$).

Experiment 2: Comparing the Fort and Toy

To directly examine the differences in children's drawings across the two experiments, the same mixed-model regressions as above were conducted, but with experiment as an additional predictor variable. First, for element count, including walls and objects, there were main effects of both spatial element (children drawing more objects than walls; Wald Test, $\chi^2(1) = 11.34$, $p < .001$) and experiment (children drawing more elements for the toy versus the fort; Wald Test, $\chi^2(1) = 5.45$, $p = .019$). Critically, and as in all prior analyses, there was a significant spatial element by experiment interaction (Wald Test, $\chi^2(1) = 12.83$, $p < .001$): Children drew significantly more walls than objects for the toy versus fort. Planned Holm-corrected pairwise contrasts revealed that children did not draw significantly more objects for the toy versus fort ($p = 1.000$), but they did draw significantly more walls for the toy versus fort ($p < .001$).

Finally, a mixed-model ordinal logistic regression examining element dimensionality for walls and objects revealed that children drew objects with greater dimensionality than walls. The odds of children's drawing objects with greater dimensionality were 296% more likely than the odds of children's drawing walls with greater dimensionality (95% CI = [120, 614], $p < .001$). Children also drew elements with greater dimensionality for the fort versus toy: The odds of children's drawing elements with greater dimensionality for the fort were 71% more likely than the odds of children's drawing elements with greater dimensionality for the toy (95% CI = [48, 84], $p < .001$). The model did not reveal a significant element type by condition interaction (odds ratio = 1.70, 95% CI = [0.79, 3.66], $p = .178$).

Analysis of the dividing wall

As stated in the main text, the pilot data revealed no effects of the dividing wall on the relative number of wall and object elements that children drew, and so our preregistered analysis indeed treated these four-wall (dividing wall present) and three-wall (dividing wall absent) configurations as all probing children's drawing of walls and objects in a layout more generally. Although an analysis of the dividing wall was not planned for the test data, such an analysis further illustrates the generalizability of the findings: Just as in the pilot data, the dividing wall had no effect on the relative number of wall and object elements that children drew in either experiment, further supporting the conclusions from the main text.

In particular, for the fort in Experiment 1, a mixed-model Poisson regression with spatial element (wall or object) and dividing wall (present or absent) as predictor variables and participant included as a random-effects intercept revealed main effects of spatial element (Wald Test, $\chi2(1) = 45.87$, $p < .001$) and dividing wall (Wald Test, $\chi2(1) = 9.57$, $p = .002$), suggesting that children drew more objects than walls and that children drew more elements in configurations with a dividing wall (where there were, in fact, more elements to draw). Critically, there was no spatial element by dividing wall interaction (Wald Test, $\chi2(1) = 0.16$, $p = .688$), and Holm-corrected, pairwise contrasts revealed that children drew more objects than walls in configurations *with* and in configurations *without* a dividing wall (ps $< .001$). For the toy in Experiment 2, there was also no effect of the dividing wall. The regression revealed main effects of spatial element (Wald Test, $\chi2(1) = 4.45$, $p = .035$) and dividing wall (Wald Test, $\chi2(1) = 7.89$, $p = .005$), but no interaction between spatial element and dividing wall (Wald Test, $\chi2(1) = 0.01$, $p = .942$).

Analysis using mixed-model linear regressions on the count data

Preregistered analyses of count data included mixed-model Poisson regressions because counts are bounded at zero, only take on integer values, and are often heavily skewed. The findings were also robust to a mixed-model linear regression framework, with analyses conducted post-hoc and reported here.

Experiment 1: Fort

A mixed-model linear regression with spatial element (wall or object) and configuration included as predictor variables, and participant included as a random-effects intercept, revealed main effects of both spatial element (Wald Test, $\chi^2(1) = 39.92$, $p < .001$) and configuration (Wald Test, $\chi^2(3) = 10.93$, $p = .012$). As in the main text, children drew more objects than walls and the number of elements they drew varied based on the fort configuration. When examining the configurations with decals, a second mixed-model linear regression with spatial element (wall, object, wall decal, or object decal) included as a predictor variable and participant included as a random-effects intercept revealed a main effect of spatial element (Wald Test, $\chi^2(3) = 18.95$, $p < .001$). Holm-corrected pairwise contrasts also revealed that children drew significantly more objects than walls ($p < .001$).

Experiment 2: Toy

A mixed-model linear regression with spatial element (wall or object) and configuration included as predictor variables and participant included as a random-effects intercept, revealed a main effect of configuration (Wald Test, $\chi^2(3) = 20.93$, $p < .001$) and spatial element (Wald Test, $\chi^2(1) = 7.48$, $p = .006$). As in the main text, children drew more walls than objects and the number of elements they drew varied based on the fort configuration. A similar analysis for the configurations with decals also revealed a main effect of spatial element (Wald Test, $\chi^2(3) = 25.93$, $p < .001$). Holm-corrected pairwise contrasts also found that children drew more walls than objects ($p = .005$).

Experiment 2: Comparing the Fort and Toy

To directly examine the differences in children's drawings across the two experiments, the mixed-model linear regressions were conducted as above, but with experiment as an additional predictor variable. First, for element count, including walls and objects across all four configurations, there were main effects of both spatial element (children drawing more objects than walls; Wald Test, $\chi^2(1) = 9.57$, $p = .002$) and experiment (children drawing more elements for the toy versus fort; Wald Test, $\chi^2(1) = 8.30$, $p = .004$). Critically, and as in the main analysis, these results were further characterized by a significant spatial element by experiment interaction (Wald Test, $\chi^2(1) = 38.62$, $p < .001$): Children drew significantly more walls than objects for the toy versus fort. As in the main analysis, Holm-corrected pairwise contrasts revealed that children did not draw significantly more objects for the toy versus fort ($p = .065$), but they did draw significantly more walls for the toy versus fort ($p < .001$). The second regression, examining element counts in the two configurations with four spatial elements also revealed a main effect of spatial element (Wald Test, $\chi^2(3) = 13.82$, $p = .003$) and experiment (Wald Test, $\chi^2(1) = 4.52$, $p = .034$). There was again a significant element type by experiment interaction (Wald Test, $\chi^2(3) = 28.35$, $p < .001$). Moreover, Holm-corrected pairwise contrasts revealed that children did not draw significantly more objects for the toy versus fort ($p = .316$), but they did draw significantly more walls for the toy versus fort ($p < .001$).

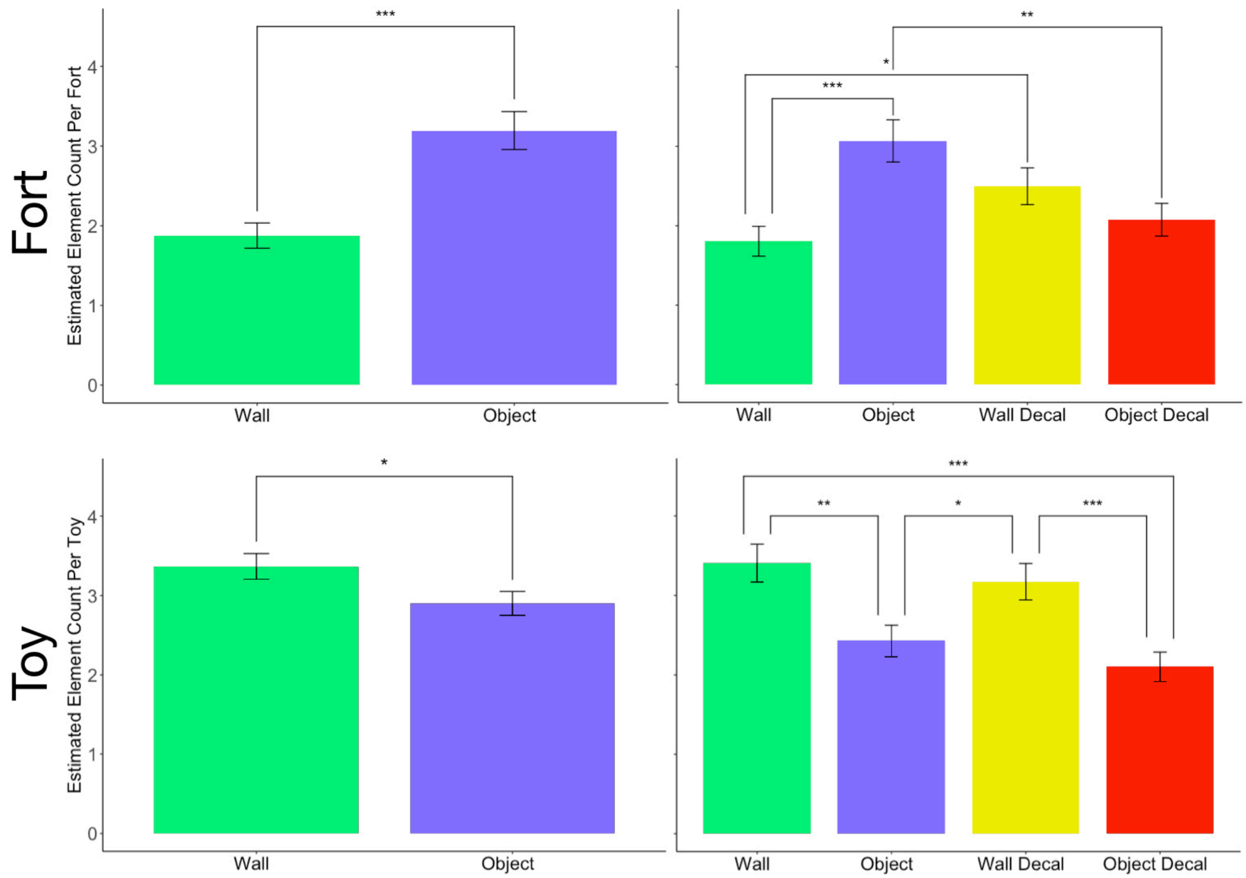

Figure S1. Spatial element counts as predicted by the model for the fort (Experiment 1, top) and toy (Experiment 2, bottom). Across all configurations, children drew more objects than walls for the fort, but not for the toy (left column). In the configurations with decals, children drew more objects than other spatial elements for the fort but appeared to draw the larger spatial elements more frequently for the toy (right column). Planned Holm-corrected pairwise contrasts, ***$p < .001$, **$p < .01$, *$p < .05$, † $p < .1$. Contrasts not shown are not significant. Error bars display the standard error of the model fits.

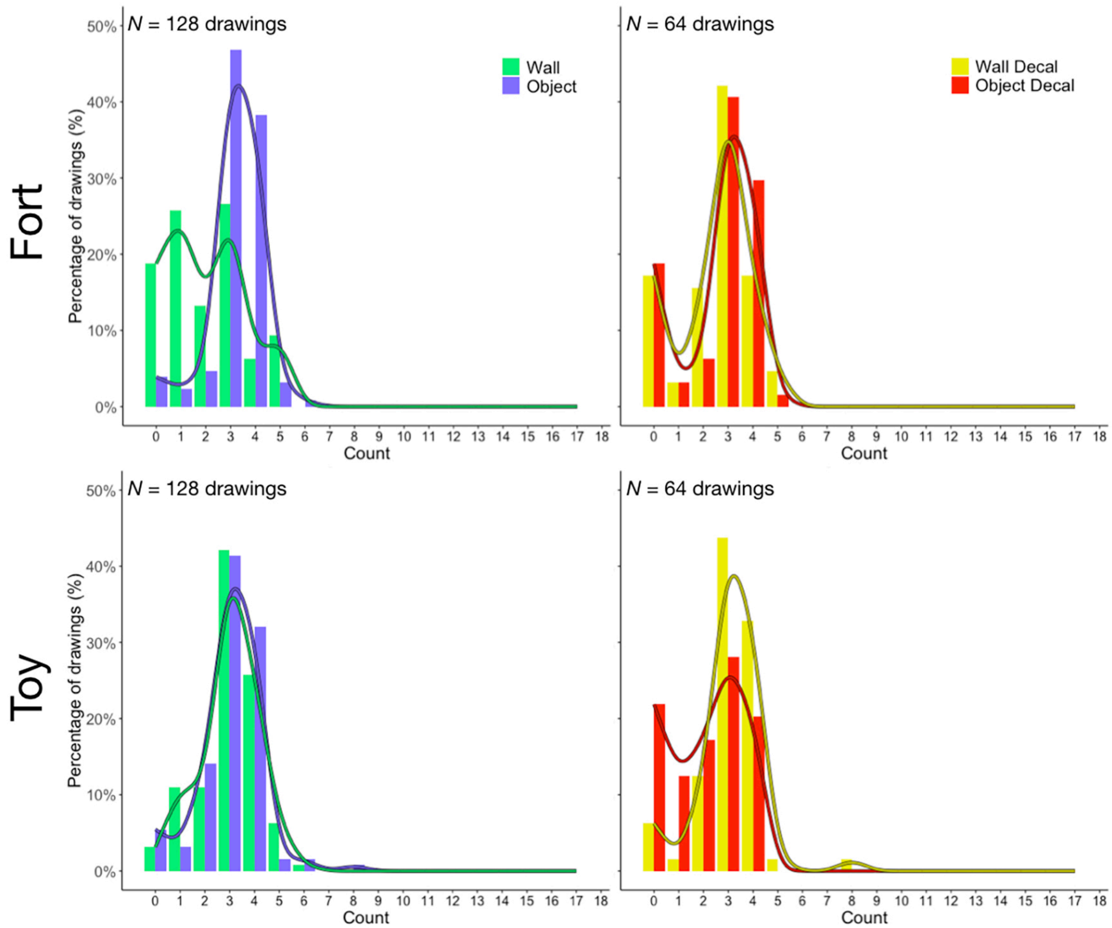

Figure S2. The raw counts of spatial elements for the fort (Experiment 1, top) and toy (Experiment 2, bottom) for the four configurations in which there were walls and objects (left) and for the two configurations in which there were also wall decals and object decals (right), as coded by the naïve coder. To illustrate the distribution of these counts, overlaid on each set of counts is a smooth curve, generated by a kernel regression on Count and Percentage. Across all configurations of the fort the count distribution for walls is strikingly different from the count distributions for all of the other spatial elements, with wall counts peaking at 0-1 and all other element counts peaking at 3-4. In contrast, across all configurations of the toy the count distribution for walls is strikingly similar to those for all other spatial elements, with all element counts peaking at 3-4.

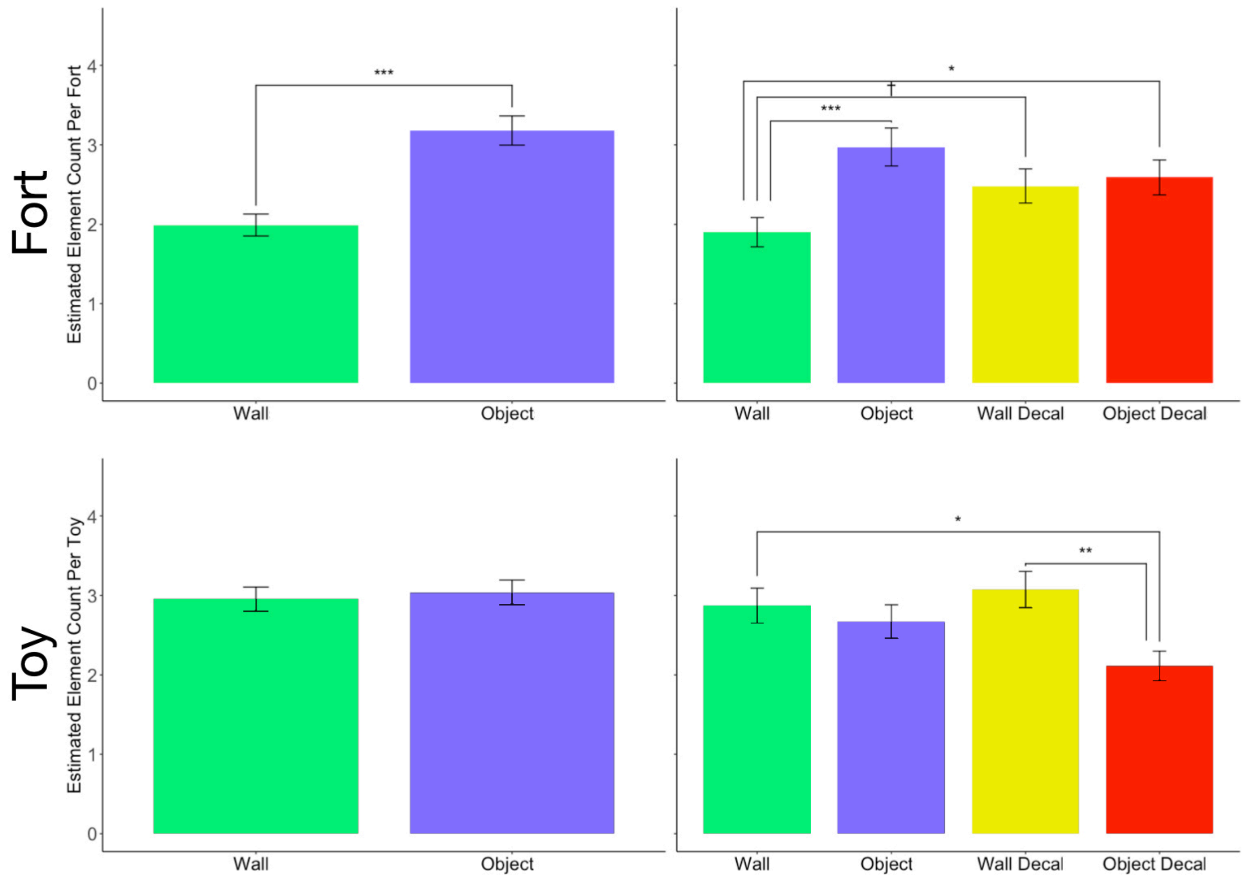

Figure S3. Spatial element counts as predicted by the model for the fort (Experiment 1, top) and toy (Experiment 2, bottom), as coded by the naïve coder. Across all configurations, children drew more objects than walls for the fort, but not for the toy (left column). In configurations with decals, children also drew more objects than walls for the fort, but not for the toy (right column). Planned Holm-corrected pairwise contrasts, ****p* < .001, ***p* < .01, **p* < .05, † *p* < .1. Contrasts not shown are not significant. Error bars display the standard error of the model fits.

Table S1A. The mixed-model ordinal logistic regression from the main analysis, evaluating the dimensionality with which children drew each spatial element in configurations with decals for the fort (Experiment 1)

Reference	Comparison	*p*-Value[a]	% Change in odds ratio	95% CI for % change
Wall	Object	.002	248	58 - 661
Wall	Wall Decal	< .001	463	135 - 1248
Wall	Object Decal	< .001	1245	353 - 3891

Table S1B. The mixed-model ordinal logistic regression from the main analysis, evaluating the dimensionality with which children drew each spatial element in configurations with decals for the toy (Experiment 2)

Reference	Comparison	*p*-Value[a]	% Change in odds Ratio	95% CI for % change
Wall	Object	< .001	897	446 - 1723
Wall	Wall Decal	< .001	1147	602 - 2116
Wall	Object Decal	< .001	1602	756 - 3281

Note. Percentage changes in the proportional odds ratios produced by the ordinal logistic regression model, quantifying the degree to which the odds of producing a given element with greater dimensionality would be greater for the comparison group than the reference group. For example, in **Table S1B**, the odds of children drawing objects with greater dimensionality were 897% more likely than the odds of children drawing walls with greater dimensionality. [a]Planned Holm-corrected pairwise contrasts.