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Simultaneous Judgments of Time-to-Contact for Auditory and Visual Objects

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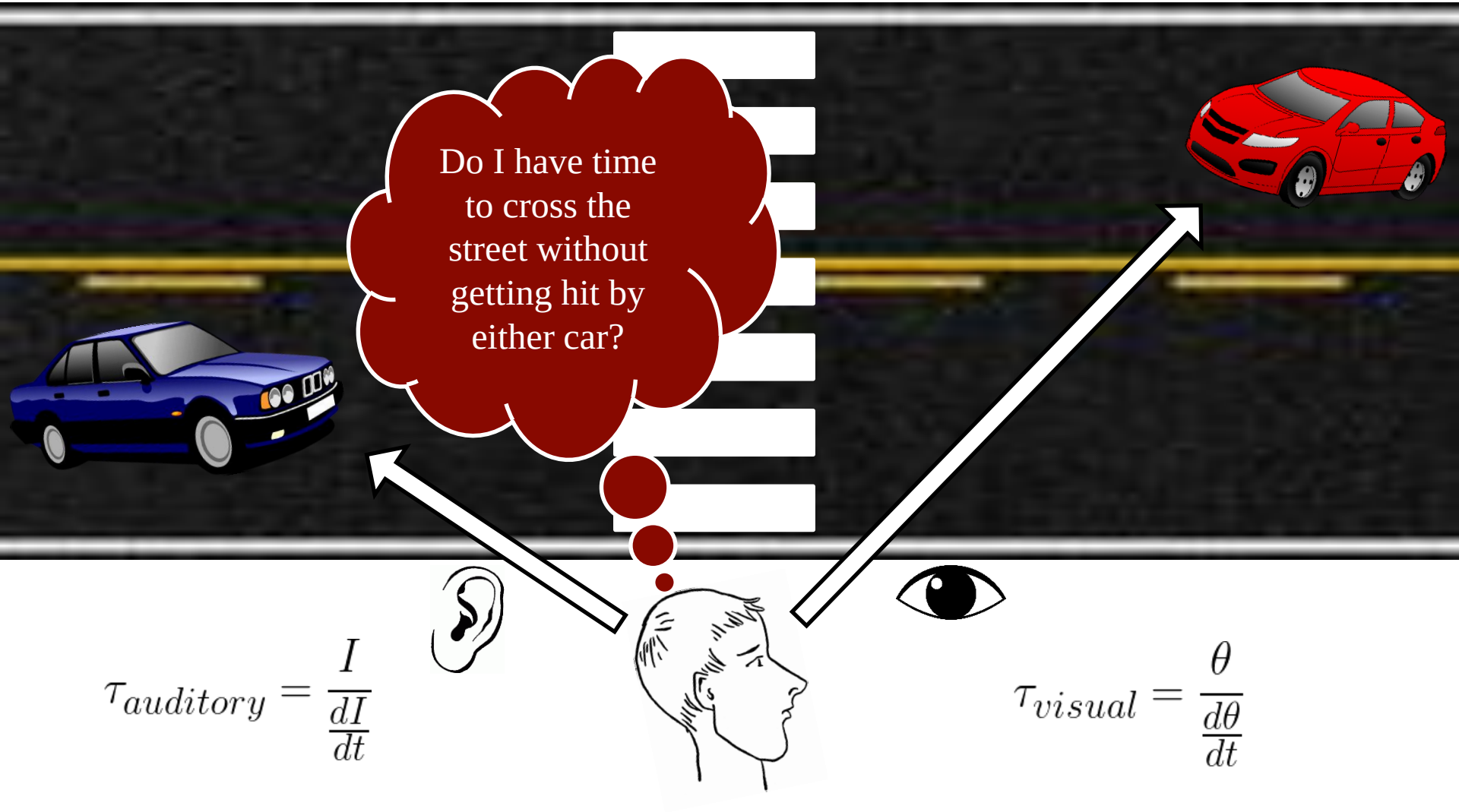
Time-to-Contact (TTC)

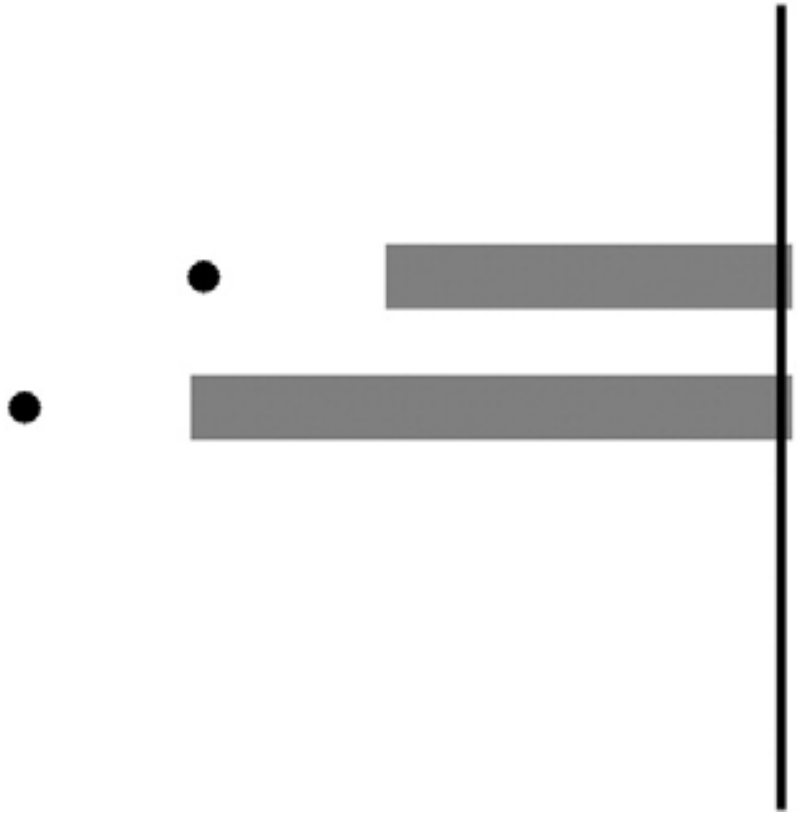


$$\tau_{auditory} = \frac{I}{\frac{dI}{dt}}$$

$$\tau_{visual} = \frac{\theta}{\frac{d\theta}{dt}}$$

Background

- Simultaneous Judgments of Multiple Objects
  - Baurés, Oberfeld, & Hecht (2010)
    - Compared judgment of two balls to judgments of one ball
    - Second object didn't affect judgment of leading object
    - Second object delayed judgment of trailing object
    - Asymmetry implicates limitations in cognitive processing



Baures, Oberfeld, and Hecht, 2010

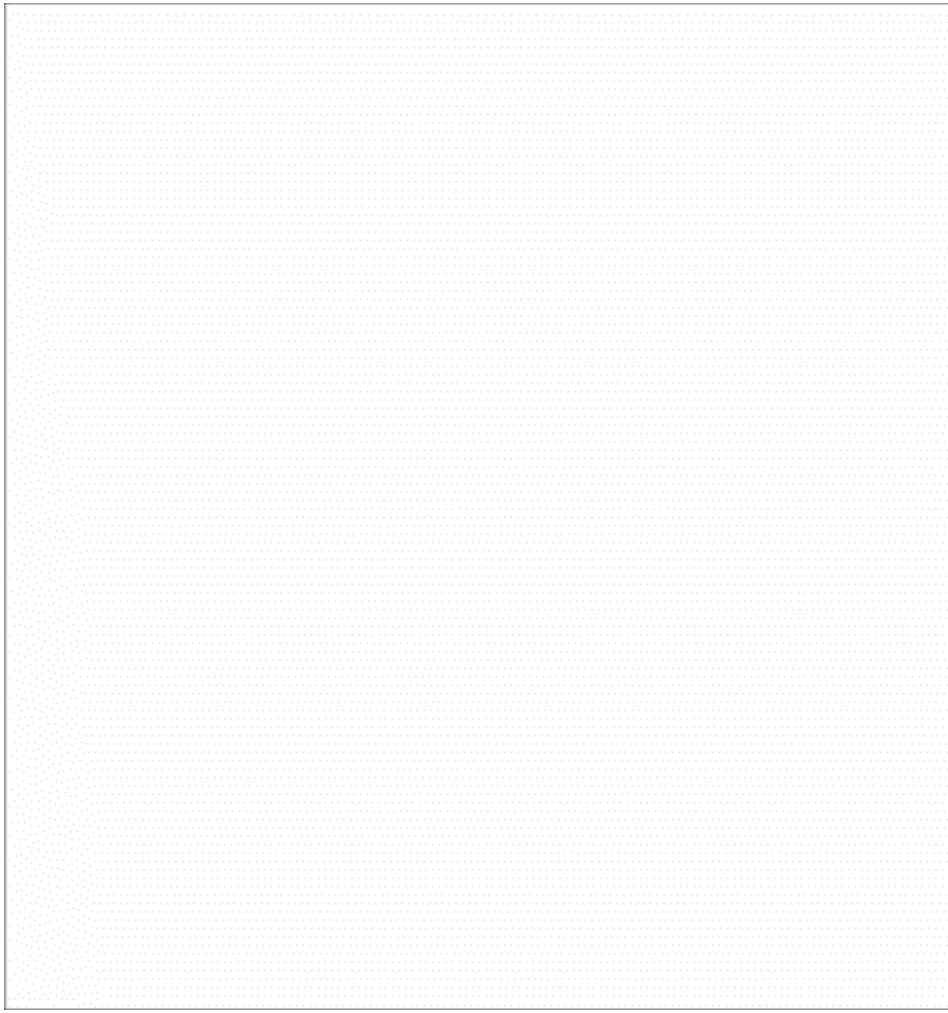
The Current Study

- Purpose and Potential Outcomes
  - How do judgments of an auditory and a visual object compare to the judgments of two visual objects?
  - IF the auditory and visual objects use the same resources as two visual objects
    - THEN we'd expect the same pattern of asymmetry
  - Outcome: Asymmetric relationship between visual and auditory objects
    - Different pattern than Baures'
    - Indicating a different use of resources

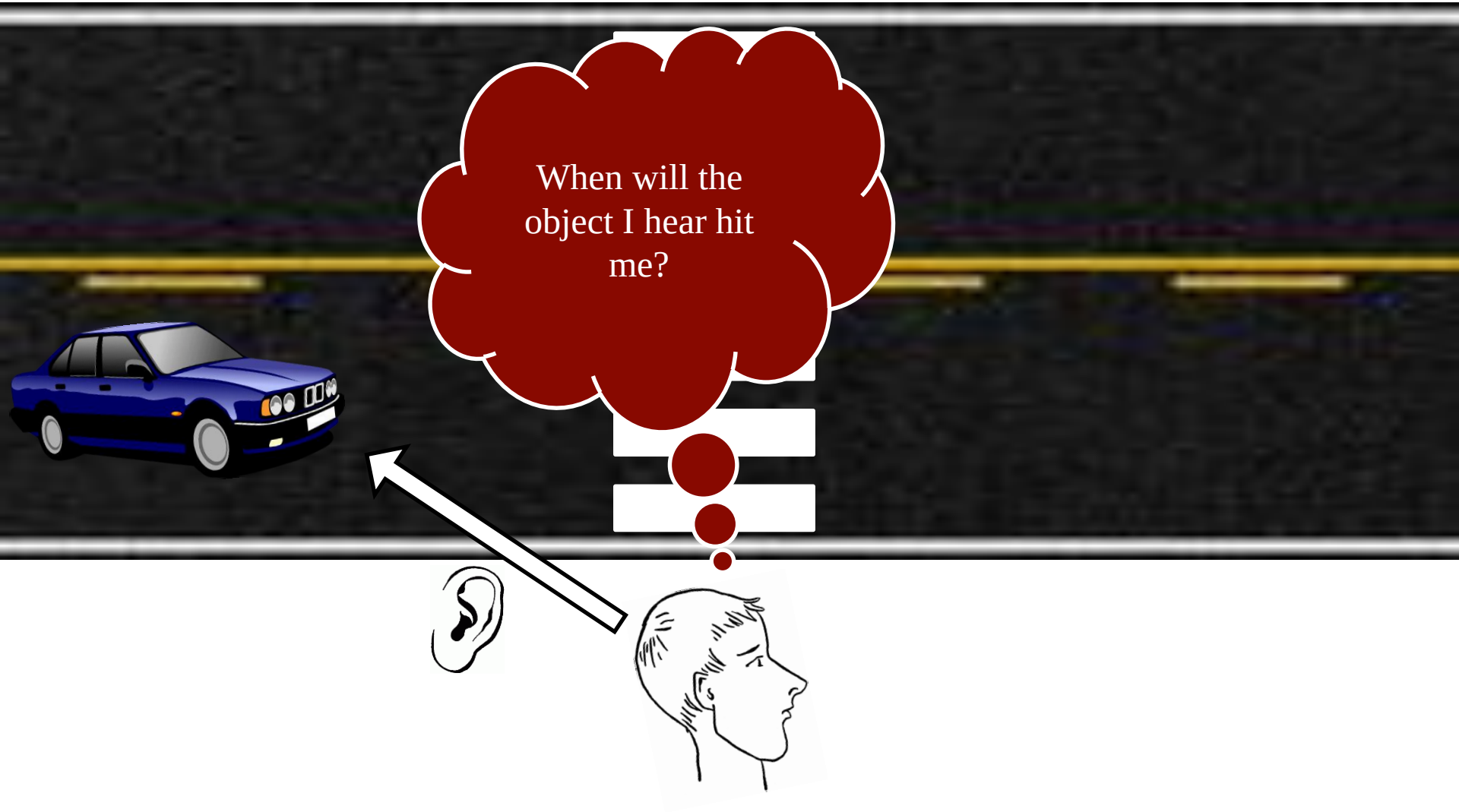
Method

Method

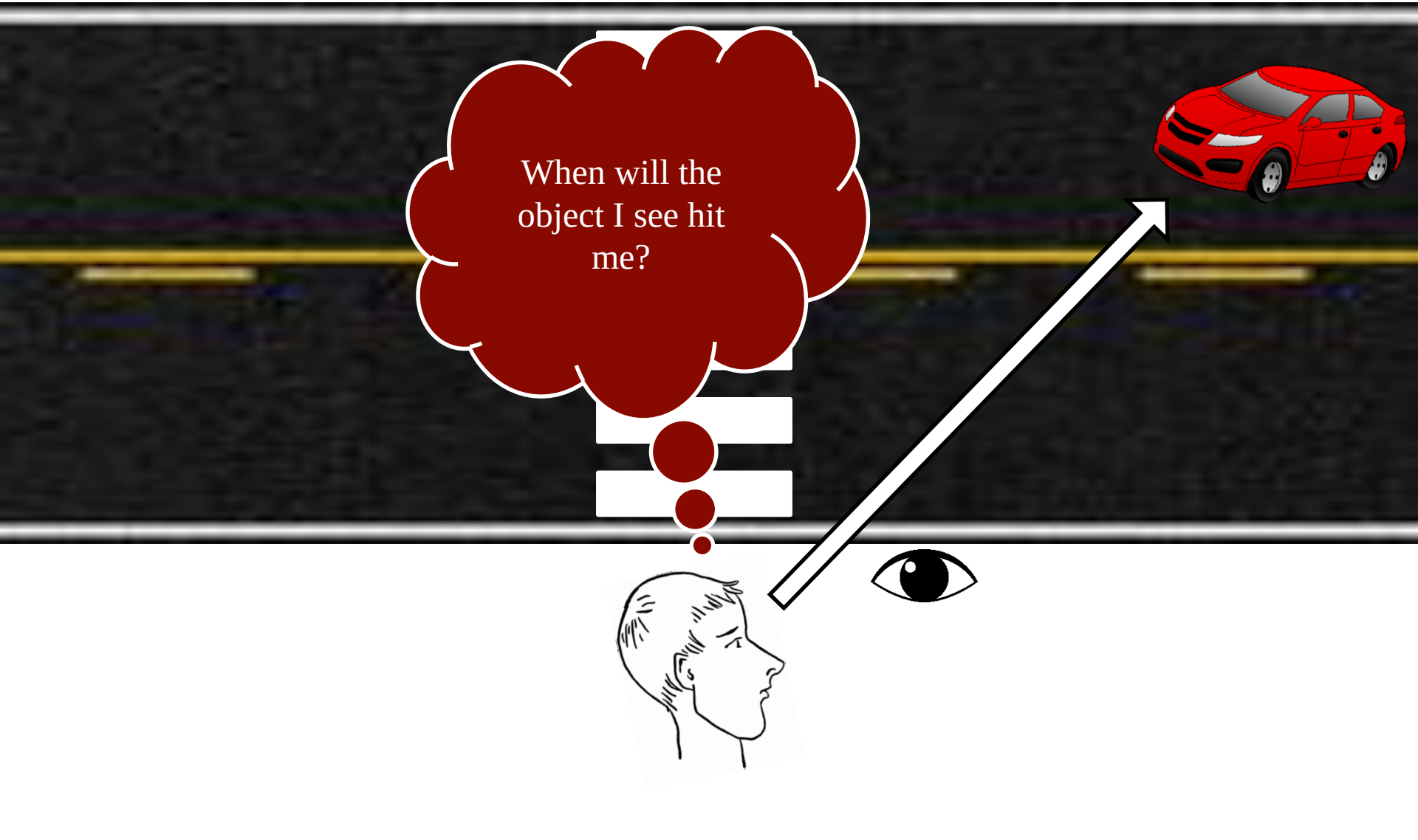
- Participants
  - 24 students
- Procedure
  - Simulation(s) of approaching object
  - Square or 1 khz tone
  - Pressed a button when they thought it would hit them



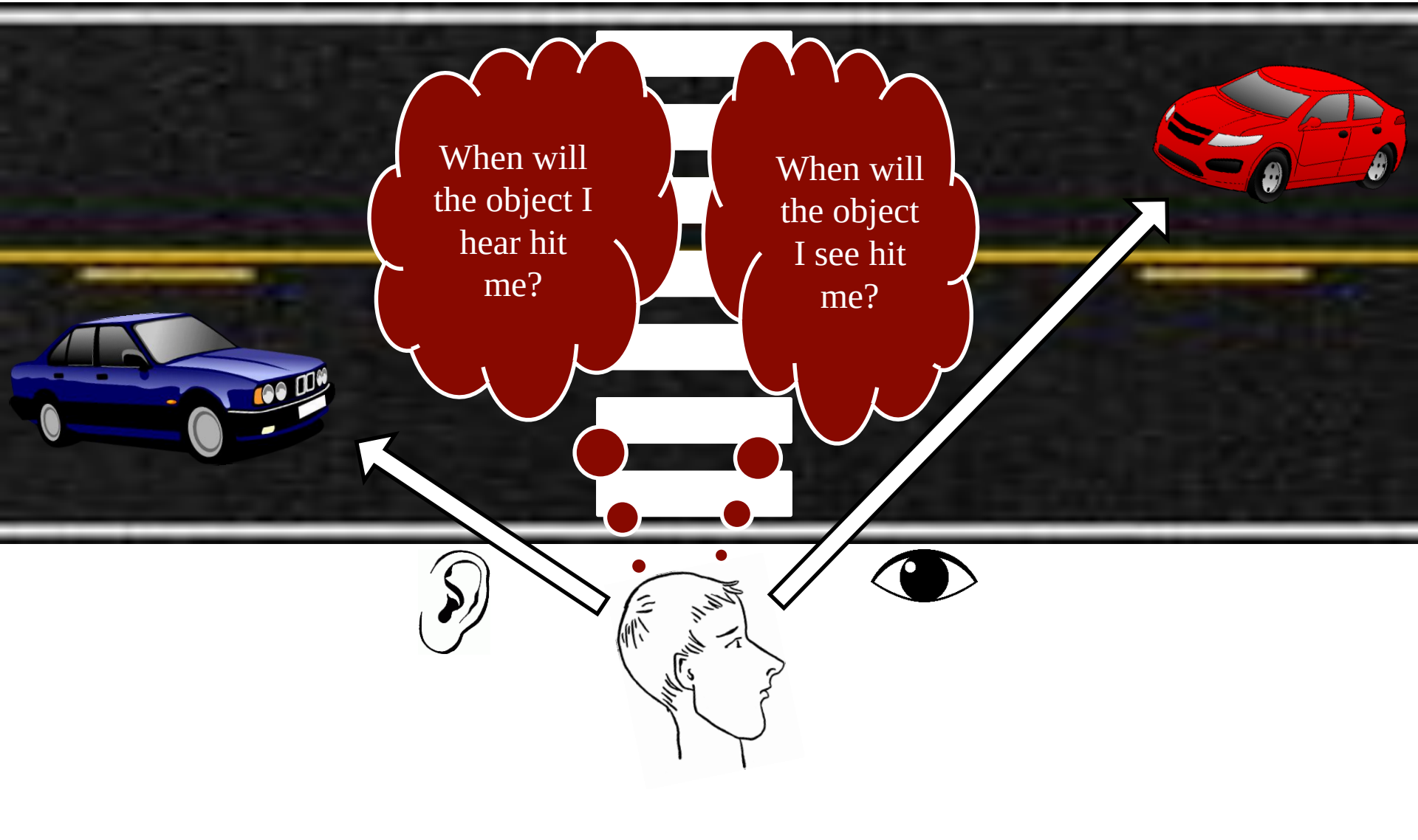
Unimodal (1 judgment), Auditory Block



Unimodal (1 judgment), Visual Block



Multimodal (2 judgments)
Auditory and Visual Block



Results

Results

- Two-Object Analyses
  - Used one-object results as a baseline
  - Error = judgment of TTC - actual TTC
    - Reflects accuracy of the TTC judgments
  - Analyzed change in error attributable to making a second judgment
    - Compared error of judgment in the two-object condition to the error of judgment in the one-object condition

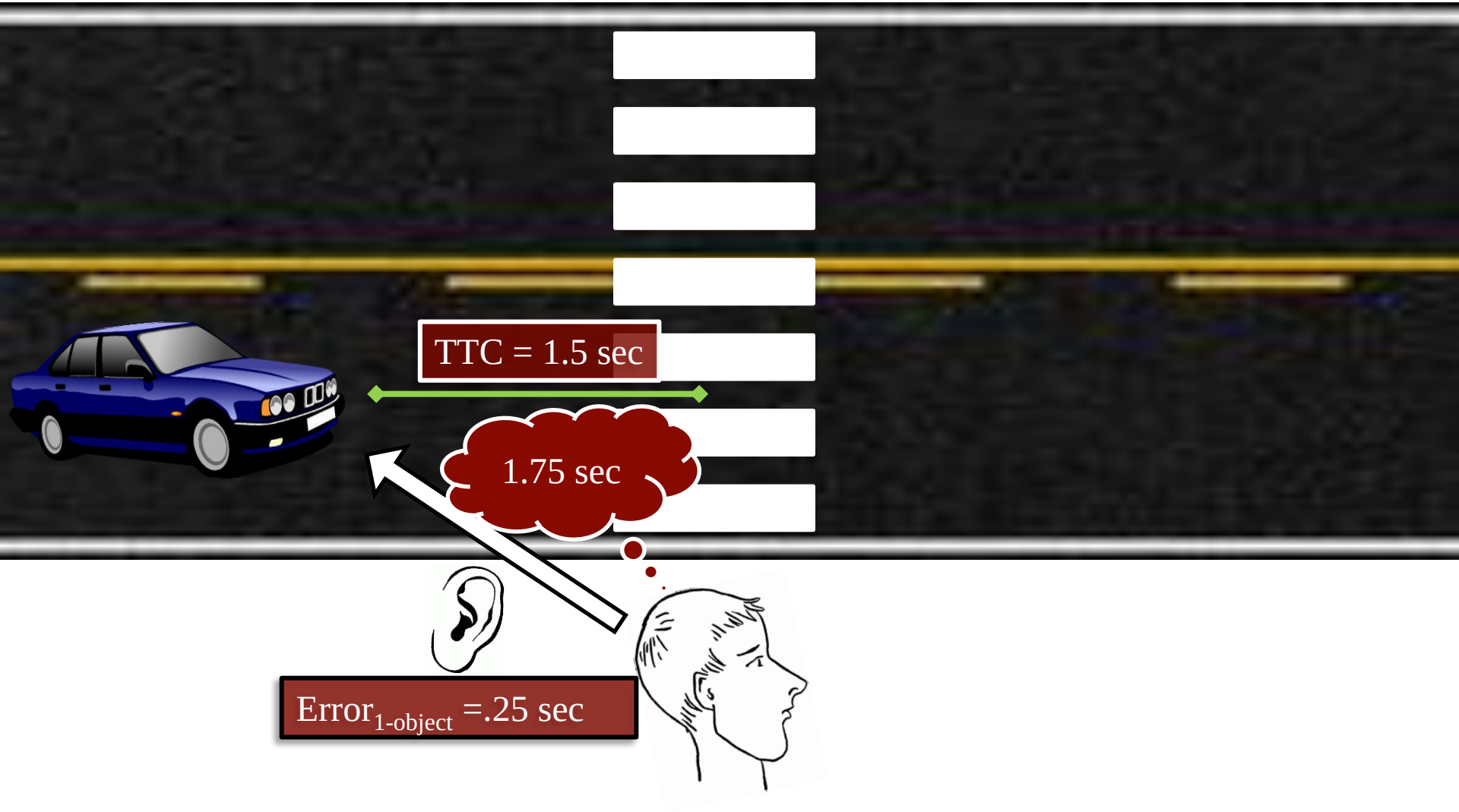
Results

- Two-Object Analyses
  - Object with TTC of 1.5 second = Reference Object
  - Other object of other modality =Distractor Object
    - Differed in arrival time from reference object by ±0.5 or =±1.0 second
  - Considered the effect of making the judgment of the distractor object on the judgment of the reference object

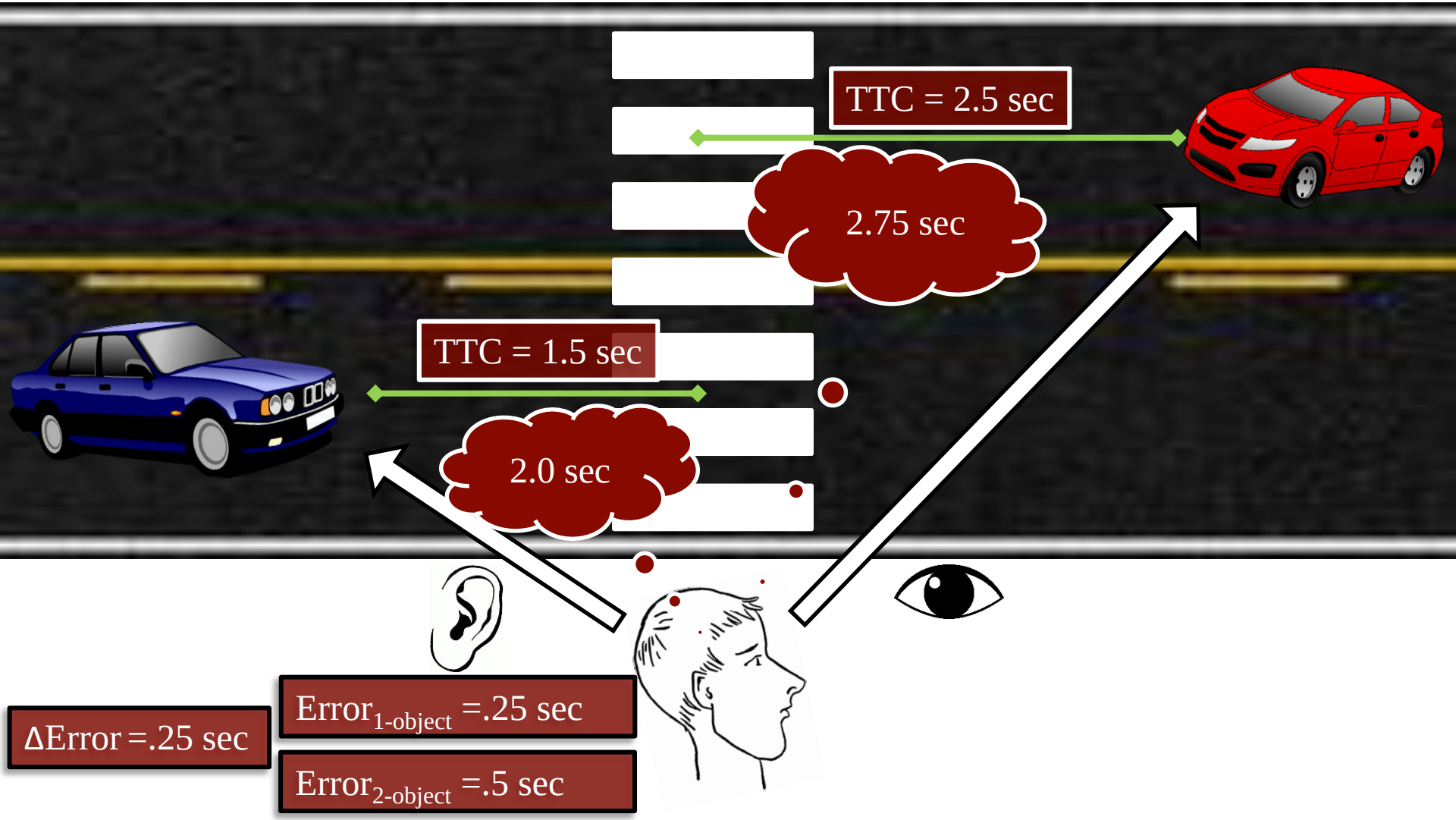
Results

- Two-Object Analyses: DV
  - $\Delta Error = Error_{2\text{-object trials}} - Error_{1\text{-object trials}}$
    - Reflects shift in TTC estimates of reference object when a second object is judged

Analysis of 2-object trials



Analysis of 2-object trials



$\Delta Error = .25$ sec

$Error_{1\text{-object}} = .25$ sec

$Error_{2\text{-object}} = .5$ sec

Results

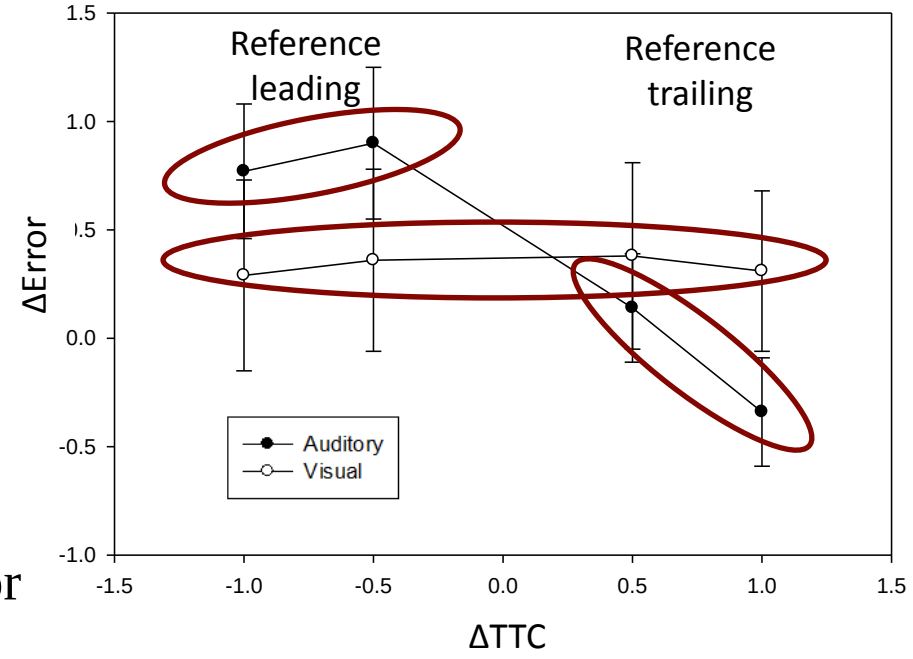
- Two-Object Analyses: IVs
  - IV: $\Delta TTC = TTC_{reference} - TTC_{distractor}$
  - IV: Modality of the reference object: auditory, visual
  - IV: Distance: near, far

Results

- Two-Object Analysis
  - 3-way ANOVA on ΔError
    - 2 (distance: near vs. far) x 2 (modality: auditory, visual) x 4 (ΔTTC: -1, -0.5, 0.5, 1.0)
  - Three-way interaction between modality, distance, and TTC
    - $F(3, 69)=6.80$, $p<.001$*, $\eta_p^2=0.23$
    - Examined by conducting a 2 (modality: auditory, visual) x 4 (ΔTTC: -1.0, -0.5,0.5, 1.0) ANOVA at each distance (near and far)

Results

- DV: ΔError
  - Far distance only
  - Modality x ΔTTC: $F(3, 69)=9.65$, $p<.001$*, $\eta_p^2=0.30$
    - ΔTTC was nonsignificant for visual objects
    - ΔTTC was significant for auditory objects $F(3,69)=19.43$, $p<.001$*, $\eta_p^2=0.46$
    - Leading auditory object estimated arriving later
    - Trailing auditory object estimated arriving earlier



Results

- Two-Object Summary
  - Asymmetric difference for auditory and visual objects leading and trailing
  - In the far condition…
    - Visual object judgment was largely unaffected by additional judgment
    - Auditory object judgment was shifted in the direction of the visual object's TTC

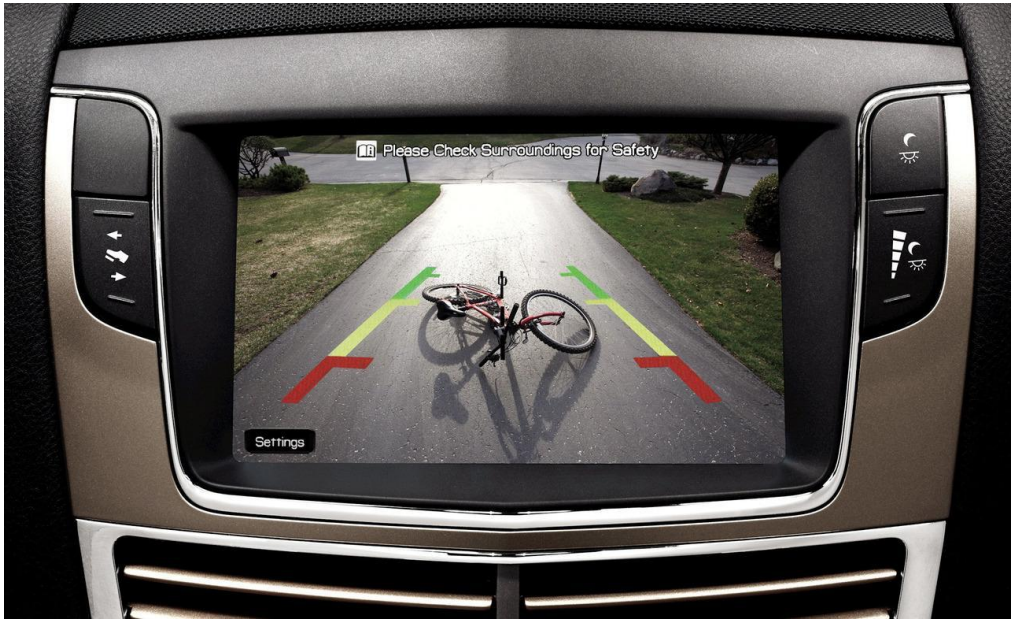
Discussion

Discussion

- Comparison to Baurés' results
  - Baures et al., 2010
    - 2 visual objects
    - Judgment of trailing object was systematically delayed
    - Implied limited cognitive resources for TTC judgments
  - The present study
    - 1 auditory object + 1 visual object
    - Far condition, auditory judgment was shifted towards visual TTC
    - Asymmetry implicates some type of limitation in cognitive processing
    - Future study: Visual object as a distractor for the auditory object

Practical Implication

- Application: Backup Warning System
  - Manipulate the TTC indicated by the auditory and visual components of the warning



http://images.dailytech.com/nimage/backup_camera_car_and_driver.jpg

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Questions?

Acknowledgments

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- Dr. Daniel Oberfeld and Doug Preddy
- Sam Levulis and Eric Bowen

Method

- Stimuli: 2 objects (Audio + Visual)

		Visual TTC				
		0.5	1.0	1.5	2.0	2.5
Auditory TTC	0.5			X		
	1.0			X		
	1.5	X	X		X	X
	2.0			X		
	2.5			X		

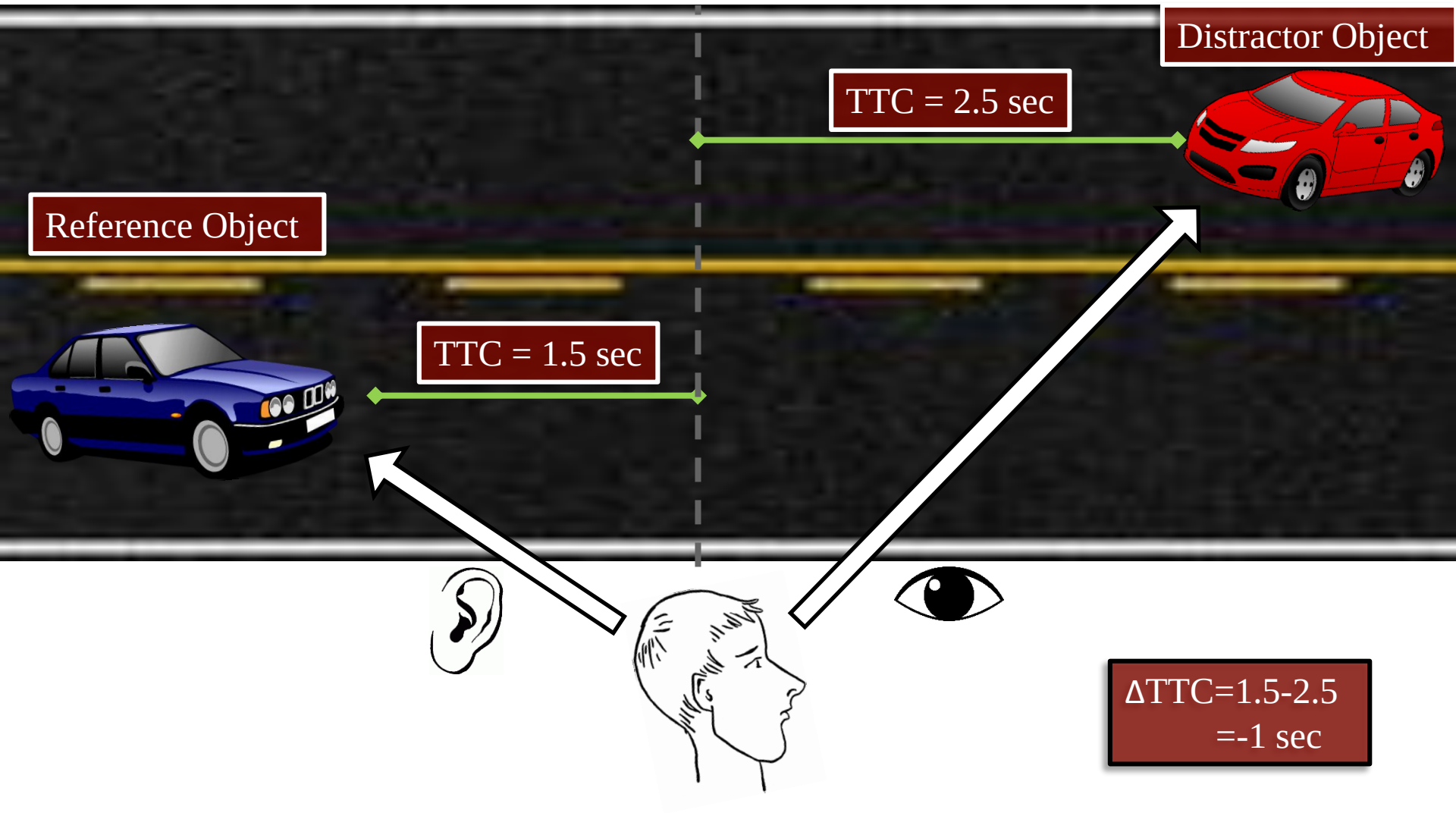
Method

- Stimuli: 2 objects (Audio + Visual)

		Visual TTC				
		0.5	1.0	1.5	2.0	2.5
Auditory TTC	0.5			X		
	1.0			X		
	1.5	X	X		X	X
	2.0			X		
	2.5			X		

Auditory object:
TTC = 0.5 seconds
Arrives first (leading)
Visual object:
TTC = 1.5 seconds
Arrives second (trailing)
Difference between the two arrivals = 1 second

Analysis of 2-object trials (IV's)



What's Next?

- Possible Mechanism/Future Possibilities: A Visual Distractor
  - The trailing visual object was a distractor for the leading auditory object.
  - Draws on previous literature:
    - Use of visual information for auditory judgment from crossmodal binding (Sekuler, et. al, 1997)
    - Modal asymmetry from visual dominance effect (Colavita, 1974)
    - Limited resources for processing leading and trailing stimuli's TTC described by Baures