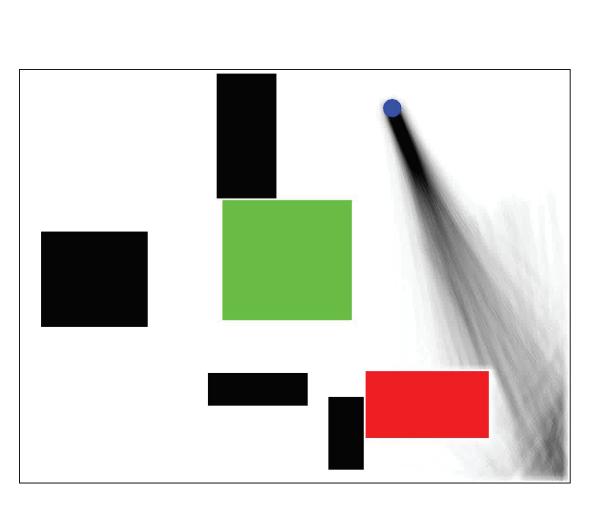
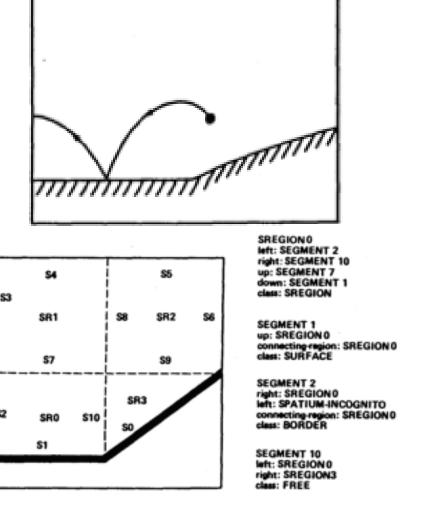
Thinking inside the box: Motion prediction in contained spaces uses simulation Kevin A Smith,¹ Filipe de A B Peres,² Edward Vul,³ Joshua B Tenenbaum¹

Introduction

• When do people use physical simulation versus logical reasoning to make predictions about physical events?



Smith, Dechter, Tenenbaum, Vul (2013)

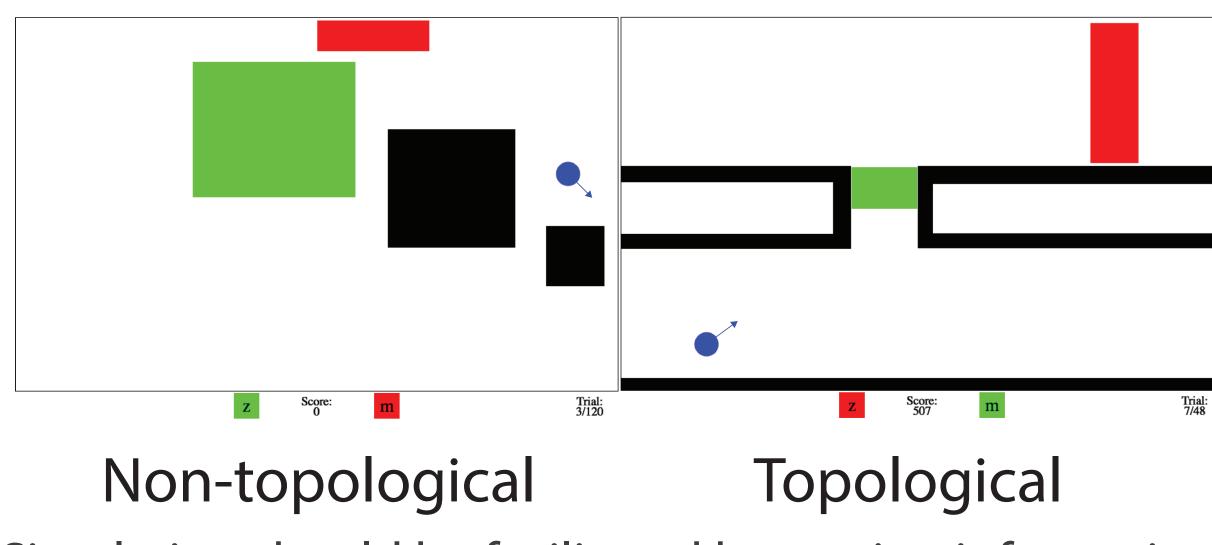


Forbus (1983)

- Test case: predicting where a ball will end up when spatially contained
- Can be explained by simulation (Smith, Dechter, Tenenbaum, & Vul, 2013)
- But possibly simpler to logically parse scene (Davis, Marcus & Chen, 2013)

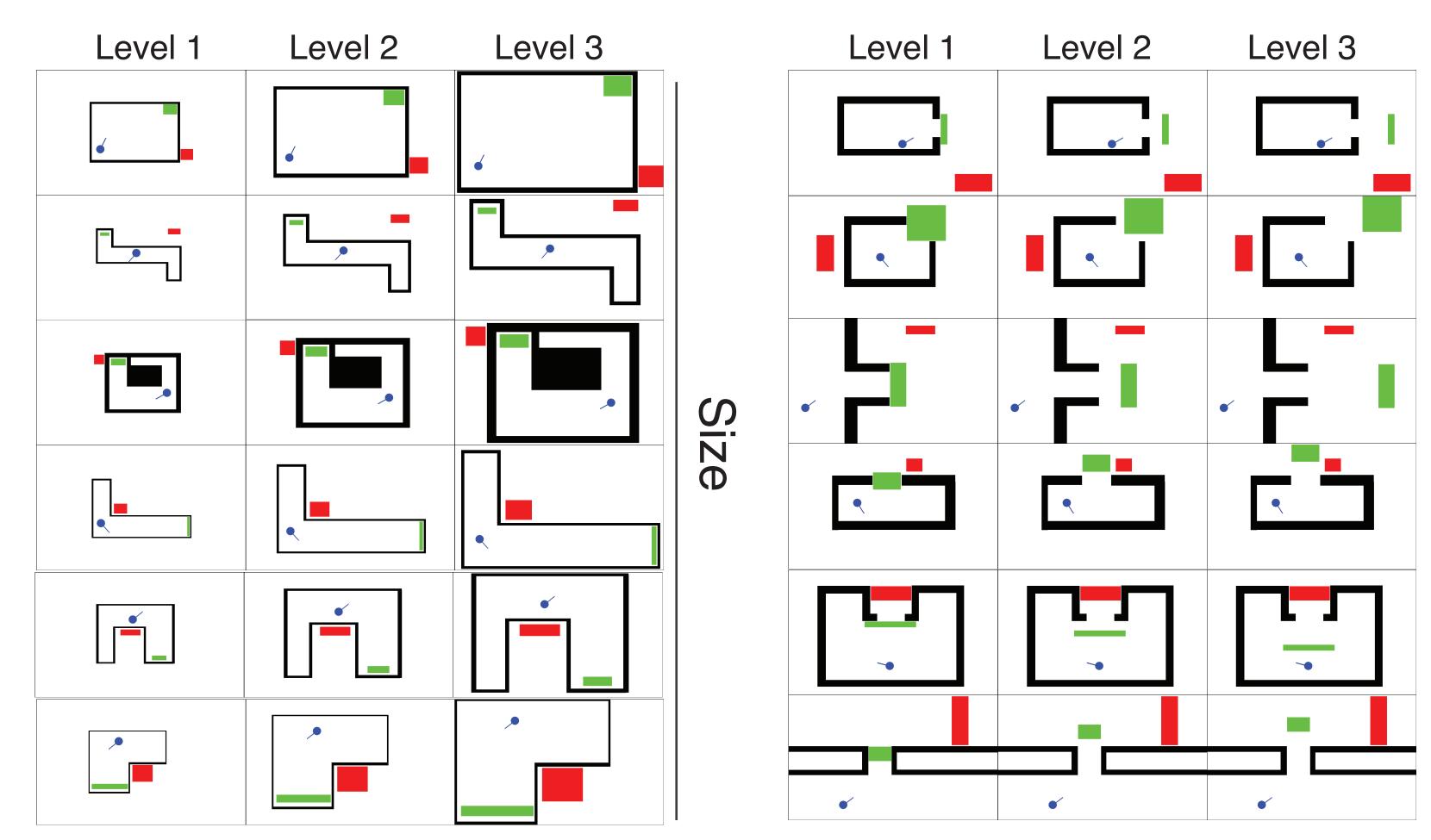
Task

- Observe scene with ball bouncing around table (or static)
- Decide: Will the ball reach the green or red goal first?
- Incentivized for accuracy and speed
- Recorded goal choice and reaction time



- Simulation should be facilitated by motion information -> faster RT with motion towards the goal
- Motion is irrelevant to logical topological parsing -> no difference in RT between motion conditions

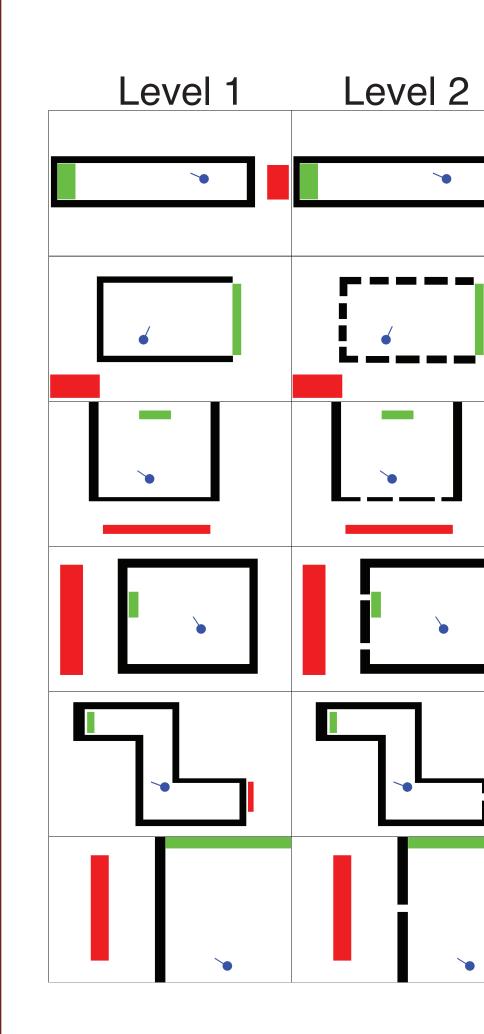
- 100 participants judged 120 trials: 24 topological, 96 non-topological
- Tested four dimensions of topology: - No motion in 1/3rd Size, Porousness, Stoppers, Complexity



Level 3

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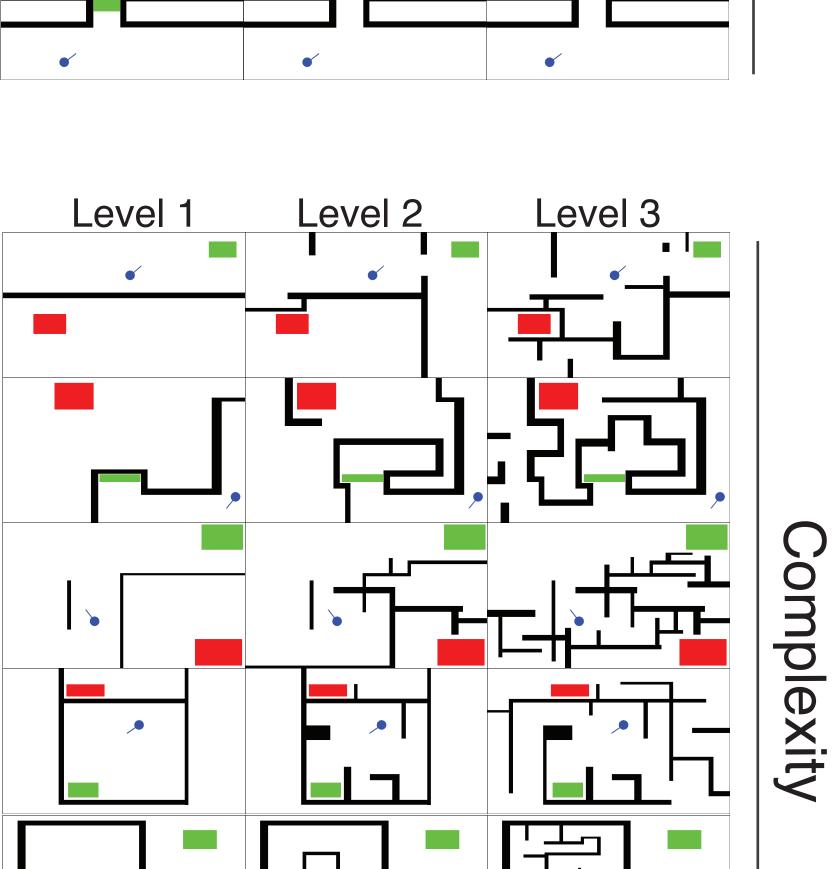


1: MIT, 2: Columbia University, 3: UC San Diego

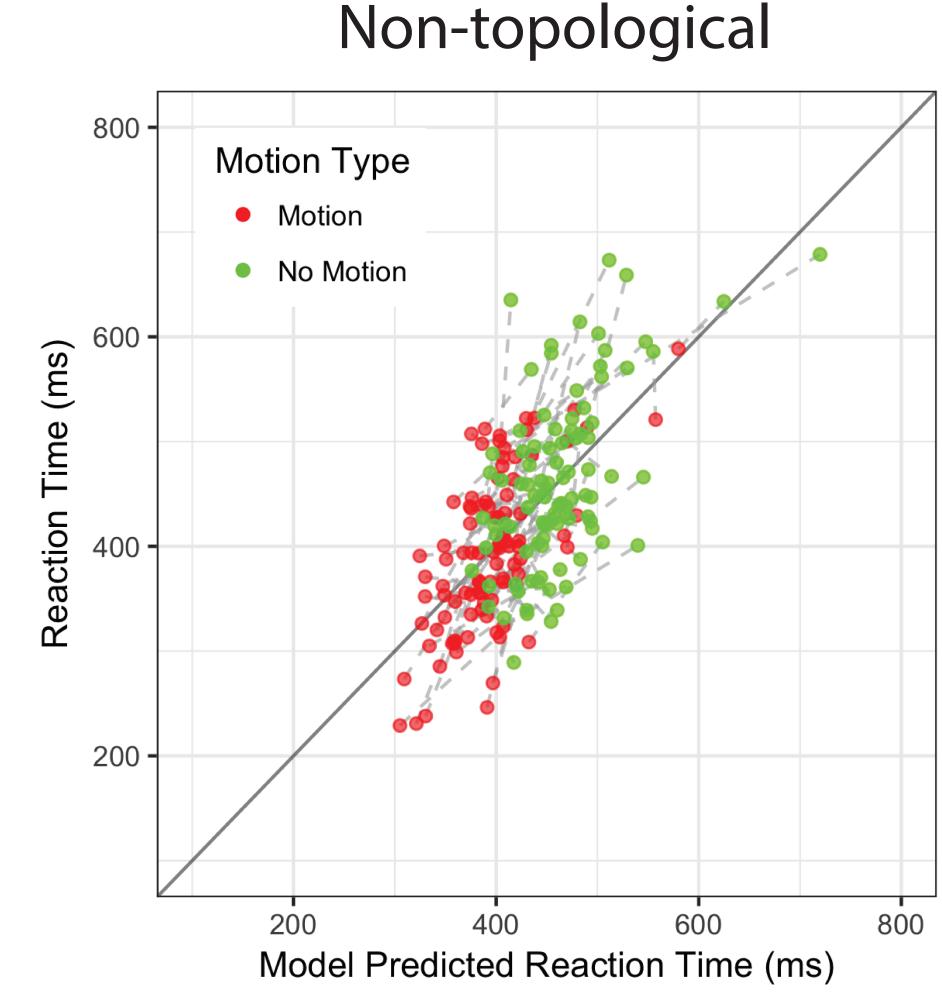
Experiment 1

Experiment

- Of the "topological" trials:
- Motion towards goal in 1/3rd
- Motion away from goal in 1/3rd



- motion (487ms)
- motion in 61 of 72
- combinations
- decision model of Hamrick, Smith, Griffiths, & Vul (2015)



Topological Trials

Sto

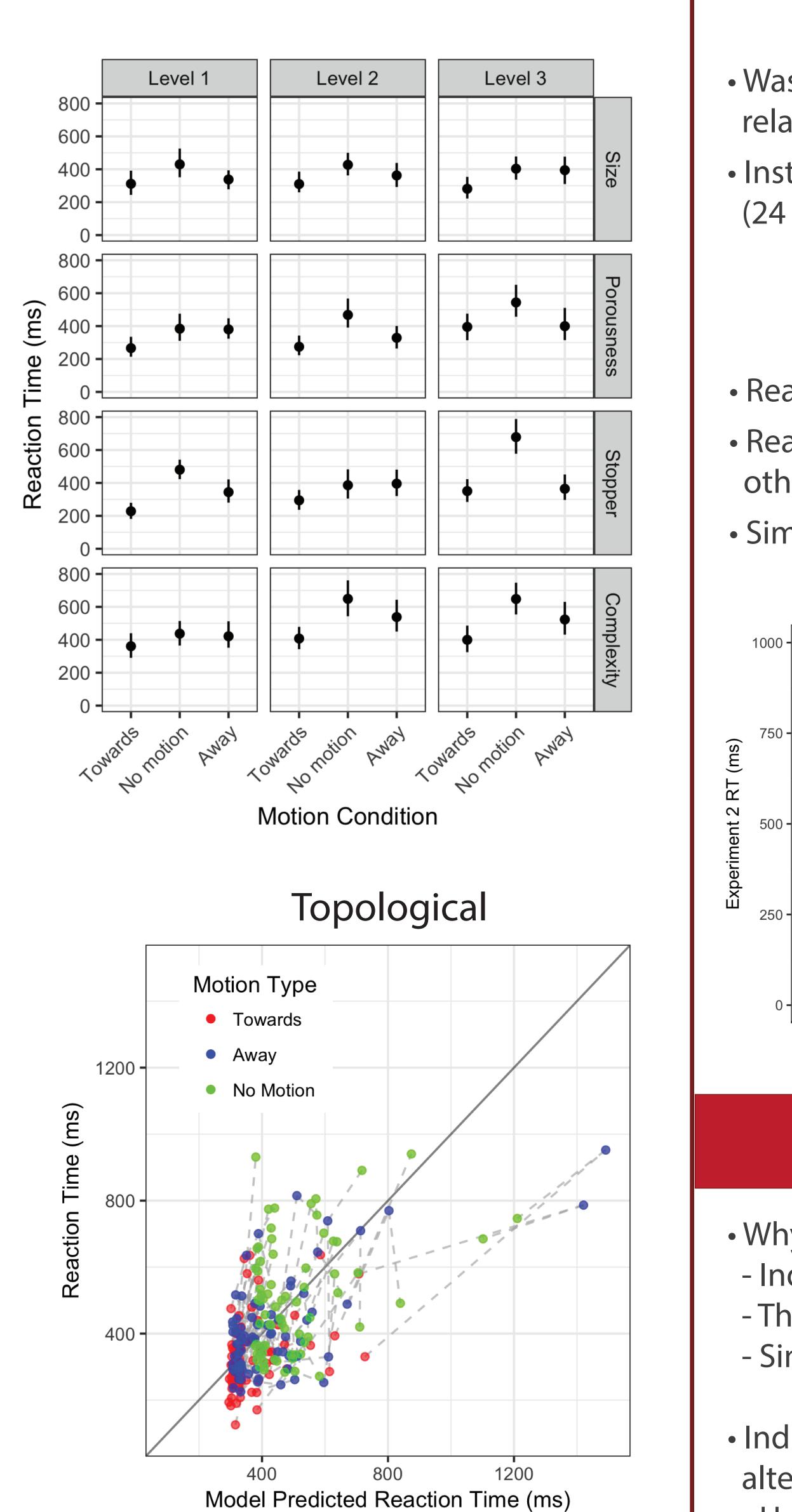
Results

 Participants were consistently faster to respond with motion towards the goal (321ms) vs. motion away (394ms) or no

 Responses with towards motion faster than away in 52 of 72 trials, faster than no

 Towards motion facilitates responses on average for all topology type and level

 RTs can be explained by simulation and - Fit on non-topological (r=0.67) - Extends well to topological (r=0.55)



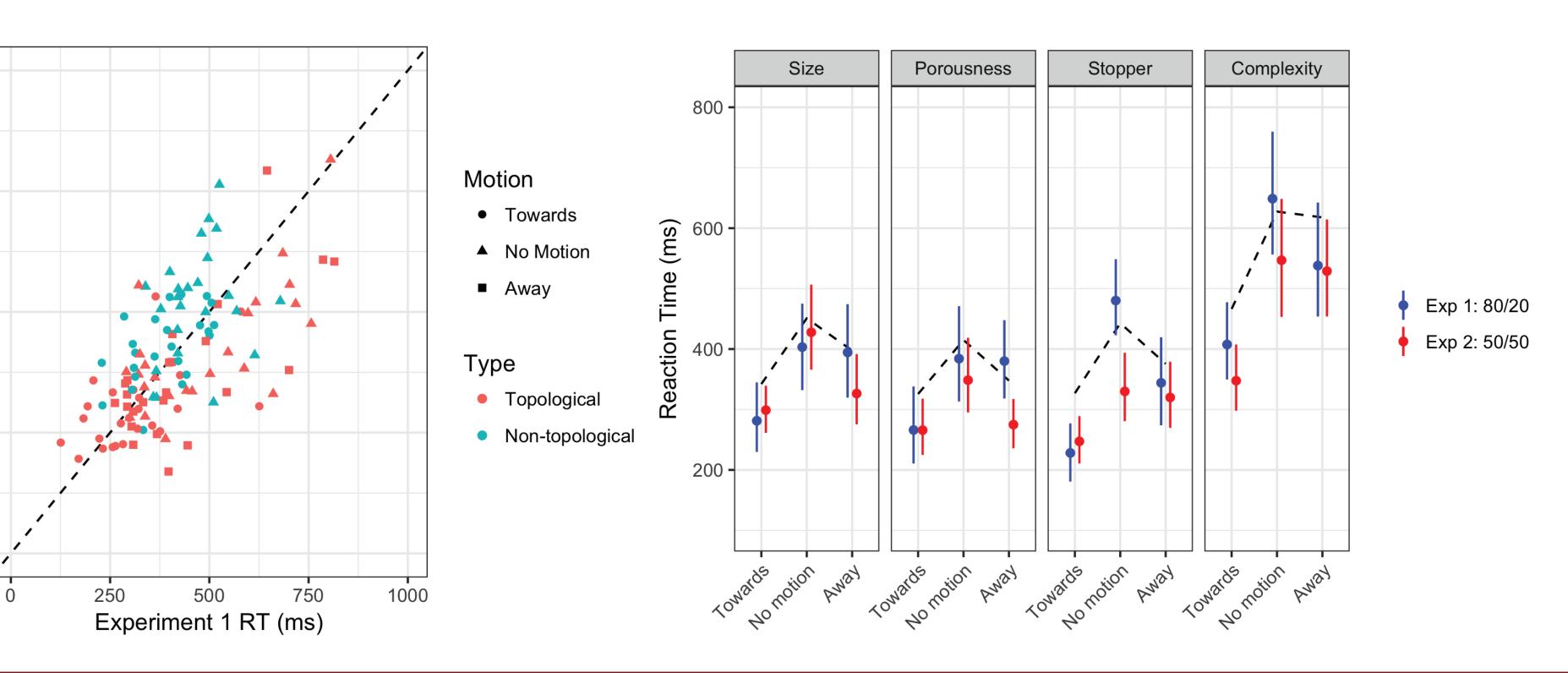
Experiment 2

Experiment

- Was reliance on simulation in Experiment 1 because trials with topological relationships were rare (e.g., impose switching costs)?
- Instead test with equal number of topological and non-topological trials (24 of each; subsets of Experiment 1 trials)

Results

- Reaction times on identical trials were correlated across experiments (r=0.61) • Reaction times were still consistently faster with motion towards the goal vs. other motion information
- Similar consistency with simulation model on topological trials (r=0.49)



Discussion

- Why are people faster for forward motion vs. other motion?
- Individual differences some use simulation, some topology?
- This task particularly suited for simulation over logical parsing? (Davis, Marcus, 2015) - Simulation / reasoning processes running in parallel?
- Indicates that simulation is activated for short-tem motion prediction, even when alternate strategy is available
- Under what conditions do / can people use topological rules for prediction?