Driver Foot Behavior with Regenerative Braking

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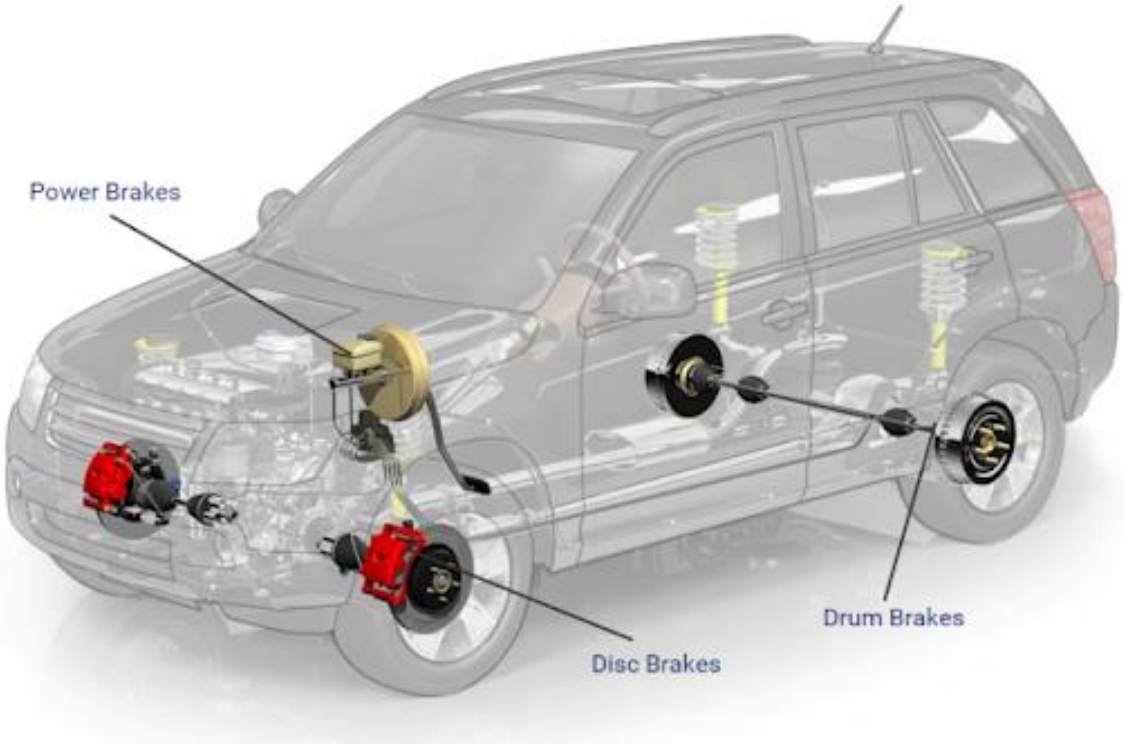
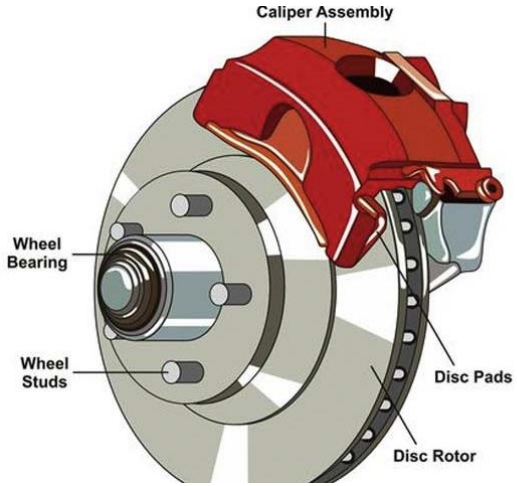
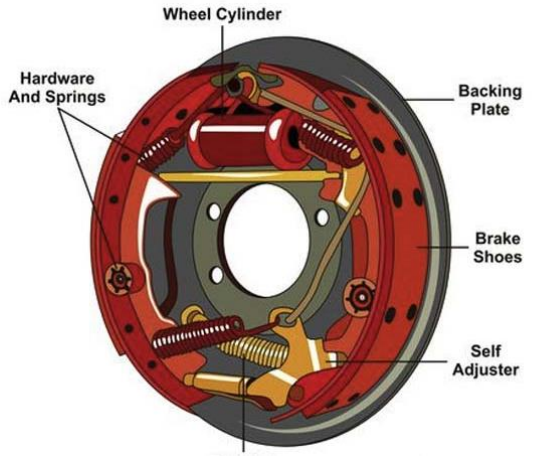
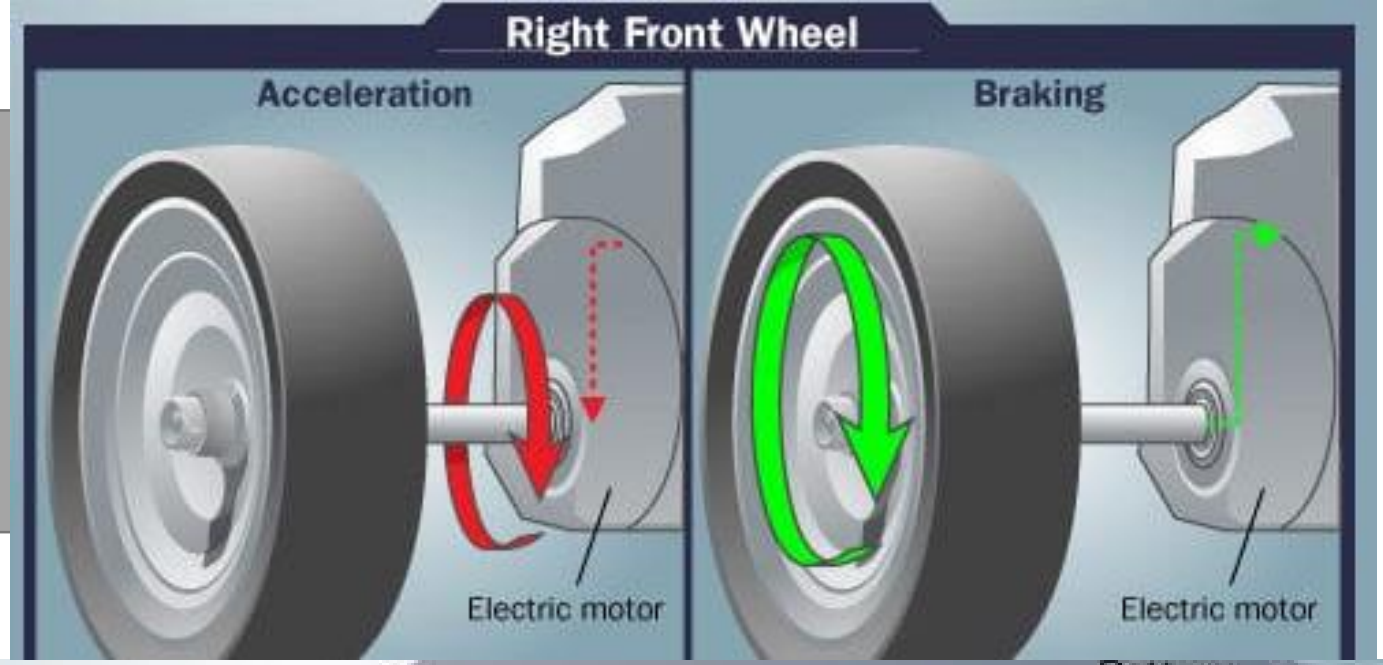
Service Braking (SB)

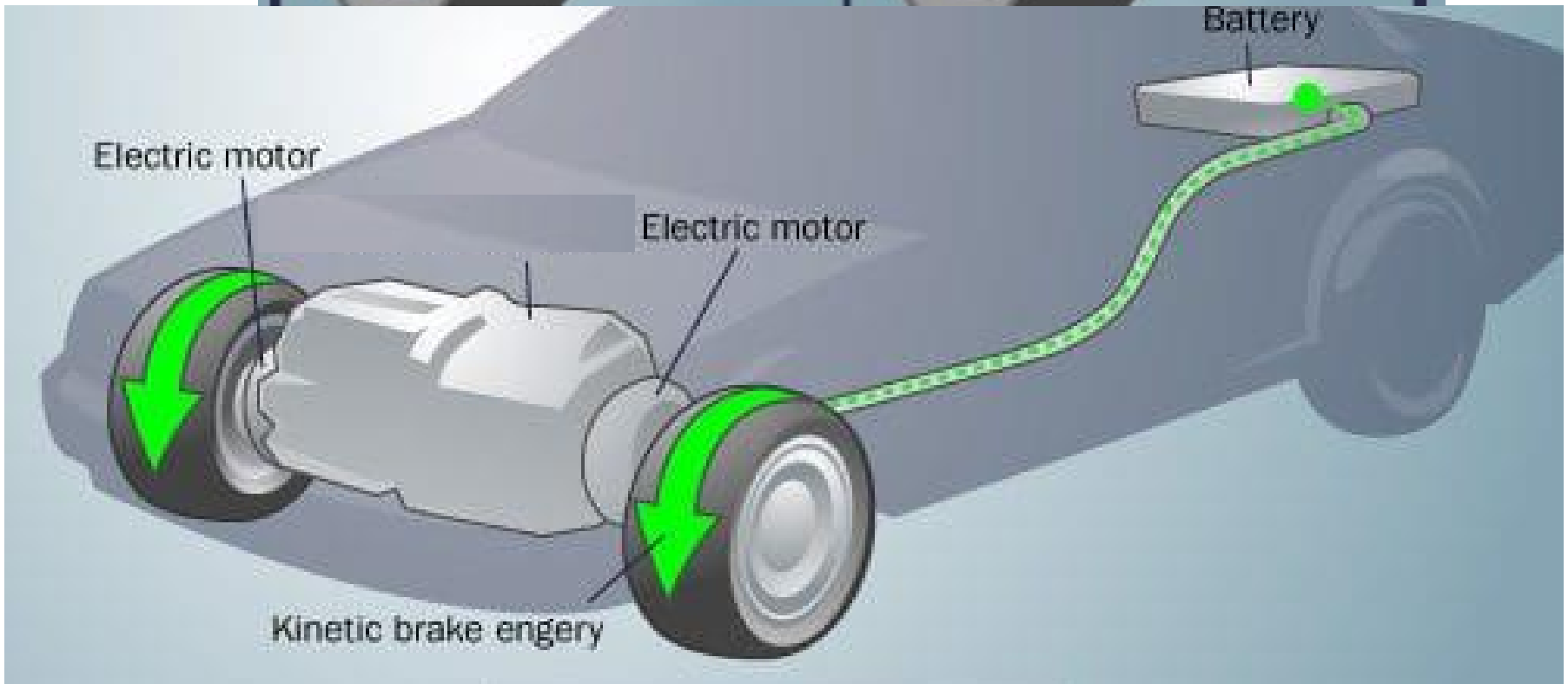






Regenerative Braking (RB)





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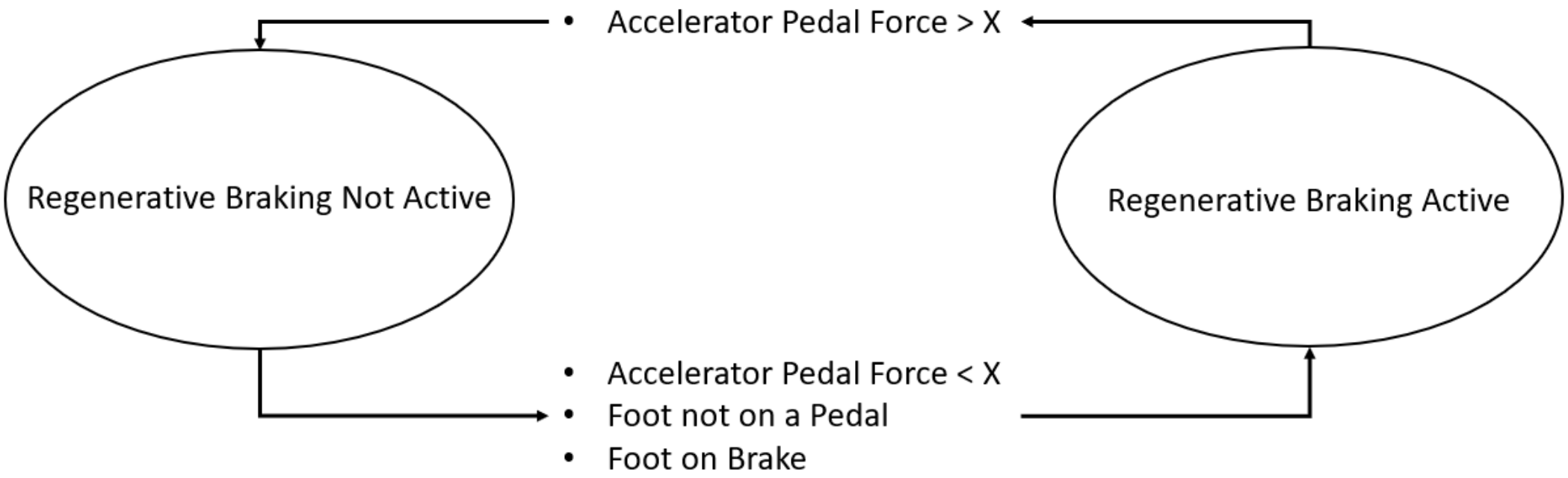
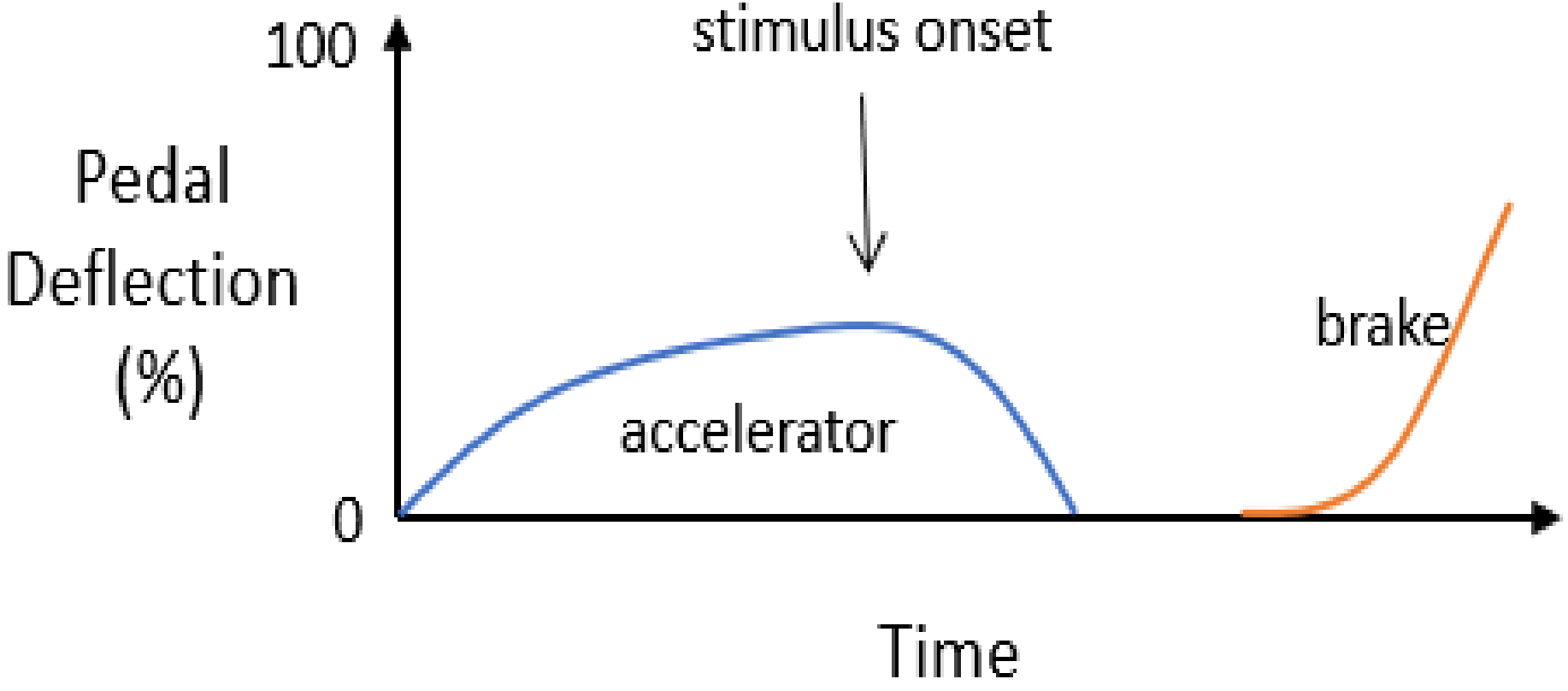
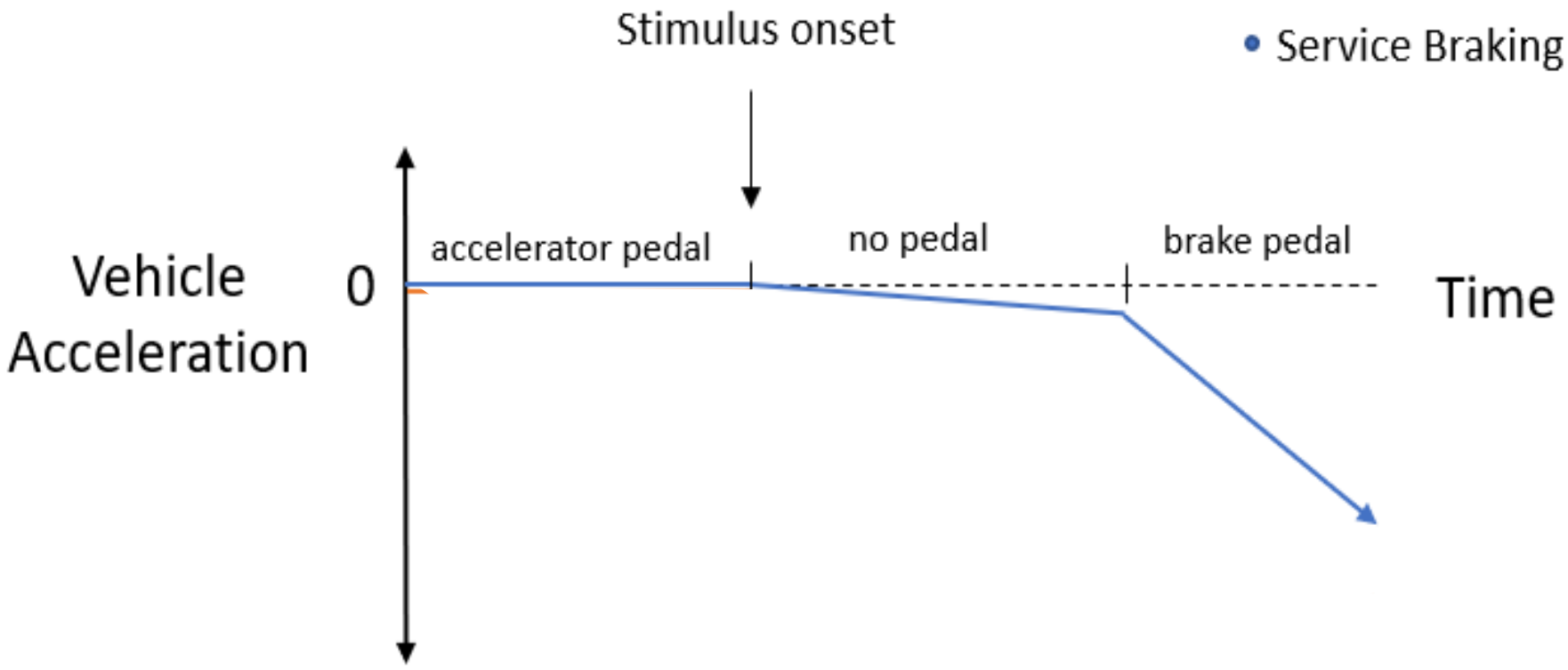


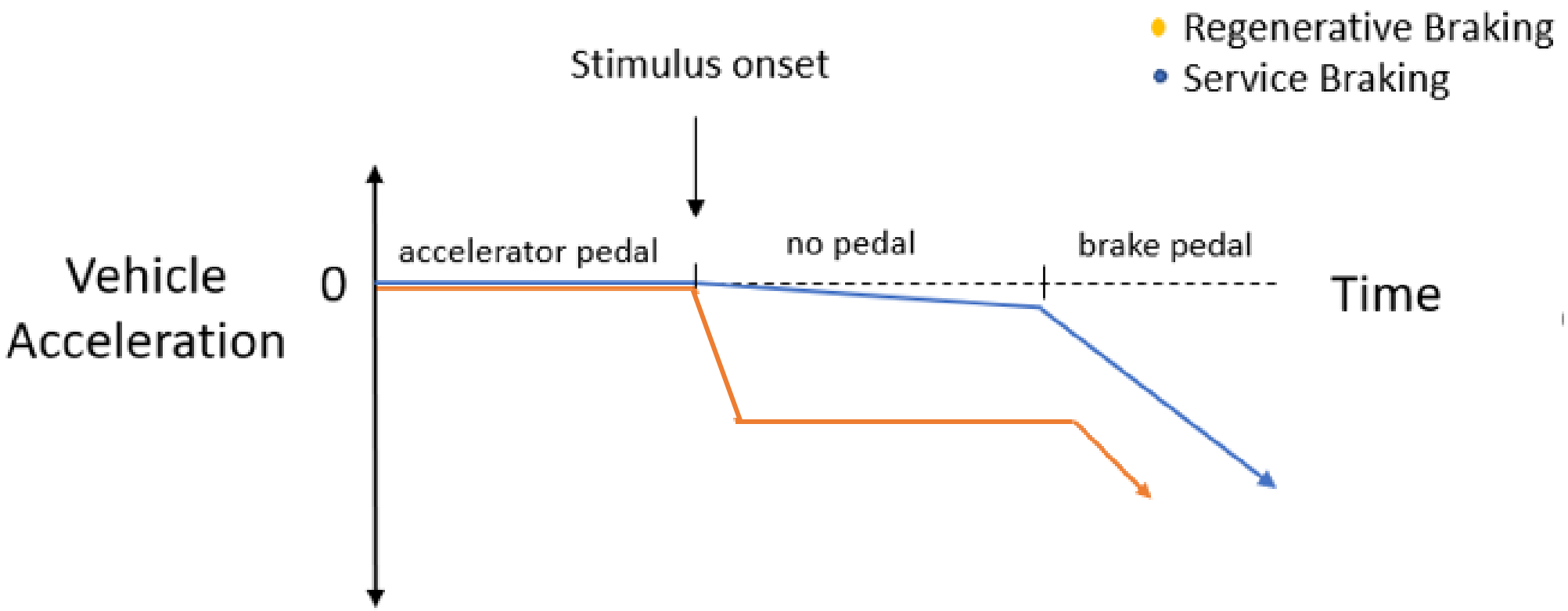
Driver Braking Behavior



Driver Braking Behavior with Traditional Service Braking



Driver Braking Behavior with Regenerative Braking



Literature Gaps

- Little research regarding human factors and RB
  - Cocron et al. (2013) explored how quickly drivers learn RB systems
  - Other research looks at RB from an implementation standpoint
- Differences in driver behavior between RB and SB has not been explored

Research Question

1. Is there a difference in driver foot behavior between RB and SB?

Study Design

3 Braking Conditions

- Service Braking (deceleration of 0.01-0.04 g)
- Low level of RB (deceleration of 0.02-0.05 g)
- High level of RB (deceleration of 0.15-0.2 g)

30 participants (randomly assigned to condition)

- 10 per condition (5 female, 5 male)

Between subjects design


THE NATIONAL ADVANCED DRIVING SIMULATOR
THE UNIVERSITY OF IOWA


THE UNIVERSITY OF IOWA
THE NATIONAL ADVANCED DRIVING SIMULATOR
NHTSA
My Car DoesWhat.org
Know More. Drive Safer.

Equipment

The Simulated Drive

- Driver was instructed to drive 55 mph.
- Lead vehicle in front of participant vehicle throughout the drive (fixed gap).
- 3 separate braking events.
- Rural two-lane highway.
- Day-time, light traffic.

Data

- Simulator data
- Video data was also used for coding purposes

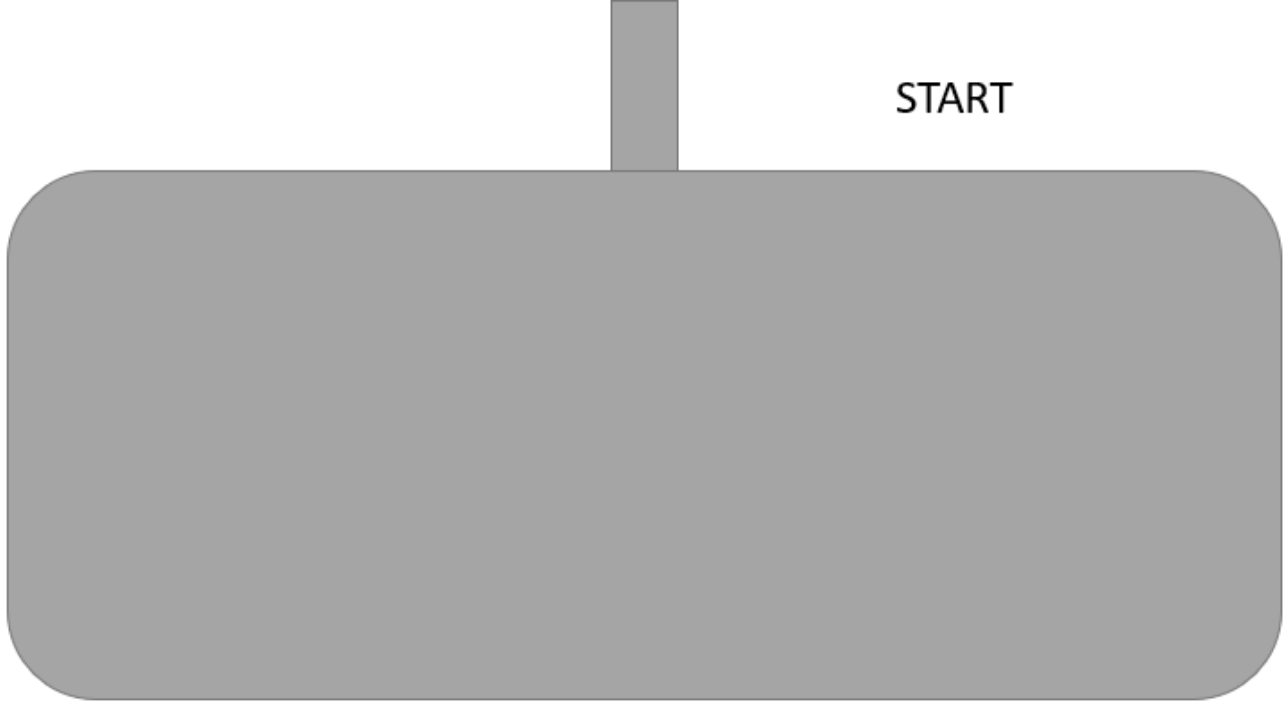
Time Based Measures

- Time period from accelerator release to brake press
- Time period from lead vehicle brake lights illuminating to accelerator release

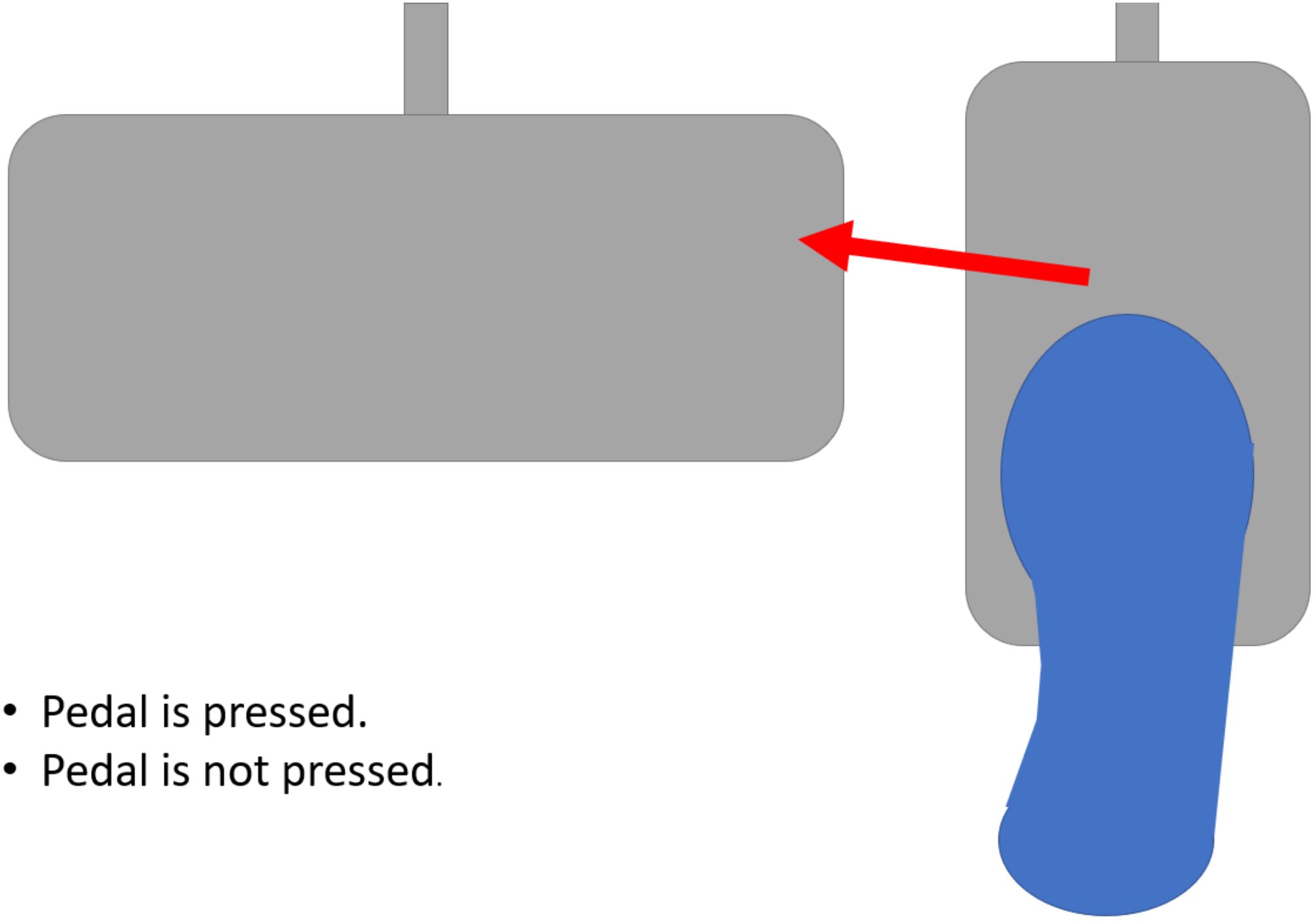
Driver Foot Behavior Categories (adapted from McGehee et al, 2016)

Category Number	Description
1	Wrong pedal press
2	Pedal miss
3	Both pedals pressed
4	Pedal slip
5	Uncertainty – “wagging foot”
6	Back pedal hook
7	Near-miss, reposition of foot
8	Brake tap, reposition to throttle, brake press (new)

START



- Pedal is pressed.
- Pedal is not pressed.



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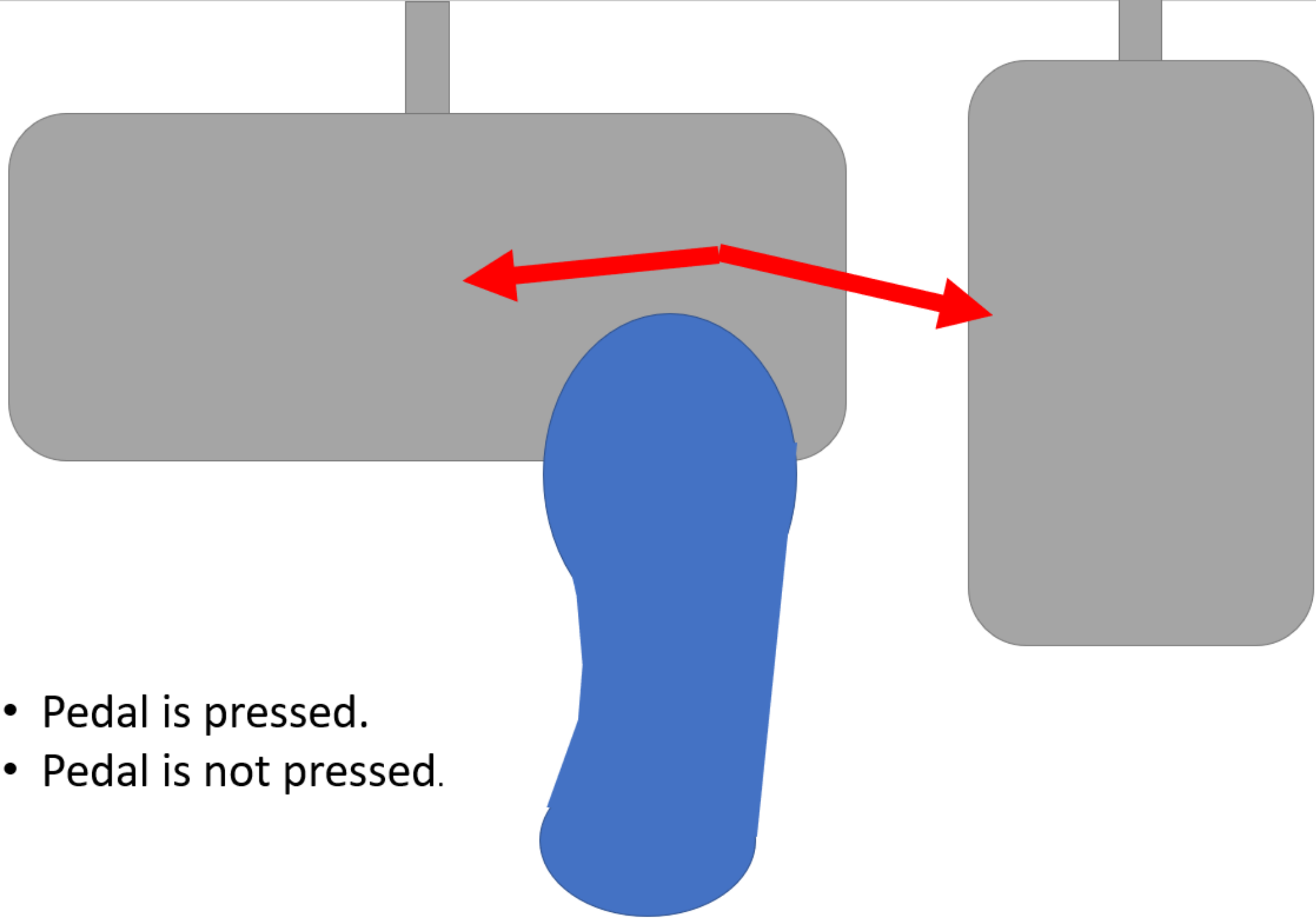

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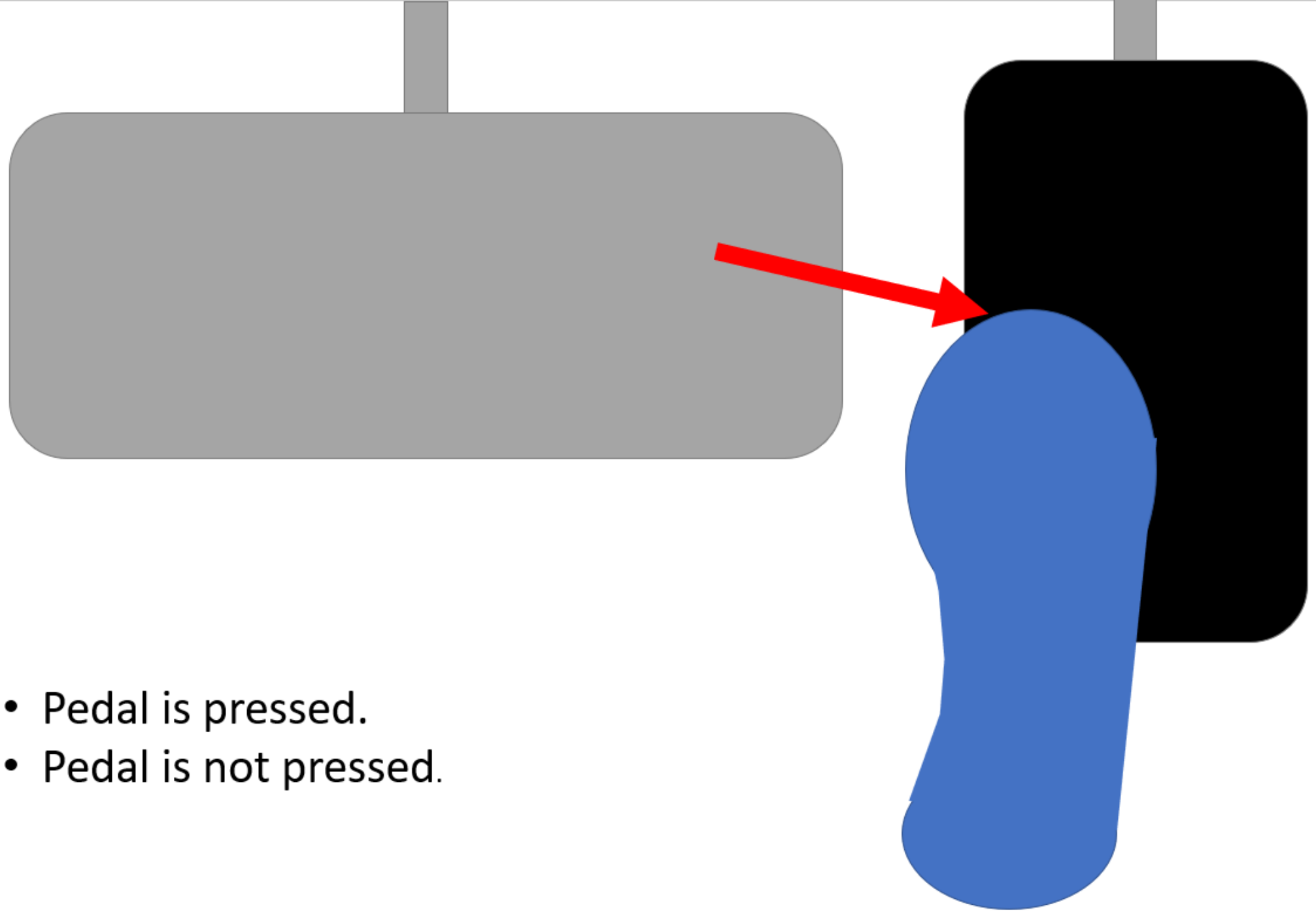

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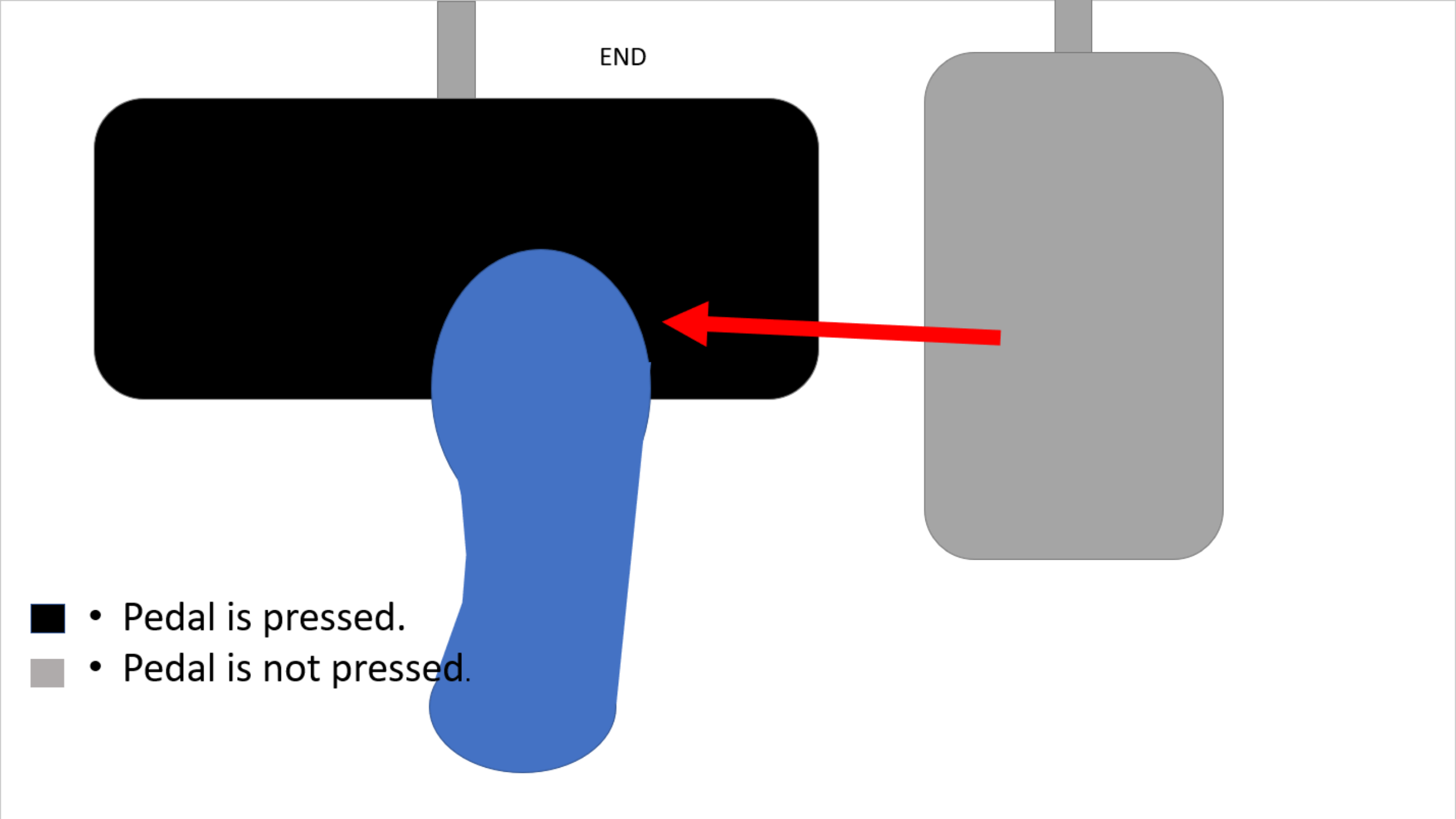
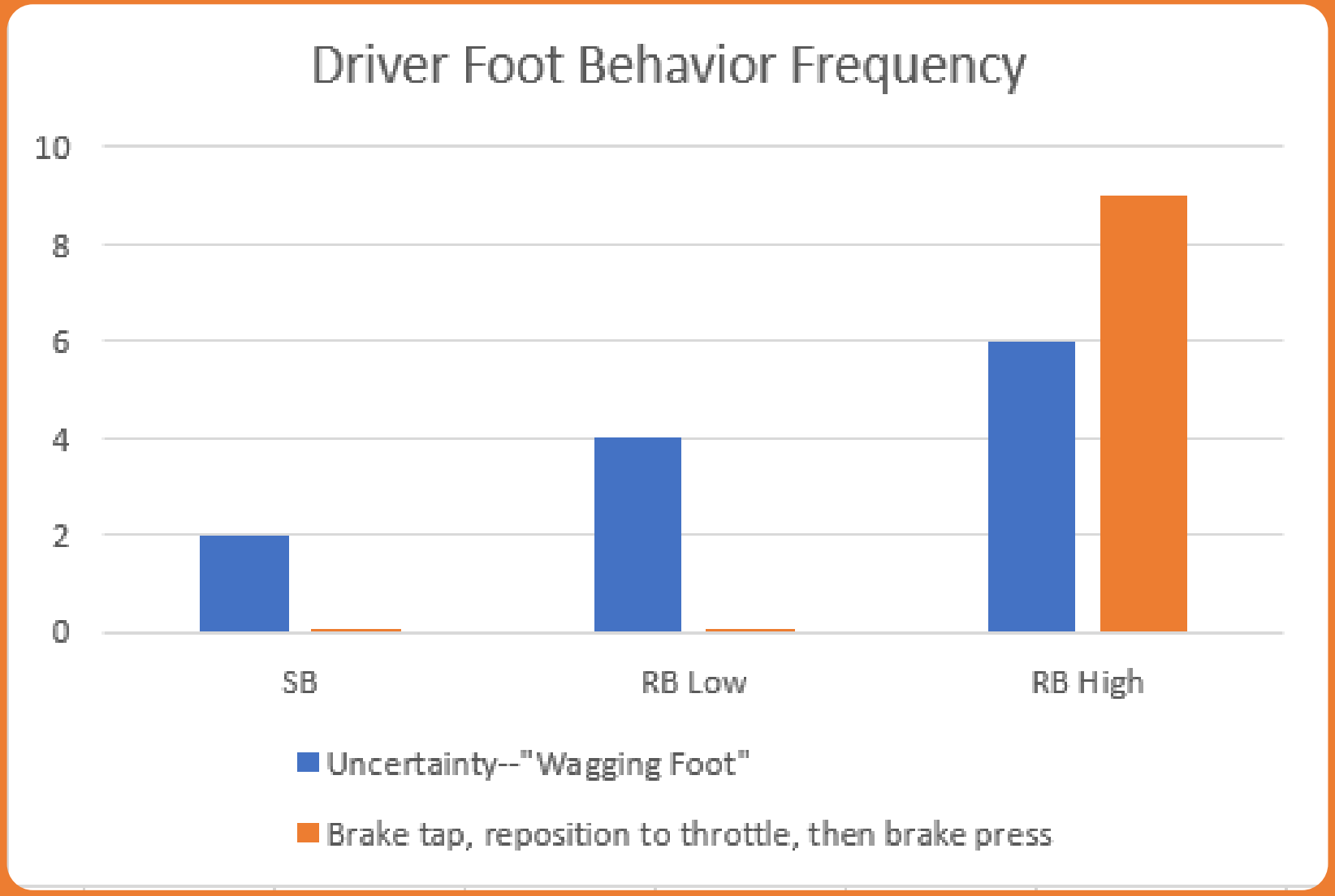

END
• Pedal is pressed.
• Pedal is not pressed.

Video Coding Results

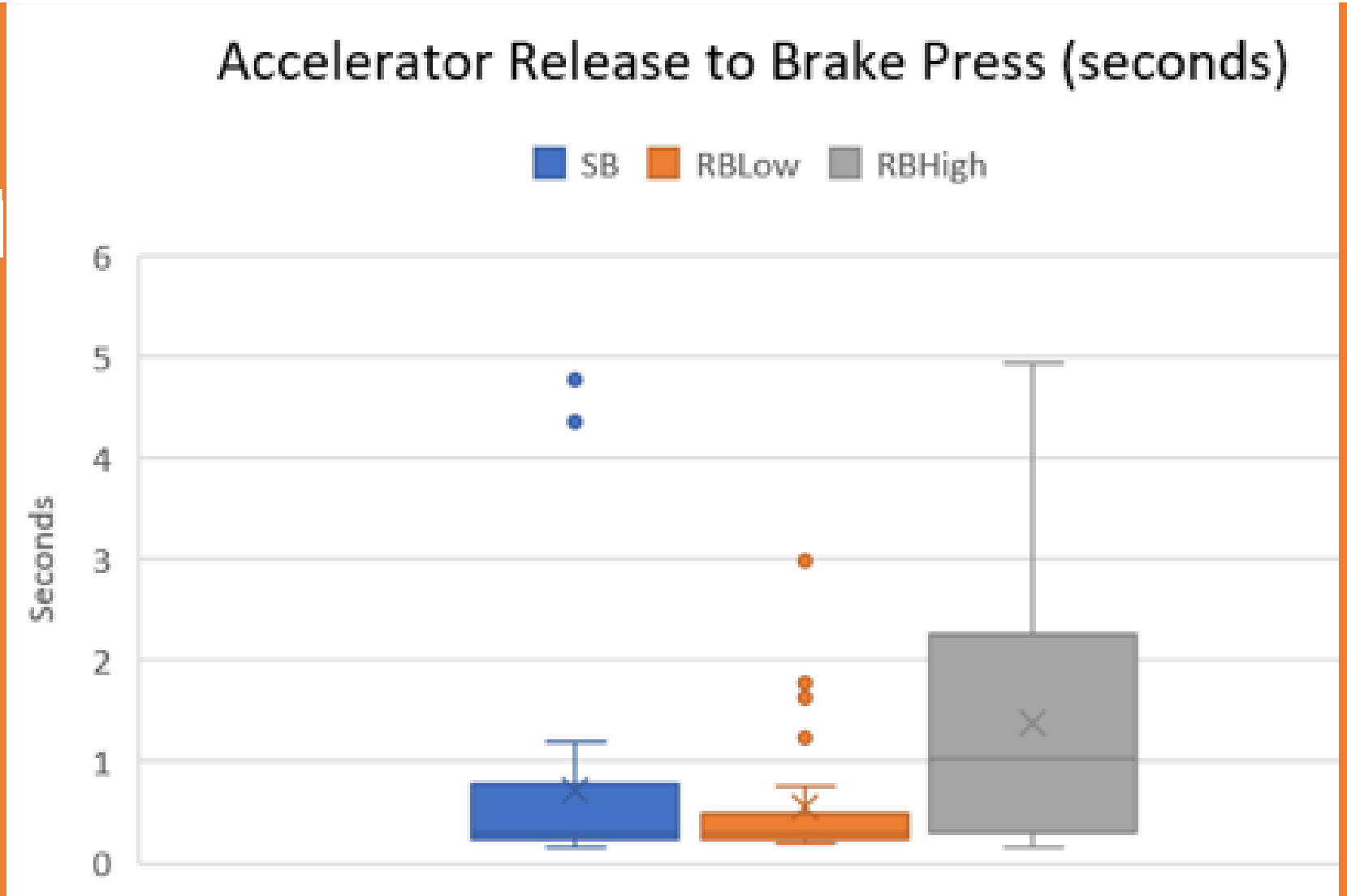
	SB	RBLow	RBHigh	Kruskal Wallis H
n	30	30	27	
Uncertainty—"wagging foot" (5)	2 (7%)	4 (13%)	6 (22%)	p=0.5997
Near-miss, reposition of foot (7)	0 (0%)	1 (3%)	0 (0%)	p=0.96813
Brake tap, reposition to throttle, then brake press (8)	0 (0%)	0 (0%)	9 (33%)	p=0.04651

Video Coding Results



Time Based Measures Results

Conditions	SB, RBLow	SB, RBHigh	RBLow, RBHigh	SB, RBLow, RBHigh
Kruskal-Wallis H/Mann-Whitney U	0.001	6.185	6.468	8.339
Degrees of Freedom	1	1	1	2
Asymptotic Significance	0.976	0.03	0.011	0.015



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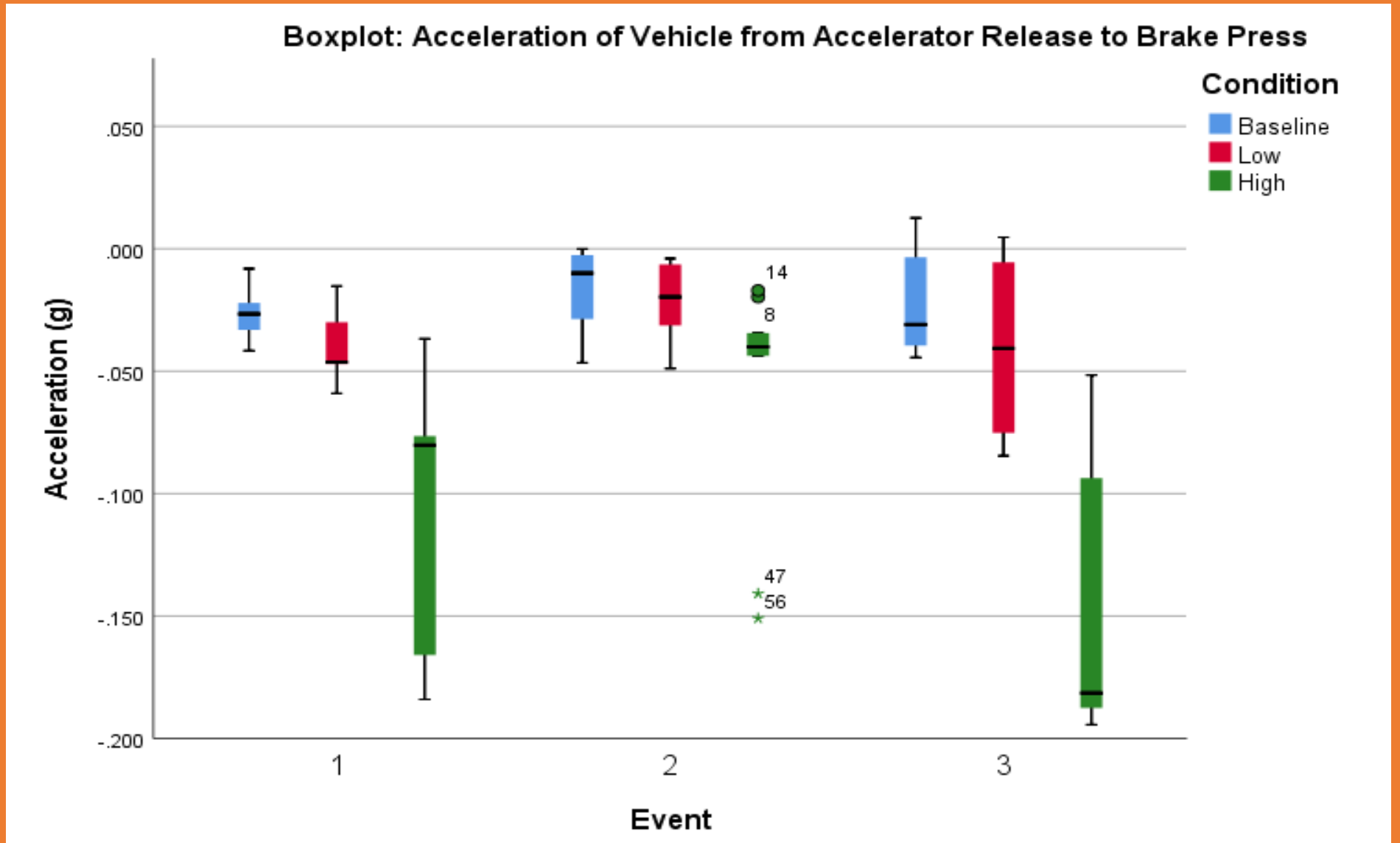
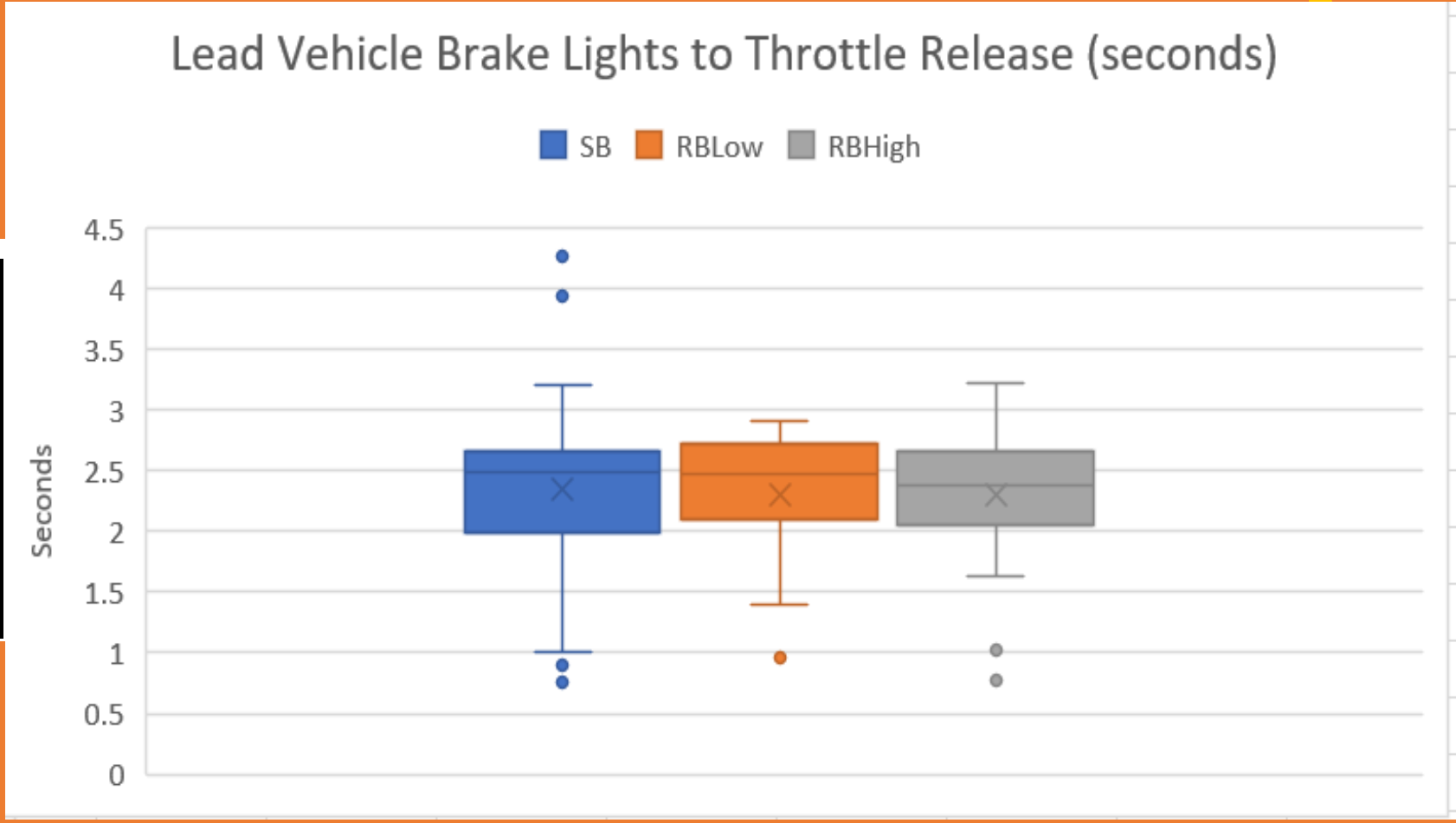


Time Based Measures Results

Conditions	SB, RBLow, RBHigh
Kruskal-Wallis H/Mann-Whitney U	0.367
Degrees of freedom	2
Asymptotic significance	0.832



Discussion

Is there a difference in driver foot behavior between RB and SB?

Time based measures

Time period from when the lead vehicle's brake lights turn on to when the driver releases the accelerator pedal

The time period from when the driver releases the accelerator pedal to when the driver presses the brake pedal

Video Coding