# Perception of Speed

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**Module: Mind, Brain and Models**

## Introduction

Perception of speed is a fundamental aspect of human vision as it is critical for many daily activities such as driving, crossing the street, and playing sports and the ability to accurately estimate speed relies on several factors including the size and distance of the object and the observer's motion relative to the environment and the object. However, the perception of speed can be influenced by various cognitive and visual factors that lead to errors and inaccuracies in estimating the speed.

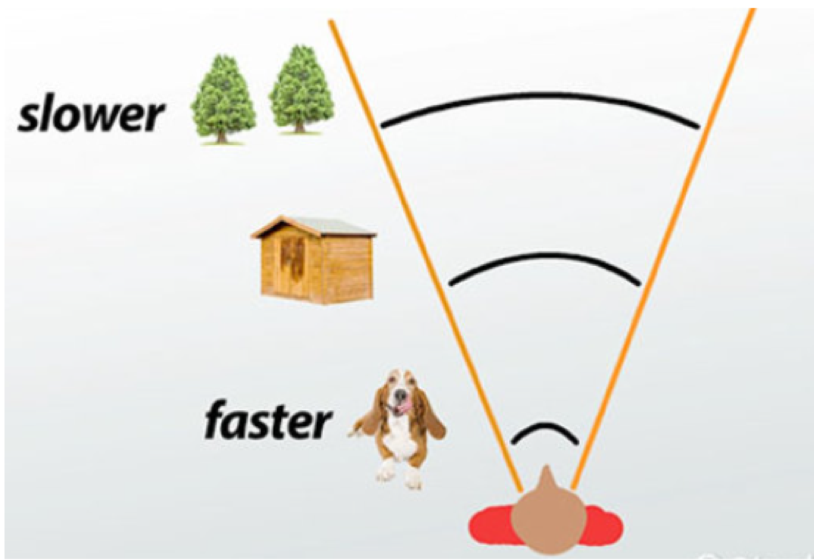


Figure 1: Motion Parallax Effect

One of the visual factors that can affect the perception of speed is the motion parallax effect shown in Figure 1. It refers to the apparent motion of objects at different distances from the observer relative to the observer's motion or the movement of the object itself i.e. When an observer focuses on an object at a farther distance whilst being in motion, the speed is perceived as slower and vice-versa. This effect occurs because the relative motion between the observer and the object is greeted for nearby objects than distant ones.

Previous studies have shown that the motion parallax effect can affect the perception of speed in various contexts,  such as judging the speed of vehicles on the road (Rushton, 2011) and estimating the speed of approaching objects (Van der Burg et al., 2013). We propose a hypothesis where the perception of speed is challenged by using the motion parallax effect. An observer sitting inside a moving train perceives the speed of the train as slower when the observer doesn't have any stationary objects relative to the train in the frame of reference and perceives the speed of the train as slower when there is a stationary object in the frame of reference. For a better understanding, there is a reference link under Figure 2 which shows a video depicting the scenario. To simulate and test this hypothesis, we created a simulation of a moving train and the surrounding environment in MATLAB.

Figure 2: Hypothesis Scenario (Source: https://youtube.com/watch?v=54Oy75Bnu_Q)

## Methods

To understand the perception of speed, we used an example of an observer sitting inside a moving train, a simulation is performed in MATLAB. The simulation models a person sitting inside a moving train and observing the environment where the person perceives the speed of the moving train differently if there is a stationary object within the frame of reference of the said person.

To perform this, we defined several parameters such as the speed of the train, observer distance, and object distance, and stored the results of the simulation in some arrays and variables. During the simulation, we calculated the perceived speed based on the distances and velocities of the train, object, and observer. The perceived speed is recorded along with the corresponding timestamp.

Beginning with the first simulation, as referenced in the code block 1 the scenario represents there is no stationary object within the frame of reference where the person is not observing any object. The observer's position is updated based on the speed of the train and the time step and the perceived speed is calculated based on the relative position of the observer and the object along with the time step.

```
% Simulate motion without observing object
while time < duration
    % Update observer position
    observer_position = observer_position + (train_speed/3.6) * time_step;

    % Calculate perceived speed
     perceived_speed1 = train_speed * (object_distance - observer_position)
/ (object_distance + observer_position);

    % Update time
```

```
    time = time + time_step;

    % Store results
    time_array1(end+1) = time;
    perceived_speed_array1(end+1) = perceived_speed1;
end
```

Code Block 1: Motion without observing an object

For the second simulation, as referenced in the code block 2 the scenario represents there is a stationary object such as the window frame, seat, etc. inside the train. The position of both the observer and the object are updated based on their respective speeds and time step and the perceived speed is calculated based on the updated positions along with the corresponding time step.

```
% Simulate motion while observing object
for object_speed = object_speeds
    % Reset variables
    observer_position = observer_distance;
    object_position = object_distance;
    time = 0;

    while time < duration
        % Update observer and object positions
             observer_position  =  observer_position  +  (train_speed/3.6)  *
time_step;
        object_position = object_position + (object_speed) * time_step;

        % Calculate perceived speed
         perceived_speed2 = train_speed * (object_distance + object_position
- observer_position) / (object_distance + observer_position);

        % Update time
        time = time + time_step;

        % Store results
        time_array2(end+1) = time;
        perceived_speed_array2(end+1) = perceived_speed2;
                   observer_distance_array2(end+1)  =  observer_position  -
object_position;
    end
end
```

Code Block 2: Motion while observing an object

## Results

The results obtained from the simulation show hot the perceived speed of an object changes over time depending on whether it is observed or not and the speed at which it is moving relative to the observer.

Figure 3 shows the first plot with two lines red and blue which represent the perceived speed of a stationary object when it is not observed and when it is observed respectively. The blue line is a straight line that indicates the perceived speed is constant over time when the object is not observed. The red line is more jagged which infers that the perceived speed is changing over time when the object is observed.

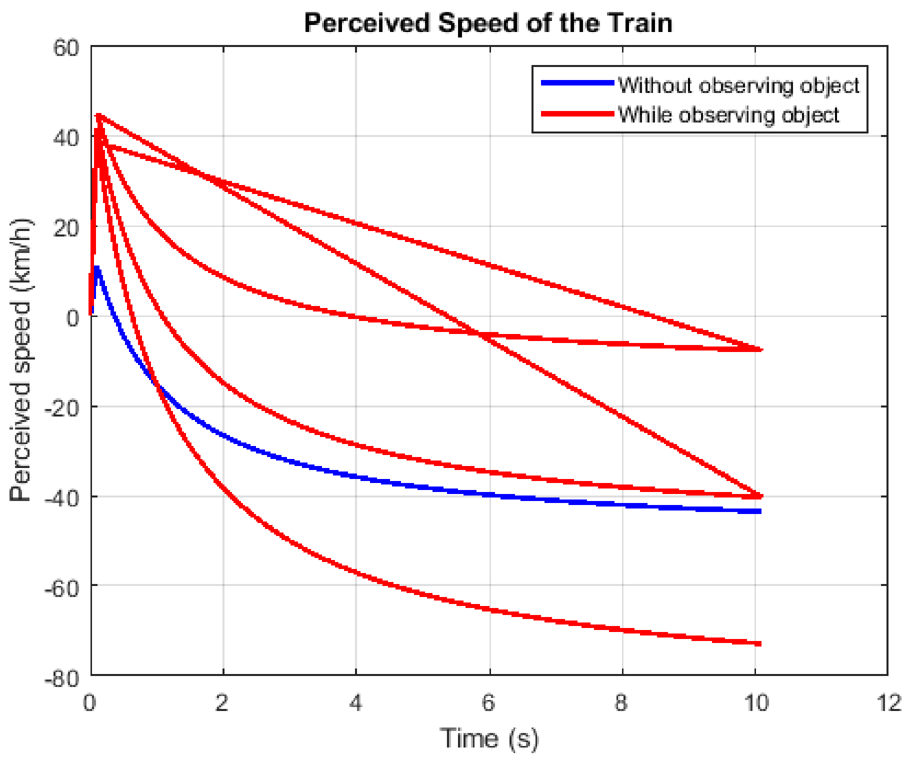


Figure 3: Comparison of perceived speed with and without observing an object

The second plot figure 4 shows the perceived speed of an object that is moving at different speeds relative to the observer. The red line is plotted against the distance between the observer and the object. Different speeds of the object correspond to the peaks and valleys shown; at certain distances, the perceived speed of the object appears to be zero, which indicates that the object is moving at the same speed as the observer, while at other distances the perceived speed is higher than the actual speed of the object.

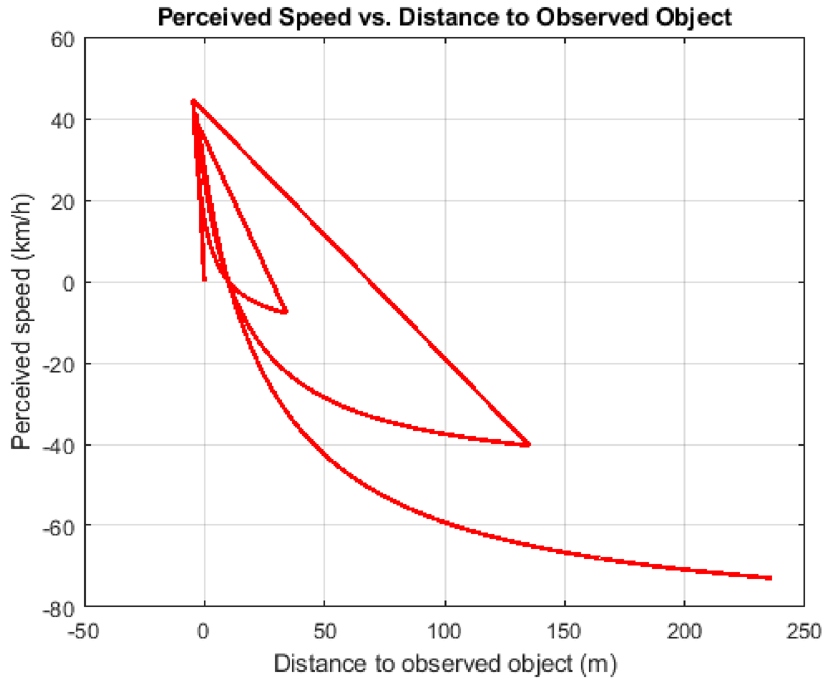

Figure 4: Perceived speed of observed objects at different distances

## Discussion

The simulation results confirm the hypothesis that an observer’s point of view can have a significant impact on their perception of speed when observing the surrounding environment while sitting inside a moving train. The two plots represent that when the observer has a stationary object within the frame of reference, the perceived speed of the train is relatively slower. However, when the observer does not have any object in the frame of reference, the perceived speed of the train changes depending on the relative motion of the train and the observer i.e. the speed is perceived as relatively faster, resulting in different perceived speeds.

The motion parallax effect can be clearly observed in the second plot, where the perceived speed of the train changes as the observer's distance from the object changes. As the object is stationary relative to the environment, the perceived speed increases. This effect is due to the relative motion of the train and the environment and the changes in the angles and distances between them.

## Conclusion

The simulation results demonstrate how the motion parallax effect influences our perception of speed and distance when observing the environment while moving. This simulation can be used in different scenarios to illustrate the complex relationship between the observer’s point of view and their perception of the motion of objects in the environment.

## References:


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