A Typology of In-Vehicle Eco-Driving Feedback

Angela Sanguinetti, Hannah Park, Suhaila Sikand and Ken Kurani

Abstract Eco-driving is a promising strategy for reductions in fossil fuel consumption and carbon emissions. Eco-driving is most frequently promoted via in-vehicle feedback. Eco-driving feedback studies demonstrate fuel economy improvements up to 18 %, but results are widely variable—partly due to the wide variation in feedback design. This paper addresses the need for a greater understanding of how variations in eco-driving feedback design are related to its effectiveness. We identified characteristics of feedback with implications for behavior change based on behavioral theory and evaluation of a large sample of in-vehicle eco-driving feedback interfaces. We developed a typology of in-vehicle eco-driving feedback interfaces based on these characteristics. We identified 15 distinct types of in-vehicle eco-driving feedback interfaces. We describe each feedback type and discuss implications for feedback design. Our typology provides a foundation for subsequent research to determine most effective feedback types for particular behaviors, drivers, and driving conditions.

Keywords Eco-driving · Green driving · Smart driving · Automotive interface

A. Sanguinetti (✉) · H. Park · S. Sikand · K. Kurani
Institute of Transportation Studies at University of California,
Davis 1605 Tilia, St. Davis, CA 95616, USA
e-mail: asanguinetti@ucdavis.edu

H. Park
e-mail: hnpark@ucdavis.edu

S. Sikand
e-mail: sksikand@ucdavis.edu

K. Kurani
e-mail: knkurani@ucdavis.edu

N.A. Stanton et al. (eds.), *Advances in Human Aspects of Transportation*,
Advances in Intelligent Systems and Computing 484,
DOI 10.1007/978-3-319-41682-3_80

1 Introduction

The Monroney sticker posted on every new vehicle in the US states, "Actual results will vary for many reasons, including driving conditions, and how you drive and maintain your vehicle." Eco-driving is a means of strategically taking advantage of this variability by operating one's vehicle in the most efficient manner [1]; for example, maintaining an even driving pace and minimizing use of cabin heating and air conditioning. In this paper, we define eco-driving as behavior a driver engages in while driving that reduces the vehicle's fuel consumption and/or polluting emissions.

The most common strategy to promote eco-driving is the provision of feedback, i.e., information provided to the driver about the effects of driving behavior on fuel economy and/or emissions after the behavior occurs. Eco-driving feedback includes instantaneous and average fuel economy information, as well as information about how efficiently a driver performs more specific behaviors, such as accelerating. Eco-driving feedback may be provided via manufacturer-supplied instrumentation, or after-market devices and/or apps. Our focus in this paper is on the former, which we will refer to as in-vehicle eco-driving feedback for the remainder of the paper.

1.1 In-Vehicle Eco-Driving Feedback

No policies exist requiring manufacturers to provide eco-driving feedback, yet feedback systems of increasing variety are appearing in vehicles, especially hybrid (HEVs), plug-in hybrid (PHEVs) and electric vehicles (EVs). One reason for this differential attention is that fuel economy in efficient vehicles is actually more sensitive to driver behavior. Manufacturers have deployed many different designs, reflecting various driver behaviors and vehicle states. This wide variation could indicate a belief in competitive advantage or a lack of evidence-based design and consistent assumptions about human behavior. The rapidly increasing prevalence and complexity of in-vehicle displays and concern for driver distraction [2] suggest standardization of eco-driving feedback may be warranted in the near future.

1.2 Eco-Driving Feedback Studies

A recent comprehensive review of in-vehicle feedback interventions to promote eco-driving in conventional internal combustion engine (gas) vehicles (ICEVs) calculated average fuel use reduction of 5.6 %, ranging from −6.8 to 18.4 % [1]. Some of this variation in effectiveness is undoubtedly due to the extreme variation in feedback provided (e.g., numeric indicators, haptic pedal feedback). Relatively few of these studies compared different types of feedback, but those that did identified some characteristics of feedback that make it more or less effective. For example, feedback is more effective when metrics align with the driver's goals, e.g., to save money [3] and when feedback is adaptive to performance [4]. There have been some attempts to classify eco-driving feedback interfaces according to these and other important characteristics [5–8].

1.3 Previous Eco-Driving Feedback Typologies

Tulusan et al. [5] categorized eco-driving feedback based on the timing of its presentation and/or the duration of behaviors it reflects: (a) feedback on momentary driving behavior (real-time, reflecting instantaneous behavior), (b) accumulated feedback (reflecting accumulated behavior), and (c) offline feedback (provided outside the context of driving). They suggested the mode of interface for feedback on momentary driving behavior is typically ambient (e.g., conveyed via changing light intensity or color), yet the most common form is a numeric instantaneous fuel economy indicator.

Stillwater et al. [8] classified in-vehicle eco-driving feedback in electric and plug-in hybrid vehicles (together, PEVs) based on the specific behaviors reflected, the duration of those behaviors, and the metrics used (e.g., mileage or range): (a) current efficiency, (b) deceleration efficiency (including regenerative braking), (c) trip efficiency, and (d) range comparison. They describe trip efficiency and range comparison as useful for goal-setting: trip efficiency provides drivers with energy usage of a given trip and range comparison juxtaposes current estimated range with EPA-estimated range or distance to a programmed destination.

Extensive research for the United States Department of Transportation [6, 7] provides the most granular analysis of in-vehicle eco-driving feedback, which they termed FEDI (fuel economy driver interface). They analyzed in-vehicle feedback systems in terms of "components"—discrete visual elements within a given FEDI, classifying them first by mode of interface (intensity-changing light, representative pictures, graph, single dial, single bar, text, or other), then characterizing them in terms of the metric and duration of data presented (instantaneous fuel economy, trip average fuel economy, overall average fuel economy, and miles to empty). They did not consider the specific behaviors targeted by feedback or feedback timing.

These previous typologies are insufficient. Each is based on only a subset of important feedback characteristics, the selection and description of which is neither explicit nor grounded in behavioral theory. The current research develops a typology that distinguishes among the myriad of interfaces based on an understanding of the behavioral mechanisms by which eco-driving feedback affects driver behavior.

1.4 Theoretical Framework

Kluger and DeNisi [9] developed a useful theory for understanding the behavioral mechanisms involved in feedback interventions. According to Feedback Intervention Theory (FIT), "behavior is regulated by comparisons of feedback to goals or standards" (p. 259). There may be one or more standards to which feedback is compared, including comparisons to self (e.g., past performance) and comparisons to others. A discrepancy between feedback and its standard is called the feedback-standard gap. A key tenet is that only feedback-standard gaps receiving attention will be addressed; thus, a critical aspect of any feedback intervention is controlling the locus of attention.

Principles established by the science of behavior analysis [10] can also aid in understanding the underlying behavioral mechanisms of effective eco-driving feedback. In general terms, feedback may affect behavior by reinforcing or punishing particular responses, prompting behavior, or creating conditions of motivation (e.g., via comparison to social norms or past performance). These behavioral theories guided the development of our eco-driving feedback typology.

2 Methodology

2.1 Sampling Eco-Driving Feedback Systems

Our first goal was to obtain a representative sample of in-vehicle eco-driving feedback systems. We identified systems via previous research [5–8] and Internet searches using Google; search terms "eco-driving system", "dashboard", "multi-information display", "instrument panel", "instrument cluster", "audio-navigation display". After identifying a relevant system, we gathered further information from vehicle manufacturer websites, YouTube videos, and owner's manuals. We focused on the US market, although two systems in our sample are unavailable in the US. When we discovered the same or similar systems in multiple models from the same manufacturer or multiple years of the same model, we included only one model or the most recent model, respectively. We identified 14 eco-driving feedback systems—all in alternatively-fueled vehicles (HEVs: Ford Fusion 2016, Honda Insight 2014, Lexus 300H 2014, Nissan Sentra 2014, Toyota Camry 2015, Volkswagen Jetta Hybrid 2013; PHEVs: Cadillac ELR 2014, Chevy Volt 2013, Toyota Prius 2014, Toyota Prius C 2015; EVs: Ford Focus 2015, Kia Ray 2014, Nissan Leaf 2013, Toyota RAV4 2013).

2.2 Defining the Feedback Stream

Eco-driving feedback systems can be composed of multiple distinct feedback types, therefore the system as a whole is not an appropriate unit of analysis. Manser et al. [7] articulated the feedback component as their unit of analysis based on mode of interface as the defining parameter (e.g., a graph is one component, a colored light is another). In some in-vehicle feedback systems, visual interface components are interdependent and complimentary, so separating them would compromise the validity of our analysis. We therefore defined a new unit of analysis: the feedback stream.

A feedback stream consists of at least one interface component corresponding to at least one driver behavior related to fuel consumption. Multiple interface components are considered the same feedback stream if they (a) are presented together, reflect the same behavior(s), and differ only in terms of data or design, or (b) if they reflect different behaviors but are similar in terms of feedback attributes and are visually integrated. We excluded interfaces with only forecast information (e.g., fuel remaining) or information specific to maintenance behaviors (e.g., check engine and tire pressure). We identified 116 distinct feedback streams among the 14 feedback systems.

2.3 Defining Behaviorally Relevant Feedback Attributes

Based on our review of the literature and examination of these 116 in-vehicle eco-driving feedback streams, we inventoried and defined in-vehicle eco-driving feedback attributes that have implications for behavior change according to FIT [9] and behavior analytic principles [10]. The attributes we identified correspond to ten feedback parameters that fall into three categories: data, timing, and design (Table 1).

Table 1 Feedback parameters and attributes

	Parameter	Attributes
Data	Behavioral granularity	Aggregate—all affecting mileage; all affecting power source. Specific—accelerating; cruising; decelerating; driving mode selection; cabin comfort (climate control, auxiliary electronics) [16]
	Data granularity	Low (≤3 levels). Mod. (4–10 levels). High (≥10 levels)
	Temporal granularity	Instantaneous. Accumulated—event within a trip; intervals during trip; trip level; tank/charge/reset; lifetime
	Metric	Fuel economy (MPG or mi/kWh). Environmental impact (CO_2 saved/emitted). Money ($ saved/spent). Distance traveled or range

(continued)

Table 1 (continued)

	Parameter	Attributes
		(mi). Power/energy required/regenerated (kW, %). Fuel (gallons). Points/score
	Feedback standard	Optimal zone. Score. Past performance (average, best). EPA-estimated mileage. Expected range
Timing	Immediacy	Immediate. Retrospective
	Frequency	Continuous. Discrete
Design	Mode of interface	Numeric. Histogram. Pie chart. Meter (bar). Pictorial. Light (color change and/or blinking). Movement. Haptic
	Gameful design	Yes. No
	Biophilic design	Yes. No

2.3.1 Data

In-vehicle eco-driving feedback data vary in terms of the behaviors reflected (behavioral granularity), the duration of behavior reflected (temporal granularity), and the magnitude of behavior required to produce changes (data granularity). More granular feedback on all these levels (i.e., reflecting specific behaviors, reflecting momentary behaviors, and sensitive to small changes in behavior, respectively) is useful for learning because it can function to reinforce or punish behavior [10] and the driver can more readily comprehend the connection between behavior and consequences.

Numeric feedback corresponds to a metric (e.g., dollars, MPG, miles), which can be framed positively or negatively (e.g., money saved or spent). Feedback expressed in meaningful metrics can increase drivers' awareness of consequences of their behavior, which may activate moral norms and motivate behavior [11]. Feedback is sometimes accompanied by a standard, or referent (e.g., optimal zone of acceleration). According to FIT [9], feedback-standard comparison is the mechanism by which feedback regulates behavior. Standards may be adaptive based on driver performance to support incremental improvement [4], i.e., the process of behavioral shaping [10].

2.3.2 Timing

Parameters of eco-driving feedback timing include immediacy and frequency. Immediacy refers to the immediacy of feedback with respect to the behavior it reflects. Feedback frequency refers to the frequency with which feedback is presented (e.g., continuously or at discrete times). Similar to granular feedback, immediate and frequent feedback is useful for training new behavior. Immediacy is critical for feedback to function as a reinforcement. Retrospective feedback may motivate drivers to engage with the feedback, but may be too far removed to function as reinforcement.

2.3.3 Design

Design attributes include mode of interface and whether the feedback employs gameful or biophilic design. Broad categories of mode of interface are visual, auditory, or haptic. Mode of interface has implications for feedback saliency and driver distraction; for example, ambient interfaces [12] are potentially less distracting compared to numbers or graphs [13]. Gameful design refers to the use of game design elements (e.g., points, levels, leaderboards, and badges) that may promote engagement with eco-driving feedback [14, 15]. Biophilic design [16] refers to the integration of elements of nature (e.g., plants, animals) to promote a sense of connection to nature. Biophilic design in energy feedback has been effective in promoting conservation behaviors [17].

2.4 Data Analysis

We coded the 116 feedback streams in terms of each parameter of attributes (Table 1). Attributes within each parameter were not mutually exclusive, with the exception of gameful and biophilic design which were coded as binary (yes or no). We sorted the feedback streams by behavioral granularity to give it more weight in the two-step cluster analyses, which we performed with SPSS software. In an iterative process, we refined feedback attribute definitions and codes, ran multiple cluster analyses, and adjusted based on prioritization of target behaviors. An example of our prioritization of target behaviors is that we did not include driving mode selection indicators (Fig. 3) in statistical cluster analyses; we judged them to be a unique type of feedback based on the specific target behavior (pressing an ECO mode button). This approach has aspects of taxonomic classification (hierarchical approach of prioritizing target behaviors) and some aspects of typological classification (all other attributes were weighted equally).

3 Results

Our analysis yielded 15 types of in-vehicle eco-driving feedback, including basic interfaces for alternatively-fueled vehicles (Figs. 1, 2), feedback specifically targeting accelerating, cruising, and/or decelerating (Figs. 4, 5, 6), and feedback reflecting fuel economy, inclusive of an aggregate of behaviors (Figs. 7, 8).

Fig. 1 Power Meter. The power meter in a hybrid or electric vehicle is analogous to a tachometer in an ICEV, but often includes an optimal zone standard and regenerative braking feedback

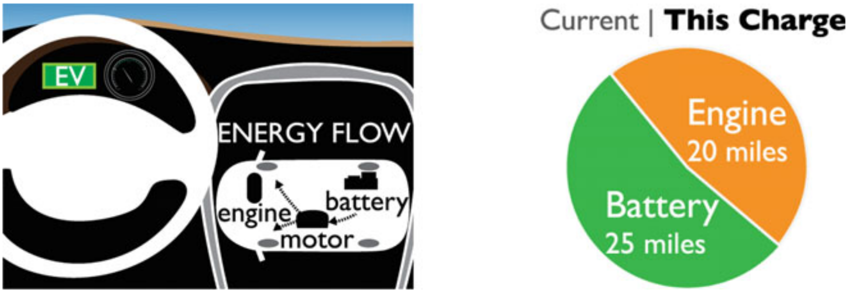

Fig. 2 Hybrid system indicators. Hybrids indicate the drive train(s) currently in operation with a single lamp or pictorial diagram (*left*), as well as a breakdown of current power demand or accumulated miles traveled with each fuel source (*right*)

Fig. 3 Driving mode selection indicator. The driver can press a button to select a driving mode that will improve fuel economy (ECO mode) or control fuel sources (EV mode), reflected by a single lamp with icon or colored glow surrounding elements of the instrument cluster

Fig. 4 Eco-accelerometer (*left*) and eco indicator (*right*). Feedback on accelerating and cruising speed is provided by a meter (Eco-accelerometer) or single lamp (Eco Indicator)

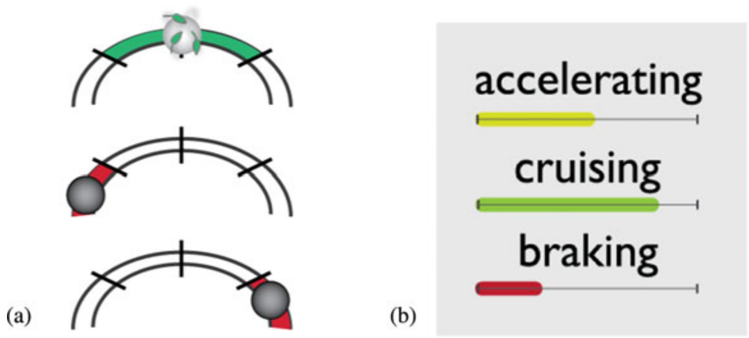

Fig. 5 **a** Pedal feed (*left*). Efficient accelerating, cruising, and decelerating are reflected, with the center as the feedback standard. **b** Eco-driving coach (*right*). Behavior-specific feedback is provided either in real-time and/or at the end of each accelerating, cruising, and braking event

Fig. 6 **a** Haptic pedal (*left*). Haptic feedback was found in only one on-market vehicle, not available in the US. Pressure exerted by the driver on the throttle is met with corresponding counter-pressure to teach the driver most efficient throttle position during acceleration events. **b** Regenerative braking feedback (*right*). A display dedicated to regenerative braking feedback depicts total percentage of lost mechanical energy recaptured during a braking event

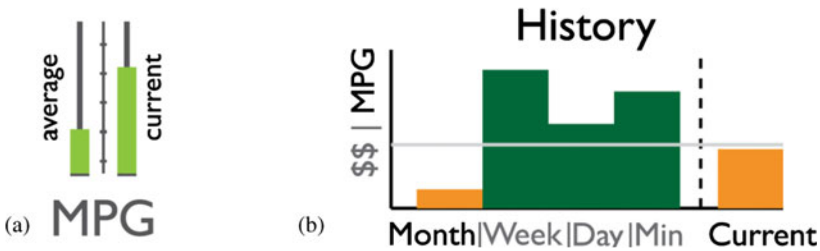

Fig. 7 **a** Mileage meter (*left*). Meters are a common mode of interface for current and average aggregate efficiency, sometimes presented together as pictured here, where average MPG serves as a feedback standard for current performance. **b** Efficiency history (*right*). Past performance is reflected in a histogram with intervals of some duration (e.g., minute, day), providing a standard for recent or current performance

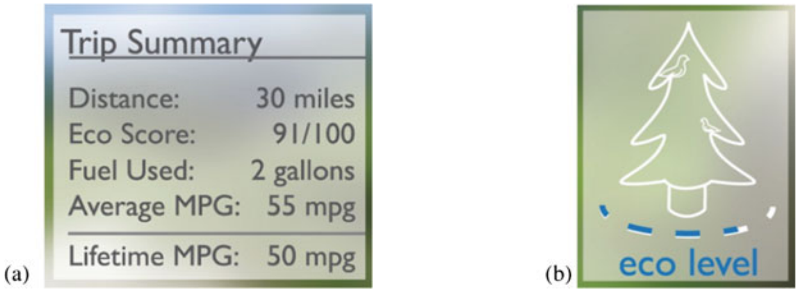

Fig. 8 **a** Summary statistics (*left*). Eco-driving behavior is reflected in numeric indicators of mileage and other metrics, such as distance traveled, fuel consumed, or efficiency score. **b** Biophilic rewards (*right*). Eco-driving behavior is rewarded with the accumulation of nature imagery, often paired with graduated levels or scores

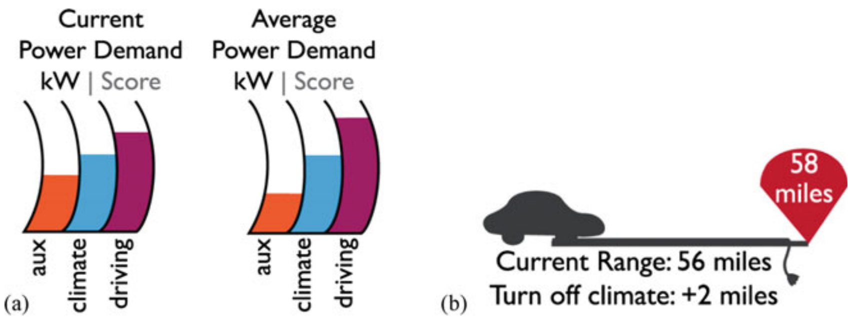

Fig. 9 **a** End-use analysis (*left*). Current and average power demand for different end-uses/driver behaviors may be presented in terms of power demand or an efficiency score. **b** Relative range (*right*). A remaining range estimate based on current driving style and/or use of climate settings may be presented juxtaposed with a feedback standard such as the potential maximum range, distance to destination, and/or additional range gained or lost if climate settings are changed

4 Discussion

This typology allows us to compare within and among feedback types and consider implications for maximizing the effectiveness of feedback. In this discussion, we focus on the implications of six feedback parameters, as manifested in identified feedback types, on three general behavioral mechanisms underlying feedback effectiveness: attention, learning, and motivation. We find that mode of interface has significant implications for driver attention; behavioral granularity for driver learning; and metrics, standards, gameful design, and biophilic design for driver motivation.

4.1 Salient Feedback for Driver Attention

The Haptic Pedal (Fig. 6a) is the only non-visual mode of interface we found and it was only present in one vehicle, not available in the US. Research suggests that Haptic Pedal can promote eco-driving with less potential for driver distraction than visual feedback [13]. One might hypothesize that it is also less susceptible to a novelty effect whereby feedback is attended to initially then tuned out. The same may be true for other non-visual modes of feedback, such as auditory feedback, analogous to the beep of a seat belt reminder. Auditory feedback is altogether absent from the on-market systems we analyzed, but examples can be found in after-market apps. It seems that non-visual eco-feedback warrants further consideration from vehicle manufacturers.

There may sometimes be a trade-off between salience and data granularity, which has implications for feedback sensitivity to behavior. For example, numeric feedback is more granular but less salient than a meter, which is more granular but less salient than a colored light. One strategy we saw to maximize salience and sensitivity in visual feedback was integration of colored lights and blinking or spinning movement with a meter (Figs. 4 and 5a).

4.2 Precise Feedback for Driver Learning

In some cases, we had trouble determining which eco-driving behaviors were reflected by Eco Indicators (Fig. 4). For example, some manufacturers note that their Eco Indicator reflects only acceleration, whereas others claim it reflects both acceleration and deceleration, and for yet others we were unable to rule out whether they included all engine loads, such as climate control and auxiliary electronics. Given the similarity of the interface and the ambiguity from the driver's perspective, we considered all these as the same type of feedback. It is notable that even owner's manuals do not always sufficiently define the eco-driving behaviors targeted by their feedback systems. Lack of precision in the behavioral granularity of feedback is sub-optimal for learning.

Other types of feedback do a much better job of precisely conveying the target behaviors. For example, Eco-driving Coach (Fig. 5b) targets three key driving behaviors: accelerating, cruising, and braking. Such precision supports learning. End-use Analysis (Fig. 9a) and Relative Range (Fig. 9b) disaggregate feedback in a similar way, e.g., calling out the impacts of climate settings, use of auxiliary electronics, and/or driving behaviors (an aggregate of accelerating, cruising, braking). However, some cases of End-use Analysis showed "Motor" and "Other" as end-uses, which are less useful in teaching a driver what to do compared to "Driving Style" and "Aux" (for the latter, "Accessories" or "Electronics" might be more meaningful still). Climate settings and use of electronics are unique targets in that they are available to passengers as well as drivers.

In cases where feedback on aggregate behavior reflects actual fuel economy, a myriad of behaviors become relevant, i.e., those classified by Kurani et al. [1] as driving behavior (accelerating, cruising, decelerating, waiting, parking, and driving mode selection), cabin comfort (behaviors related to thermal comfort, communications, and entertainment), trip planning (e.g., route selection, timing), load management (interior and exterior cargo weight and aerodynamics), fueling (e.g., fuel selection), and maintenance (e.g., tire pressure, engine oil). This lack of precision could be sub-optimal for learning and motivation as the effects of any one behavior are washed out. Aggregate feedback could also be perceived as specific when it is highly sensitive to a particular behavior, e.g., accelerating; when that is the case, that particular behavior might be the only behavior affected by the feedback.

4.3 Meaningful Feedback for Driver Motivation

Efficiency expressed as a number, meter, or graph, is typically in terms of MPG or kWh/mi, but several tactics are employed to make metrics more meaningful for some drivers. For example, points, scores, levels, and progress bars are applications of gameful design (e.g., Fig. 5b, Fig. 8a and b). Translating metrics is also useful when the actual metric is unfamiliar, abstract, or poorly understood; e.g., power demand can be displayed as percentage points or score rather than kilowatts (e.g., Fig. 9a).

One feedback system displayed money mileage ($/mi). According to Dogan et al. [18], if financial costs are negligible this could actually be a disincentive to eco-driving. This suggests that money mileage may be most effective when reflecting accumulated behavior (e.g., weekly or monthly) and/or juxtaposed with a feedback standard that reflects accumulated behavior (Fig. 7b). On repeated commutes, fuel cost on prior trips could serve as a meaningful feedback standard.

In the case of Biophilic Rewards (Fig. 8b), metrics are sometimes abstracted away altogether—replaced by imagery. Biophilic Rewards range from a more quantitative, gameful design that includes numeric or metered scores or levels, to a more qualitative, aesthetic design where the only quantitative data is number of trees, leaves, or flowers. The visualization may be labeled as fuel efficiency, remaining range, or CO_2 reduction. Aesthetic designs that prompt reactions similar to reactions to actual nature and use preferred nature imagery should be most successful in priming consideration and care for the natural world, which might motivate eco-driving.

4.4 Limitations

Stated implications and recommendations regarding feedback types should be considered in a broader context when applied to feedback design and related policy-making. For example, we did not consider feedback location (e.g., instrument cluster, center console, or head-up display), which has implications for saliency and distraction. Implications of the holistic composition of a feedback system with multiple streams should also be considered in future research. Finally, our identified feedback types are not entirely orthogonal, but we contend that our method of classification yielded a typology that best reflects the current distinctions among in-vehicle feedback systems.

4.5 Conclusion

This research presents an in-vehicle eco-driving feedback typology based on behavioral theory. Our discussion of 15 distinct types of feedback points to opportunities for optimized and novel designs. We highlighted the importance of saliency, precision, meaningful metrics, and multiple feedback standards to promote eco-driving learning and motivation. Future research is needed to systematically evaluate these feedback types in relation to specific eco-driving behaviors, driver characteristics, and driving conditions in order to determine the most effective configurations.

Acknowledgments This research was supported by the National Center for Sustainable Transportation (NCST), University of California Multicampus Research Programs and Initiatives (MRPI), and University of California, Davis, Research Investments in the Sciences and Engineering (RISE).

References

1. Kurani, K.S., Sanguinetti, A., Park, H.: Actual results may vary: a behavioral review of eco-driving for policy makers. A white paper for the National Center for Sustainable Transportation (2015)
2. Rouzikhah, H., King, M., Rakotonirainy, A.: Examining the effects of an eco-driving message on driver distraction. Accid. Anal. Prev. **50**, 975–983 (2013)
3. Kurani, K.S., Stillwater, T., Jones, M.: Ecodrive I-80: A Large Sample Fuel Economy Feedback Field Test Final Report. Institute of Transportation Studies Report ITS-RR-13-15, University of California, Davis (2013)
4. Wada, T., Yoshimura, K., Youhata, H., Tomiyama, K.: Proposal of an eco-driving assist system adoptive to driver's skill. In: 14th International IEEE Conference on Intelligent Transportation System, pp. 1880–1885. ITSC (2011)

5. Tulusan, J., Soi, L., Paefgen, J., Brogle, M., Staake, T.: Eco-efficient feedback technologies: which eco-feedback types prefer drivers most?. In: 12th IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks, pp. 1–8. WoWMoM, Lucca (2011)
6. Jenness, J.W., Singer, J., Walrath, J., Lubar, E.: Fuel Economy Driver Interfaces: Design Range and Driver Opinions (Report on Task 1 and Task2). DOT HS 811 092, National Highway and Traffic Safety Administration, Washington, D.C. (2009)
7. Manser, M.P., Rakauskas, M., Graving, J., Jenness, J.W.: Fuel economy driver interfaces: develop interface recommendations (Report on Task 3). DOT HS 811 319, National Highway Traffic Safety Administration, Washington, D.C. (2010)
8. Stillwater, T., Davies, J., Kurani, K.S.: EV and PHEV Energy HMI Function and Usability. Unpublished report for CEC, Public Interest Energy Research (PIER) Program (2013)
9. Kluger, A.N., DeNisi, A.: The effects of feedback interventions on performance: a historical review, a meta-analysis, and a preliminary feedback intervention theory. Psychol. Bull. **119**, 254–284 (1996)
10. Cooper, J.O., Heron, T.E., Heward, W.L.: Applied Behavior Analysis, (2nd. Ed.). Pearson, UK (2007)
11. Ahmed, S., Sanguinetti, A.: OBDEnergy: Making metrics meaningful in eco-driving feedback. In: Human Computer Interactions International Conference Proceedings, pp. 395–401. Springer International Publishing, Switzerland (2015)
12. Pousman, Z., Stasko, J.: A taxonomy of ambient information systems: four patterns of design. In: Proceedings of the Working Conference on Advanced Visual Interfaces, pp. 67–74 (2006)
13. Seewald, P., Ahlström, C., Aleksic, M., Fors, C., García, E., Hibberd, D., Iviglia, A., Jamson, S., Jamson, H., Josten, J., Kircher, K.: Deliverable D13.2.: Results of HMI and feedback solutions evaluations. Version 10, ecoDriver (2013)
14. Zichermann, G., Cunningham, C.: Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps. O'Reilly Media, Sebastopol (2011)
15. Diewald, S., Möller, A., Roalter, L., Stockinger, T., Kranz, M.: Gameful design in the automotive domain: review, outlook and challenges. In: Proceedings of the 5th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, pp. 262–265. ACM (2013)
16. Kellert, S.R., Heerwagen, J., Mador, M.: Biophilic Design: The Theory. Science and Practice of Bringing Buildings to Life. Wiley, New York (2011)
17. Loeb, L., Loeb, G., Tice, E., Tregubov, T.: Emotionally engaging students to change behaviors and conserve resources: unplug or the polar bear gets it! Int. J. Environ. Cult. Econ. Soc. Sustain. **6**(2) (2010)
18. Dogan, E., Bolderdijk, J.W., Steg, L.: Making small numbers count: environmental and financial feedback in promoting eco-driving behaviours. J Consum. Policy. **37**, 413–422 (2014)