Evaluating Low-Cost Cues for Reducing Child Pedestrian Accident Risk

DATASCI 241, Section 2
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Background

The Problem: Risks to Child Pedestrians

Substantial Risk on Residential Streets

Child pedestrians continue to experience substantial risk on residential streets in the United States; in 2023, approximately 385 fatalities and over 9,300 injuries were reported among children walking (Safe Kids Worldwide, 2023).

Influence of Vehicle Velocity

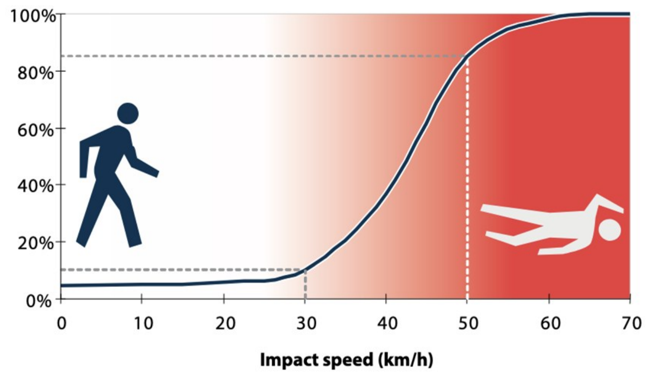
Specific temporal periods and contexts present heightened danger. For instance, the after-school period, between 3:00 and 7:00 PM, accounts for 36% of pedestrian fatalities among children under 16, coinciding with times when children are frequently outdoors walking or playing (CSN, 2013).

Significance of Environmental Indicators

Young children are particularly vulnerable to sudden street entry incidents, commonly referred to as “dart-out” accidents, which constitute approximately 43% of child pedestrian injuries (PMC, 2015).

Why Does Speed Matter?

- Vehicle speed determines both crash likelihood and injury severity.
- 5% death risk at 20 mph vs 45% at 30 mph (1)
- Higher speeds = less reaction time + longer stopping distance + greater crash energy.
- Even small speed reductions can save lives.



Source: *Speed management: a road safety manual for decision-makers and practitioners (GRSF, 2008)*

(1) Pilkington, P. (2000). Reducing the speed limit to 20 mph in urban areas: Child deaths and injuries would be decreased. *BMJ*, *320*(7243), 1160. https://doi.org/10.1136/bmj.320.7243.1160

Background

What Has Been Done to Reduce the Speed?

01

Physical Traffic Calming

- Speed humps: 37.5% reduction in pedestrian crashes under 21

- Lowering school zone limits 31→19 mph: 45% decrease in serious crashes

- Raised crosswalks, curb extensions, roundabouts

02

Warning Signs

- Very limited research on sign effectiveness

- Minnesota study: "Children at Play" signs showed 0.9-1.5 mph reductions

- Authors concluded effects "not significant in any practical sense"

03

Creative Low-Cost Solutions

- London painted speed bumps: 3 mph reduction

- New Delhi 3D crosswalks: 15% speed drop (4 mph)

- Kansas City street mural: 25→14 mph (11 mph reduction)

Research Question

Can low-cost, child-themed visual cues meaningfully slow drivers and reduce child injury risk?

Research Hypotheses:

H1: The installation of a 'Children at Play' sign will result in a statistically significant reduction in vehicular speeds compared to a control condition without any signage.

H2: The combined presence of the 'Children at Play' sign and strategically placed toys will produce a greater reduction in vehicle speeds than the sign alone.

H3: The integration of the 'Children at Play' sign, toys, and balloons will lead to the most substantial decrease in vehicular speeds, exceeding the effects observed with either the sign alone or the sign plus toys.

Experimental Setup for Low-Cost Traffic-Calming Cues

Experiment Design and Methods

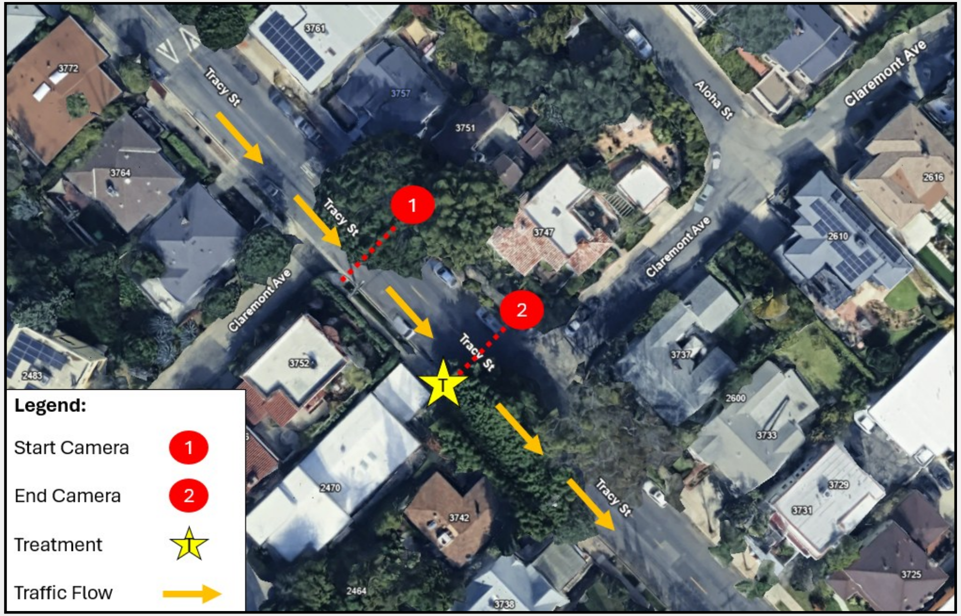
- Location: Tracy St., Silver Lake, Los Angeles, CA.
- Design: 1 × 4 factorial field test of "Kids at Play" cues.
  - Control: No sign or objects.
  - T1: Yellow "Slow – Kids at Play" sign.
  - T1 sign + ~300 children's toys on roadside
  - T3: T2 setup + 3 "Happy Birthday" balloons
- Measurement: Two fixed phone cameras at a known distance
  - speed = distance ÷ time between crossings.

Session Schedule Details

Day	Date	Condition	Time	Spacing
1	7/15/2025	C	5:00 – 6:00 PM	23.63 m
2	7/17/2025	C	5:30 – 6:30 PM	18.57 m
3	7/20/2025	C and T1	1:00 – 4:00 PM	21.95 m
4	7/27/2025	T1	5:00 – 6:30 PM	21.95 m
5	7/30/2025	T2	3:30 – 6:00 PM	21.95 m
6	7/31/2025	T3	3:30 – 6:00 PM	21.95 m

- Cameras: Two fixed phones, known spacing, started simultaneously
- Free-flow traffic only: Excluded parked or turning vehicles

Study Site Layout and Camera Placement



Power analysis indicated a target of approximately 100 vehicles per condition. Each session lasted 2.5-3 hours to reach target observations.

Experiment Design (ROXO Grammar)

- We are conducting 1 × 4 between-subjects factorial field experiment measuring vehicle speeds under four treatment conditions.
- This is a between-subjects design and causal inference relies on random (or as-good-as-random) assignment across time slots and consistent measurement.

Group (Condition)	Random Assignment	Treatment (X)	Observation (O=Speed)
C1	As-good-as-random	No cue (baseline)	Vehicle speed measured
T1	As-good-as-random	“Slow, Kids at Play” sign	Vehicle speed measured
T2	As-good-as-random	Sign + toys	Vehicle speed measured
T3	As-good-as-random	Sign + toys + balloons	Vehicle speed measured

Causal Comparisons

- We are using linear regression to compare average speed across groups, adjusting for covariates vehicle class, color, and fuel type.

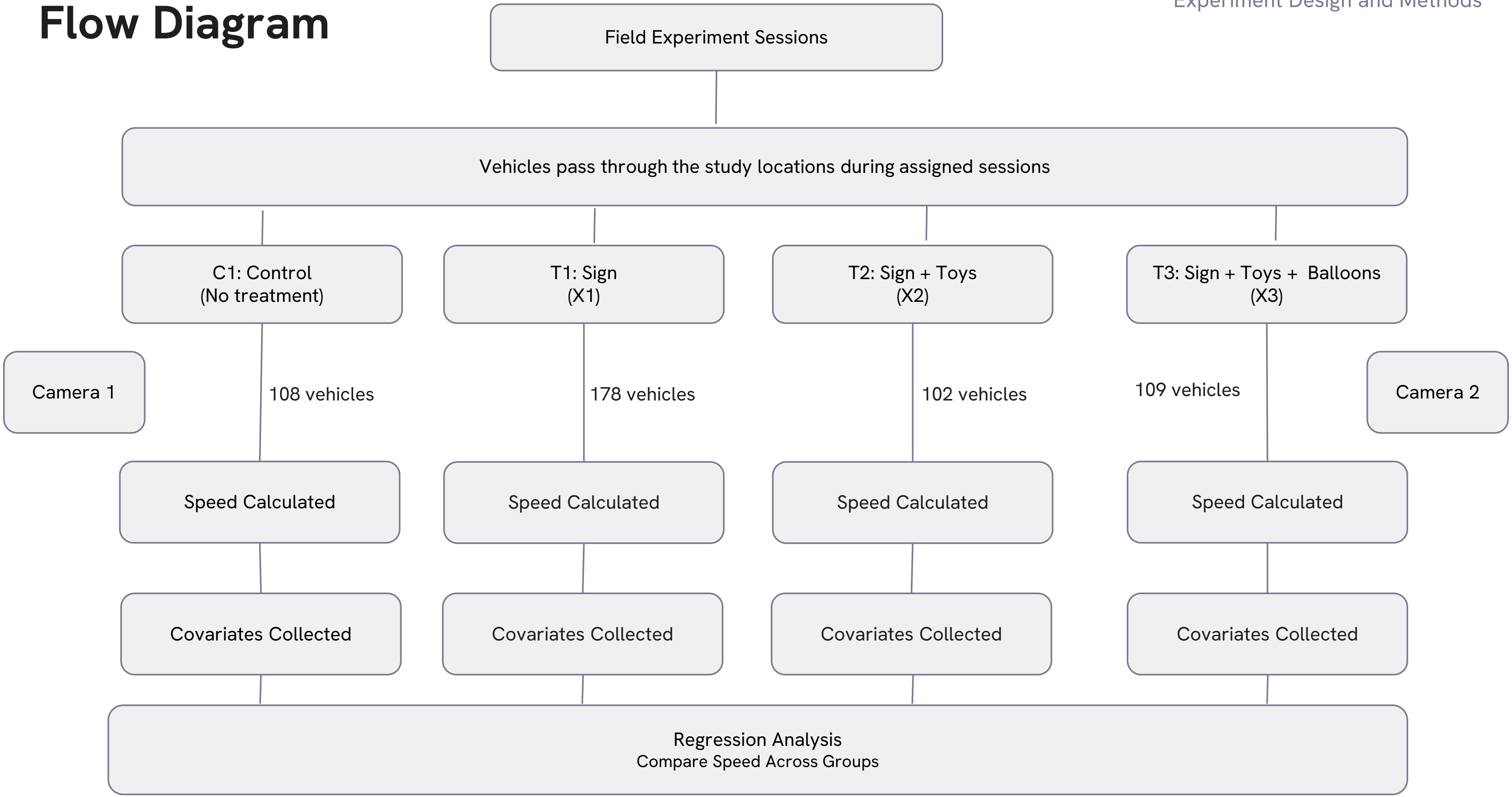
- The core causal questions are:
  - Does any intervention (X1–X3) reduce vehicle speed compared to no cue (C1)?
  - Does adding toys (T2) reduce speed more than sign alone (T1)?
  - Does adding balloons (T3) further reduce speed beyond T2?

- Each of these is a between-groups causal comparison

- These comparisons assume no other systematic differences across sessions, and that the covariates are not confounding the treatment effect handled via regression controls.

- Causal interpretation: “Differences in speed between groups are attributed to treatments if assignment is as-if random and confounders are adjusted for”

Flow Diagram



Randomization Process

Randomization Level

Randomized by day (not individual vehicle) due to visible props. Treatments could not be changed in real-time without attracting attention.

Key assumptions:

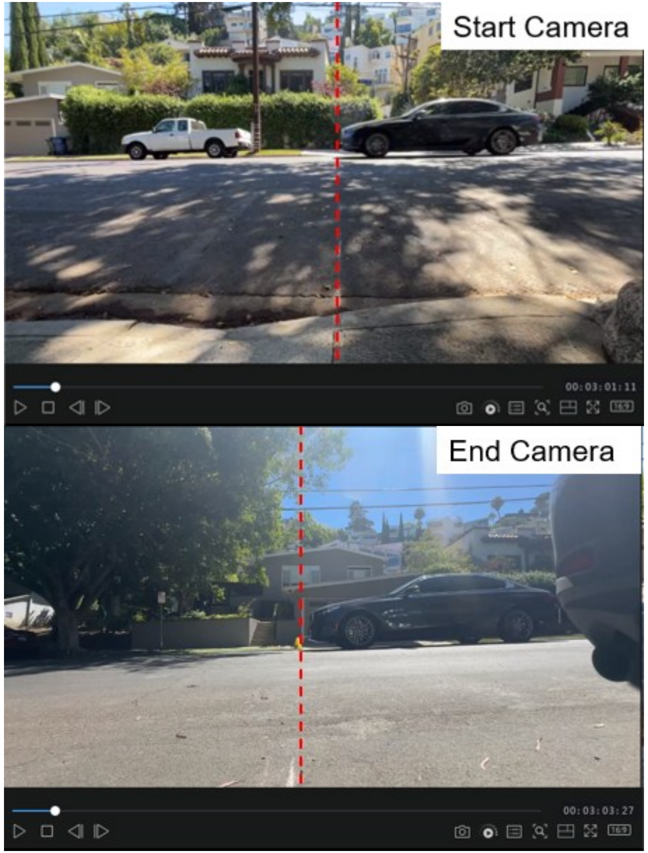
Assumptions Supporting Randomization

1. Assume that each vehicle encounters only one treatment during the study, minimizing repeat exposure.
2. Assume that baseline and treatment speeds remain consistent across all test days (no day-to-day speed variation))

What makes these assumptions reasonable and applicable?

- A large, varied pool of vehicles each day makes repeat exposures unlikely.
- L.A.'s heavy traffic further reduces the likelihood of any driver seeing more than one treatment.
- Sessions were held 3–6 PM on non-consecutive days to keep conditions consistent and mask the study's pattern

How Do We Measure a Car’s Speed?



- Timestamp Extraction

Videos are uploaded to editing software, virtual 'start' and 'end' lines are marked, and the time when the vehicle’s front bumper crosses each line is recorded.

- Vehicle Covariates

Class (L/S/U/H):

- L: Light commuters (sedans, hatchbacks)
- S: Sport/performance (coupes, sports cars)
- U: Family utility (SUVs, minivans)
- H: Heavy/commercial (trucks, buses)

Color (Light vs. Dark):

- Light/Bright: white, silver, yellow, red, etc.
- Dark/Neutral: black, dark blue, gray, brown

Fuel Type:

- E: Electric (no tailpipe, EV badge)
- G: Gas/diesel/hybrid (visible exhaust, no EV marking)

Analysis Methodology

$$\text{Speed}_i = \beta_0 + \beta_1 T1_i + \beta_2 T2_i + \beta_3 T3_i + \beta_{4\text{VehicleClass}_i} + \beta_{5\text{Color}_i} + \beta_{6\text{FuelType}_i} + \varepsilon_i$$

Linear Regression with Robust SE

- **Outcome:** Average vehicle speed (mph) over fixed camera interval
- **Key Predictor**: Treatment condition (Control, T1, T2, T3)
- **Model Specification**
  - Base: Speed ~ Treatment
  - Nested extensions: + Vehicle_Class, + Vehicle_Color, + Fuel_Type
- **Inference**
  - **Coefficient estimates = average treatment effects (mean speed difference vs. control)**
  - Robust SE (HC1) to guard against heteroskedasticity
  - 95% CIs via HC3 for coefficient estimates
  - F-tests to check whether adding each block of covariates improves fit

Experiment Outcome

Total Number of Vehicles Observed: 497

Condition	Cars (N)	Average Speed (mph)	SD Speed (mph)
C	108	24.89	3.67
T1	178	24.33	4.54
T2	102	22.97	3.63
T3	109	23.33	5.22

- Control
    - Highest mean speed
    - Lowest speed variability (SD)
- Treatment 3
    - Lowest mean speed
    - Highest speed variability (SD)

Example Recording of Day 6 (T3)

(Click to play video)

Results

Covariate Balance Check

Vehicle Class

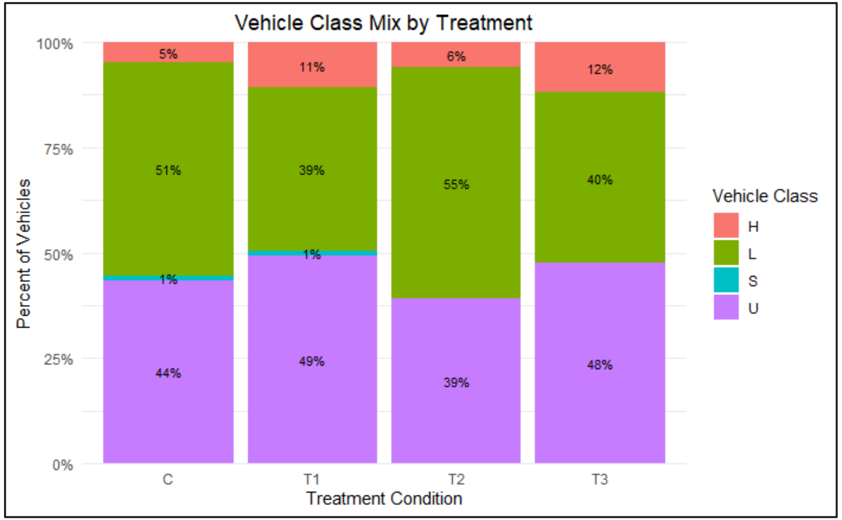
Family Utility (U) vehicles made up ≈40–50%, Light Commuters (L) ≈39–55%, Heavy/Commercial (H) trucks 5–12%, and Sport/Performance (S) cars were nearly absent (<1%). Class mix was similar across C, T1, and T3, indicating randomization did not skew vehicle types.

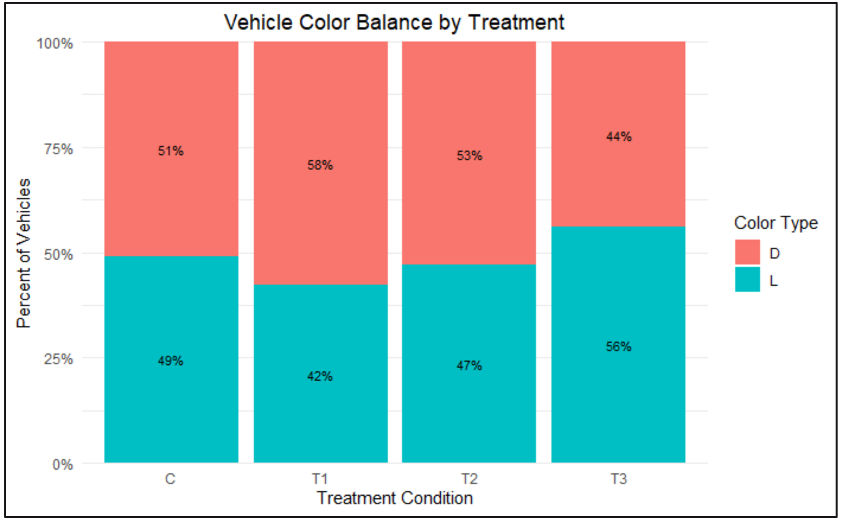
Vehicle Color

About half of vehicles were Light/Bright (white, silver, yellow, red, etc.), the rest Dark/Neutral (black, dark blue, charcoal). T1 had more dark cars (≈58%), T3 more light cars (≈56%). Color balance was within ±8 pp across conditions.

Fuel Type

Most vehicles were Gas/Diesel/Hybrid (≈93%), with only ≈7% Electric. Note: EV identification was sometimes ambiguous on video, making fuel type a noisier covariate.





Regression Results

Regression Results: Average Speed (mph)

	Dependent variable:			
	Average			
	(1)	(2)	(3)	(4)
TreatmentT1	-0.559 (0.491)	-0.509 (0.493)	-0.518 (0.495)	-0.525 (0.494)
TreatmentT2	-1.918*** (0.503)	-1.951*** (0.513)	-1.954*** (0.514)	-1.955*** (0.514)
TreatmentT3	-1.556** (0.612)	-1.522** (0.595)	-1.514** (0.595)	-1.511** (0.596)
Vehicle_ClassL		0.134 (0.917)	0.122 (0.913)	0.114 (0.914)
Vehicle_ClassS		-0.366 (1.347)	-0.396 (1.351)	-0.388 (1.352)
Vehicle_ClassU		-0.558 (0.912)	-0.581 (0.908)	-0.578 (0.908)
Vehicle_ColorL			-0.127 (0.391)	-0.123 (0.387)
Fuel_TypeG				-0.098 (0.803)
Constant	24.887*** (0.353)	25.065*** (0.922)	25.144*** (0.929)	25.237*** (1.218)

Note: *p<0.1; **p<0.05; ***p<0.01
Robust (HC1) standard errors in parentheses

Key Takeaways from the Regression Table

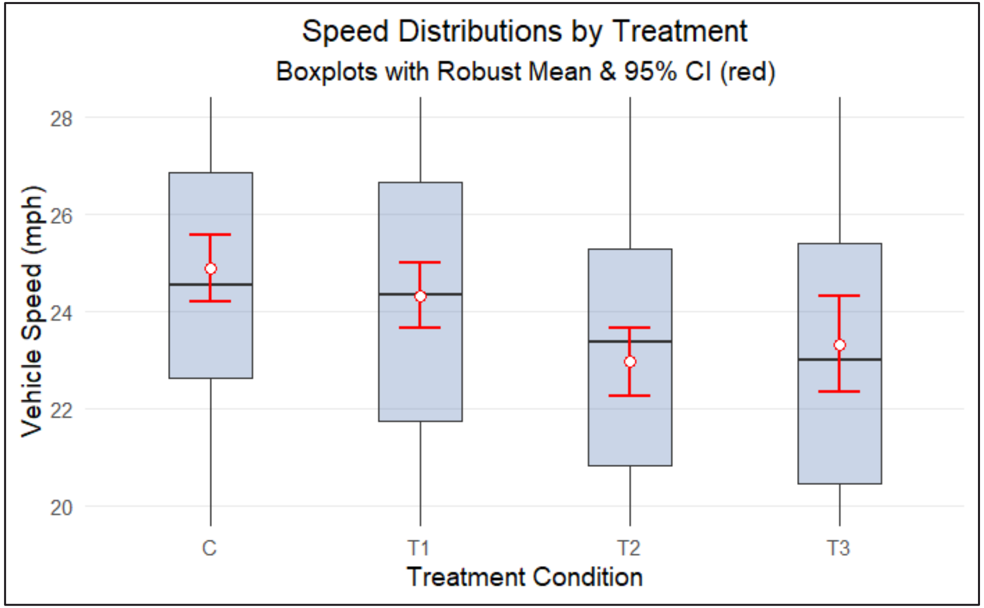
- **Treatment Effects (Model 1):**
  - T1 (Sign only): −0.56 mph (SE 0.49), not statistically significant.
  - T2 (Sign + Toys): −1.92 mph (SE 0.50), highly significant ($p<0.01$).
  - T3 (Sign + Toys + Balloons): −1.56 mph (SE 0.61), significant ($p<0.01$).
- **Robustness Across Specifications:**
  - Adding vehicle class (Model 2), color (Model 3), and fuel type (Model 4) changes treatment coefficients by <0.05 mph and does not alter significance levels.
- **Covariates:**
  - Vehicle_Class (Light, Sport, Utility): small, non-significant coefficients ($|\beta|<0.6$ mph).
  - Vehicle_Color (Light vs. Dark) and Fuel_Type: near-zero effects, non-significant.
- **Intercept (Control Mean):** ~24.9 mph, stable across models.
- **Covariate F-Tests:** Added Vehicle_Class, Vehicle_Color, and Fuel_Type to the base regression via sequential F-tests; none significantly improved model fit (all $p > 0.05$).

Conclusion:

The "Toys" treatment (T2) yields the largest average speed reduction (~1.9 mph), followed by the full setup (T3) at ~1.5 mph, both robust to covariate adjustment. Covariates add little explanatory power beyond treatment condition.

95% Confidence Intervals (CI)

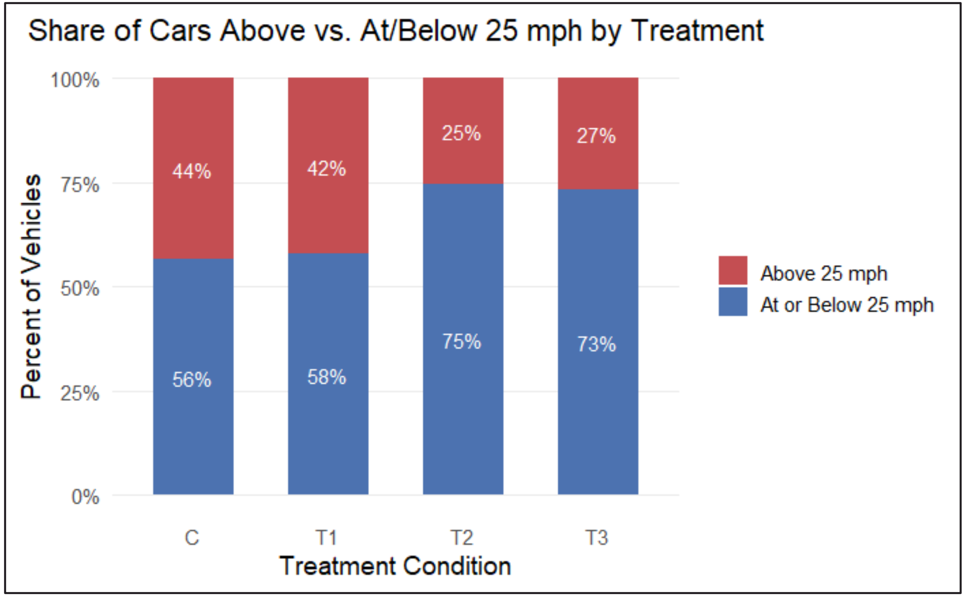
Condition	ATE (mph)	Robust SE	95% CI Lower	95% CI Upper	P-Value
C[1]	24.89	0.35	24.19	25.58	<2.2e-16
T1	-0.56	0.49	-1.53	0.41	0.2551
T2	-1.92	0.50	-2.91	-0.92	0.0001
T3	-1.56	0.61	-2.76	-0.35	0.0113



1. For Condition C (the "control" row), the value labeled "ATE" is not a treatment effect but rather the mean speed of the control group.

- **Intercept (Control speed):** True average speed likely between 24.19 and 25.58 mph (95% confidence).
- **Treatment 1 (Sign only):** Interval (−1.53 to +0.41 mph) crosses zero; no clear speed change.
- **Treatment 2 (Sign + Toys):** Interval (−2.91 to −0.92 mph) is fully negative; speed reduced by 1–3 mph significantly.
- **Treatment 3 (Sign + Toys + Balloons):** Interval (−2.76 to −0.35 mph) fully negative; speed slowed by 0.3–2.8 mph significantly.

Compliance Overview



- The “Slow - Kids at Play” sign (T1) did not meaningfully change the share of drivers obeying the 25 mph limit.

- The introduction of visual play cues, such as toys and balloons, coincided with greater increases in driver compliance, suggesting that more noticeable "child at play" signals may be more effective in encouraging drivers to slow down.

Results

Verifying Day-to-Day Speed Consistency (No Baseline Drift)

Visual Evidence Boxplots for Control (Days 1–3) and Treatment 1 (Days 3–4) show overlapping medians and interquartile ranges, suggesting consistent speed distributions.

Statistical Tests Kruskal–Wallis test (Control Days 1–3) and Wilcoxon rank-sum test (Treatment 1 Days 3–4) both yield $p > 0.05$, indicating no significant speed differences between days.

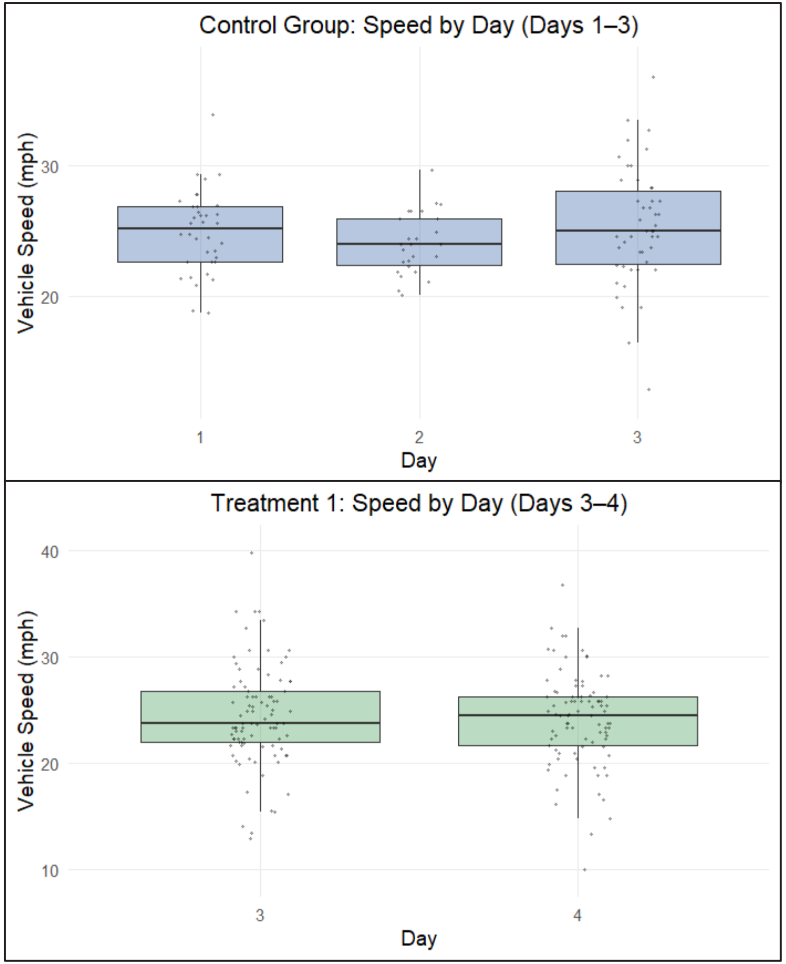
```
        Kruskal-Wallis rank sum test

data:  Average_Speed_mph by Day
Kruskal-Wallis chi-squared = 2.5222, df = 2, p-value = 0.2833


        Wilcoxon rank sum test with continuity correction

data:  Average_Speed_mph by Day
W = 3954.5, p-value = 0.9884
alternative hypothesis: true location shift is not equal to 0
```

Conclusion Visual and statistical analyses support the assumption of stable baseline traffic speed, validating the day-randomized experimental design.



Limitations

Potential Bias and Gaps

Repeated Exposure

Local drivers may have seen the setup multiple times, reducing the treatment's impact due to familiarity.

Missing Covariates

Factors like driver gender, passenger presence, phone use, and local vs. non-local drivers were not recorded.

No Real Children Present

Drivers may have noticed the absence of actual children, leading to reduced perceived risk.

Generalizability

The study was conducted at a single location in Los Angeles, so results may not apply elsewhere.

Long Term Effects?

Conclusion

Key Findings from Speed Reduction Study

- **Sign Alone (T1):** No statistically significant speed reduction
- **Improved Cues (T2 & T3):**
    - T2 (sign + toys): −1.9 mph (95% CI −2.91, −0.92)
    - T3 (sign + toys + balloons): −1.6 mph (95% CI −2.76, −0.35)
- **Practical Impact:** ≈2–3 pp decrease in fatality risk per collision
- **Literature Consistency:** Minnesota DOT "Kids at Play" signs yielded ≤1.5 mph drop (Davis et al., 2012)
- **Compliance Improvement:** % ≤ 25 mph rose from 56% (control) to 73–75% (T2/T3)

Novel visual cues (toys/balloons) may capture attention more than standard signage

Next Steps

Future Work

Next Steps on a Limited Budget

We'll automate speed and vehicle attribute extraction using a computer-vision pipeline with deep learning, replacing manual timestamping and coding. This efficiency gain lets us scale the experiment to more streets and replicate quickly, expanding our test network without hiring extra personnel.

Next Steps with Substantial Funding

We'd implement vehicle-level randomization via license-plate recognition, collect driver demographics, and test across varied times and seasons. High-precision sensors (LIDAR/radar) and edge computing would yield real-time speed data, enabling richer causal insights and broader geographic coverage.

Alternative Approaches

Combine with enforcement, test larger, more visible displays, and investigate street art/mural effectiveness.

Questions?

1. **How can we streamline vehicle speed measurement?**

   Our current method of manually recording timestamps is time-consuming. What automated or more efficient approaches would you recommend?

1. **What other low-cost cues could we explore?**

   Beyond signs, toys, and balloons, are there additional visual or environmental cues that might be effective in encouraging drivers to slow down?

1. **How can we assess long-term effectiveness?**

   Signs and decorations may become less effective over time as drivers get used to them. What study designs or evaluation methods could help us measure whether drivers habituate to these cues?

Closing

Thank You

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