Using Naturalistic Driving Study Data to Investigate the Impact of Driver Distraction on Driver's Reaction Time in Freeway Rear-ending Events

Jingru Gao
Department of Civil, Environmental and Geo-Engineering
University of Minnesota
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Overview

- Research Objectives
- Data Collection
- Analysis Methodologies
- Results
- Conclusion

Research Objectives

- Understand the mechanism of ***freeway rear-ending*** events

- Identify the ***driving behavior*** associated with freeway rear-ending events

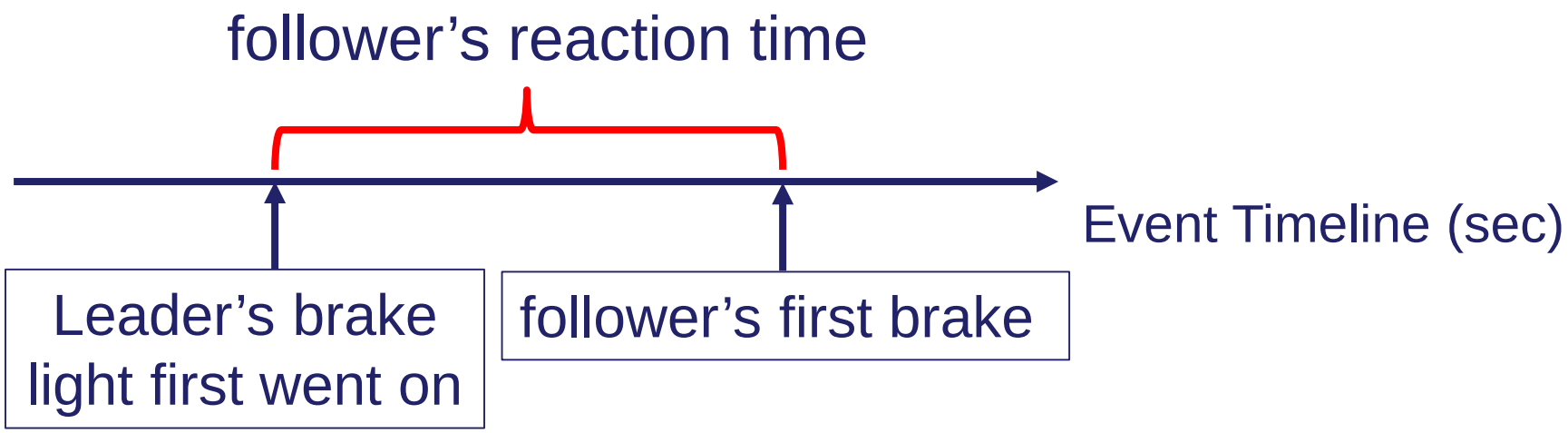
- Mechanism by which ***driver distraction*** could influence ***crash risk*** (indicator: ***reaction time***) in freeway rear-ending events

Research Objectives

- Important Definition
- *Distraction*:
- A driver is regarded as ***distracted*** if the driver "has chosen to engage in a ***secondary task*** that is not necessary to perform the primary driving task (Klauer, et al., 2006)".

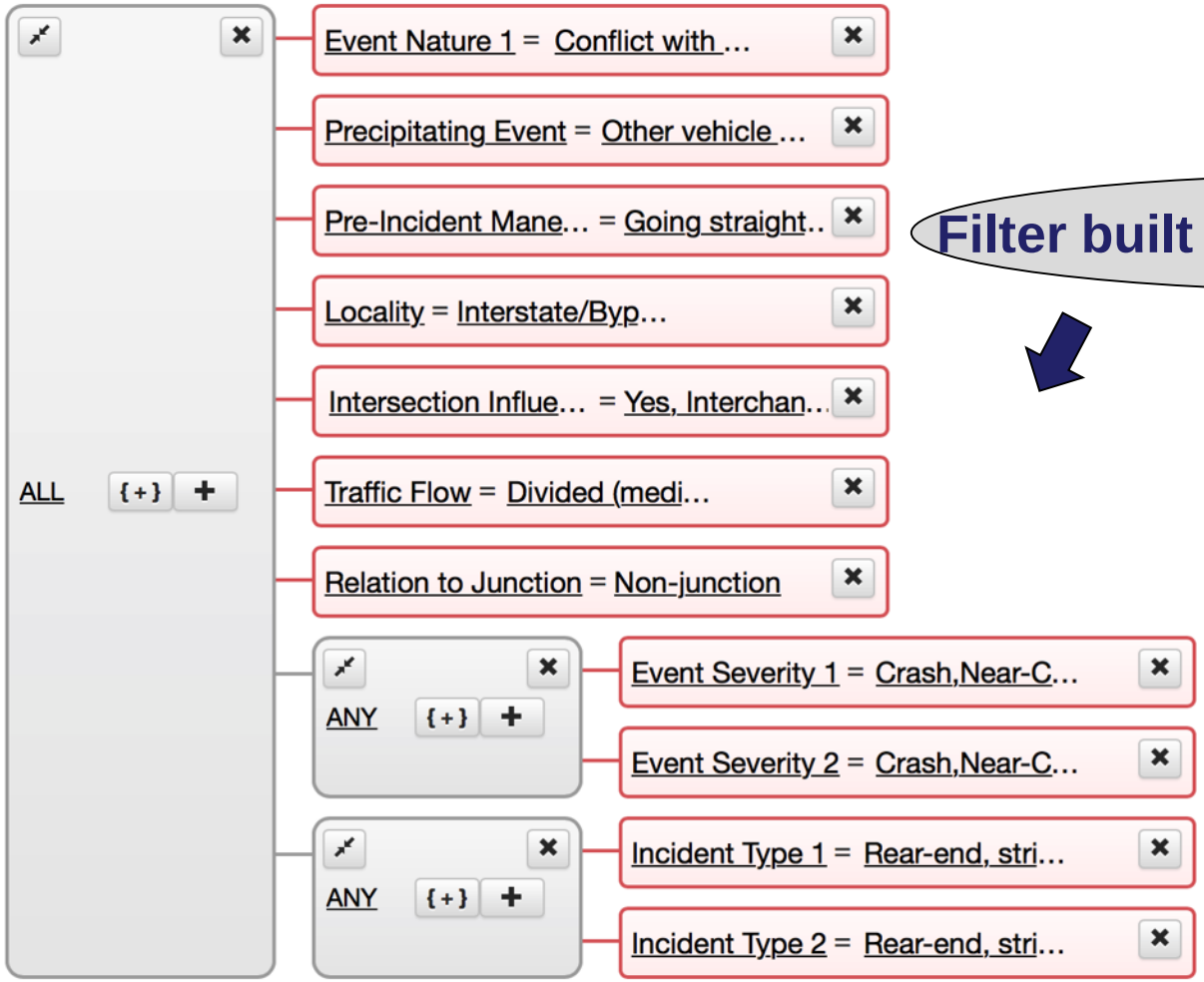
Research Objectives

- Important Definition
- *Reaction Time*:



Data Collection

- 1. Included Cases



Filter built to extract subject events

(*Source: SHRP 2 Insight Website*)

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Data Collection

- 2. Data Coding

Data availability:

Data available for viewing on the Insight website (front-facing video, non-PII, etc.).

Data Collection

- 2. Data Coding

(1) Response Variable: ***Reaction Time***

(2) Explanatory Variable

(i) Endogenous Variable

Driver-related, ***Distraction-related*** variables

(ii) Exogenous Variable

Environment-related variables

Data Collection

- 2. Data Coding

Driver-related Variables:

Age, *Gender*

Distraction-related Variables :

*Distraction Duration**, *Distraction Scenario*, *Secondary Task Type*

Environment-related Variables :

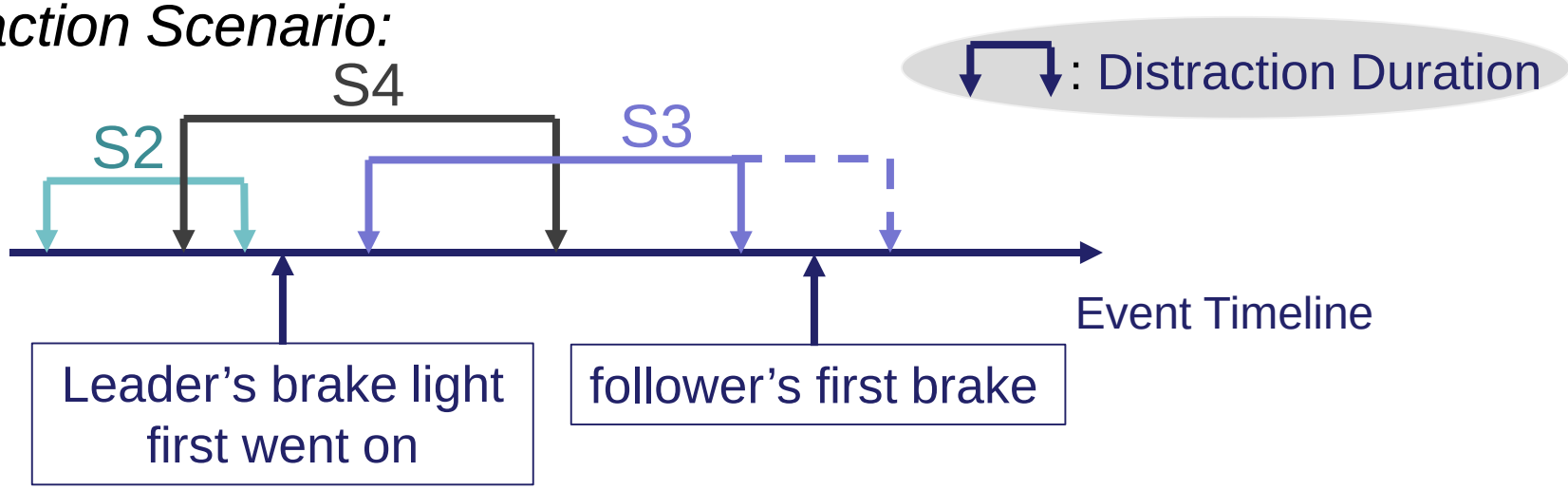
Visual Obstruction, *Weather, Lighting*

*A**: Continuous variable
A : Categorical variable

Data Collection

- 2. Data Coding

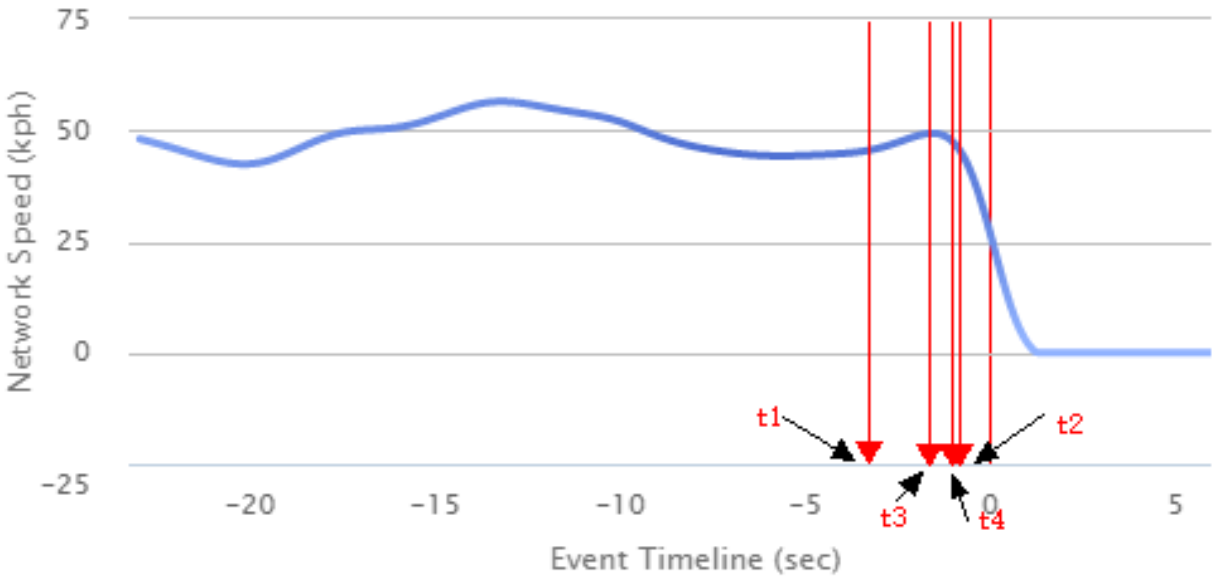
Distraction Scenario:



S1: normal driving;
S2: follower's distraction ended before leader braked;
S3: follower's distraction began after leader braked;
S4: follower driver was distracted when leader braked.

Analysis Methodologies

1. Driving Feature Estimation



(*Source: SHRP 2 Insight Website*)

t_1= the time point when the leader's brake first went on,
t_2= the time point when the follower's brake first went on,
t_3= the time point when the follower's distraction began,
t_4= the time point when the follower's distraction ended.

Reaction Time: $r = t_2 - t_1$
Distraction Duration: $d = t_4 - t_3$

Analysis Methodologies

- 2. Model Validation

- Basic model: Linear Model

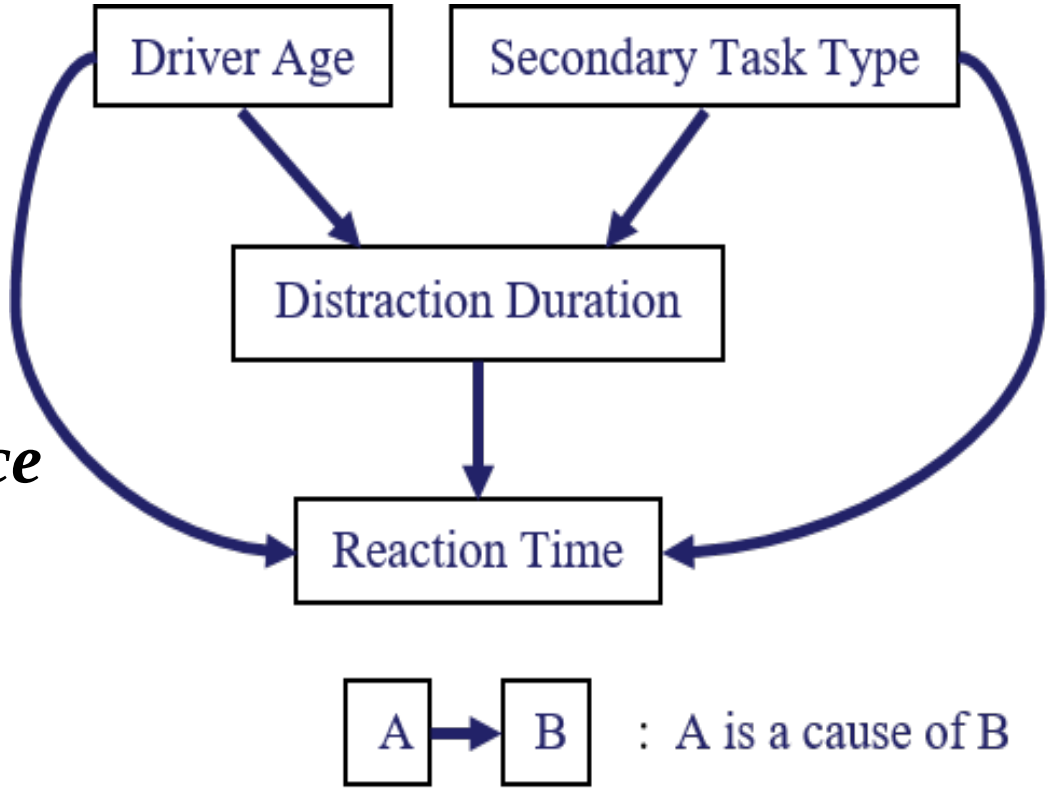
Analysis Methodologies

2. Model Validation

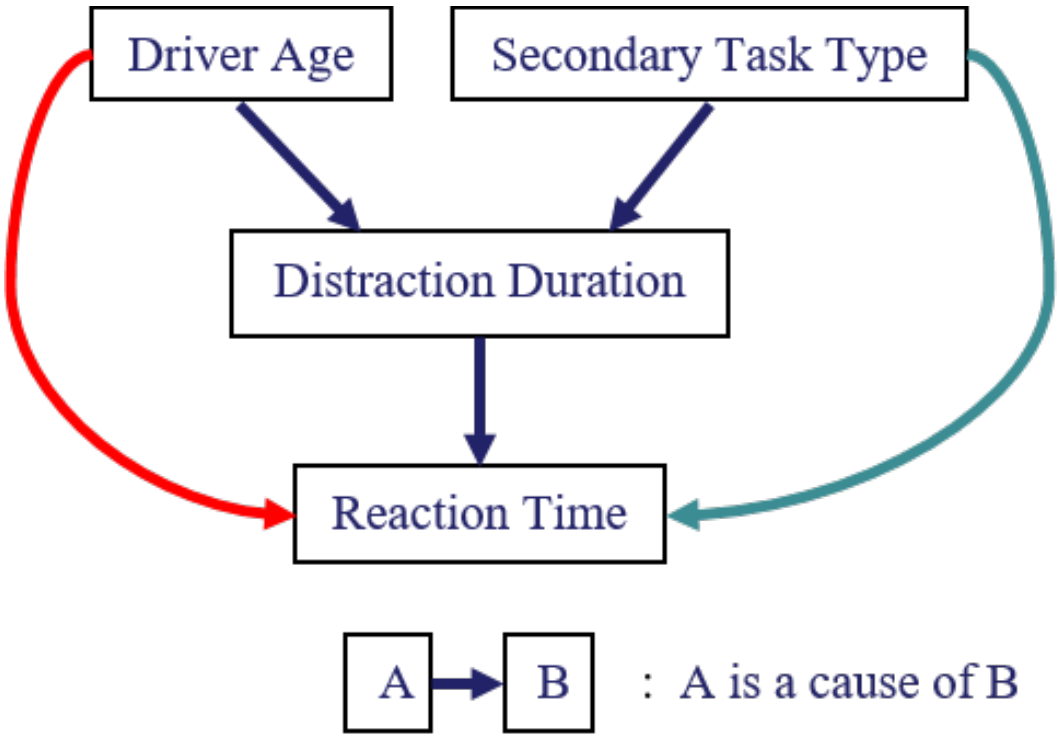
(1) *Tetrad* exploration

Causal model search based on

Conditional Independence



Analysis Methodologies



Existence of ⇉:

Reaction Time independent of ***Driver Age***/***Secondary Task Type*** given ***Distraction Duration***?

Analysis Methodologies

- *Tetrad* exploration

Attempt was not pursued because limitation in:

(i) software usage: continuous/discrete set only

(ii) sample size: issue with continuous data discretization

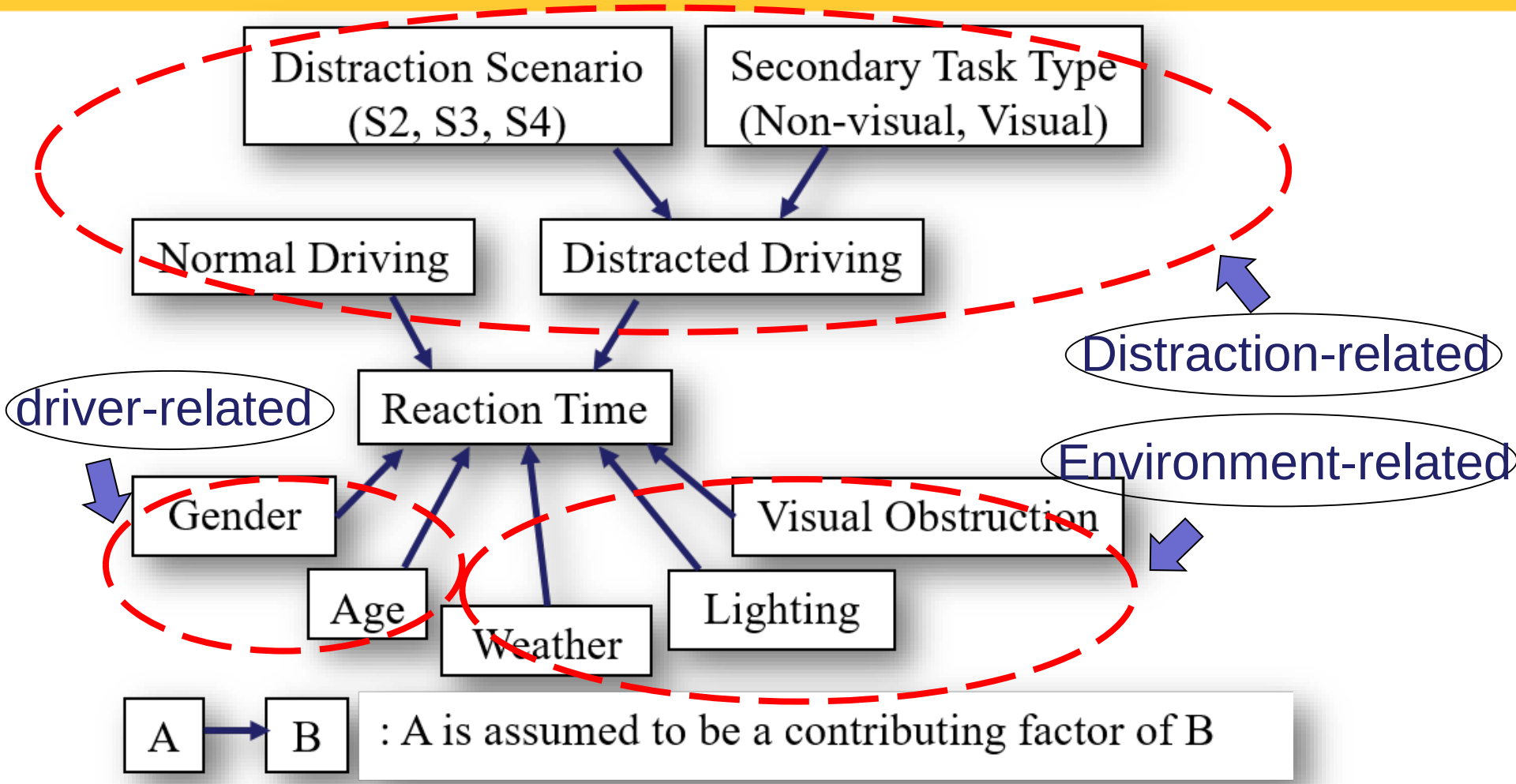
Analysis Methodologies

2. Model Validation

(2) Linear regression

(testing proposed model structure)

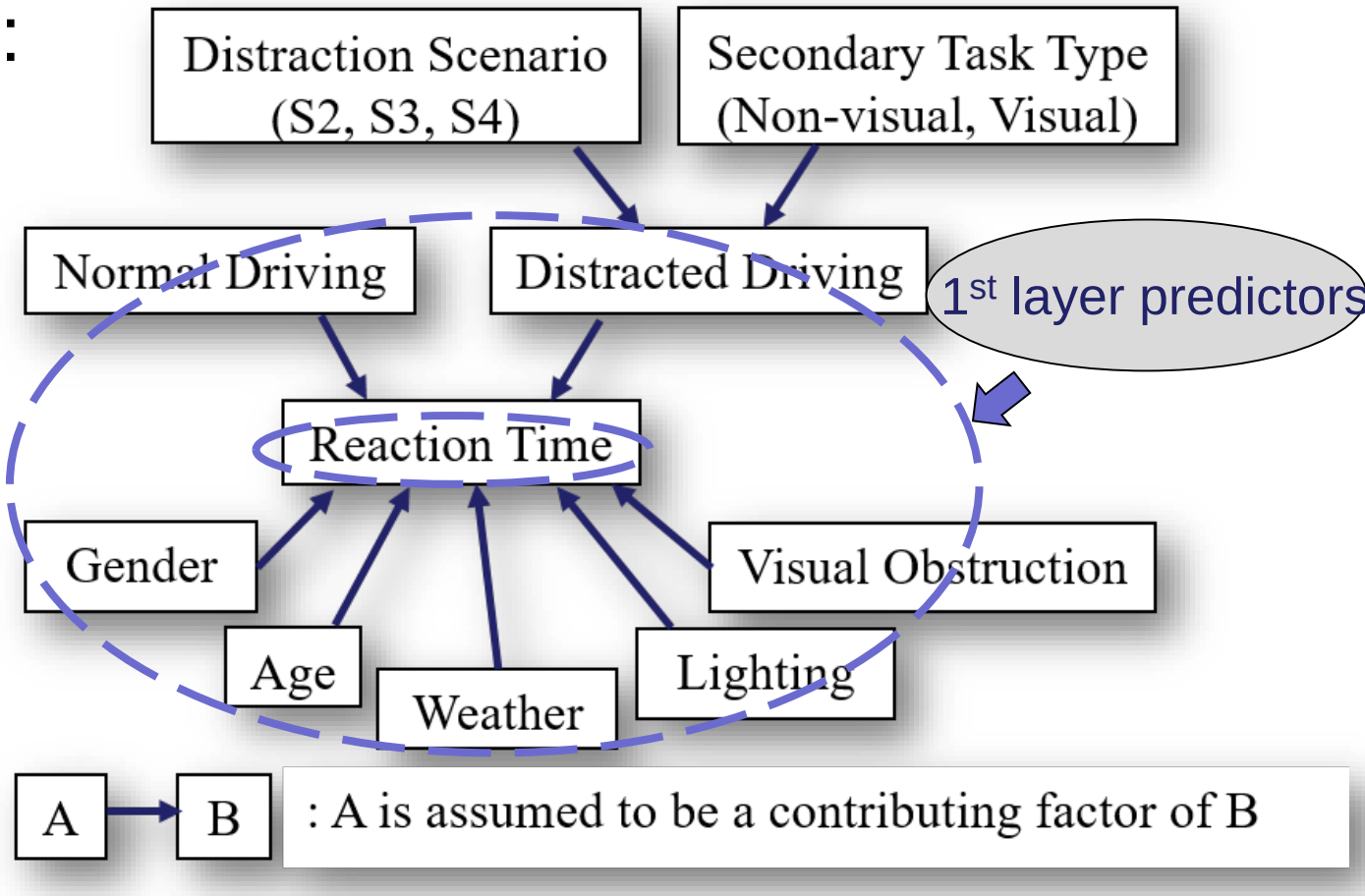
Analysis Methodologies



Analysis Methodologies

- Step 1 of 3:

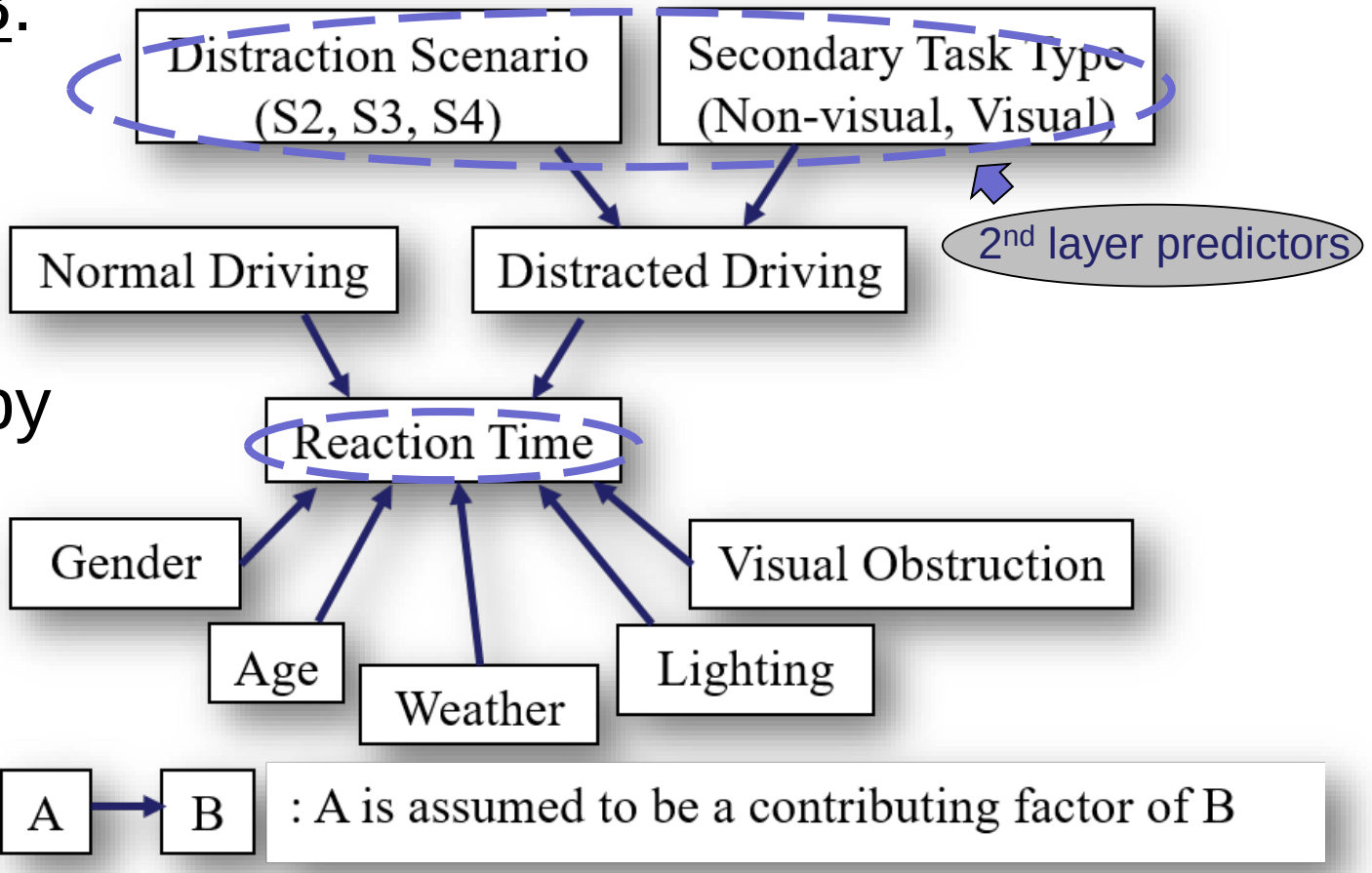
Association between ***Reaction Time*** and ***1st-layer predictors***?



Analysis Methodologies

- Step 2 of 3:

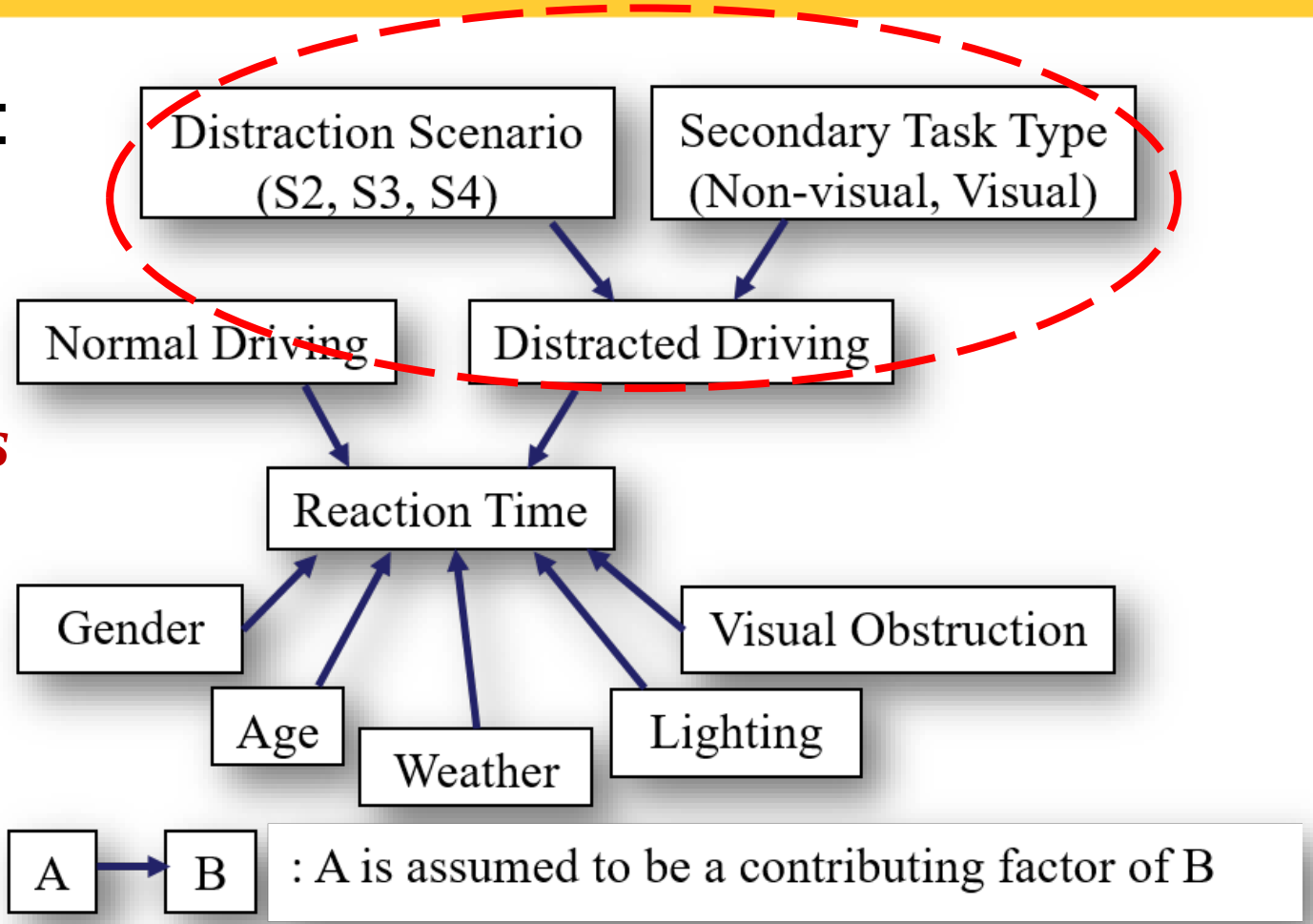
Reaction Time and ***2nd-layer predictors*** are d-separated by ***1st-layer predictors***?



Analysis Methodologies

- Step 3 of 3:

Association between ***1st-layer predictors*** and ***2nd-layer predictors***?



Results

- Final sample size: 108 events

  (from 108 different drivers)

- 62 female, 46 male drivers
- 45 normal driving, 63 distracted driving

Results

Statics of ***Reaction Time*** in different driving groups:

	N	M	Mdn	SD
Normal Driving	45	1.669	1.290	1.254
Distracted Driving	63	2.192	1.956	1.317

N=Number of events, M=Mean, Mdn=Median, SD=Standard deviation

T-test of ***Reaction Time*** in different driving groups:

Two Sample t-test		
t = 2.075	df = 106	p-value = 0.020
95 percent confidence interval:	(0.104232744, 0.941767255)	

Results

- Linear regression
- Step 1:

- ***M1:***
- $$Reaction\ Time = \beta 0 + \beta 1 \times Distraction\ Duration + \beta 2 \times Gender + \beta 3 \times Age + \beta 4 \times Weather + \beta 5 \times Lighting$$

Results

```
lm(formula = ReactionTime ~ factor(Gender) + factor(Age) + DistractionDuration +
    Weather + Lighting, data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-2.3480 -0.8583 -0.2692  0.5050  5.3122

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)          1.44920    0.39537   3.665 0.000397 ***
factor(Gender)M      0.14696    0.26190   0.561 0.575948
factor(Age)Old       0.40695    0.48725   0.835 0.405597
factor(Age)Teen      0.04204    0.43847   0.096 0.923806
factor(Age)Young     0.09372    0.38637   0.243 0.808840
DistractionDuration  0.12890    0.04315   2.987 0.003540 **
Weather             -0.21928    0.41441  -0.529 0.597879
Lighting             0.09328    0.31231   0.299 0.765815
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.294 on 100 degrees of freedom
Multiple R-squared:  0.09005,    Adjusted R-squared:  0.02636
F-statistic: 1.414 on 7 and 100 DF,  p-value: 0.2081
```

Distraction Duration is the only factor associated with ***Reaction Time***.

Results

- Linear regression
- Step 2:

- ***M2:***
- ***Residuals of M1= β0+ β1 × Distraction Scenario +β2 × Secondary Task Type***

Results

```
lm(formula = Residuals ~ factor(DistractionScenario) + factor(SecondaryTaskTyp
e),
    data = datad)

Residuals:
    Min      1Q  Median      3Q     Max
-1.3575 -0.6502 -0.1905  0.4490  3.8944

Coefficients:
                                  Estimate  Std. Error  t value  Pr(>|t|)
(Intercept)                        0.38730   0.34557    1.121    0.267
factor(DistractionScenario)S3      0.09531   0.49935    0.191    0.849
factor(DistractionScenario)S4     -0.56486   0.36537   -1.546    0.127
factor(SecondaryTaskType)Visual    0.01316   0.26576    0.050    0.961

Residual standard error: 1.002 on 59 degrees of freedom
Multiple R-squared:  0.07338,       Adjusted R-squared:  0.02626
F-statistic: 1.557 on 3 and 59 DF,  p-value: 0.2093
```

Neither ***Distraction Scenario*** nor ***Secondary Task Type*** has direct impact on ***Reaction Time***.

Results

- Linear regression
- Step 3:

- ***M3:***
- $$Distraction\ Duration = \beta 0 + \beta 1 \times Distraction\ Scenario + \beta 2 \times Secondary\ Task\ Type$$

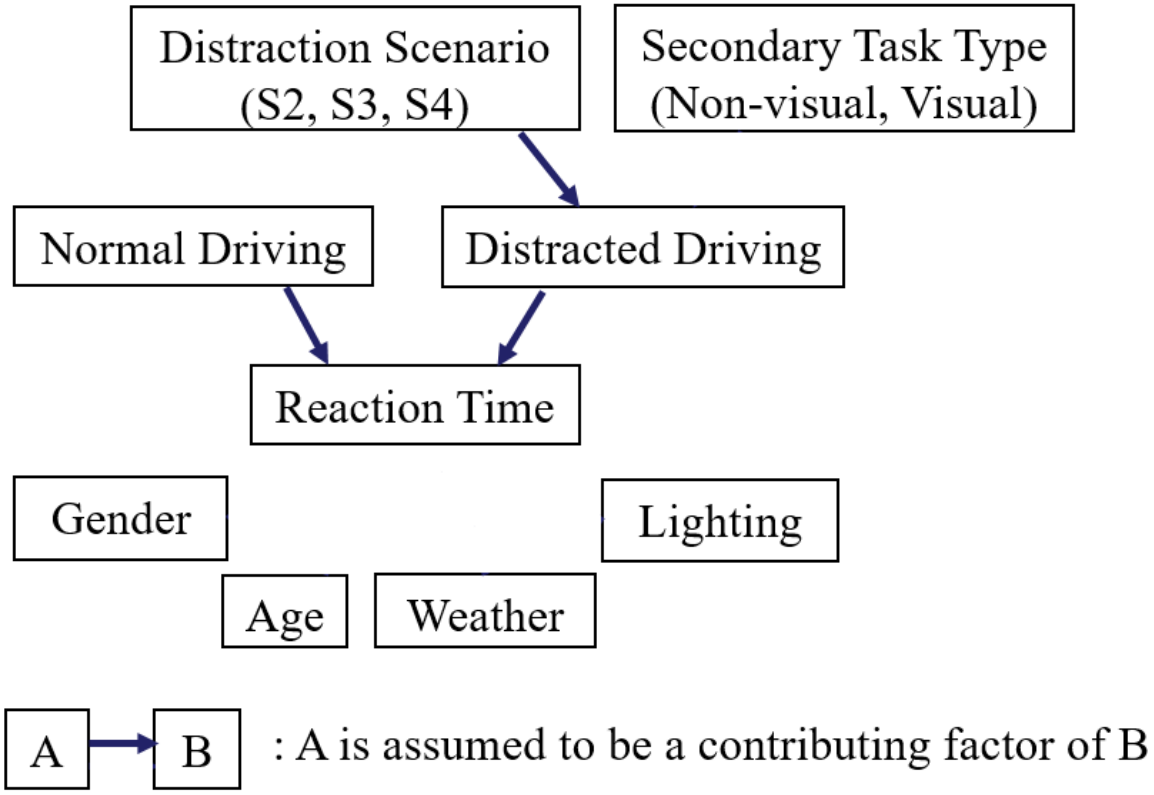
Results

```
lm(formula = DistractionDuration ~ factor(DistractionScenario) +
    factor(SecondaryTaskType), data = datad)

Residuals:
    Min      1Q  Median      3Q     Max
-4.9840 -0.7934  0.2074  1.1762  3.6440

Coefficients:
                                  Estimate Std. Error t value Pr(>|t|)
(Intercept)                        2.0217     0.6589   3.068  0.00325 **
factor(DistractionScenario)S3     -0.4735     0.9522  -0.497  0.62084
factor(DistractionScenario)S4      4.0403     0.6967   5.799 2.78e-07 ***
factor(SecondaryTaskType)Visual   -0.4201     0.5068   0.829  0.41043
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.911 on 59 degrees of freedom
Multiple R-squared:  0.5239,    Adjusted R-squared:  0.4997
F-statistic: 21.64 on 3 and 59 DF,  p-value: 1.415e-09
```

Only ***Distraction Scenario*** has significant effect on ***Distraction Duration***.

Results

- Final model structure validated:



Conclusion

- Driver distraction could affect reaction time
- In the studied events, driver distraction duration is the primary direct cause of reaction time, with other factors having indirect effects mediated by distraction.
- Longer distraction duration and the distracted status when a leader braked tended to result in longer reaction times.
- Limitations in this study
- Limited access to NDS data, e.g. situation kinematics
- Small sample size

Acknowledgement

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- Questions?

- Jingru Gao
- University of Minnesota
- gaoxx692@umn.edu