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Title: Situation awareness fast-tracking, including identifying escape routes (SAFER):
Evaluation of the impact of SAFER on learner driver situation awareness skills

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ABSTRACT

Background

Despite a plethora of education, engineering, and enforcement-related intervention, the pernicious problem that is young driver road safety remains of global interest. Compared to more experienced drivers, young novice drivers have been found to have deficits in situation awareness skills (SAS), an essential repertoire of knowledge and abilities in perceiving, comprehending, and appropriately responding to a breadth of driving risks (projection). Current practice requirements in Queensland, Australia, do not incorporate SAS-specific training for parents, the most common supervisor. The current study evaluates the impact of SAFER, a SAS acquisition acceleration ‘game’ in which parents foster SAS in their child during the period before licensure, on novice driver SAS at learner licensure.

Method

Sixty parent/pre-learner dyads recruited from the Sunshine Coast and randomly allocated to intervention (n=30) and control (n=29). Using a SAS-based coding taxonomy, SAS was measured via simulator-based verbal commentary protocol at learner licensure as part of a larger longitudinal project.

Results

Intervention learners exhibited significantly greater SAS (perception/comprehension/projection of breadth of driving risks), than Control learners. Intervention learners exhibited significantly less perception, and considerably greater perception/comprehension/projection SAS than Intervention parents.

Discussion and implications

Currently in Queensland’s licensing program there is limited support for parents/supervisors of learner drivers, and no SAS-focused intervention is available. SAFER is an innovative SAS-acquisition acceleration intervention which has been shown to build SAS even before the young novice is licensed to drive. A larger state-wide pilot is in development to explore the merit of incorporating SAFER within Queensland’s graduated driver licensing program.
INTRODUCTION

The intractable global problem that is young driver road safety is evidenced as a persistent overrepresentation in road crashes despite a plethora of targeted and more general engineering, education, and enforcement interventions (1). In Australia in 2016 youth aged 17-25 years had a fatality rate of 9.0 fatalities/100,000 population, compared to 5.5 fatalities/100,000 population of rod users aged 40-64 years, with young males fatally-injured (13.4) at almost three times the rate of young females (4.4) (2). Moreover, young driver crashes involve more than the young driver; for example, in Queensland in 2016 young drivers were involved in 33.8% of hospitalisation crashes and 24.7% of hospitalisation crashes across the Australian state (3), despite comprising 12.7% of the licensed population (4).

To mitigate road safety risks, jurisdictions such as Queensland have implemented a multi-stage graduated driver licensing (GDL) program. The first – learner – licence phase is entered after passing a learner theory test which can be taken at the earliest age of 16 years. The learner phase is characterised by mandatory practice requirements including a minimum 100 certified logbook hours (a minimum of which must be at night) over a minimum 12 month period (5). Perhaps, unsurprisingly give the cost of professional driving lessons, parents are the most common driving supervisor (6, 7). Perplexingly, however, parents are typically ‘left to their own devices’, with no option for gaining training in how-and-what-to-teach their young novice driver, and a dearth of resources beyond compliance with the road rules (e.g., compliance with regulatory signs such as posted speed limits), safe vehicle operation (e.g., sharing the road with vulnerable road users such as cyclists and pedestrians), and vehicle safety (pre-driving checks of indicators and windscreen wipers) (8, 9).

Parents are also largely unaware that, as experienced drivers, they have developed a wealth of situation awareness skills (SAS) which are critical – and likely automatic (10) – for road safety. While the precise attributes and/or mechanisms of cognitive processes pertaining to the concepts of hazard detection, hazard perception, and thus situation awareness can differ according to the manner in which SAS is examined, there is some consensus in the literature that SAS mean that the experienced driver can (a) correctly perceive and identify hazards in the driving environment (perception), (b) understand why they hazards are a road safety-related problem (comprehension), and (c) can anticipate how these hazards may impact on their road safety (projection), thus informing the regulation of their behaviour to ameliorate or mitigate these hazards altogether (11, 12). Unsurprisingly young and novice drivers have SAS deficits (13, 14); therefore it seems logical that GDL and other licensing programs that require mandatory practice before unsupervised on-road driving incorporate a training program for the main driving supervisor – in the case of Queensland, Australia, parents – so that learner drivers receive optimal training to accelerate the acquisition of SAS.

It is noteworthy that in jurisdictions such as Queensland, there is limited pre-licence (and thus, pre-on-road driving) systematic training for young and novice drivers. Young and novice drivers may have exposure to programs such as RYDA (Rotary Youth Driver Awareness) program, in which key road safety-related factors such as travelling speed, the influence of personality and social factors, and hazardous behaviour such as driving distracted are discussed during a whole-of-class visit to a central location for a fee. Note that RYDA is not available in all areas of Queensland, and that SAS are not a key education component. It is also noteworthy that in jurisdictions such as Queensland, there is no pre-licence (and thus, pre-on-road driving) systematic training for parents of soon-to-be young novice drivers. Experiencing this situation for herself and her own teen, and given her expertise in young and novice driver road safety, the first author piloted a SAS acquisition acceleration program – situation awareness fast-tracking, including identifying escape routes.
(SAFER) – with her pre-licence teen, with superior SAS objectively noted by a professional driving instructor just a handful of hours into learner licence practice. Given the success of the n=1 pilot, the first author secured government funding for a larger pilot study.

Regarding the larger pilot study, SAFER training emphasises the breadth of risks related to – and thus the realms within which SAS require development – the key factors of other road users (e.g., to the side of trucks), infrastructure (e.g., avoid telegraph posts), manoeuvres (e.g., drive left in an emergency), and exposure (e.g., if route unclear due to sun glare, do not plan to drive in that direction). The importance and identification of potential escape routes was also demonstrated. Briefly, the SAFER game follows this basic procedure (refer also to Figure 1):

1. Before commencing the SAFER game,
   a. The parent demonstrates what potential and actual driving hazards look like (perception), why they are a hazard (comprehension), and how to regulate their own behaviour to eliminate or ameliorate the hazard (projection).
   b. The parent and the child agree on a prize if the child wins as
      i. They are able to exhaustively demonstrate SAS through perception, comprehension, and projection of risks to themselves (i.e., to all occupants of the vehicle in which they are travelling) AND
      ii. They are able to exhaustively demonstrate SAS through perception, comprehension, and projection of risks to other road users (i.e., to all road users within a reasonable distance who could be harmed by the vehicle in which they are travelling).

2. The parent asks the teen to start identifying hazards and to use the perception, comprehension, and projection (PCP) approach. For example, using the ‘road users’ image in Figure 1:
   a. Teen: “There is a car coming towards us in the oncoming lane, and I am watching his lane position in case he is distracted or avoids a risk I can’t yet see, such as a kangaroo; if I need to avoid a crash with this driver I can drive a little to the left but I am blocked in a smooth exit as there is a gutter, so I will travel in the furthest left of the lane to minimise the risk of collision. There is a car in front of me slowing for the roundabout so I am slowing down also. There is a road worker standing at the entrance to the roundabout – he has his back to me and may not realise I am even behind him so I am really slowing down so I can safely brake in an emergency in case he steps backwards or to his left without checking; there are road work vehicles at the left of the roundabout – they may be parked there and so the lane may be shut, but I am going to drive through the roundabout very slowly while keeping an eye on them in case they drive forward as part of their work and do not check for vehicles already on the roundabout.”
   b. Parent: “Great job, but it looks like there is another car behind the front car in our oncoming lane, so I will also watch that car and see how that driver is behaving; this will influence my driving and where we can drive in case of an emergency also; If that second car stays on the roundabout, I will need to give way so I am slowing down until I can see in which direction that driver is travelling. Also, the road work truck on the left looks like it is parked in the median strip, but by doing this he is blocking a clear view of the drivers in the lane to his left; so I am going to drive slowly and have a look past this road work truck as I get closer, just in case there is a car that does not see our vehicle and I need to brake in an emergency.”
3. (c) In this instance, the parent is the winner of the game, given they could identify other driving-related risks, explain these risk to their child, and explain the potential impact of these risks upon their driving and escape behaviour.

The development of SAFER, the baseline SAS evaluation of the $n=60$ parent-young driver dyads ($n=30$ intervention; note $n=60$ young drivers and $n=59$ parents, as 2 parents had participating triplet young drivers), and the process evaluation of the SAFER intervention by parents has been reported elsewhere (15). Of note, at baseline, parents were found to exhibit considerably greater comprehension and projection SAS compared to pre-licence drivers, with no significant difference in SAS (perception, comprehension, and projection) between parents in the intervention and control groups, and between learners in the intervention and control groups. Regarding the process evaluation, there was strong support for SAFER, with nearly every one of the 30 intervention parents agreeing that helping their child to develop SAS was beneficial for their road safety, that they were prepared to play SAFER with their child, and that they know how to improve their own SAS also (15). The night-time SAS and the escape route skills of the participants is currently under analysis and is not considered in the manuscript. This manuscript explores the day-time SAS of young driver participants now the majority have progressed to their learner licence and thus the intervention learners have been playing the SAFER game with their parents for a period of approximately six months.

**METHOD**

**Participants at learner licensure**

As at 3 June 2017, 46 of the 60 participants ($n=31$ male young drivers; $n=23$ male parents) had completed the second stage of the study (teens progressed from pre-licence drivers to learner licence). While most pre-learner drivers were accompanied by their parent, one was accompanied by his grandfather while another was accompanied by his sister. Removal of these (age) outliers revealed no significant differences in age between parents in the control and intervention conditions ($M(\text{SD})=46.92(5.27)$, range 35-57; $M(\text{SD})=46.28(5.58)$, 27-58; respectively). Parents had

**Simulator video presentation and procedure**

Three GoPro Hero 3+ Black cameras were mounted to a vehicle internally to capture real-world driving footage of a 15-minute day-time driving segment (see Figure 2). Clips were trimmed to fit the dimensions of the Immerse cave simulation studio, a three wall projection room with total projection area of 19.4m long by 2.25m high (10,548 by 1,200 pixels) (see also 15, 16, 17). The study was advertised through presentations and follow-up emails at local high schools, in a local newspaper article, and via a local radio discussion regarding young driver road safety more generally, and sought to recruit pre-licence teens and their intended main driving supervisor. Parent-teen dyads attended the University together. Participation in the baseline and subsequent measures required approximately 1.25 hours for each dyad, while participation in the SAFER training required approximately 50-60 minutes for Intervention group parents. After consenting to participate and completing a baseline survey exploring demographics and driving experience, the dyads, individually as parent participant and teen participant, were shown an example of verbal commentary and given the opportunity to practice before proceeding to the Immerse studio for the simulated driving activity. Verbal commentary protocol requires participants to ‘think aloud’ as if they were the driver in the video, verbalising where they were looking and what they were paying attention to as they watched the driving video. In this way, we were able to elucidate where the participants’ attention was focused and/or drawn throughout the driving task, thereby gaining an understanding of their situation awareness within the various driving contexts. For the
practice, three television screens were assembled at 90° to each other, driven by a commodity computer, and participants viewed a training clip.

SAFER intervention training
The following summarises the group intervention activity for intervention group parents.
1. Overview of crash risks for young novice drivers;
2. Discussion around the importance, and nature, of SAS and that parents’ SAS differs considerably from their young novice child’s SAS, escape route identification skills (ERIS), and that the intervention will teach them how to develop SAS and ERIS in their child from pre-licence through the learner phase;
3. Exemplars of SAS [and ERIS] within the realms of other road users (e.g., pedestrians, [to the side of trucks]), infrastructure (e.g., roundabouts, [avoid telegraph posts]), manoeuvres (e.g., merging, [drive left in an emergency]), and exposure (e.g., dusk, [if you cannot see because of glare, drive in a different direction]) (see Figure 1 for example visual stimulus);
4. A demonstration of SAFER using previously-unseen driving footage;
5. An opportunity to practice with the presenter and fellow-group participants with previously-unseen driving footage; and
6. An opportunity to ask questions/provide comments (11).
Note that parents in the control group did not undergo any group-based training or receive any information regarding the importance of SAS and ERIS.

Coding Situation Awareness Skills
Nearly 24 hours of day-time verbal commentary at the point of learner licensure was recorded and transcribed. Given the highly time-consuming task that is manually coding SAS (two coders, ________ inter-rater reliability, third person as tie-breaker), for the purposes of the current manuscript, SAS was analysed for a specific section of the real-world day-time driving footage. A 76.7-second high-risk driving segment was selected, featuring the car merging as it descended a rise from a low speed local road (60 km/hr), joining a flat local council motorway as an additional lane (rapidly accelerating to 100 km/hr), before merging into one lane immediately before merging into two lanes of a state highway, a road that had just reduced its posted speed limit from 110km/hr to 100km/hr. Thus, this segment exposed participants to complex infrastructure (dis/appearing lanes, trees obstructing views, travelling down/uphill), a variety of vehicles (sedans, utilities, SUV/4WDs, trucks), exposure (sunny main high/motorway, trees shading approach to second high-speed merge) and manoeuvres (merging).

All commentaries were transcribed verbatim. The entire commentaries for this segment were coded according to whether situation awareness skills were evidenced as:
(a) Perception only (P, e.g., Green signs; 100 zone);
(b) Perception and comprehension (PC, e.g., Big sign about entering the motorway; we’re coming up to the corner so now I have to indicate); or
(c) Perception, comprehension, and projection (PCP, e.g., We can turn at any time but we need to take care that nothing’s coming on my right; A red light, says stop, I need to stop here). Sentences in which the entire content was related to the perception, perception/comprehension, or perception/comprehension/projection of infrastructure, vehicles, exposure, and/or manoeuvres were coded in their entirety, for example: “Truck in front of me is indicating that he’s going to move into the right hand lane so why is he doing that? It probably means that there’s someone slower in front of him so I’ll need to be aware that I will be behind a slow vehicle or more than one as it happens.”
In contrast, sentences in which the participant moves between levels of situation awareness are coded separately. For example, “This is a school zone, construction work on the right hand side, there could be heavy vehicles etc.” is split so that “This is a school zone” is coded as perception, P; while “construction work on the right hand side, there could be heavy vehicles etc.” is coded as perception/comprehension, PC. Verbal transcripts were analysed using the Leximancer™ version 4 qualitative content analysis software. Based on the use of text representations of natural language which identifies themes, concepts, and relationships between them, Leximancer™ uses program algorithms to build a thesaurus of concepts according to text characteristics of word counts, proximity, and salience (18). The identification of shared and unique concepts thus provides further insight into SAS.

RESULTS

Situation awareness skills of Control learners compared to Intervention learners

Independent t-tests (reporting results pertaining to equal variance not assumed for a significant Levene’s test) revealed that there was a significant difference in the average number of words pertaining to PCP for Control learners compared to Intervention learners (t(42)=-2.49, p<.05), with a considerably greater number of words uttered by the Intervention learners. Table 1 summarises the average number of words uttered in each SAS category, and Figure 3 shows the proportions of P/PC/PCP words used by Intervention and Control learners, with findings demonstrating that the Intervention learners have substantially greater SAS than the Control learners. An analysis of concepts in Leximancer revealed that seven concepts were shared between Control and Intervention learners, with four concepts (2 each) differing between the groups (Table 2). The shared concepts again relate to important general road features, however highway is a shared concept amongst the learners and coming is a unique concept for the Control learners. For control learners, car was used in relation to other cars (e.g., so can see those cars coming up on my right here) and lane was used in relation to location (e.g., end of my lane so I would have to merge to the right). Intervention learners lane was the primary concept (e.g., merge into the other lane and make sure there’s no one behind so that we can do it safely), clearly exhibiting a substantial difference in SAS in the two learner groups.

Situation awareness skills of Intervention learners compared to Intervention parents

There was a significant difference in the average number of words pertaining to P for Intervention learners compared to Intervention parents (t(48)=-2.36, p<.05), with parents uttering more words on average. No significant difference was in the average number of words pertaining to PC and PCP. Table 1 summarises the average number of words uttered in each situation awareness skill category, and Figure 4 shows the proportions of P/PC/PCP words used by Intervention learners and parents. Thus it appears that learners have much greater situation awareness – as evidenced by the greater proportion of PCP – than their parent driving supervisors, notwithstanding that statistical significance was not reached. An analysis of concepts in Leximancer revealed that six concepts were shared between Intervention learners and parents, and that six concepts differed, with three unique concepts each (Table 2). The shared concepts again relate to important, general, road features (such as lane and car) and safety-critical manoeuvres such as merge/merging and travelling speed. The unique concepts for Intervention parents relate to the general road environment, including traffic that is coming and in front of the vehicle, while pleasingly the Intervention learners unique concepts contains a key situation awareness construct – sure – which suggests they are surveying and checking their environment more than once for (potentially) hazardous road users, manoeuvres, and exposure.
GENERAL DISCUSSION

The wicked problem that is global overrepresentation of young drivers in road crashes has generated a wealth of engineering, education, and enforcement-focused interventions. GDL is an intervention that arguably meets all three criteria in the Queensland, Australia context: parents are the most common educator of the young and novice driver (6, 7), parents act as enforcers of GDL and general road rules in their supervisory role during the learner licence phase (19), and as enforcers of GDL and road rules through the P1 phase such as by monitoring compliance with passenger limits (19, 20, 21, 22) and the P1 phase of the Queensland GDL has specific vehicle engine power limits to dissuade young and novice drivers from engine-related risks such as hooning and other risky driving behaviours (4). Similarly, the critical role parents play in GDL programs is apparent in jurisdictions beyond Queensland, Australia (23).

Furthermore, it appears that there is a missed opportunity within the Queensland GDL to provide parents with engaging, informative, and easily applied evidence-based support to develop essential driving skills and abilities not only during the learner licence phase, but during the period immediately preceding on-road driving – the pre-licence phase. Interventions that specifically target parents have been found to be effective in improving the driving behaviours of young novice drivers (e.g., Checkpoints (24), TeenDrivingPlan (25, 22) and interventions that are designed to build hazard perception and other SAS in young novice drivers have also had some success (27, 28, 29, 30). The results of the learner evaluation of SAFER further support the case for targeting parents and targeting SAS, with additional evidence regarding the intervention efficacy in targeting the pre-licence period.

Overwhelmingly the pre-driving SAFER intervention has equipped the Intervention learners with far deeper, broader, and thus safer, SAS than the Control learners (note there were no significant differences in the proportion of PCP for Control learners and parents), despite the study’s small sample size. These differences critically are around perception, comprehension and projection, suggesting that the Intervention learners can scan their environment and identify the various hazards (noting that in Queensland’s GDL, an online hazard perception test which must be passed before they progress from the P1 to the P2 licence, 5), they understand why the road user, infrastructure, or exposure-related variables are a hazard, and they can regulate their interaction with that variable to minimise that hazard. It is noteworthy that the Intervention learners actually built these skills before they drove behind the wheel of a car, with SAS measured at the moment they progressed to a learner licence. In many respects this is ground-breaking, particularly within the context that Queensland’s GDL does not even expect, nor measure, the most basic SAS skill – perception – until they are trying to enter the P2 licence phase.

Interestingly, both Intervention and Control learners do not seem to have been prompted to gain their learner licence earlier than expected as a consequence of participating in this longitudinal project. Rather, the opposite effect may have happened: all teen participants recruited at approximately 15.5 years of age, with a learner licence able to be gained at 16 years. At the time of these analyses which were completed more than 6 months post-recruitment of the last participant, 14 participants were yet to progress to their learner licence. The road safety benefit of delaying licensure is well-recognised as one of the road safety benefits of GDL programs (31), and may be a road safety benefit of SAFER.

Strengths and limitations

The SAFER pilot project has a number of strengths, including a process evaluation of parent and teen perspectives regarding the appeal and usability of SAFER throughout pre-licence and learner licence training and supervision (15), and a sequential, longitudinal impact...
evaluation of SAS 6 months pre-licensure and throughout key driving milestones including
at learner licensure, after 25 hours of learner driving (which includes GoPro-captured driving
lesson content), and at P1 licensure (33). SAS was captured via an established simulator-
based verbal commentary technique (34, 35), with the same visual stimulus presented at each
interval. Transcription and coding revealed that all commentary in the selected clip pertained
to the driving context. While parents generally may have a more elaborate vocabulary
regarding perception, comprehension and projection of driving risks, it is likely that
intervention group learners may develop a similar lexicon as a consequence not only of
playing SAFER during the pre-licence period, but as a consequence of being taught to drive
within the paradigm of SAFER’s principles of risk and risk mitigation, as a learner driver.
The participants were recruited from the Sunshine Coast locale, and that the day-time
stimulus was captured in the Sunshine Coast, therefore it is likely participants are familiar
with the road environs. Given the extended intervals between data capture (a minimum of 6
months), and that participants are either actively playing SAFER (during the pre-licence
phase) or actively learning to drive with parents using a SAFER-styled approach to teaching
(learner licence phase) it is unlikely that participants will experience practice effects and thus
inflated SAS as a result of seeing the same footage up to three times during the life of the
study. The low attrition from the longitudinal project – almost 9 months in, just 2
participants appear to have withdrawn (1 implicitly) from the project – is testament to the
strong parental engagement in the project. This may reflect the biased nature of sampling,
however, as parents self-selected for themselves and by extension their child, to participate
in the longitudinal project. At this time it is unclear how frequently parents played SAFER
with the pre-licence teen; thus conclusions regarding the optimal (and minimum) practice
requirements cannot be drawn at this time.

Future research directions
The next measurement interval for SAFER participants (both Control and Intervention
groups) involves the recording of one week’s in-car driving practice at approximately 25
hours of logged driving. The teaching content and style will be manually coded, and the
techniques and lesson content of parents in the Intervention group will be compared to the
Control group. This evaluation will provide insight into how, and if, SAFER is
operationalised during the learning-to-drive phase. SAS data pertaining to the night-time
driving footage has been captured, and coding is currently underway for a comparable highly
complex driving segment. The SAS of parents and learners in both the Control and
Intervention groups will be compared in the same way for the day-time SAS, as reported in
this manuscript. In addition, a SAS-categorisation neural network is currently in
development so that the SAS for learners and parents during the entire night-time and day-
time driving clips can be elucidated. A coding taxonomy regarding escape route
identification skills (including content and related infrastructure, road users and exposure) is
currently in development based on night-time and day-time driving clips, and is particularly
relevant for young driver road safety given their overrepresentation in tailgating crashes (36).
SAFER is currently being revised and applied to suit a larger Queensland population (37)
and other high risk driving populations, including learner drivers with ASD (38) and older
drivers (39).

CONCLUDING REMARKS
The wicked problem of young driver road crashes suggests that innovative intervention is
required. Targeting parents, as an indirect way to target teens, is one such innovative
approach. Throughout the learner licence phase, parents are ‘left to their own devices’ in
many respects, with limited guidance regarding what to teach their child and how to teach
their child. Moreover, typically parents do not begin to consider learning-to-drive and
teaching-to-drive until their child has already gained their learner licence. SAFER harnesses
the potential of parents as future providers of instruction and supervision during the last six
months leading up to learner licence acquisition, a time during which SAFER can become a
habitual driving activity, and the dialogue can begin to become prefaced with ‘You will soon
be in this driver’s seat’. The situation awareness of Intervention learners in a highly complex
driving circumstance is clearly broader and deeper than the situation awareness skills of
Control learners, suggesting that these can be acquired pre-licensure. Moreover, the
substantial perception, comprehension, and projection skills apparent in Intervention learners
relate to a breadth of risks associate with infrastructure, other road users and driving
exposure: all critical risk factors for and contributors to young novice driver crashes. While a
number of analyses are pending (e.g., an evaluation of the SAFER intervention impact upon
situation awareness skills during night-time driving and upon escape route identification
during day-time and night-time driving), it appears that SAFER is an effective situation
awareness skill acquisition acceleration program, particularly during the pre-licence period.
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FIGURE 1 SAFER game training resources pertaining to road users (top), infrastructure (middle) and exposure (bottom).

FIGURE 2 An example of day-time, city, driving footage.

TABLE 1 Average Number of Words according to Perception, Perception/Comprehension, and Perception/Comprehension/Projection

FIGURE 3 Proportion of perception, perception/comprehension, and perception/comprehension/projection words used by Control Learners and Intervention Learners.

TABLE 2 Frequency of Concepts for Learners and Parents

FIGURE 4 Proportion of perception, perception/comprehension, and perception/comprehension/projection words used by Intervention Learners and Intervention Parents.