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The DO-IT BEST Feedback Model -

Distracted Driver Behaviour Management and Prevention Before, While And After Driving

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Abstract

Applied to driver distraction and inattention prevention/mitigation, this paper expresses how to enhance attention allocation using the DO-IT BEST Feedback Model – a model on ‘behavioural change’. Today, there are two main approaches to improve traffic safety through feedback to drivers. One approach is Advanced Driver Assistance Systems (ADAS), which are concurrent feedback systems that warn the driver in a dangerous situation (e.g. taking the eyes off the road). The other approach, behaviour-based safety management programs (BBS), use deferred feedback (i.e. pre- or post-trip) and target, for example, a habit of sending text messages while driving. If both approaches are used, feedback to drivers is provided during different timescales before, while and after driving. Each approach on its own is an effective crash prevention strategy, however they tend to be used independently and would benefit from being integrated into *one* holistic crash prevention strategy. The DO-IT BEST Feedback Model is such a holistic and integrated crash prevention strategy. DO-IT BEST is an acronym for **D**efine, **O**bserve, **I**ntervene, and **T**est targeted at-risk and/or safe behaviour as well as to assimilate **B**ehavioural check-ups, **E**ducation, **S**afety benefit analysis and **T**raining on targeted at-risk and/or safe behaviour. The model consists of a closed circuit set of feedback strategies, based on the driver’s own behaviour, and ranging from concurrent on-board driver feedback to deferred post-trip feedback. The various feedback sources (e.g. technology- or human-based feedback) are included in the model.

"The whole is something over and above its parts, and not just the sum of them all..."
Aristotle

Introduction

Driver distraction and inattention may be caused by a range of factors including drivers willingness to engage in distracting tasks (Klauer, Dingus, Neal Sudweeks & Ramsey 2006, Victor, Harbluck & Engström 2005, Dingus et al 2011), sleepiness (Bunn, Slavova, Strttmann & Browning 2005), day dreaming (Forster 2013) or reaching for an object or person inside the vehicle (Roney, Violano, Klaus, Lofthouse & Dziura 2013). In some traffic situations distraction and inattention can have fatal consequences. Driver distraction has been identified as a major contributor for crashes (Klauer et al. 2006, Hanowski, Olson & Bocanegra 2009, Hanowski, Perez & Dingus 2005). As "distraction […] is part of everyday driving" (Aitkin, Chairman NRMA-ACT Road Safety Trust 2009), we need to develop strategies on how best to manage and/or prevent distraction and inattention. Two strategies, Advanced Driver Assistance Systems (ADAS) and behaviour-based safety management programs (BBS), already exist. However they have never been synthesized into *one* holistic model. It is expected that when these approaches are used together, it will improve crash prevention. This paper describes such a holistic model for how to manage safety by providing behavioural feedback about a specific, pre-defined behaviour before it occurs, while it occurs in the vehicle and after it has occurred. Thereby, the focus of the 'behavioural change' is on how to enhance attention allocation to the driving scene.

Present countermeasures for (visual) driver distraction

Today, there are two main approaches to improve traffic safety through feedback to drivers. Although having the same goal, the two approaches take into account different time-scale perspectives for crash prevention. One approach is *Advanced Driver Assistance Systems (ADAS)* which are technology-based safety countermeasures. ADAS are concurrent feedback systems (i.e. immediate feedback) that warn the driver in a dangerous situation (e.g. taking the eyes off the road). ADAS are defined as pre-crash *driver warning systems* that alert the driver by providing immediate risk-relevant feedback prior to a near-crash or crash event. It has been speculated that the implementation of ADAS may lead to a fatality decrease of 40% (Thalen 2006). Today's distraction countermeasures in the automotive industry are almost exclusively ADAS of the type of 'reactive pre-crash mitigation' systems ((e.g. FCW, LDW), for a review see Engström and Victor (2008)). A conceptual framework to cluster various ADAS is presented by Victor (2011). This framework is time-based by classifying ADAS to the time prior to a (possible) crash.

The other approach, *behaviour-based safety management programs (BBS)* are safety countermeasures that use deferred feedback (i.e. "offline", pre- or post-trip feedback) to target a 'behavioural change' (e.g. a habit of sending text messages while driving). Geller (2001) was among the first who introduced the BBS-concept in the area of industrial work safety and occupational behaviour research. *Safety program techniques* following the BBS-principles have proven to be relatively easy to implement, cost-effective and highly efficient for reducing occupational injuries and fatalities in a variety of industrial domains. Meta-analysis of health and safety BBS studies found a significant reduction in injuries in 96.6% cases (Sulzer-Azaroff & Austin 2000), 59.6% cases (Guastello 1993) or 69% cases (Krause 1998). Research on BBS programs applied to traffic safety is however limited. Only a few studies have examined the effects of BBS principles applied to the automotive domain (Hickman et al 2007, Hickman & Hanowski 2010, 2012, Victor et al 2011). Hickman et al (2007) and Horrey, Lesch, Dainoff, Robertson and Noy (2012) provide comprehensive overviews of existing BBS approaches in commercial vehicle operations. In this context, Hickman and Hanowski (2010) have identified four main BBS techniques: 1) training and education, 2) behaviour-based incentives and goal-setting, 3) behavioural observation, and 4) feedback. See Wege and Victor (in press) for a further discussion of these BBS techniques.

Motivation for the development of the DO-IT BEST Feedback Model

Both the ADAS and BBS approaches, although proven to be effective, have shortcomings which may lead to an overestimation of the safety effects that they actually have (Wege & Victor, in press). The magnitude of shortcomings of present countermeasures motivated the development of a more comprehensive, holistic crash prevention strategy: the DO-IT BEST Feedback Model (Figure 1). ADAS as countermeasures may not lead to sustainable, long-term behavioural adjustment (long-term effect on behavioural change), such as taking decisions to stop engaging in distracting activities. The reasons why may be a) the “failure of memory”, a phenomenon whereby an estimated 80 % of near-crashes are forgotten after two weeks (Chapman & Underwood 2000), b) the “failure of association” whereby the driver cannot associate an overall increase in lane departure warning with lane deviations caused by a distracting activity and/or c) that the driver might not have access to potential feedback (Toledo & Lotan 2006). The main shortcoming of BBS as a countermeasure is that feedback is provided a fairly long time after a certain behaviour occurred. According to previous research, feedback is most effective when given immediately or as soon as possible after the occurrence of the behaviour (e.g. Geller 2001, Skinner 1953). Research shows that when drivers only receive deferred feedback, at-risk behaviour does not continuously decrease.

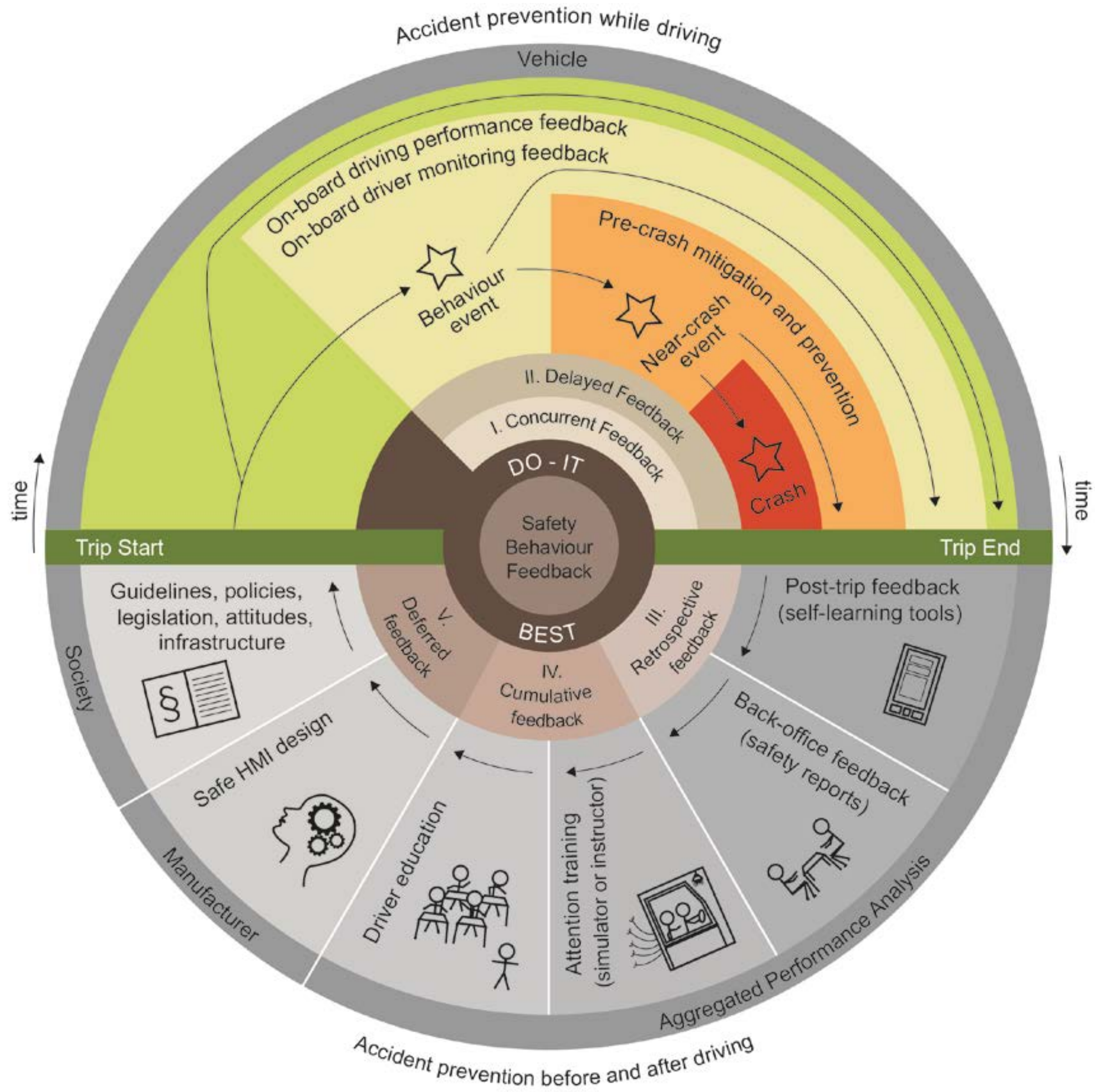

Figure 1. DO-IT BEST Feedback Model

Previous work as a basis for the model

The DO-IT BEST Feedback Model was developed based on previous research and developments within the automotive domain, the educational domain, and the behavioural psychology domain.

BBS-programms in industrial work settings (Geller 2001)

The original BBS process is a four-step process called DO-IT process which was developed by Geller (2001). DO-IT is an acronym for the following terms: (1) **D**efine the critical target behaviour(s) to increase or decrease, (2) **O**bserve the target behaviour(s) during a pre-invention baseline period to set behaviour-change goals and, perhaps, to understand natural environments or social factors influencing the target behaviour(s), (3) **I**ntervene to change the target behaviour(s) in desired directions, and (4) **T**est the impact of the intervention procedure by continuing to observe and record the target behaviour(s) during the intervention program. According to Geller safety feedback is most effective when given immediately or as soon as possible after the occurrence of the behaviour. Ludwig and Geller (1997, 2001) recommend involving participants as much as possible in the implementation of the DO-IT approach at their work site. The self-involvement has positive effects on participants self-regulatory capacities which allow them to motivate and regulate behaviour through internal standards and self-evaluation of their behaviour. If it is possible for individuals to monitor and record their own behaviour, behavioural and cognitive change is possible through self-management. The DO-IT process has been successfully applied in a variety of industrial domains such as secure prison management (Geller et al 1977), community recycling (Geller 1980), effectiveness of child dental care (Kramer & Geller 1987) and safety for pizza deliverers (Ludwig & Geller 1991). For an extensive review on a number of BBS studies involving a total of 25,852 people see Cooper (2009).

As Geller and colleagues conceptualized the DO-IT process it targeted at-risk and/or safe behaviour which was usually systematically observed by trained safety managers (“human watch guards”) in industrial work settings during so called intervention programs. Feedback on safe versus at-risk behaviour of employees was provided later. The DO-IT process has (to our knowledge) never before been applied in the automotive context focusing on distracted drivers, especially not in an online automotive context (i.e. giving feedback while driving). Thus, we have taken the classic DO-IT process out of its original context (industrial work settings) into the context of online crash prevention. More specifically, the human performance analyst (“the human watch guard”) is transferred to the automotive setting by replacing it with technologies (on-board monitoring devices). Online technologies are able to observe the situation and either to intervene appropriately online and/or to log events for a later occasion. Thus, Geller’s original process is interpreted here as an online crash prevention strategy in the DO-IT BEST Feedback Model.

‘Behavioural change and behaviour adaptation’ (Wege, Pereira, Victor & Krems, in press)

Adaption processes become important each time a driving situation embodies one or several unfamiliar components. These processes involve a behavioural change emerging into previously established behavioural patterns. A variety of concepts, theoretical models as well as empirical research regarding the concept of ’behavioural changes’ exist. For a review of the literature see Wege, Pereira, Victor and Krems (in press). In general, it is the role of feedback in changing behaviour that is of importance because ‘behavioural change’ is largely based on human learning theories and their underlying cognitive, motivational and energetic processes. One particular learning theory is the theory of operant condition by Skinner (1953). Skinner influenced the “behavioural approach” which assumes that once behaviour can be operationally defined, and reliably tracked, it can be influenced.

Research on on-board safety monitoring devices (OBSMD) (Hickman et al 2007, 2010a)

In recent years, driver monitoring systems have been developed and tested during on-road field studies (Hickman et al 2007). In these studies, the goal of driver monitoring is to record safety critical behavioural events for post-trip analysis and *post-trip behavioural feedback* which is provided either hours, days or even weeks later. On-board safety monitoring devices (OBSMD) enables safety managers at fleet companies to collect safety-specific information (e.g. instances of seatbelt non-compliance, distraction, or fatigue) related to driver on-road behaviour and performance. Employers with drivers who operate a motor vehicle as part of their job usually do not have the opportunity to directly observe workers and interact with them in an effort to improve safety to the same extent as employers with a fixed worksite have. Technologies such as OBSMD and real-time distraction feedback systems have several benefits. These systems have the potential benefit 1) to detect and identify behavioural events while driving; 2) to give the opportunity for proactive, corrective, immediate feedback (thus, bringing the event to the awareness of the driver and requiring an immediate, appropriate response); 3) to automatically store data surrounding a behavioural event for later download, for subsequent review, for generation of individual trip awareness scores and/or recordings for driver training and coaching (thus, preventing events from reoccurring in future trips). Knipling and Hyten (2009) noted additional benefits of using such systems in commercial fleet operations: 4) the feedback and related evaluations are objective, timely, and frequent; 5) drivers can receive positive feedback and rewards for good behaviours (these rewards can also be structured to reinforce group or fleet-level achievements); 6) benchmarks for driving behaviours can be set in order to establish carrier or group norms and expectations; and finally 7) the systems may replace time consuming ride-along observations conducted by a human. According to Horrey, Lesch, Dainoff, Robertson and Noy (2012) OBSMD can offer valuable information to drivers concerning undesired behaviours, driving errors and lapses, including those that the drivers themselves might not be aware of. Thus, drivers benefit most from actually experiencing their own errors.

Several OBSMD that log dangerous behaviour but do not give immediate feedback exist, for example Tripmaster®, DriveCam®, Driver Alert Support System® and Transsecurity System®. Horrey, Lesch, Dainoff, Robertson and Noy provide a comprehensive state-of-the-art review of studies concerning OBSMD. The primary safety behaviours measured by these systems are extreme braking events, speeding, sudden acceleration and lateral control performance. The consequences of distracting behaviour are logged and send via a wired or wireless connection to a fleet safety management software. Toledo, Musicant and Lotan (2008) investigated the effects of an on-board driving performance monitoring device over a 5-month period. It was found that drivers only reduced their at-risk behaviour for the first month after performance feedback was provided, after that the effect remained stable. Although the mentioned products have been shown to reduce fleet-wide crashes up to 52.2% (Hickman & Hanowski 2010), no OBSMD measuring off-road glances is yet on the market. Research in this field is active and systems such as a Visual-Distraction-Alert System have been studied in simulator experiments (e.g. Lee et al 2013, Ahlström, Kircher & Kircher 2011, Wege & Victor, in press). One example of a device measuring visual behaviour (based on head movement, but again, no off-road glances) is the Driver State

Sensor System® (DSS). The DDS is a fatigue warning and driver behaviour monitoring device based on head rotation and eye-lid closure, which was validated in a field study with 18 trucks over a period of 41 weeks and 86000. This study showed a significant elimination of crashes attributed to distraction or fatigue as well as a 78% reduction in distraction event frequency (Croke & Cerneaz 2009).

The conceptual framework for distraction and inattention countermeasures (Victor 2011)

Within the DO-IT BEST Feedback Model, the conceptual framework on technology-based safety countermeasures found in Victor (2011) is further developed by extending the time-based nature of the framework into a circular time scale from a linear time scale progressing from normal driving to a (potential) crash. In the original conceptual framework 16 emerging technology-based safety countermeasures are clustered according to descriptive characteristics and functions. The division of pre-drive, normal driving, pre-crash, crash, crash and post-drive countermeasures is adapted based on this framework.

The"information-processing model with temporal feedback" (Donmez, Boyle & Lee 2008).

Four of the five driver feedback timescales in the DO-IT BEST Feedback Model (i.e. concurrent, delayed, retrospective and cumulative feedback in Figure 1) are based on the "information-processing model with temporal feedback" by Donmez, Boyle and Lee (2008). An additional fifth timescale ('deferred cumulative') was added in order to address long-term societal impacts like to laws that restrict distracting behaviours while driving as a form of deferred feedback.

Research on driver training, education and formal driver retrospective feedback

The beneficial effects of driver training and education have been studied especially for young and novice drivers (e.g. Roelofs, Vissers, van Onna, Kern 2012, Washington, Cole & Herbel 2011, Weiss, Petzoldt, Bannert & Krems 2013). A recent study involving professional drivers showed that professional driver training is associated with enhanced safety attitudes and less frequent self-reported risk behaviour. Concerning driver distraction and inattention, Regan (Regan, Lee & Young 2008, p. 559) stated that driver distraction, as an issue, has been largely neglected in the design of driver education and training programs. The same holds true for programs providing retrospective driver feedback targeting visual distraction and inattention. Although retrospective feedback has shown successful effects with bus drivers (Olsen & Austin 2001), short haul truck drivers (Hickman & Geller 2003) and truck drivers (Hickman & Hanowski 2010, Victor et al 2011), it has mainly targeted driving performance measures instead of visual behaviour measures.

In particular, retrospective driver feedback about *their own* errors has the potential to allow drivers to experience the consequences of unsafe behaviours. This was shown to lead to greater improvements compared to conditions in which drivers are only informed of possible driving errors or when no individual driving error were identified (Horrey, Lesch, Dainoff, Robertson & Noy 2012). McGehee, Raby, Carney, Lee and Reyes (2007) conducted a naturalistic driving study over 6 months and showed an 89 % decrease in the number of incidents for the more at-risk drivers when retrospective feedback was provided. Furthermore, a combination of concurrent and retrospective feedback resulted in 57 % reduction of crash (Hickman & Hanowski 2010). Toledo and Lotan (2008) investigated driving performance over a 5-month period as influenced by cumulative feedback presented on a personal webpage. Using this webpage, drivers could access the information on all their previous trips and also received information about performance of other drivers. Initially, feedback improved safety, but this effect diminished over time as drivers accessed their webpages less frequently. Wang, Lesch and Horrey (2009) examined whether feedback delivered at one timescale persisted through different follow-up intervals. In their study drivers received video-based feedback regarding their own simulated driving performance, with an emphasis on the contribution of dual-tasking to degraded performance. Perception and attitude toward cellular phone use while driving was investigated using a questionnaire before, immediately after, and one month following the testing. The feedback treatment group showed significant attitude change toward cellular phone use while driving (toward being less favorable), whereas the control group had no attitude change. At the one-month follow-up, the benefit of feedback was sustained. Self-coaching systems can improve safe driving behaviour by allowing drivers to review a record of their own driving activity. On-road risky driving behaviour was detected from driving performance signals (e.g. acceleration and brake pedal pressure, steering-wheel angle, velocity, and following distance) and was reduced by 50 % for non-expert drivers after receiving feedback about their own driving (Takeda et al 2012). A two-year follow-up study investigating customized training coupled with active learning in a driving simulator effectively improved driver scanning behaviour (Romoser 2013). Other examples of self-coaching systems as well as web-based training and their potential to counteract driver distraction can be found in Prahdan et al (2009), Robin et al (2005) and Gordetsky (2000).

In sum, safety training and education is a necessary, but not sufficient safety management technique. Drivers need the knowledge on how to drive safely and identify unsafe behaviors, but this does not imply that they drive safely. If a driver has no knowledge, he/she has a knowledge gap; however, if he/she has the knowledge but still engages in unsafe behavior, then it’s a motivation gap (i.e., “I know what to do, but I choose not to.”).

Model description

The DO-IT BEST Feedback Model is a model on ‘behavioural change’ which focuses on *providing the driver with both concurrent and deferred feedback about their own behaviour* by integrating ADAS and BBS approaches and their associated technologies. The intended goal is to encourage positive behavioural change over a plurality of timeframes, for instance: (1) immediate (e.g. short-term compensatory behaviours like changing braking behaviour, or aborting a complicated task), (2) trip (e.g. turning off mobile phone), (3) day to day (e.g. removing distracting devices from front seat), and (4) long-term (adoption of a different distraction attitude).

The main assumption of the DO-IT BEST Feedback Model is that once behaviour can be operationally defined, and reliably tracked, it can be influenced based on classic learning theories as mentioned above (e.g. Skinner 1953). Further, more specific assumptions were embedded in the development of the model. First, was assumed that drivers are willing to change behaviour, consent that their behaviour is monitored, recorded and reviewed. A second assumption was that technical equipment is sophisticated enough to reliably track, identify, warn and record certain behaviour as well as technical solutions exist that are capable to store, process, aggregate, analyze, visualize and display behavioural data. Third, it was assumed that after-market devices or in-vehicle information displays are sufficiently mature, safety analysts are well trained, safety managers well educated and safety educators sufficiently competent in order to provide feedback to drivers. A fourth assumption was that vehicle manufacturers will develop safe products and carry out research on products and services. Fifth, that traffic authorities will collaborate with research and industries and communicate guidelines and policies. The sixth and final assumption was that society is willing to create, to value and to maintain a safety attitude in the traffic environment.

The DO-IT BEST Feedback Model is divided into different areas (Figure 1) which are crash prevention strategies or safety behaviour feedback strategies. They are illustrated in a closed circuit as a “flow” (continuously ongoing). The source of the feedback is illustrated as part of the outer circle around these areas. Once a trip starts and no driver feedback on degraded driving or visual behaviour is detected, the driver is traveling safe (green in Figure 1). If the driver is distracted a ‘behavioural event’ is detected either by an ‘on-board driver monitoring system’ or ‘on-board driving performance monitoring system’. Behaviour events are for example a long off-road glance or lane departures. The driver is warned for the behavioural event and/or the event is logged to file and recorded for future analysis. Depending on the driver’s reaction, a behaviour event can either lead to a safe continuation of the trip (arrow in yellow area from behaviour event to trip end, Figure 1) or to a ‘near crash event’. Near crash events are behaviour events associated with an external event or consequence and are usually defined as an event whereby a vehicle comes “dangerously close” to another vehicle, object, person(s), or animal(s) (Hickman & Hanowski 2012). ‘Pre-crash mitigation and prevention systems’ such as Forward-collision-warning systems (FCW-systems) or Lane-departure-warning systems (LDW-systems) warn the driver immediately and/or the event is logged to file and recorded for future analysis and feedback. Again, depending on the drivers reaction, a near-crash event can either lead to a safe continuation of the trip (arrow in orange area from near-crash event to trip end, Figure 1) or to a ‘crash event’. A crash is usually defined as any occurrence involving a motor vehicle coming in contact with another vehicle, property, person(s), or animal(s) that resulted in human death, bodily injury, and/or any property damage (Hickman & Hanowski 2012).

The feedback in behaviour events and near crash events is defined as concurrent (ms) and/or delayed feedback (s). For both feedback types the source of the feedback is an intelligent monitoring device installed in the vehicle. As described above, the original DO-IT process is applied in an on-line driving setting wherein the safety behaviour feedback strategies *while* driving are:

D **Define target behaviour**

Target behaviour is for example defined as “poor timing of long off-road glance(s) due to distracting activities while driving”

O **Observe target behaviour**

Behaviour is observed by means of ‘on-board driver monitoring systems’ or ‘onboard driving performance monitoring systems’

I **Intervene to influence target behaviour**

Intervention is made by providing a concurrent (ms), or delayed (s) feedback such as a warning immediate or as soon after the target behaviour occurs

T **Test the measured effectiveness of the intervention**

Effectiveness is measured by measuring the consequences of the intervention such as total increased on-road glance time and/or reduction of lane deviation within a defined time after the warning occurred

The logged events are then aggregated and analyzed as a source for retrospective post-trip driver feedback (min, hours, days) or cumulative (weeks, months). This feedback can be carried out by a safety manager (Hickman & Hanowski 2010), a parent (McGehee, Raby, Carney, Lee & Reyes 2007) or an automated data algorithm software (Takeda et al 2012). The retrospective or cumulative feedback could include an analysis of the magnitude or frequency of distracting behaviour events which is displayed on an in-vehicle or portable device (e.g. in the instrument cluster or on a mobile phone application). Further, in a one-on-one feedback session, a driver receives direct feedback about his/her own behaviour events from a safety analyst and/or fleet manger. In one-on-one meetings behavioural events are examined and performance (attention) scores are reviewed. In this coaching session video events examples of risky behaviours (e.g. near-crashes or close following behaviours) and feedback on aggregated driving performance data (e.g. of last three months) is provided. The primary benefit of coaching sessions is that individual drivers are collaboratively engaged in the behaviour improvement process. In a personal plan, agreed upon goals and objectives for future trips can be negotiated. Alternatively, retrospective feedback could be provided by parents or through self-coaching software. As a further step, attention training in a driving simulator or on a test-track with or without a physical instructor providing guided feedback could be given. The role of driver education has been well established (see above). Safety education courses should target specific driver issues (e.g. driver overconfidence while using cell phones while driving) rather than driving skills in general which is the focus of traditional driver education.

The safety behaviour feedback strategies *before* and *after* driving described above usually fall in one of these four categories:

B Behavioural check-ups

Behavioural check-ups and feedback on target behaviours over an extended period of time (e.g. per trip, per day, per week or per month) with the option of comparing them to previous periods (e.g. "Today´s trip was x improved compared to yesterday´s trip")

E Education

Goal-directed safety education can include case studies or cognitive learning activities and knowledge on risk-perception, laws, policies and regulations

S Safety benefit analysis

Aggregated safety benefit analysis on a fleet, community and/or society level including the benefits on reduction of injuries, repair costs and/or insurance costs

T Training

Professional and/or informal attention training in a driving simulator and/or with a (web-based) self-training tool

Part of the crash prevention before and after driving can be seen as deferred feedback, such as safe human-machine interface design of ADAS and mobile communication devices. The source of the feedback is the manufacturer (vehicle or mobile device manufacturer) which design human-centered products. Real-life data records of a driver's reaction during behaviour events could lead to new conclusions regarding guidelines, hours of service regulation or cell-phone policies at a product development level. Deferred feedback also includes impacts on societal guidelines, policies, legislation, attitudes and infrastructure that restrict distracting behaviours while driving. In this case the source of the feedback is the society. The society has the potential to direct, for example attitudes towards cell phone use while driving which then in turn influences a driver's day-to-day habits.

The expected effects of the DO-IT BEST Feedback Model

The expected effects of the DO-IT BEST Feedback Model are similar to the safety effects of ADAS (real-time feedback) and BBS (aggregated feedback) but go beyond, because of the combination of ADAS and BBS. For a further description on how to combine ADAS and BBS as team players see Wege and Victor (in press). Possible safety effects could be based on enhanced self-awareness (Bandura) and self-reflection about distracting habits, driver calibration (Roberts, Horrey & Liang 2008) and different safety attitudes and responsibilities. The safety effects could be reflected in a reduction of injuries and fatalities as well as less repair costs for property damages along with less insurance costs.

Conclusion

The DO-IT BEST Feedback model is a model on how to *'encourage positive behavioural change'* over a plurality of timeframes on various impact levels. In this paper the focus is on strategies for preventing/mitigating adverse effects of (visual) distraction and inattention before, while and after driving. The target of the behavioural change is the *individual driver* and his/her behaviour (e.g. a habit of sending text messages while driving), cognition and attitudes (e.g. driver overconfidence while using cell phones while driving). It is assumed that, in order to achieve sustained change regarding safe glance performance, *a combination* of immediate driver feedback (ADAS) *and* deferred driver feedback (BBS) is most effective. In the model different *feedback timescales* (adapted from Donmez, Boyle & Lee 2008) and different *feedback sources* on the vehicle level, the aggregated performance level, the manufacturer level (automotive and telematics devices industry) and the society level are illustrated (Figure 1). In future research, the model clearly needs to be further validated. In particular, there are a number of open issues regarding empirical testing and analysis. Research is also needed to define further potential application areas both within the automotive domain (e.g. fuel efficiency management) and within other domains (e.g. global energy saving or healthier lifestyle).

The novelty of the model is that it further develops and integrates existing theories and research into *one holistic view*. Thereby the essence of effective ´behavioural change´ is to be found along lines of Aristotle's famous words *"The whole is something over and above its parts, and not just the sum of them all..."*

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References

Ahlström, C., Kircher, K., & Kircher, A. (2011). *Considerations when calculating percent road center from eye movement data in driver distraction monitoring.* Proceedings of the Fifth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design 132.

Aitkin, D. (2009). NRMA-ACT Road Safety Trust. http://www.roadsafetytrust.org.au/c/rtt?a=da&did=1008468

Aristotle (1966). *Metaphysics.* Trans. Hippocrates Gorgias Apostle. Bloomington: Indiana U. Press.

Bunn, T.L., Slavova, S., Struttmann, T. W., & Browning, S. R. (2005). Sleepiness/fatigue and distraction/inattention as factors for fatal versus nonfatal commercial motor vehicle driver injuries. *Accident Analysis & Prevention*, 37, 5: 862–869.

Chapman P., & Underwood G. (2000). Forgetting near-accidents: the role of severity, culpability and experience in the poor recall of dangerous driving situations. Applied Cognitive Psychology. 14**:**31-44.

Cooper, M.D. (2009). Behavioural Safety Interventions. A review of process design factors. *Safety Management - Professional Safety*, pp. 36.

Croke, D., & Cerneaz, N. (2009). *Real time distraction detection and warning system improves safety on public roads: A case study*. First International Conference on Driver Distraction and Inattention, Göteborg, Sweden.

Dingus, T. A., Klauer, S. G., Neale, V. L., Petersen, A., Lee, S. E., & Sudweeks, J. (2006). *The 100-Car Naturalistic Driving Study, Phase II: Results of the 100-car field experiment* (Tech. Rep. No. DOT HS 810 593). Washington, DC: National Highway Traffic Safety Administration.

Donmez, B., Boyle, L. N., & Lee, J. D. (2009). Designing feedback to mitigate distraction. In M. A. Regan, J. D. Lee, & K. L. Young (Eds.), *Driver distraction: Theory, effects, and mitigation* (pp. 465–484). Boca Raton, FL: CRC Press.

Engström, J., & Victor, T. (2009). Real-time distraction countermeasures. In M. A. Regan, J. D. Lee, & K. L. Young (Eds.), *Driver distraction: Theory, effects, and mitigation* (pp. 465–484). Boca Raton, FL: CRC Press.

Forster, S. (2013). Distraction and mind-wandering under load. *Front. Psychol*., 4: pp. 283.

Geller, E. S. (2001). *The Psychology of Safety Handbook*. Boca Raton, FL: CRC Press, LLC.

Gordetsky M. (2000). Simulator Gives Better Sense of the Road. *Transportation Research Board. Transport Topics*, No. 340, p. 37-39.

Guastello S. J. (1993). Do We Really Know How Well Our Occupational Accident Prevention Programs Work?'. *Safety Science*, 16:445–463.

Hanowski, R. J., Perez, M. A., & Dingus, T. A. (2005). Driver distraction in long-haul drivers. *Transportation Research Part F, 8:* 441–458.

Hanowski, R., Olson, R., & Bocanegra, J. (2009). *Driver distraction in commercial vehicle operations*. Webinar, National Highway Traffic Safety Administration, Washington, DC.

Hickman, J. S., & Hanowski, R. J. (2010). *Evaluating the Safety Benefits of a Low-cost Driving Behaviour Management System in Commercial Vehicle Operations* (No. FMCSA-RRR-10-033). Washington, DC: Federal Motor Carrier Safety Administration, USDOT.

Hickman, J. S., Knipling, R. R., Hanowski, R.J., Wiegand, D.M., Inderbitzen, R.E. & Bergoffen, G. (2007). *CTBSSP Synthesis 11: Impact of Behaviour-based Safety Techniques on Commercial Motor Vehicle Drivers*. Washington, DC: Transportation Research Board of the National Academies.

Hickman, J. S., Knipling, R.R., Olson, R. L., Fumero, M.C., Blanco, M. & Hanowski, R.J. (2011). *Heavy Vehicle-Light Vehicle Interaction Data Collection and Countermeasure Research Project: Preliminary Analysis of Data*

Collected in the Drowsy Driver Warning System Field Operational Test. Washington, DC: Federal Motor Carrier Safety Administration, USDOT.

Hickman, J.S., & Hanowski, R. J. (2010). *Evaluating the Safety Benefits of a Low-Cost Driving Behaviour Management System in Commercial Vehicle Operations*. *Transportation*. U.S. Department of Transportation. Report No. FMCSA-RRR-10-033.

Horrey, W. J., Lesch, M. F., Dainoff, M.J., Robertson, M. M., & Noy, Y. I. (2012). On-Board Safety Monitoring Systems for Driving: Review, Knowledge Gaps, and Framework. Journal of Safety Research, 43, pp. 49-58.

Horrey, W., Lesch, M., Garabet A. (2008). Assessing the awareness of performance decrements in distracted drivers. *Accident Analysis and Prevention.* 40(2): 675-82.

Klauer, S. G., Dingus, T. A., Neale, V. L., Sudweeks, J. D., & Ramsey, D. J. (2006). *The impact of driver inattention on near-crash/crash risk: An analysis using the 100-Car Naturalistic Driving Study data* (USDOT Report No: DOT HS 810 594). Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration.

Knipling, R. R., & Hyten, C. (2009). Commercial Vehicle Safety: Onboard Safety Monitoring as Part of Behaviour Safety Management. *The Performance Management Magazine.*

Krause, T.R. (1998). Safety incentives from a behavioural perspective. *Professional Safety, 43*(5): 24-28.

Lee, J. D., Moeckli, J., Brown, T. L., Roberts, S. C., Schwarz, C., Yekhshatyan, L., Nadler, E., Liang, Y., Victor, T., Marshall, D., & Davis, C. (2013). *Distraction Detection and Mitigation Through Driver Feedback: Appendicies*. (Report No. DOT HS 811 547B). Washington, DC:National Highway Traffic Safety Administration.

Ludwig, T.D., & Geller, E.S. (1997). Assigned versus participative goal-setting and response generalization: Managing injury control among professional pizza deliverers. *Journal of Applied Psychology, 82,* 253-261.

McGehee, D. V., Raby, M., Carney, C., Lee, J. D., & Reyes, M. L. 2007. Extending parental mentoring using an event-triggered video intervention in rural teen drivers. *Journal of Safety Research*, 38: 215–227.

Olsen, R,. & Austin, J**.** (2001). ABCs for lone workers: A behaviour-based study of bus drivers. *Professional Safety, 46*(11), 20-25.

Pradhan K., Divekar G., Masserang K., Romoser M., Zafian T., Blomberg R. D., & Thomas F. D. (2011). The effects of focused attention training on the duration of novice drivers' glances inside the vehicle'. *Ergonomics,* ;54(10), p. 917-31.

Regan, M. A., Lee, J. D., & Young, K. L. (2009). *Driver distraction: Theory, effects, and mitigation*. Boca Raton, FL: CRC Press.

Roberts, S., Horrey, W., & Liang, Y. (2012). Effect of performance feedback (or lack thereof) on driver calibration. Proceedings of the 4th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, pp. 67-74. NY, New York.

Robin J. L., Knipling R. R., Derrickson M. L, Antonik, C., Tidwell S. A., &McFann J. (2005). Truck Simulator Validation (‘SimVal’) Training Effectiveness Study. *Proceedings of the 2005 Truck & Bus Safety & Security Symposium;* Alexandria, VA, November 14–16 2005.

Roelofs, E., Vissers, J., van Onna, M., & Kern, G. (2012). *Coaching Young Drivers in a Second Phase Training Programme.* Dorn, L. (Ed.). Driver Behaviour and Training, Volume V, London: Ashgate.

Romoser, M. R. E. (2013). The long-term effects of active training strategies on improving older drivers` scanning in intersections: a two-year follow-up to Romoser and Fisher (2009). *Human Factors*, 55/2: 278-284.

Roney, L., Violano, P., Klaus, G., Lofthouse, R., & Dziura, J. J. (2013). Distracted driving behaviours of adults while children are in the car. *Trauma Acute Care Surg.*

Skinner, B. F. (1953). *Science and human behaviour*. New York: Macmillan.

Sulzer-Azaroff, B., & Austin, J. (2000). Does BBS work? Behaviour-based safety and injury reduction: A survey of the evidence. *Professional Safety*, *45* (7): 19-24.

Takeda, K., Miyajima, C., Suzuki, T., Angkititrakul, P., Kurumida, K., Kuroyanagi, Y., Ishikawa, H., Terashima, R., Wakita, R., Oikawa, M., & Komada, Y. (2012). *Self-Coaching System Based on Recorded Driving Data: Learning From One’s Experiences.* IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS, 13, 4.

Thalen, J. (2006). *ADAS for the Car of the Future. Interface Concepts for Advanced Driver Assistant Systems in a Sustainable Mobility Concept of 2020.* Design Report. Faculty of Engineering Technology, University of Twente.

Toledo T., & Lotan T. (2006). In-vehicle data recorder for evaluation of driving behavior and safety’. *Transportation Research Record*, p. 112-119.

Tronsmoen, T. (2010). Associations between driver training, determinants of risky driving behaviour and crash involvement. *Safety Science*, 48, 35-45.

Victor, T. (2011). Distraction and Inattention Countermeasure Technologies. *Ergonomics in Design: The Quarterly of Human factors Application*, 19: 20.

Victor, T., Harbluk, J. L., & Engström, J. A. (2005). Sensitivity of eye-movement measures to in-vehicle task difficulty. *Transportation Research Part F: 8*, 167–190.

Victor, T., Hickman, J., Camden, M., Jarlengrip, J., Larsson, C., Morgan, J., Tidwell, S. & Toole, L. (2011). *Driver Distraction: An Inattention-Mitigation Component for Behaviour-Based Safety Programs in Commercial Vehicle Operations (IM-BBS).* Final Report. NTRCI University Transportation Center

Washington, S., Cole, R. J., & Herbel, S. B. (2011). European advanced driver training programs : reasons for optimism. *IATSS Research.*

Wang, Y., Zhang, W., Lesch, M.F., Horrey, W.J., Chen, C., & Wu, S. (2009). Changing Drivers' Attitudes Towards Cell Phone Use Through Participative Simulation Testing and Feedback. *Injury Prevention*, 15 (6), pp. 384-389.

Wege, C. A., Pereira, M., Victor, T., & Krems, J. (in press). Behavioural adaptation in response to driving assistance technologies A literature review. In A. Stevens, J. Krems, & C. Brusque (Eds). *Driver Adaptation to Information and Assistance Systems*. Institution of Engineering and Technology.

Wege, C. A., & Victor, T. (in press). Distraction and Inattention Prevention by Combining Behaviour-Based Safety with Advanced Driver Assistance Systems. In A. Stevens, J. Krems, & C. Brusque (Eds). *Driver Adaptation to Information and Assistance Systems*. Institution of Engineering and Technology.

Weiß, T., Petzoldt, T., Bannert, M., & Krems, J. (2013). Calibration as side effect? Computer-based learning in driver education and the adequacy of driving-task-related self-assessments. *Transportation Research Part F, 17:* 63–74.