Behavior and Social Issues, 26, 190-193 (2017). doi: 10.5210/bsi.v.26i0.6891

RESEARCH NOTE

THE USE OF AN ONBOARD DIAGNOSTIC DEVICE TO PROVIDE FEEDBACK ON DRIVING BEHAVIORS RELATED TO FUEL ECONOMY

Brian V. Jadro[1]
Simmons College

ABSTRACT: Despite the link between greenhouse gases and climate change, drivers in the United States continue to operate vehicles that consume more fuel per mile and emit higher levels of greenhouse gases than the vehicles driven in other developed nations. Intervention packages that include feedback and goal setting are common in behavior analytic research, specifically in the Organizational Behavior Management literature, but are also used to establish and maintain sustainable human behaviors such as recycling and energy reduction. The current study examined the effects of a treatment package utilizing feedback and goal setting to increase fuel economy in three participants who drove a minimum of 15 consecutive miles at least once per day. Feedback regarding average miles per gallon (MPG), moment-to-moment MPG, and MPG in relation to the participants' goal were provided by the Scangauge-eTM, a small onboard diagnostic-2 device that connects to the vehicles' electronic control unit and mounted within the car. Results indicated that treatment effects were noticeable in 2 of the 3 participants for increasing overall MPG.
KEYWORDS: feedback, goal setting, driving behavior, fuel economy

According to the U.S. Energy Information Association (EIA; 2016), the greatest contributor of greenhouse gases is the burning of fossil fuels, such as gasoline and diesel, with transportation vehicles accounting for nearly 1,545 million metric tons of carbon dioxide (CO_2) in 2015. In the United States in 2014, 26% of greenhouse gas emissions came from the burning of fossil fuels used for transportation, a 17% increase from total transportation-related emissions since 1990 (U.S. Environmental Protection Agency, 2016). Globally, carbon dioxide levels have risen by 1.9 ppm per year between 1995 and 2005 (Forster et al., 2007) and from a global mean concentration of 379 ppm in 2005, to 390.5 ppm in 2011 (Forster et al., 2007; Hartmann et al., 2013). With over 97% of climate scientists agreeing upon human led climate change (Cook et al., 2016) and 2016 on course to be the hottest year in history (Lynch, 2016), progress towards decreasing carbon emissions will require changes in various aspects of general human behavior.

These behavioral changes will need to include not only the type of vehicles that consumers purchase, but also operational factors. Behaviors such as speeding, idling, use of cruise control,

[1] This report was submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Applied Behavior Analysis from Simmons College. Special thanks to Drs. Gretchen Dittrich, Jonathan Kimball, and Donny Newsome for their help in identifying relevant research and working towards creating more sustainable human behavior.

Correspondence concerning this article should be addressed to Brian Jadro, Department of Applied Behavior Analysis. Simmons College, 300 Fenway. Boston, MA 02115. Email: brian.jadro@simmons.edu

and aggressive driving play an important role in fuel efficiency (Sivak & Schoettle, 2011). These behaviors are similar to most other human behaviors in that they are susceptible to modification through operant conditioning.

One of the most widely utilized behavioral interventions is feedback (Alvero, Bucklin, & Austin, 2001; Balcazar, Hopkins, & Suarez, 1985; Nolan & Jarema, 1999). Feedback constitutes information that conveys what an individual is doing and how well that individual performs those actions (Rummler & Brache, 2012). In fact, Karlin, Zinger, and Ford (2015) identified feedback as an effective strategy for increasing energy efficiency, particularly when combined with strategies such as goal setting and goal based comparisons.

Real-time feedback on driving behavior can be provided by on-board diagnostic-2 (OBD-2) devices such as the Scangauge-e ™, which can read engine codes, gather and display engine and vehicle performance data, and even increase safety by communicating with emergency response services. According to Alessandrini, Filippi, Orecchini, and Ortenzi (2006), OBD-2 devices are able to provide almost immediate feedback, providing a driver with information about their current driving performance and potentially allowing for changes in driving behavior to increase safety and efficiency (Orfila, Saint Pierre, & Messias, 2015). These devices provide a cost-effective, simple, and versatile means of collecting data on specific vehicle output parameters. This information is collected by connecting to the vehicle's sensors, is collected and processed by the vehicle's electronic control unit (ECU), and displayed by an OBD-2 device such as the Scangauge-e ™. The present report demonstrates the use of the Scanguage-e to provide such feedback and goal setting as a component of a driving behavior modification plan.

The Scangauge-e ™access port is easily accessible, with federal law requiring that the connection is within 3 feet of the steering wheel and that accessing the connection does not require any tools. A picture of the device and an OBD-2 connection port can be found in the Appendix. Users can be provided with a suction cup mount that attaches to either the dashboard or the windshield, in compliance with all state laws and regulations.

The Scanguage-e requires multiple calibrations, including entering vehicle specifications such as fuel tank size, engine displacement, and fuel type. Secondary calibrations will occur at each fill-up, during which the device reports an estimate of how much fuel was required for the tank to be filled. This requires users to compare the measurement provided by the device to the actual amount of fuel added, and to calibrate the device if there is a discrepancy.

The Scanguage-e measures MPG a primary unit of efficiency. Data are automatically recorded and then reported by users via taking a picture and self-reporting. For example, at the end of each drive of at least 15 consecutive miles, the user can take a picture of the device and send that picture to the experimenter by text message or by email.

Users must be given brief instructions about how the device works, how to navigate through the necessary features, and on the initial device setup and calibration process that occurs during fill-ups. Written instructions can be given to users at this time along with offers of a telephone or video call during the fill-up process if they are still not comfortable with the device.

After users are comfortable with the device, baseline data can be collected by covering the screen of the device with a piece of thick paper. The screen therefore is not visible to the user during baseline condition; at the end of the baseline data collection period, he driver lifts the cover and takes a picture of the screen.

During an intervention phase, users are able to view the screen of the Scangauge-e ™ device at all times and have access to real-time information regarding their moment-to-moment MPG and average overall MPG for their current drive. Prior to their first drive in the intervention phase,

participants can be provided with their average baseline MPG and asked to set a goal that is an increase of between, say, 5% and 15% of their baseline. Current performance in relation to each user's goal is provided by the Scangauge-e ™ device and displayed as an updating bar graph. The bar graph is updated from right to left and each bar on the graph represented the previous 10-second interval. Bars positioned above the centerline (i.e., the goal line) of the graph represents intervals during which the participant averages an MPG that is higher than the goal; bars below the centerline represent 10 second intervals during which the user attained an average MPG that is below the goal. A picture of the device displaying the bar graph can be found in the Appendix.

In preliminary tests of the device, two of the three participants evidenced statistically significant increases in their average MPG with immediate feedback and goal setting (18% and 11%), while the third showed no change.

Future research can utilize the Scangauge-e ™ OBD-2 device to provide immediate feedback and goal related performance to adult drivers. Researchers may also examine the extent to which feedback is effective, alone or as part of an intervention package, in changing driving behaviors related to increased fuel economy.

References

Alessandrini, A., Filippi, F., Orecchini, F., & Ortenzi, F. (2006). A new method for collecting vehicle behaviour in daily use for energy and environmental analysis. *Proceedings Of The Institution Of Mechanical Engineers, Part D: Journal Of Automobile Engineering*, *220*(11), 1527-1537. doi:10.1243/09544070JAUTO165

Alvero, A. M., Bucklin, B. R., & Austin, J. (2001). An objective review of the effectiveness and essential characteristics of performance feedback in organizational settings. *Journal Of Organizational Behavior Management*, *21*(1), 3-29. doi:10.1300/J075v21n01_02

Balcazar, F. E., Hopkins, B. L., & Suarez, Y. (1985). A critical, objective review of performance feedback. *Journal Of Organizational Behavior Management*, *7*(3-4), 65-89. doi:10.1300/J075v07n03_05

Cook, J., Oreskes, N., Doran, P.T., Anderegg, W.R., Verheggen, B., Maibach, E.W., … Rice, K. (2016). Consensus on consensus: A synthesis of consensus estimates on human-caused global warming. *Environmental Research Letters*, *11*(4), 1-24. doi:10.1088/1748-9326/11/4/048002

Forster, P., Ramaswamy, V., Arttaxo, P., Berntsen, T., Betts, R., Fahey, D. W.,…Van Dorland, R. (2007). Changes in atmospheric constituents and in radiative forcing. In S. Solomon et al. (Eds.), *Climate change 2007: The physical science basis*. *Contributions of Working Group I to the 4th assessment of the IPCC* (pp. 129-234). Cambridge, UK: Cambridge University Press.

Hartmann, D. L., Klein Tank, A. M. G., Rusticucci, M., Alexander, L. V., Brönnimann, S., Charabi, Y. A. R., … Zhai, P. (2013). Observations: Atmosphere and surface. In J. Hurrell et al. (Eds.), *Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 159-254). Cambridge, UK: Cambridge University Press. doi: 10.1017/CBO9781107415324.008

Karlin, B., Zinger, J. F., & Ford, R. (2015). The effects of feedback on energy conservation: A meta-analysis. *Psychological Bulletin*, *141*(6), 1205-1227. doi:10.1037/a0039650

Lynch, P. (2016, July). 2016 Climate trends continue to break records. Retrieved November 20, 2016, from https://www.nasa.gov/feature/goddard/2016/climate-trends-continue-to-break-records

Nolan, T. V., & Jarema, K. A. (1999). An objective review of the journal of organizational behavior management: 1987-1997. *Journal Of Organizational Behavior Management*, *19*(3), 83. Doi: 10.1300/J075v19n03_09

Orfila, O., Saint Pierre, G., & Messias, M. (2015). An android based ecodriving assistance system to improve safety and efficiency of internal combustion engine passenger cars. *Transportation Research: Part C*, (*58)*772-782. doi: 10.1016/j.trc.2015.04.026

Rummler, G. A., & Brache, A. P. (2012). *Improving performance: how to manage the white space on the organization chart* (3rd ed.). San Francisco, CA: The Jossey-Bass Management Series.

Sivak, M., & Schoettle, B. (2011). *Eco-driving: strategic, tactical, and operational decisions of the driver that improve vehicle fuel economy.* (Technical Report No. UMTRI-2011-34). Ann Arbor, MI: University of Michigan Transportation Research Institute.

U.S. Energy Information Administration. (2016) *Monthly energy review, May 2016*. Retrieved from http://www.eia.gov/totalenergy/data/monthly/archive/00351207.pdf.

U.S. Environmental Protection Agency. (2016). *Inventory of U.S. Greenhouse gas emissions and sinks 1990-2014.* Retrieved from https://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2016-Main-Text.pdf

Appendix

OBD-2 connection and Scangauge-e ™