

Normal Pedal Activation in Real World Situations

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ABSTRACT

This study reports pedal activation forces and typical acceleration and deceleration rates during everyday driving activities. Twenty subjects of varying ages, height and weight participated in the study. Each subject was asked to drive a four-door sedan along 2.3 miles of roadway in DuPage County, Illinois. Vehicle speed, acceleration, and position were measured using a global positioning system that was synchronized with force data collected from load cells rigidly mounted on the vehicle's accelerator and brake pedals. Pedal forces and vehicle behavior were measured during common driving tasks such as, shifting the transmission into reverse, backing out of a parking spot, and, making a right hand turn from a stop sign. Our data suggests that simple vehicle dynamic tasks produced in experimental settings may not reliably reproduce vehicle and occupant behavior. The pattern of brake pedal force when decelerating to a stop sign was usually not constant; but instead, displayed a dip, indicating that occupants were modulating their brake application. Also, the acceleration and deceleration rates recorded in this study were within the lower range of standard passenger acceleration rates used in accident reconstruction. The results from this study add to the body of literature on normal acceleration rates of passenger car during typical driving maneuvers.

INTRODUCTION

Research on pedal forces and displacements are primarily focused on vehicle design. The design and placement of automotive brake and accelerator pedals involves a delicate balance of consumer expectations and compliance with Federal requirements. The evaluation of consumer expectations has been based on subjective and objective measures and mostly focused on brake pedal "feel" [1, 2].

Recent research has shifted focus to investigating driver comfort and expectations apropos the ergonomics of the driver's compartment [3, 4, 5, 6]. These studies do not document what pedal force is required to achieve a particular acceleration or deceleration. Additionally, there is very little empirical data on the typical pedal force applications by drivers under real-world driving conditions.

Research that has published brake pedal force data has not reported vehicle deceleration during everyday driving situations [7]. There is even less published data on accelerator pedal forces. The investigation of typical pedal activation force could be an important variable in understanding pedal errors and unintended acceleration. Since the everyday driver is constantly exposed to indirect feedback variables such as visual, auditory, kinesthetic, vestibular, and/or proprioceptive sensations, it is important to expose the driver to as many of these variables as possible to accurately measure the pattern of pedal force application during everyday driving maneuvers. This study fills the gap in the literature by documenting pedal activation forces and typical acceleration and deceleration rates during real world driving scenarios.

METHODS

OVERVIEW

This study was approved by an internal Institutional Review Board. All subjects gave informed consent prior to their participation in the study and were given the opportunity to discontinue the test at any time. All subjects drove the same instrumented test vehicle, which was not owned by any of the subjects to insure the subjects did not have muscle memory associated with the test vehicle. The vehicle selected was a 2011 Ford Taurus because it has been one of the top three best selling midsize sedans in the last two decades [8]. The predetermined test route was a 2.3 mile loop on public

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roadway that began and ended in a private parking lot located in DuPage County, Illinois. The test route contained vehicle traffic, but little pedestrian traffic. There were three traffic lights and three stop signs along the route. Testing was conducted during daylight with clear visibility and no precipitation.

SUBJECTS

Twenty subjects were recruited via email solicitation from the experimenters' office. The subjects consisted of 10 females and 10 males (age range 24 to 63) that had been driving since the average age of 17.1 years old (Table 1). Prior to testing, subjects were informed that the study involved measurement of accelerator and brake pedal forces along with observation of their feet position inside a vehicle.

INSTRUMENTATION

The test vehicle was instrumented with load cells rigidly mounted over the original manufactured pedals using adjustable brackets. The load cell used for the brake pedal was manufactured by Michigan Scientific Corp (Model No. BPFT-101), while the load cell used for the accelerator was manufactured by Sensotec (Model No. 31). The output signal from the load cells was amplified by a signal conditioner (BA660, Vishay). The speed and location of the vehicle was recorded with a Global Positioning System (GPS; VBOX Mini, RLVB01, Racelogic). The force and GPS data were collected simultaneously using a National Instruments data acquisition system (CompactDAQ) and Lab View software (Laboratory Virtual Instrumentation Engineering Workbench, version 8.6). Force data was collected at 100Hz, while data from the GPS system was collected at 10Hz and linearly interpolated to increase the sampling rate. The load cells fitted to each pedal were approximately the same size and shape as the vehicle's original manufactured pedals and the surface interface consisted of a non-slip material. All instrumentation wires were carefully routed to the passenger's side to ensure that they did not present an impediment to the driver while s/he was operating the vehicle. The instrumented pedals were elevated equally from the original pedals by approximately 1.2 inches (Figure 1). Two onboard video cameras were mounted inside the test vehicle. One camera captured the position of the drivers' feet during the driving task, and the other recorded the scene as seen by the driver ahead of him/her on the road while driving. Figure 2 shows the position of the instrumentation and cameras within the test vehicle.



Figure 1. Accelerator and brake pedals fitted with load cells.

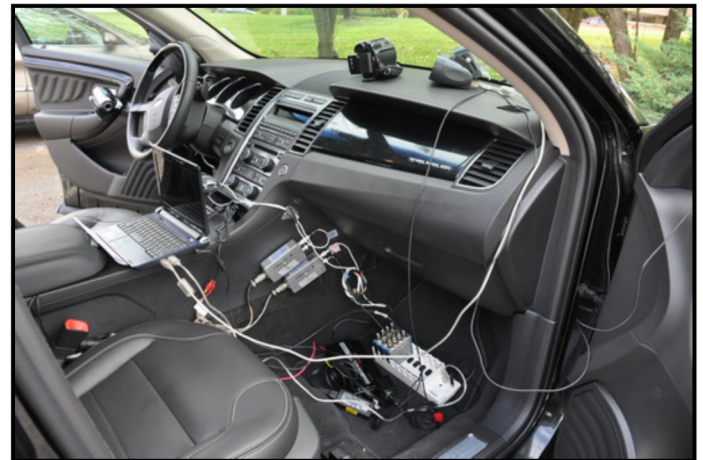


Figure 2. Data logging equipment.

TEST PROTOCOL

All subjects were asked to read and sign an informed consent form and to complete a questionnaire about their height, weight, age, and driving experience prior to operating the vehicle. Each subject was given a map of the route highlighting the locations of stop signs and stoplights and indicating the speed limits along the route. The subjects were instructed to obey speed limits and traffic signals. They were also instructed to familiarize themselves with the equipment in the vehicle and to adjust the seat and mirrors to a comfortable position. Each subject was then instructed to back out of the parking spot and drive within the parking lot around a private building to insure they were comfortable with the instrumentation and driving posture prior to driving on the public roadway. Once the subject felt comfortable with the vehicle, s/he was then instructed to leave the parking lot, drive the predetermined route and return to the same location.