



Emotions, behaviour, and the adolescent driver: A literature review



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ABSTRACT

Background: The intractable global road safety problem of the overrepresentation of young drivers in road crashes, despite a plethora of intervention, suggests that innovative approaches to understanding – and thus intervening in – road crash risks is required. The current research recognises that young drivers frequently are adolescents, and that adolescence is characterised by rapid physical, psychological, cognitive, and social development, each of which interacts with, contributes to, and is impacted upon by a wealth of negative, neutral and positive moods and emotions. The literature regarding relevant to adolescent drivers and emotions between 1 January 2005 and 30 September 2015 will be synthesised, in addition to posing future research questions regarding adolescents, emotions, and driving behaviour.

Results: One hundred and three peer-reviewed articles were identified, and these were summarised within emotions and the adolescent (44 papers); emotions, the adolescent, and driving risks (23 papers); emotions, the adolescent, and risky driving behaviour (30 papers); and emotions, the adolescent, and road safety interventions (6 papers). The findings were synthesised within the context of the characteristics of the adolescent driver, their emotions, the driving context and their driving behaviour, including a pictorial representation of two temporal models depicting the sequence via which emotions can impact upon adolescent driving behaviour (Path A in which the adolescent driver experiences emotions after entering the car; Path B in which the adolescent experiences emotions before entering the car).

Discussion and implications: The relatively recent proliferation of literature pertaining to adolescents, emotions, and their driving behaviour suggests that the breadth of research questions posed in relation to the domains of the adolescent driver, their emotions, the driving context, and their driving behaviour are timely. Indeed, recent applications of systems thinking within road safety, including young driver road safety specifically, maintain that a holistic approach to the understanding of who plays what role in this system that currently contributes to crash risks, and conversely can play a role in effective and efficient intervention, is essential before the real world realisation of a safe road system. Addressing these research questions are fundamental to sustaining progress on the path to young driver road crash prevention through a safe young driver road safety system.

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1. Introduction

The persistent overrepresentation of young drivers in road crashes – and fatalities and injuries arising from those crashes – is an unrelenting global injury prevention and public health problem. Importantly for young driver road safety is the fact that young drivers – typically aged 15–24 years – are adolescents. While an adolescent is defined by the *Oxford Dictionary* (2014) as “(of a young person) *in the process of developing from a child into an adult*”, actually defining clear age-related parameters for young drivers within this developmental stage is less specific. To illustrate in the context of papers published elsewhere in this journal, ‘adolescent’ participants are aged 12–19 years (Zhou & Horrey, 2011), 13–18 years (Nabipour, Khanjani, Nakhaee, Moradlou, & Sullman, 2015), 14–17 years (Cerniglia et al., 2015), and 16–20 years (Smorti, Guarnieri, & Ingoglia, 2014), with each of these examples clearly overlapping to some extent with other papers reporting research with ‘young adults’ aged 17–25 years (e.g., Delbosc & Vella-Brodrick, 2015; Mann & Lansdown, 2009). Within the context of the statistics pertaining to driving licensure, in Queensland, Australia, ‘young drivers’ are aged 17–24 years at the state level (12.8% of the licensed population, 23.8% of all hospitalised casualties in 2013; 22.2% of year-to-date to 31 May 2016 fatalities, *Transport and Main Roads*, 2015, 2016), and 17–25 years at the national level ($n = 114$ and 20.1% of the fatally injured drivers in Australia in the 2016 calendar year, BITRE, 2016). In contrast, Australian injury statistics categorise ‘adolescents’ as 15–17 years, and ‘young adults’ as 18–24 years ($n = 9759$, 18–24 year olds hospitalised for transport-related injuries in 2011–2012, Australia-wide, Pointer, 2015). The lack of clarity regarding the simple measure of defining adolescents and young drivers has been raised elsewhere as a methodological issue which impacts upon the utility and generalisability of young driver research, ultimately hampering effective intervention (e.g., Scott-Parker & Senserrick, 2013, 2017).

Not only is adolescence characterised by rapid development physically (e.g., puberty), psychologically (e.g., development of self-identity), cognitively (e.g., increased capacity in decision-making skills), and socially (e.g., increased importance of peers), with adolescents most likely positioned along a continuum of ‘developing’ within these realms rather than a dichotomous ‘undeveloped’ vs ‘developed’, adolescence is also characterised by emotional development (Headspace, 2015). Such emotional development is typically associated with the experience of turbulent emotions, defined by the *Oxford Dictionary* as “*strong feeling(s) deriving from one’s circumstances, mood, or relationship with others*”, and the experience of turbulent moods, “*temporary state(s) of mind or feeling*” (*Oxford Dictionary*, 2014). Unlike emotions, moods tend to generally be positive or negative, and can emerge from a complex blend of multiple emotions and relatively stable personality traits. Importantly, however, both moods and emotions are experienced as internal subjective states which can be externalised through behaviours in response to relatively stable personality characteristics such as trait factors (e.g., sensation seeking), less-stable state factors (e.g., depression), and/or in response to context-specific triggers (e.g., interaction with another road user, including vehicle passengers). It is noteworthy also that the influence of emotion and/or mood upon the adolescent’s driving behaviour may be positive or negative, and indeed there may be occasion in which the emotion and/or mood has a neutral effect (i.e., no influence) on the adolescent driver’s behaviour.

Moreover, much road safety research and intervention generally, and young driver road safety research and intervention specifically, ignores the ‘human’ element altogether. As attributed to Plato, *Human behaviour flows from three main sources: Desire, emotion and knowledge*. Arguably, road safety intervention does not ponder questions such as ‘What does it mean to be human?’, and ‘What does it mean to be an adolescent?’, notwithstanding that theories such as the Prototype/Willingness Model (e.g., see Gibbons & Gerrard, 1995) recognises that adolescents do not necessarily *intend* to engage in risk behaviour, rather they are *willing* to engage in risky behaviour in particular circumstances such as if their peers are present (e.g., Scott-Parker, Hyde, Watson, & King, 2013). Indeed, the proliferation of technologies which has facilitated the advent of autonomous vehicles further dissociates these questions from road safety, perhaps implicitly recognising that human emotion is indeed problematic for road safety more generally. Regarding intervention in young driver road safety specifically, graduated driver licensing (GDL) has emerged as the most effective intervention to date, and arguably GDL in Queensland addresses the influence of emotions on young driver behaviour through regulating context-specific influences such as passengers carried at night, with a maximum of 1 peer-aged passenger in the vehicle during the first independent driving licence phase (Provisional 1 licence; see Scott-Parker, Bates, Watson, King, & Hyde, 2011, for an overview of Queensland’s GDL). However it is notable that GDL does not, and may not be able to, address the purpose of driving, with research consistently finding that driving a vehicle serves many purposes for adolescents beyond efficient transport from points of departure to destinations, including emotional purposes such as driving for a sense of freedom (Scott-Parker, King, & Watson, 2015).

Earlier research by the author (e.g., Scott-Parker, Watson, King, & Hyde, 2012) elucidated two temporal sequences in which emotions can and do influence young driver behaviour, and which consider the influence of personal characteristics (well-recognised in the young driver literature, e.g., age, gender) in addition to the driving context. As illustrated in Fig. 1, the adolescent can get in their car, begin driving, and experience emotions which arise from driver-specific and/or context-specific triggers which result in changes in their driving decision-making (consciously or unconsciously) and ultimately changes in their driving behaviour (Path A). Alternatively, the adolescent driver may experience strong emotions, then get in their car (Path B), and thus their driving decision-making and driving behaviour is influenced by pre-driving emotions. In addition, Path A and Path B may co-occur, such that the adolescent driver who experiences strong emotions may get in their car (Path B) however a context-specific or relatively stable trait or state may further increase or decrease the impact of their emotions on their driving decision-making and their behaviour.

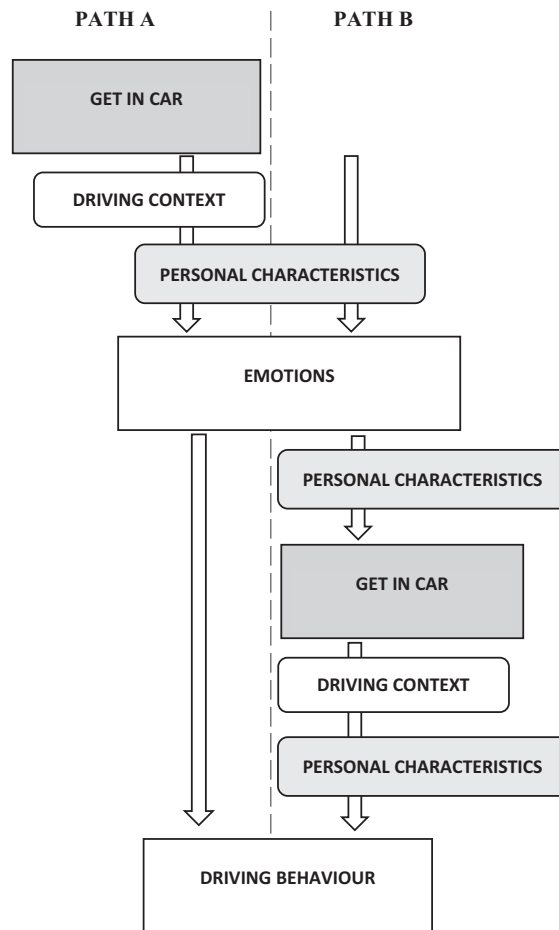


Fig. 1. Representation of emotions, personal characteristics, driving context, and driving behaviour.

The relationship between emotions and driving behaviour – and indeed the path(s) as depicted in Fig. 1 – has received attention within the domain of aggressive and angry driving behaviour of drivers more generally (e.g., Philippe, Vallerand, Richer, Vallières, & Bergeron, 2009) and within the context of young drivers specifically (e.g., Arnett, Offer, & Fine, 1997). In addition, the importance of adolescent/young adult driver (herein referred to as adolescent driver/s) moods and emotions is increasingly being recognised as influential factors in their driving behaviour, and consequentially as influential factors in their road safety outcomes and in intervention (Scott-Parker & Watson, 2015, chap. 10). As such, the aim of this review is to summarise the literature relevant to adolescent drivers and emotions, synthesising the findings regarding their driving behaviour in particular. In addition, avenues for future research, based on the extant findings, will be identified.

2. Materials and methods

Consistent with the recommendations of Transportation Research Circular E-C194 (Transportation Research Board., 2015), the following steps were operationalised:

1. *Define the search scope and topic:* All peer-reviewed literature (journals and conference proceedings) regarding adolescents, moods and/or emotions, and risky driving; publication date between 1 January 2005 and 30 September 2015;
2. *Choose the resources to search:* Selected two key resources, with the search initially conducted in the Transportation Research International Documentation (TRID) database, with the Google Scholar search engine subsequently searched;
3. *Choose search terms:* “adolescent/s”, “mood”, “emotion/s”, “risky driving”;
4. *Compile the search strategy and run the search:* Using Boolean operators “AND” and “OR”, such that the TRID search used “adolescent*” AND “mood*” OR “emotion*”;

5. *Review the search results:* TRID search returned 391 results, Google Scholar returned 154 results. Each result was reviewed, and the search results were trimmed by retaining only literature with links to full text online, articles which referred to motor vehicle driving,¹ and articles which (a) related to emotion and/or mood in driving and included adolescent participants, or (b) related to adolescents and/or mood and risky behaviours in general²; and
6. *Organise the results:* 103 articles (TRID: 358 excluded, 33 retained; Google Scholar: 84 excluded, 70 retained), organised, and summarised.

3. Results

3.1. Emotions and the adolescent

Table 1 summarises the literature regarding emotions and the adolescent, more generally. Within this broader category, the literature is synthesised within the scope of the following subsections: Adolescent development; Emotions in general; and Emotion regulation.

3.1.1. Adolescent development

Of 15 papers examining emotions and the adolescent, 12 papers were review articles which summarised the extant literature regarding the breadth of developmental changes inherent in adolescent development, with an emphasis on how these developmental changes increase health risk per se. The recent year of publication of most of these reviews reflects the increasing recognition of the factors in adolescent development impacting on adolescent behaviour, with 11 of the papers (73.3%) published between 2008 and 2013. The differential cognitive development in particular of adolescents has been supported by an American fMRI study which compared 10 adolescents (average age 14 years) to 10 adults (e.g., Passarotti, Sweeney, & Pavuluri, 2009) and New Zealand neuropsychological tests of executive function in $n = 136$ 13–17 year olds and $n = 57$ 18–22 year olds (e.g., Pharo, Sim, Graham, Gross, & Hayne, 2011). As such, the risky behaviour of adolescent drivers, emerging and/or associated with emotional driving, appears to be inextricably intertwined with simultaneous differential structural and functional cognitive development.

In addition, many articles also explicitly highlighted how the adolescent's increased risk of road injury emerges through a combination of greater sensation seeking (propensity and behaviour), greater influence of peers, greater sensitivity to incentives, including social rewards, and limited capacity for self-regulation. For example, while the 'young driver problem' is well-recognised, in that all young drivers are at increased risk due to age- and inexperience-related factors, Australian longitudinal survey research with 378 young novice drivers (17–25 years old) by Scott-Parker et al. (2013) identified a subset of 'problem young drivers' (with a profile of risky driving behaviours and psychosocial characteristics) appears to exemplify this differential social, psychological, cognitive, physical, and emotional development.

3.1.2. Emotions in general

Of 18 papers examining emotions in adolescence in general, 6 operationalised questionnaire/survey methodology, 4 papers utilised simulator-based research, 2 papers each comprised review articles and combined simulator/survey research, and 1 paper each used instrumented cars/face-video/surveys, interviews, video-clips/surveys, and naturalistic data. Half of the papers emerged from Europe, the British Isles and the Middle East, with 5 papers from North America, and one each from Australia and Asia. Nearly two thirds of the papers were published in 2013, 2014 and 2015, again reflecting the growing interest in – and recognition of – the influence of emotions on adolescent behaviour.

Consistent with the psychosocial purpose of driving discussed in the introduction, driving for emotional purposes for adolescents (16–24 years, Wundersitz & Burns, 2008) such as to gain social status also contributes to risky driving behaviour, including driving errors (noting participants aged 19–74 years, Nordfjærn & Şimşekoğlu, 2014). Further, consistent with behaviour emerging from emotion, the self, and desire, as also discussed in the introduction and captured within Fig. 1, it appears that emotionally-charged young drivers make poor choices as emotions affect both risk perception and risk attitudes which contributes to risky driving behaviour (noting participants aged 20–59 and 20–73 years, Hu, Xie, & Li, 2013; and participants aged average 35.95 years, Sarma, Carey, Kervick, & Bimpeh, 2013), with emotions related to both driver-specific factors (for 18–20 year olds, Taubman-Ben-Ari, Mikulincer, & Iram, 2004) and context-specific factors (average age 26.27 and 30.49 years, Roidl, Frehse, Oehl, & Höger, 2013). A synthesis of the main findings within these papers reveals that a breadth of young driver-specific characteristics are associated with greater risky driving behaviour as reported via self-report measures and observed in simulation studies, including anger (drivers average age 20.3 years, Jeon, Walker, & Yim, 2014; 19–76 years, Mesken, Hagenzieker, Rothengatter, & de Waard, 2007; average age 25 years Stephens & Groeger, 2009).

The mechanism of influence of emotions and moods has been elucidated in some instances; for example, self-efficacy appears to contribute to a disregard of negative consequences and therefore results in risky driving behaviour by adolescents (Taubman-Ben-Ari et al., 2004), while depressed states lead to greater driving risk through not engaging in protective behaviour like wearing seatbelts (12th graders, Testa & Steinberg, 2010). While the consistent impact of strong negative emotions

¹ Articles exploring road safety of cyclists, pedestrians, bus drivers, motorcyclists, pilots, truck drivers, horse riders, and public transport excluded.

² Articles which included older participants only (>25 years) or younger participants only (<16 years) were excluded, while articles with a wide participant range (e.g., 17–60 years) were retained if participants aged under 25 years were included.

Table 1

Emotions and the adolescent.

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
<i>Adolescent development</i>						
Steinberg (2005) NA	Review of (a) Brain development; (b) Cognitive development (c) Implications of new brain maturation research; (d) Cognitive development in context; (e) Affect, cognition; (f) Decision-making, risk-taking; (g) Development of regulatory competence; in adolescence	NA	NA	NA	Review	Adolescence sensitive or critical developmental period for normative and maladaptive patterns of development; Puberty (restructuring of many body systems) influences social information-processing; A concentration of changes in the adolescent brain in the prefrontal cortex together with the enhanced interregional communication between the prefrontal cortex and other brain regions; Evidence of substantial synaptic pruning and for non-trivial physiological reversibility of behavioural and neuroendocrine patterns arising from early developmental experiences
Allen and Brown (2008) NA	Reviews a range developmental and structural factors that potentially increase risks associated with adolescent driving	NA	NA	NA	Review	Developmental risk factors: propensity towards engaging in deviant/risky behaviour, desire to please peers, and potential cost to adolescent of alienating peers with his/her behaviour. Structural features of driving situation that create risks for negative peer influences: inability to look at peers who may be pressuring, divided attention, need to behave in conventional manner among peers who may not value conventional behaviour, lack of accountability by peers for effects of risky driving promoted. Potential peer influences: passive and active distraction, direct disruption, peer modelling of good driving behaviour and positive reinforcement of good driving
Casey, Jones, and Hare (2008) NA	A model of adolescent brain development presented in context of risk factors including suboptimal decision-making and heightened emotional reactivity	NA	NA	NA	Review	Evidence there is a heightened responsiveness to incentives and socio-emotional contexts during this time, when impulse control is relatively immature. Differential development of bottom-up limbic systems, implicated in incentive and emotional processing, to top-down control systems during adolescence as compared to childhood and adulthood. Developmental pattern may be exacerbated in adolescents prone to emotional reactivity, increasing likelihood of poor outcomes

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Table 1 (continued)

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
Dahl (2008) NA	Overview of recent advances in understanding adolescent brain maturation	NA	NA	NA	Review	Sleep regulation provides not only an illustration of brain-behaviour-social-context interactions leading to a negative spiral of effects, but also a specific and pragmatic target for intervention
Steinberg (2008) NA	Proposes frame-work for theory and research on risk-taking informed by developmental neuroscience	NA	NA	NA	Review	Structural and functional changes within the prefrontal cortex and its connections to other brain regions; Mid-adolescence a time of heightened vulnerability to risky and reckless driving. "Why does risk-taking increase between childhood and adolescence?" Changes in brain's socio-emotional system leads to increased reward seeking, especially in presence of peers, fuelled mainly by dramatic remodelling of the brain's dopaminergic system. "Why does risk-taking decline between adolescence and adulthood?" Changes in brain's cognitive control system – improve individual's capacity for self-regulation
Passarotti et al. (2009) Chicago, US	Whether there is more efficient prefrontal modulation of affective circuits with development	Adolescents (n = 10, M age 14), adults (n = 10, M age 30)	'Directed' emotion processing condition- judgment of facial expressions (positive/happy, negative/angry) 'incidental' emotion processing condition- age judgment	Reaction time and accuracy, Brain activation.	Functional magnetic resonance imaging (fMRI) task - incidental face processing condition (judged whether presented face was older or younger than 35 years) and a direct face emotion processing condition (judged whether facial affect was positive/happy or negative/angry)	Incidental emotion processing condition: adolescents showed less activation in right ventrolateral prefrontal cortex (VLPFC) and greater activation in paralingual regions, suggesting greater emotional reactivity and immature prefrontal circuits for affect regulation Direct emotion processing condition: adolescents showed decreased recruitment of both the dorsal and pregenual right anterior cingulate cortex (ACC), suggesting immature modulatory functions of the ACC during directed face emotion processing. Results indicate that neural circuitries for affect regulation are still developing in adolescence and have not yet reached the adult level
Dayan, Bernard, Olliac, Mailhes, and Kermarrec (2010) NA	How cognitive neuroscience can complement psychoanalytic constructs and thus enhance understanding of risky behaviour including drug taking	NA	NA	NA	Review	Neuroimaging studies have shown neural circuitry undergoes major reorganisation during adolescence; particularly in those regions of the brain relating to executive functions, the self and social cognition, and that the "emotional brain" may play a role in that reorganisation

Sebastian, Viding, Williams, and Blakemore (2010) NA	Review developmental functional imaging studies of social cognition, mentalising and self-processing; discuss recent models of adolescent neurocognitive development	NA	NA	NA	Review – summarise recent work exploring link between social cognition and functional brain development during adolescence. Describes study comparing affective consequences of experimental ostracism manipulation (Cyber-ball) in female adolescents and adults	Many aspects of social cognition and their neural substrates, including face processing, social emotion processing and mentalising, are still developing during the second decade of life The ostracism condition led to significantly greater affective consequences in the adolescents compared with adults. Ability to regulate distress resulting from ostracism continues to develop between adolescence and adulthood
Somerville, Jones, and Casey (2010) NA	Understanding the biological basis of emotional and incentive-seeking behaviour of adolescents	NA	NA	NA	Review – discusses emotional and incentive-driven behavioural changes in adolescents and associated neural mechanisms, focusing on dynamic interactions between amygdala, ventral striatum, and prefrontal cortex	Common behavioural changes during adolescence may be associated with a heightened responsiveness to incentives and emotional cues while the capacity to effectively engage in cognitive and emotion regulation is still relatively immature
Pharo et al. (2011) New Zealand	Examine relation between neuro-psychological tests of executive function, personality characteristics, and real-life risk-taking behaviour across a community sample of adolescents and emerging adults	Adolescents N = 136, 13–17 years, Emerging adults N = 57, 18–22 years	Personality questionnaire (Zuckerman Personality Questionnaire-Short Form), neuro-psychological testing	Risk-taking questionnaire (Life Experiences Questionnaire: ZK-LEQ, modified version Self-Report Early Delinquency scale, Alcohol Use Disorder Identification Test)	Questionnaires (risky behaviour and personality), neuropsychological tests of executive function	Individual differences in risk-taking behaviour. Risky personality and performance on the neuropsychological tests were both significant predictors of real-world risk-taking
Sturman and Moghaddam (2011) NA	Adolescence is a period of increased behavioural and psychiatric vulnerabilities, a time of dramatic structural and functional neurodevelopment	NA	NA	NA	Review	Central to most of the neurobehavioural models: immature processing in the prefrontal cortex and other cortical and subcortical regions, along with their interaction, leads to behaviour that is biased towards risk, reward, and emotional reactivity during the adolescent period
Gilbert (2012) NA	Review of normative adolescent emotional development and negative emotional regulation, discussion of current theories of positive emotion, grounded in adult literature	NA	NA	NA	Review	Emotion regulation important in adolescence, but more effort to integrate positive and negative emotional regulation needed. Evidence found for beneficial outcomes of normative positive emotional regulation and detrimental effects of dysregulated positive emotion; suggests understanding how adolescents experience and regulate positive emotion might illuminate one reason why there is such a sharp increase in onset of psychopathology during this developmental period

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Table 1 (continued)

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
Arain et al. (2013) NA	Adolescent brain maturation	NA	NA	NA	Review	Adolescent brain is structurally and functionally vulnerable to environmental stress, risky behaviour, drug addiction, impaired driving, and unprotected sex. Brain maturation due to surge in synthesis of sex hormones implicated in puberty significantly influence food intake and sleep requirements; secondary changes in sex characteristics influence learning, intelligence, memory, and behaviour. Development and maturation of prefrontal cortex – important for complex behavioural performance – occurs primarily during adolescence and is fully developed around age 25 years
Scott-Parker, Watson, King, and Hyde (2013) Queensland, Australia	Identify problem young drivers within the larger young driver problem	N = 378 novice drivers, aged 17–25 years, Provisional (restricted) driver's licence	Anxiety, depression (Kessler's Psychological Distress Scale), reward sensitivity (abridged sensitivity to reward questionnaire, sensation seeking (Brief Sensation Seeking Scale)	Learner survey (pre-learner, learner driving experiences), Provisional survey (driving experiences, attitudes), Self-reported driving behaviours (Behaviour of Young Novice Drivers Scale)	Online survey, longitudinal study	Highest risk group characterised by greater self-reported pre-licence driving, unsupervised learner driving, speeding, driver errors, risky driving exposure, crash involvement, and offence detection during provisional period. Medium risk – more risky road use than low risk. High risk young drivers reported significantly greater driving in response to their mood (faster if angry) than medium and low risk drivers; medium risk drivers reported significantly greater driving in response to their mood than low risk drivers
Smith, Chein, and Steinberg (2013) NA	Examine research on relation between puberty and risk-taking in adolescence, to begin sorting developmental processes that are likely to be puberty-dependent and puberty-independent	NA	NA	NA	Review	Discuss changes in decision making during adolescence, focusing on the asynchronous development of affective, reward-focused processing system and the deliberative, reasoned processing system. Differential maturation in the structure and function of brain systems associated with these systems leaves adolescents particularly vulnerable to socio-emotional influences and risk-taking behaviours. Argue that this asynchrony may be partially linked to pubertal influences on development and specifically on the maturation of the affective, reward-focused processing system

Emotions in general

Taubman-Ben-Ari et al. (2004) Israel	Examine the joint contribution of personal perceptions of reckless driving and its environmental determinants	N = 295 young drivers, 18–21 years, combat and service soldiers	Threat appraisal/Challenge appraisal/Self-efficacy appraisal of reckless driving scale; Disregard for negative consequences scale, Modelling; Negative environment-al climate questionnaire; Positive feedback regarding driving	Self-reported reckless driving habits (Reckless Driving Habits Scale)	Questionnaires	Challenge and self-efficacy appraisals, along with negative environmental influences were related to higher frequency of risky driving, whereas threat appraisals, as well as positive feedback, were related to lower frequency of reckless driving. For males, self-efficacy in driving strongly predicted reckless driving. For females disregard for negative consequences was an important predictor
Mesken et al. (2007) Netherlands	To investigate frequency, determinants, and consequences of three relevant emotions (anger, anxiety, and happiness) in traffic	N = 44 licensed car drivers, 19–76 years	Driving Anger Scale (DAS), trait anger/anxiety, sensation seeking), Self-reported emotion and risk	Instrumented car test drive (speed and heart rate registered and traffic environment recorded on video), Driving Behaviour Questionnaire (DBQ)	Survey, Instrumented car (heart rate measured, video recorded traffic environment and participant facial expressions, every 3 min asked for emotion and risk ratings at that particular moment)	Most frequently occurring emotion was anxiety, followed by anger, and happiness. Emotions while driving were related to emotional traits, and to traffic events, anger and anxiety both associated with goal incongruent events, and happiness with goal congruent events. Anger mostly associated with other-blame and anxiety with situation-blame. Anger also mostly associated with events affecting impeded progress, and anxiety with events affecting safety. Anxiety, but not anger or happiness, was associated with increased perceived risk and with increased heart rate. Participants who reported anger drove faster and exceeded speed limits more often on a 100 km/road section than participants who did not report anger
Llewellyn (2008) NA	Establish which forms of risk taking associated with 5-factor model of personality, and may be influenced by ventromedial prefrontal cortex functioning	NA	NA	NA	Review	People may make rash decisions and take risks without considering consequences; alternatively, may evaluate situation and yet make poor choices because of their emotional states, the inappropriate prioritisation of immediate needs, or their personality traits. Young men also more likely to take counterproductive risks, and drugs have been shown to interfere with effective decision making
Rivers, Reyna, and Mills (2008) NA	Provide an overview of the Fuzzy-Trace Theory; delineate how emotion shapes adolescent risk taking	NA	NA	NA	Review	(1) Gist representations often incorporate emotion including valence, arousal, feeling states, and discrete emotions (2) Emotion determines whether gist or verbatim representations are processed Recommend interventions to reduce unhealthy risk-taking that inculcate stable gist representations, enabling adolescents to identify quickly and automatically danger even when experiencing emotion, which differs sharply from traditional approaches emphasising deliberation and precise analysis

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Table 1 (continued)

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
Wundersitz and Burns (2008) South Australia	Identify personality characteristics and attitudes associated with young drivers caught engaging in risky driving behaviour and driving exposure, using a prospective design and official driving records	N = 208, young drivers, 16–24 years, detected committing one or more traffic offences (169 males), Provisional driver's licence (M = 1.4 years)	General personality traits: assertiveness, depression, emotional adjustment, sensation seeking. Five measures of expression of hostility/aggression	Driving aggression, driving inhibition, extent to which driving reduced tension; self-reported driving style/risky driving, official driving records	Questionnaire	Risky driving style and the use of driving to reduce tension were associated with a greater number of kilometres driven per year. Kilometres driven per year and the use of driving to reduce tension made independent contributions to the prediction of risky driving behaviour
Stephens and Groeger (2009) United Kingdom	Influence of anger and anxiety traits on driver evaluations and behaviour during a simulated drive	N = 48 licensed drivers, M age = 25 years	Prior to drive: DAS, Trait Anxiety Scale. Prior to and after drive: State Anxiety Inventory, Wellness questionnaire	Prior to drive: DBQ	Driving simulator, rating pre-determined traffic scenarios in terms of anger, calmness, and frustration (anger-evaluation group) or levels of danger, calmness and difficulty (threat-evaluation group)	Anxiety-prone drivers – higher ratings of anger and frustration, but evaluations and anger tendencies were unrelated to general driving behaviours. Driving behaviours in high and low anger-provoking situations were contrasted, in low anger-provoking situations, drivers higher in trait anger reported more anger and frustration and also drove faster and with more sideward movement. When driving behaviours considered separately, behaviour and emotions were related: when forced to move sideward, drivers reported more frustration; when forced to drive more slowly, they reported more anger, and subsequently increased acceleration, throttle pressure and steering wheel use. Only drivers with high trait anger become angry and behaved aggressively in circumstances most would not consider provocative
Testa and Steinberg (2010) Philadelphia	Relation between symptoms and a variety of health-related risk-taking behaviours during adolescence	N = 20, 45 adolescents, 7th – 12th grade, (Using Wave 1, 1995 data from National Longitudinal Study of Adolescent Health)	Depressive symptoms (20-items from Centre for Epidemiologic Studies Depression Scale), Anhedonia; hopelessness; suicidality	Seatbelt use, drunk-driving	Computer-based in-home interviews	More depressive symptoms – wear seatbelts less often, drive while drunk more frequently. Relations were mediated by reported levels of hopelessness. Reported levels of anhedonia and suicidality also mediated some of the found relations. Adolescents experiencing depressive symptoms, especially those reporting hopelessness, should be considered at jeopardy for a variety of health-related risk taking behaviours

Hu et al. (2013) China	Explore how two states of affect (mood, emotion) influences driver's risky behaviour through risk perception and risk attitude	Study 1 N = 218, 20–56 years, 93% male, driving exp. 1–30 years. Study 2 N = 500, 86% male, 20–73 years	Adjective pairs rated (pleasant-unpleasant, tense-relaxed, vigorous-tired), overall feeling (bad-good), driving risk, worry concerning traffic crash, Driving Risk Attitude Scale	Risky driving behaviour (after seeing clips shown 3 pictures of road on TV, asked to report the speed they would like to drive on these 3 roads)	Study 1: Watched 1 of 4 video clips. Study 2: Paper surveys	Study 1: Negative emotion elevated driver's risk perception but such perception failed to develop an appropriate attitude for drivers. A more favourable risk attitude resulted in increased reports of speeding. Study 2: Mood states affected drivers' risky driving behaviour through risk perception as well as risk attitude, which was in line with the results of Study 1
Roidl et al. (2013) Germany	Identify specific characteristics of traffic situations that can explain self-reported emotions	Study 1 N = 100, M age = 30.49 years Study 2 N = 187, M age = 26.27 years.	Each scenario (16) indicate emotion would feel, rate intensity: Geneva Emotion Wheel (GEW), Dispositional driving anger (DAS-German), Trait anxiety (STAI-German)	Personal characteristics: Driving experience (annual mileage), Driving motivation (how much like driving and how important driving is to them – rated 1–5)	Online questionnaire	In both studies different combinations of goal congruence, goal relevance and blame influenced participants' emotions. Anger, anxiety and positive feelings such as hope, relief and satisfaction were related to situational factors. Second study showed the development of pride, guilt and shame could also be traced back and associated with appraisal of those situational characteristics
Sarma et al. (2013) Ireland	Examines differences in frequency of engaging in, and psycho-demographic predictors of, a range of indices of driving behaviour	N = 1638, M age = 35.95 years	International Personality Item Pool (IPIP), Norm-less Scale, Eysenck Personality Questionnaire, multi-dimensional Traffic-Locus of Control Scale, Driving Related to Self-Esteem scale, Normative influences of family and friends	Speeding and rule violation, reckless driving, use of seat belts, cautious driving, drink driving.	Questionnaire battery	Males engaged in more risky and less cautious driving behaviours than females. Participants under 25 years were more risky and less cautious than those >24 years. Best model fit was for speeding and rule violation, predicted by a model including positive attitudes towards speeding, greater normative influences of friends and higher perceived behavioural control, extraversion and driving anger
Schmidt-Daffy (2013) Germany	Impact of visibility and monetary stakes on driver's behavioural, experience-related, and physiological adaptations to threat	N = 36, males, 19–39 years	How attentive/concentrated, anxious/worried, aroused/tense and happy/amused felt during run, after drive in which a deer appeared; level of startle response, danger rating	Speed choice, tap latency, braking latency, physiological measures while driving and after deer appeared (electrodermal activity, pulse volume amplitude, heart rate)	Driving simulator, survey	Choosing a lower driving speed compensates for an increase in fear but does not decrease anxiety
Jeon et al. (2014) United States	Explore effects of specific emotions on subjective judgment, driving performance, and perceived workload	N = 70 undergraduate students, M age = 20.3 years, M years driving exp. = 4.7 years	Subjective judgment of driving confidence, risk perception, safety level	Driving errors: lane keeping, traffic rules, aggressive driving, collision while driving; NASA-TLX	Driving simulator, 3 road conditions, induced affective states (anger, fear, happiness, or neutral)	Induced anger showed negative effects on subjective safety level and led to degraded driving performance compared to neutral and fear. Happiness showed degraded driving performance compared to neutral and fear. Fear did not have any significant effects on subjective judgment, driving performance, or perceived workload

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Table 1 (continued)

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
Megias, Di Stasi, Maldonado, Catena, and Cándido (2014) Spain	Effects of emotion-laden stimuli (emotional roadside advertisements) on driver decision making	N = 24 university students, 18–34 years, licensed	Evaluation of possible risk (i.e., evaluative behaviour)	Decision to stop/speed up (i.e., urgent behaviour)	Simulator	Negative emotion aroused by roadside advertisements made drivers brake more often than positive and neutral ones, which led drivers to be more cautious and to cross less often during a yellow traffic light. However, when drivers decided to cross the intersection, the negative advertisement increased their response time
Nordfjærn and Şimşekoğlu (2014) Turkey	Examine role of empathy and conformity traits, cultural individualism/collectivism and uncertainty avoidance, for aberrant driving behaviours	N = 179 drivers, average annual mileage of 18,474 km, 45% females, 19–74 years	Empathy Quotient, Conformity Scale, Turkish version of horizontal and vertical collectivism and individualism instrument; Uncertainty avoidance	DBQ Turkish version	Paper Survey	Traits and cultural factors associated with driving violations and errors. Empathy was related to lower levels of reported driving errors and violations, whereas conformity was related to higher levels. Avoiding uncertainty also had a relation to more reported error conduct. Vertical individualism (striving to be distinct and for social status) was associated with higher levels of driving errors and violations, while vertical collectivism (striving for social equality and hierarchy) was related to lower levels of driving violations
Roidi et al. (2014) Germany	Observe effect of specific emotions on driving performance	N = 79, 18–43 years, M driving exp. = 5.67 years	Emotion after drive (4 pictures, critical drive sections), revised Geneva Emotion Wheel, German DAS	Driving behaviour (mean speed, acceleration, lateral acceleration)	Simulator	Anger leads to stronger acceleration and higher speeds. Anxiety and contempt yielded similar but weaker effects, yet showed same negative and dangerous driving pattern as anger. Fright correlated with stronger braking momentum and lower speeds directly after the critical event
Aduen, Kofler, Cox, Sarver, and Lunsford (2015) United States	Examine relative risk of violations, collisions, collision-related injuries, and collision fault associated with ADHD and depression relative to drivers with no known psycho-pathology	ADHD N = 275, Depression N = 251, Healthy control N = 1828	Barkley adult ADHD quick screen (BAQS), Psychological diagnoses questionnaire	Driving history (traffic collisions, moving violations, collision-related injuries, collision fault, last 3 years)	The Strategic Highway Research Program (SHRP-2) Naturalistic Driving Study	Accounting for demographic differences, ADHD but not depression portended increased risk for multiple violations, multiple collisions, and increased risk for collision fault. Depression but not ADHD predicted increased risk for self-reported injury following collision

Chan and Singhal (2015) Canada	Examine nature of distraction due to emotion by measuring behavioural and electro-physical effects elicited by auditorily presented words of different emotional valence (neutral, negative, and positive)	N = 25, 18–30 years	Emotion-related auditory distraction: words selected from Affective Norms for English Words database with each word having an assigned valence and arousal value	Driving performance: speed, lane maintenance, steering wheel rate. Response times/error rates for animal target words. Proportion of words recalled for each word type, Event-related potentials (ERP) (EEG recording – cognitive workload)	Simulator	Emotion-related auditory distraction can differentially affect driving performance depending on valence of emotional content. Negative distractions reduced lateral control and slowed driving speeds compared to positive and neutral distractions. An arousal effect on memory and decision-making during driving as performance improved with both negative and positive distractions. ERPs elicited by auditory distractions were reduced in amplitude during driving compared to non-driving, revealing a division of cognitive resources under dual-task demands
Guerra and Morris (2015) United States	How emotions like happiness, pain, stress, sadness and fatigue vary during travel, by mode	N = 13,260, aged 15+	Subset of ATUS data (well-being module): 5 emotions, how meaningful was activity, and whether it involved interaction with others	ATUS (amount of time Americans spent performing different activities on day prior to the survey, based on trip purpose and destination)	American Time Use Survey (well-being module), telephone survey	Mood is generally no worse during travel than on average. However, compared to other influences, travel has only a small total impact on how we feel
<i>Emotion regulation</i> Ben-Zur and Zeidner (2009) NA	Review literature on relationship between perceived threat to life and risk-taking behaviours	NA	NA	NA	Review	There are circumstances under which exposure to trauma (a) increases future discounting (of risk) (if making decisions under high emotional arousal, individuals may resort to aggressive behaviours for evolutionary purpose of enhancing prospects for survival); (b) decreases significance of perceived risk in future; and (c) leads to risk-taking behaviour that can be seen in terms of defensive reactions (i.e., avoidance, emotion regulation) (suggests 'near future' of more importance than 'far future'). There are circumstances under which negative affect caused by trauma exposure interferes with higher cognitive function and rational decision-making
Catrett and Gaultney (2009) United States	Investigate whether previously reported links between sleep and risk taking among adolescents are associated – concurrently, longitudinally, or both – with sleep or underlying depression	N = 4353, 7th–12th grade students	Depressive symptoms, possible insomnia	Risky behaviours: safety violations, delinquency, and violence, drinking and smoking	Waves I and II of the National Longitudinal Study of Adolescent Health Survey	Possible insomnia significantly predicted smoking, delinquency (within each wave but not longitudinally), and drinking and driving (Wave II and longitudinally). Possible insomnia may contribute to some types of risky behaviours over the effects of depressive symptoms

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Table 1 (continued)

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
Fischer et al. (2012) Germany	Investigate how availability of self-control resources affects risk-taking inclinations and behaviours	Study 1 N = 33, 17–56 years. Study 2 N = 30, 18–53 years. Study 3 N = 74, 19–49 years. Study 4 N = 38, 19–31 years. University students	Study 1 sensation seeking, cognitive imagination Study 2 reported positive/negative emotions Study 3 anger Study 4 experienced exhaustion	Study 1 risk-taking survey. Study 2 Vienna Risk Taking Test (willingness to take driving risks). Study 3 risk taking Study 4 risk taking	Study 1: Survey. Study 2: Emotion control task (watch cartoon), computer-based driving simulations. Study 3: survey with emotionally shocking pictures (ego-depletion manipulation) in surveys. Study 4: survey	Study 1: Ego-depleted participants reported higher levels of sensation seeking Study 2: Ego-depleted participants showed higher levels of risk-tolerance in critical road traffic situations Study 3: Ruled out two alternative explanations for these results – neither cognitive load nor feelings of anger mediated the effect of ego-depletion on risk-taking Study 4: Clarified the underlying psychological process – ego-depleted participants feel more cognitively exhausted than non-depleted participants and thus are more willing to take risks
Gwyther and Holland (2012) United Kingdom	Whether drivers adopt self-regulatory behaviours and effects of affective and instrumental attitudes on self-regulation across lifespan	N = 395 drivers, 267 females, 18–78 years, driving exp. 2 months – 55 years	Instrumental and affective attitudes and self-regulation behaviours	Driving experience (length of full drivers licence), Mileage, MDSI	Questionnaire	Females more likely than males to engage in self-regulation, and to be negatively influenced by emotions. Younger and older drivers reported higher scores for self-regulation than middle-aged drivers (this effect was affected by experience – when experience was controlled for, self-regulation increased with age). Anxious driving style and negative affective attitude independent predictors of self-regulation. Self-regulation behaviours are present across driving lifespan and may occur as a result of driving anxiety or low confidence rather than as an effect of ageing
Rivers et al. (2013) United States	Examine relative contributions of emotional intelligence and self-esteem in explaining self-reported risky behaviours	N = 243, undergraduate students, 182 female, 18–19 years	Mayer-Salovey-Caruso Emotional Intelligence Test, Rosenberg Self-Esteem Scale	Risky behaviours (smoking, alcohol and drug use, minor delinquency, conflicts with parents and best friends)	Questionnaires	Emotional intelligence, but not self-esteem, was related significantly to risky behaviours

Rofey et al. (2013) NA	Highlight opportunities to improve self-regulatory capacities and related health outcomes during adolescence	NA	NA	NA	Review	Onset of puberty intensifies emotions and some motivational drives particularly in contexts where social goals and pressures are salient (normative and serve adaptive advantages). Changes also confer risks as skills and neural architecture for managing intense emotions and competing motivations are not yet fully realised (increasing challenges to the brain systems of cognitive control that help align these emotional responses to balance short and long term risks and rewards, and adjust motivated behaviour accordingly) – contribute to adolescents making risky or poorly considered decisions. For youths who enter adolescence with certain vulnerabilities (anxiety, proneness to sensation seeking) these challenges to emotion regulation can lead to significant problems
Baum et al. (2014) United States	Better understand effects of experimentally-induced sleep restriction on adolescents' mood and mood regulation	N = 50, 14–17 years	Mood and mood regulation questionnaire	Self-report and actigraphy	3-week sleep manipulation protocol (baseline week, sleep restriction condition (6.5 h in bed/night for 5 nights), healthy sleep duration condition (10 h in bed/night for 5 nights))	More tense/anxious, angry/hostile, confused, and fatigued, and less vigorous during sleep restriction condition. Parents and adolescents also reported greater oppositionality/irritability and poorer emotion regulation during sleep restriction compared to healthy sleep
Trogolo et al. (2014) Argentina	Examine relation between difficulties in emotion regulation and driving styles	N = 137, (80 men, 57 women, 18–65 years	Argentine version of Difficulties in Emotion Regulation Scale	MDSI Spanish-language version	Paper survey	Greater difficulties in different types of emotion regulation abilities were related to anxious, angry, dissociative and risky driving. Lesser difficulties in regulating emotions were associated with careful driving
Houck et al. (2015) United States	Evaluate intervention to enhance early adolescents' emotion regulation skill use and to decrease risk behaviours	N = 420, 12–14 years, 53% male, with mental health symptoms referred to either Emotion Regulation (ER) or Health Promotion (HP) intervention	Youth Inventory-4 and Adolescent Symptom Inventory; Emotional Competence (Emotion Regulation Behaviours Scale, Self-efficacy Questionnaire for Children-Emotional Self-efficacy subscale, Emotion Regulation Checklist)	Health Behaviours, Youth Risk Behaviour Surveillance Survey	Baseline and follow-up online questionnaires	Participants in ER intervention less likely to be sexually active and engage in other risk behaviours, such as fighting, at program conclusion and reported greater use of emotion regulation strategies and more favourable attitudes towards abstinence
Weiss et al. (2015) NA	Synthesise research on relationship between emotion dysregulation and risky behaviours to inform future research and clinical practice	NA	NA	NA	Review	Support for underlying role of emotion dysregulation in a wide range of risky behaviours. Research to date generally assessed dispositional tendencies towards emotion dysregulation and retrospective reports of risky behaviours; however evidence for the context-dependent nature of both emotion dysregulation and risky behaviours. Highlights role of physiological processes underlying the ability to regulate emotions

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Table 1 (continued)

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
Weiss et al. (2015) United States	Examine unique effects of emotion dysregulation and impulsivity on risky behaviours over time (randomly assigned to emotion modulation [EM] or impulsivity reduction [IR] brief intervention)	20 African American women enrolled in a historically Black university in the southern United States, aged 18–27 years	Emotion dysregulation, impulsivity	Past-week risky behaviours pre- and post-intervention	Self-report survey	Participants assigned to EM condition reported significant improvements from pre- to post-manipulation in overall emotion dysregulation, as well as 2 dimensions of impulsivity: negative and positive urgency. Participants assigned to IR condition reported a significant decrease in 1 dimension of impulsivity (lack of premeditation) from pre- to post-manipulation. Findings also revealed a significant effect of time on risky behaviours, with participants reporting significantly fewer past-week risky behaviours at the post- (vs. pre-) manipulation assessment. Changes in emotion dysregulation from pre- to post-manipulation accounted for observed reduction in risky behaviours over time (above and beyond changes in impulsivity dimensions)

such as anger appear to be demarcated, it is noteworthy that the influence of emotions is not universal and the valence of emotions is important, as also noted earlier. For example, while the emotion of fear has been found to reduce driving speed in some instances (e.g., after a critical incident, [Roidl, Frehse, & Höger, 2014](#)), fear was found to exert no impact upon driving behaviour in other instances (e.g., [Jeon et al., 2014](#)). Moreover, travel itself was found to have a small, negative, impact only on driver mood (participants aged 15+ years, [Guerra & Morris, 2015](#)).

3.1.3. Emotion regulation

Of 11 papers examining emotion regulation in adolescents, 6 papers comprised survey research, 3 papers reviewed literature, and one each operationalised simulator/survey and sleep manipulation methodologies. Of the experimental papers, 5 emerged from the United States, with one each from the United Kingdom, Germany, and Argentina. The three review papers were published in 2009, 2013 and 2015, with 88% of the remaining papers published since 2012, consistent with the recent, increasing, interest in adolescents and adolescent risky behaviour noted in Sections 3.1.1 and 3.1.2.

Emotion regulation is arguably a form of decision-making that appears to emerge from a complex blend of personal characteristics, and context-specific characteristics including peer influence and exposure to risk in the past and present. Perhaps counter-intuitively, such exposure to risk actually appears to contribute towards greater engagement in risky behaviour, including risky driving behaviour, in the near future ([Ben-Zur & Zeidner, 2009](#)). While difficulties with emotion regulation appear to be normative in adolescence and are impacted upon by the breadth of biological and psychosocial characteristics discussed in the introduction (see also review papers [Rofey, McMakin, Shaw, & Dahl, 2013](#); [Trógolo, Melchior, & Medrano, 2014](#); [Weiss, Sullivan, & Tull, 2015](#)), greater difficulty in emotion regulation is associated with risky behaviour including risky driving behaviour. Adolescent females appear to have greater emotion regulation skills than adolescent males, however adolescent females appear to be influenced to a greater extent by negative emotions than adolescent males. Furthermore, while young drivers appear to have fewer emotion regulation skills compared to older more experienced drivers, it appears that emotion regulation skills improve with driving experience (noting participants aged 18–78 years, [Gwyther & Holland, 2012](#)).

Two clear contributors to emotion regulation difficulties for adolescents appear to be sleep deprivation and ego depletion. Specifically, research has found that adolescents who experience sleep deprivation, including adolescents with insomnia (7th–12th grade students, [Catrett & Gaultney, 2009](#)), experience greater emotion regulation difficulties and greater emotionality (self-reported and observed irritability; 14–17 years, [Baum et al., 2014](#)). Regarding ego depletion, emotionally-drained ('ego depleted') adolescents appear to have an increased risk tolerance, increased sensation seeking and, relatedly, increased risk taking propensities (participants aged 17–56 years, [Fischer, Kastenmüller, & Asal, 2012](#)). Moreover, teens who have pre-puberty emotion-related difficulties appear to be at greatest risk as adolescents ([Rofey et al., 2013](#)), suggesting early intervention is warranted. Interestingly, greater emotional intelligence, but not greater self-esteem, seems to be related to greater emotion regulation and less engagement in a breadth of risky behaviours which commonly occur in adolescence (e.g., alcohol and drug use, 18–19 years, [Rivers et al., 2013](#)), further suggesting avenues of effective intervention in adolescence more generally. For example, interventions which improve emotion regulation skills are associated with reduced risk for early (12–14 year old boys, [Houck et al., 2015](#)) and late adolescents (18–27 year old women, [Weiss et al., 2015](#)).

3.2. Emotions, the adolescent, and driving risks

[Table 2](#) summarises the literature regarding emotions, the adolescent, and driving risks. Within this broader category, the literature is synthesised within the scope of the following subsections: Emotions and risk perception; Emotions and decision-making; Emotions and time pressure; and Emotions and social influences.

3.2.1. Emotions and risk perception

Of nine papers examining emotions and risk perception for adolescent drivers, four papers operationalised survey research, two papers each comprised simulator and hazard-perception related techniques, and one paper operationalised video/survey methodologies. In addition, two papers operationalised induced emotion techniques. Papers again were published relatively recently, with all papers published in 2011 and later, and five papers emerged from Europe/the United Kingdom, two papers from North America, and one each from Australia and Hong Kong.

It appears that emotions and risk perception are inextricably intertwined for adolescent drivers (e.g., 17–24 years, [McNally & Titchener, 2012](#)), and this is a robust finding given the breadth of methodologies exploring this phenomenon across the globe. To illustrate, fundamental differences in risk perception have been found to emerge from the experience of strong emotions by the adolescent driver; with positive affect in particular associated with lower risk perception (e.g., impulsivity, 12–14; 21–31 years, [Haase & Silbereisen, 2011](#); happiness, average age 19.1 years, [Drače & Ric, 2012](#)) and greater risky driving behaviour (e.g., steering performance, 19–23 years, [Trick, Brandigampola, & Enns, 2012](#)) for young males in particular (e.g., 16–20 years, 25–45 years, [Rhodes & Pivik, 2011](#)), while strong negative affect has been found to lead to delayed detection of driving hazards (e.g., 25 years, [Jallais, Gabaude, & Paire-Ficout, 2014](#)) and lower risk perception (e.g., [Drače & Ric, 2012](#)). Emotional contexts have been found to reduce adolescent driver sensitivity to hazards which is in stark contrasts to neutral images which have been found to increase adolescents' sensitivity to hazards (18–26 years, [Jones, Chapman, & Bailey, 2014](#)). While such strong emotions can emerge from a variety of sources, including other road users (driver anger), threats to safety (driver fear) and uncertainty (driver anxiety) (<30→50 years, [Zhang & Chan, 2014](#)), it appears

Table 2
Emotions, the adolescent, and driving risks.

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
<i>Emotions and risk perception</i>						
Haase and Silbereisen (2011) Germany	Examine effect of positive affect on risk perceptions of (e.g.) driving with a drunk driver, including moderating role of impulsiveness and sensation seeking	Study 1 N = 41, 21–31 years Study 2 N = 35 12–14 years, N = 27 16–17 years, N = 27 20–29 years	Study 1: Participants reported how felt post-video. Study 2: Impulsive-ness, sensation seeking	Study 1: Risk perceptions (adapted version of Benthin Risk Perception Measure	Study 1: Video task (36 positive or neutral pictures); Study 2: Questionnaire	Study 1: Positive affect led to lower risk perceptions than neutral affect for young adults. Study 2: Replicated effect for early adolescents, mid-adolescents, and young adults; showed effect was most pronounced at high levels of impulsiveness. Adolescents and young adults may be more risk averse in contexts that do not give rise to emotions, but have markedly lower risk perceptions under positive affect
Rhodes and Pivik (2011) United States	Examine relationships among risk perception, positive affect and risky driving	N = 504, 16–20 years; N = 409, 25–45 years	Liking towards and perceived risk of engaging in range of driving behaviours	12 behaviours: switching lanes to get ahead, fast acceleration/braking, speeding, fast on curves, sleepy, after drinking, distracted, through red light, braking hard, during rush hour, racing	Phone survey	Male drivers engage in risky driving behaviours more frequently than females. Teen drivers engage in risky driving behaviours more frequently than adult drivers. Positive affect (liking for risky driving behaviours) and perceived risk mediated the relationships of age and gender with risky driving. Affect and risk perception were independent predictors of risky driving behaviour. Positive affect more strongly predicted risky driving for teen and male drivers than for adult and female drivers
Drače and Ric (2012) France	Assess role of specific emotions on risk perception	N = 56 psychology undergraduates, 42 female, M age = 19.1 years	Emotion self-report form; Appraisal measures of certainty and control	Likelihood estimates (8 positive and 8 negative events)	Questionnaires following emotion induction. Assigned to 3 conditions (anger, sadness, happiness)	Angry, happy participants made more optimistic risk estimates than sad participants. As hypothesised by Appraisal Tendencies Framework, happiness, anger also led people to somewhat higher certainty appraisals than sadness. However, change did not mediate impact of emotions on risk estimates
McNally and Titchener (2012) Australia	Investigate application of dual process model of risk to processing of transport related risky behaviours	N = 100, 1st year undergraduate psychology students, 17–25 years, driving exp. 1–10 years	Cognitive and affective evaluations of risky situations	Self-reported likelihood of participating in risk situations	Online survey	Gender was sole significant predictor of risky choice for speeding, and significant predictor of choice to be passenger of drunk driver until inclusion of cognitive and affective perceived risk. Gender not a significant predictor for fatigued or distracted driving, with affective perceived risk identified as sole predictor for both scenarios
Trick et al. (2012) Canada	Impact of moment-to-moment fluctuations in attention by viewing emotion-evoking images while driving	N = 26 university students, 19–23 years	Indicate whether image was positive or negative	Braking in response to events of lead vehicle (braking reaction time RT)	Simulator	250 ms delay condition: RT faster after high arousal images (faster for positive). 500 ms delay condition: RT slower after high arousal images (slowest for negative images). Responding to all images reduced steering performance (period after image/before button press). Positive images had better steering performance than negative, especially in low arousal
Kinnear et al. (2013) United Kingdom	Can affective component be detected from inexperienced and experienced drivers in lead up to a potential hazard using dynamic stimuli?	Learners N = 11, 17–27 years; Inexperienced N = 21, 17–33 years; Experienced N = 18, 20–31 years	Psycho-physiological responses to development of driving hazards (Skin Conductance Responses SCR)	Continuous cognitive hazard ratings taken in response to clips	Computer-based hazard perception task (1 min, 1 major hazard, 12 clips randomly presented)	Experienced drivers 2 times as likely (compared to learners) and 3 times as likely (compared to novice) to produce an SCR to developing hazards. Suggests consideration of emotion-based signals contributing to cognitive hazard perception and subsequent decision making an important direction for research in novice driver safety and should not rule out influence of either conscious or unconscious emotion on driving behaviour

Jallais et al. (2014) France	Effects of emotion on the localization of road elements	N = 54, M age = 25 years (3 groups: sadness n = 19, anger n = 17, neutral n = 18)	Induced 3 mood states; Brief Mood Introspection Scale	Localisation of road elements	Modified version of jumble scenes paradigm task Induced emotions (4 min of music, guided imagery)	3 groups (sadness, anger, neutral) take more or less advantage of use of visual schemata to localise road elements. Sadness increased localization error rate. Participants induced in anger were slower to locate road elements than participants induced in sadness and in neutral mood
Jones et al. (2014) United Kingdom	Investigate relation between image valence and risk perception, eye movements and physiological reactions	N = 36, 18–26 years, 27 females, University students, full driver's licence	Rated clips as hazardous/safe with emotional images from international affective picture system overlaid	Galvanic skin response, heart rate, eye movements	Watched hazard perception clips (computer-based), which had emotional images	Participants more aware of potential hazards when a neutral image had been shown, in comparison to positive and negative valenced images; higher subjective ratings of risk, larger physiological responses and marginally longer fixation durations when viewing a hazard after a neutral image, but this effect was attenuated after emotional images. Emotional images reduce sensitivity to potential hazards
Zhang and Chan (2014) Hong Kong	Investigate how emotional responses of drivers may be predicted by using appraisal components of goal relevance, blame party, and certainty	N = 50 (16 females); 48% < 30 years, 26% 31–40, 14% 41–50, 12% > 50 years	16 text-described traffic scenarios, emotional responses to driving scenario measured on Arousal–Valence emotional space	NA	Questionnaire	Driving anger was most likely to be provoked when other drivers were responsible for the adverse driving outcome; driving fear was most commonly experienced in situations where driver safety was threatened by the driver himself/herself or by impersonal circumstance; and driving anxiety was an outcome of uncertain arrival-blocking events caused by driver himself/herself or impersonal circumstance
<i>Emotions and decision making</i>						
Reyna and Rivers (2008) NA	Review adolescent risk taking and science of judgment and decision making, including behavioural decision making	NA	NA	NA	Review	Adolescent risk taking is a crucially important health and public policy issue. There are many open questions that pertain to effective interventions, including the possibility that behavioural interventions might affect biological maturation and that biological factors might affect receptivity to behavioural interventions
Albert and Steinberg (2011) NA	Review most important findings during past 10 years in study of judgment and decision-making (JDM) in adolescence and look ahead to possible new directions	NA	NA	NA	Review	Three inter-related shifts in research emphasis 1. Research grounded in normative models of JDM have moved beyond study of age differences in risk perceptions and towards a dynamic account of factors predicting adolescent decisions 2. Wide spread adoption of dual process models of cognitive development that describe 2 relatively independent modes of information processing, typically contrasting an analytic (cold) system with an experimental (hot) one 3. Increase in attention to social, emotional, and self-regulatory factors that influence JDM. Shift in focus reflects the growing influence of findings from developmental neuroscience, which describe a pattern of structural and functional maturation that may set the stage for a heightened propensity to make risky decision in adolescence
Wang et al. (2015) China	Examine whether there are differences in drivers' emotions and decisions between watch a video or simulating driving	N = 40 drivers	Decision and emotion behaviours	Heart rate, driving speed	Study 1: Computer-based study with questionnaires Study 2: simulator to validate Study 1's subjective measurements through biometrics	No significant difference existed between simulator driving and a video watching for either decision or emotion behaviour

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Table 2 (continued)

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
<i>Emotions and time pressure</i>						
Møller and Gregersen (2008) Denmark	Examined relation between risky driving, psychosocial function of driving, leisure activities, car-oriented peer group interaction, educational attainment	N = 2417 drivers, 18–25 years, randomly selected from Danish Driving License Register	Psychosocial functions of driving, degree of emotional involvement in driving	Risk taking behaviour, Leisure time activities	Mailed surveys	Psychosocial function of driving is indicator of risk-taking behaviour while driving. Young drivers engaged in low structure/high impulsivity leisure time activities including driving related peer group interaction are involved in more risk-taking while driving, than young drivers engaged in high structure/low impulsivity leisure time activities. Low educational attainment is related to risk-taking behaviour while driving
Cyders and Coskunpinar (2010) United States	Examine urgency traits, lack of premeditation, frequency/intensity of emotional experiences, drinking motives to predict drinking behaviours	N = 520, Undergraduate students (68.7% females), M age = 18.46 years	Mood based questionnaire (MBQ), Drinking motives questionnaire-revised (DMQ_R)	UPPS-R impulsive behaviour scale, PUR measure (PUM), risky behaviour scale (RBS), drinking styles questionnaire (DSQ)	Questionnaire	Urgency is a significant predictor of risky behaviour, independent of frequency/intensity of emotions. Urgency predicts above and beyond additive and interactive effects of lack of premeditation and frequency/intensity of emotions. Those who are high in both urgency and drinking motives are at greatest risk for drinking/drunkenness
Cœugnet, Naveteur, Antoine, and Anceaux (2013) France	Identify situational factors eliciting time pressure behind wheel, explore emotional reactions elicited by driving under time pressure	N = 227 drivers, aged 18 + years	Questions concerning emotions experienced on the road	Driving under time pressure, driving habits Self-Assessment of Driving Ability	Roadside self-assessment	Time constraints, time uncertainty and goal importance are causal factors for time pressure. Time pressure associated with negative emotions and stress, though some motorists also appreciate driving under time pressure because doing so potentially heightens self-efficacy. Most younger drivers (< 25 years) described themselves as being only occasionally pressed for time, however were considered by others to often drive in the condition
Morris and Guerra (2015) United States	Examines the question 'are longer trips more strenuous or unpleasant than shorter ones?'	Over 22,000 instances of individuals travelling observed	Extent to which felt happy/pain/sad/stress/fatigue during 3 randomly selected daily activities	Trip duration, mode, purpose	American Time Use Survey's well-being module	Relationship between trip duration and traveller mood not strong. Significant and negative association between trip duration and mood (primarily because of rising stress, fatigue and sadness on long trips). Particularly true for drivers, while negative emotions do not rise with increasing trip duration for passengers. Long trips significantly degrade mood of drivers, bus riders
<i>Emotions and social influences</i>						
Michael and Ben-Zur (2007) Israel	Investigate associations of social and affective factors with risk-taking	N = 269, 16–18 years	Parental relationship, peer group orientation, depressive mood, aggressive behaviour	Frequency of involvement in risk-taking behaviours	Questionnaires	Risk behaviour among males was mainly related to orientation towards peer group, while for females relationships with parents was the prominent factor in risk behaviour. Parental factor also contributed to the depressive mood of both genders. Depressive mood showed a weak association with risk-taking
O'Brien et al. (2011) Philadelphia, US	Examine effect of peer presence on reward sensitivity	N = 100, 18–20 years	Intelligence (Wechsler Abbreviated Scale of Intelligence (WASI))	Delay discounting task (choose between immediate/delayed reward)	Delay discounting task to assess a preference for immediate vs. delayed rewards	Adolescents demonstrated a greater preference for immediate rewards when with peers than when alone. Heightened risk taking by adolescents in company of friends may be due in part to effect that being with one's peers has on reward sensitivity

Hu et al. (2012) China	Examining different effects of supervisors and friends as passengers, and drivers' propensities for angry driving	Study 1 N = 209 drivers, 20–56 years, driving exp. 1–24 years. Study 2 N = 100 drivers, 22–64 years, driving exp. 1–30 years	Propensity for angry driving (PAD), Chinese Self-Monitoring Scale	NA	Surveys Study 1: drivers asked to freely imagine a passenger as supervisor or friend. Study 2 – drivers read a description about either an aggressive supervisor or a cautious friend	Study 1: Compared with driving alone, drivers' propensities for angry driving increased when passenger was friend but decreased when passenger was supervisor. Study 2: Effects of passengers on drivers' angry driving propensities were reversed, indicating that a clearer behaviour standard conveyed by a passenger had a stronger effect on drivers. Self-monitoring propensity showed a main effect on drivers' propensities for angry driving in a standard-free situation. Self-monitoring propensity moderated effect of passenger's role on angry driving propensities in a standard-set situation
Segalowitz et al. (2012) Canada	Peer interaction reduces activation of medial prefrontal cortex (mPFC) required for self-regulation of reward-driven behaviour; mPFC activity reduced in greater surgency (behavioural approach, sensation seeking, positive affect)	N = 20, 15 years, males	Behavioural Inhibition and Behavioural Activation Scale, Sensation Seeking Scale Form-V, Positive and Negative Affect Schedule (PANAS)	Feedback-related negativity (FRN) event-related potential in response to impending car crash	Simulated driving video game alone and in presence of peers who were encouraged to call out advice	FRN amplitude was reduced both as a function of peer presence and increased surgency. Both greater surgency and peer presence are associated with reduce activity specifically in the mPFC. Riskier performance resulting in more car crashes resulted from presence of peers only as an interaction with surgency, this interaction being related strongly to reduced activity in the ventromedial PFC
González-Iglesias et al. (2014) Spain	Examine role of sensation seeking in drunk driving by youths, and potential mediational effect of social, cognitive and emotional variables	N = 274 drivers, 18–30 years	Arnett Inventory of Sensation Seeking (AISS), disapproval of drunk driving by peers, perceived parents' norms, self-efficacy in avoiding DUI, Perceived driving self-efficacy	Alcohol Use Disorders Identification Test (AUDIT), self-reported drunk driving	Survey	Confirmed significance of sensation seeking to drunk driving by youths and the mediating role of biased self-efficacy perceptions in relationships
Rhodes, Pivik, and Sutton (2015) United States	Examine effects of induced mood and presence or absence of passengers on risky driving in young male drivers	N = 204, 16–18 years, male	Happy/sad mood	Speed, carelessness	Simulator	Driving with a passenger resulted in faster driving than driving alone. No significant main effect of induced mood on driving. However, a significant interaction of mood and passenger conditions: when in happy mood, driving with passenger significantly increased driving speed. No significant effects on passenger or mood on careless driving
Simons-Morton et al. (2015) United States	Examine effect on risky driving of 2 levels of pre-drive, positive emotional arousal couple with peer influence	N = 81, 16–18 years, male	Heart rate; Self-Assessment Manikin Instrument, Resistance to peer influence; Identification with passenger; Passenger approval; Relative social status of passenger	Failed to stop, percent time in red, and pass slow vehicle	Simulator with eye tracking	Group differences in risky driving were in expected direction: simulated risky driving is (1) greater in presence vs absence of teen passenger (2) (2) greater in context of high vs low arousal, and (3) greater in presence vs absence of peer passenger with high vs low arousal), but were not statistically significant on any of the three outcome measures

that both conscious and unconscious emotions impact upon adolescent driving through hazard perception and decision-making mechanisms (17–33 years, [Kinnear, Kelly, Stradling, & Thomson, 2013](#)). Interestingly adolescent drivers appear most risk-averse in circumstances in which emotional responses are not evoked ([Haase & Silbereisen, 2011](#)).

3.2.2. Emotions and decision-making

Of three papers only examining emotions and decision-making for adolescent drivers, two papers were review papers, published in 2008 and 2011, while the remaining experimental paper emerged from China in 2015 and combined survey, simulator and biometric measures to investigate the relationship between emotions, decision-making and driving. The review papers synthesised the literature regarding psychosocial-biological maturation as discussed earlier, reinforcing the notion that effective intervention in young driver road safety requires a holistic approach in which the complex maturational issues (ranging from social influence of peers to the behavioural-regulation and decision-making limitations associated with the cognitive maturation of the adolescent brain) are more fully considered ([Albert & Steinberg, 2011](#)). While there has been much discussion regarding the merits of various research methodologies (e.g., [Scott-Parker & Senserrick, 2013, 2017](#)), [Wang, Wei, Liu, and Zhao \(2015\)](#) reported no decision-making or behavioural differences in response to emotional stimuli in simulator-based and video-based research methodologies, suggesting that either methodology may be suitable for emotion-focused adolescent driver research.

3.2.3. Emotions and time pressure

Of four papers examining emotions and time pressure for adolescent drivers, three papers comprised survey research and one paper operationalised interviews, thus all papers utilised self-report methodology. One paper each emerged in 2008, 2010, 2013, and 2015, with two papers each emerging from Europe and the United States. Time pressure emerges from a combination of time constraints, time uncertainty and goal importance, with young drivers surveyed at the roadside reporting they sometimes experience time pressure (18+ years, [Coeniguet et al., 2013](#)). Relatedly, greater trip durations have been found to be associated with lowered mood including increased fatigue, stress and sadness ([Morris & Guerra, 2015](#)). As noted in the Sections 1 and 3.1.2, the purpose of the trip should be considered for young driver road safety: adolescent drivers who do not experience time pressure and who engage in impulsive driving with peers also report the most risky driving behaviour (18–25 years, [Møller & Gregersen, 2008](#)). Finally, adolescents who exhibit greater urgency, a subscale within the larger personality construct of impulsiveness, engage in the greatest risky behaviour, with urgency predictive of risky behaviour such as drinking excessively, over and above the influence of frequent and intense emotions (average age 18.46 years, [Cyders & Coskunpinar, 2010](#)).

3.2.4. Emotions and social influences

Of seven papers examining emotions and social influences for adolescent drivers, three papers operationalised surveys/questionnaires, three papers comprised simulator research (including one game), and one paper operationalised a delay discounting task. Papers again were generally published recently (all but one paper (2007) published in 2011 and later), with four papers emerging from North America, and one each from China, Israel and Spain. More generally beyond the scope of this literature review, there is a burgeoning body of literature which has revealed the influence of peers and parents upon the risky behaviour of young drivers. Specifically within the realm of emotions, peers and parents again are influential upon young driver behaviour. Peers appear to increase risks for young males in particular, while parents exert a protective influence upon young females in specifically (16–18 years, [Michael & Ben-Zur, 2007](#)). Young drivers carrying peers as friends drive at higher speeds than when they travel alone, particularly when they are in a positive mood ([Michael & Ben-Zur, 2007](#); 16–18 years, [Simons-Morton et al., 2015](#)).

It appears that peer influence occurs through the capacity to provide immediate social rewards with risky driving behaviour in a driving simulator in the presence of peers also found to be associated with reduced activity in the pre-frontal cortex (15 years, [Segalowitz et al., 2011](#)). Peer passengers can also increase the risk for angry driving; however clear expectations regarding driver behaviour and greater self-monitoring (i.e., emotion regulation) has been found to be associated with less angry driving behaviour in the presence of peers (20–64 years, [Hu, Xie, Han, & Ma, 2012](#)). Peer influence can also occur through the salience of group norms, with risky norms, greater self-efficacy, and drinking alcohol mediating the influence of the young driver's sensation seeking propensity upon driving-under-the-influence (18–30 years, [González-Iglesias, Gómez-Fraguela, & Luengo, 2014](#)).

3.3. Emotions, the adolescent, and risky driving behaviour

[Table 3](#) summarises the literature regarding emotions, the adolescent, and risky driving behaviour. Within this broader category, the literature is synthesised within the scope of the following subsections: Angry and aggressive driving; and Distraction and inattention.

3.3.1. Angry and aggressive driving

Of 26 papers examining angry and aggressive driving – strong emotions and moods alike – and the adolescent driver, 17 papers operationalised survey research, 4 papers were simulator-based studies, 3 papers used a computer priming technique, and 1 paper each comprised a review and a diary. Of the 25 experimental papers, 9 papers each emerged from North

Table 3

Emotions, the adolescent, and risky driving behaviour.

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
<i>Angry and aggressive driving</i> Alsaleh (2006) Kuwait	Impact of social and psychological factors on car crashes	N = 1619, aged 18–30 years, cases (n = 984 – drivers involved in crash during lifetime), controls (n = 635 – drivers never involved in crash)	Anxiety, sensation seeking, anger	Driving habits	Survey	Driving habits, aggressive driving, and road rage situations leads to greater sensation seeking, anxiety and anger, which leads to risky driving behaviour (e.g., drivers forcing a car off the road, deliberate obstruction, running red lights, running stop signs, and tailgating), which leads to involvement in traffic crashes
Schwebel et al. (2006) United States	Independent and combined role of self-reported and simulated risky driving behaviour	N = 73 college students, aged 21–51 years (M = 27.82 years)	Personality measures (sensation-seeking, conscientiousness, anger/hostility)	Driving history	Questionnaires and Virtual Environment (VE) task (assessed risk-taking driving behaviour)	Each facet of personality was associated with risky driving behaviour (univariate analyses). Sensation-seeking was best predictor of self-reported driving violations. Anger/hostility and the interactive effect of anger/hostility by sensation-seeking also predicted one measure of self-reported driving violations. No personality trait predicted risky driving in the VE
McLinton and Dollard (2010) Nagoya, Japan	Relationship between work stress arising from effort-reward imbalance (ERI) and driving anger in a community sample of workers	N = 215 full-time workers, 18–73 years, 64% female	Effort-reward imbalance scale, Driving Anger Scale (DAS), Trait Anger (State Trait Anger Expression Inventory (STAXI), Life satisfaction	NA	Mail-out survey	Participants reported significantly higher levels of ERI than all comparative western samples, and greater ERI corresponded to elevated aggressive feelings on road. Participants reported lower total driving anger and anger on all DAS subscales compared with American and Australian samples but no difference to British samples
Villieux and Delhomme (2010) France	Driver anger and its expression on the road	N = 314 drivers, 18–25 years	Driving Anger Expression Inventory (DAX) French adaptation, DAS	Extended Violations Scale	Survey	DAX factors are useful predictors of self-reported violations
Dula et al. (2011) NA	Reviews major extant theories of general aggression to offer rationale for choice in aggressive driving	NA	NA	NA	Review	The social-cognitive model of aggressive driving is recommended, as it takes into account wide-ranging cognitive, situational, and dispositional factors
Hui et al. (2011) China	Type A Behaviour and aggressive driving	N = 114, 18–58 years (<2 years driving exp. n = 31; 2–10 years driving exp. n = 47; >10 years driving exp. n = 36)	Type A Behaviour Pattern (TABP)	Jenkins Activities Scale, Activities of Daily Living Scale, Bortner Performance Test	Questionnaire	Type A personality prone to having an aggressive behaviour. For irritable TABP driver, strong relationship among disregarding others, occupying driving space and interpersonal attack. For impatient TABP driver, strong relationship among disregarding others, occupying driving space, fast advance, obtaining leading, and interpersonal attack. For hostile TABP driver, strong relationship among disregarding other people, occupying driving space, and interpersonal attack

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Table 3 (continued)

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
Jovanović et al. (2011) Serbia	Relationship between five-factor personality traits model and aggressive driving behaviour	N = 260 (137 males), aged 18–60 years	UK DAS, DAX, Personality inventory (NEO-PI-R)	Driving experience/behaviour	Mail-out survey	Neuroticism, agreeableness, and conscientiousness predicted driving-related anger and aggression. Relationship between neuroticism and aggressive driving is mediated by driver anger, whereas agreeableness and conscientiousness had both a direct and indirect relations with aggressive driving (directly both agreeableness and conscientiousness reduced aggressive driving; indirectly agreeableness reduced and conscientiousness increased driving anger, driving anger increased aggressive driving)
Lennon, Watson, Arlidge, and Fraine (2011) Queensland	Attributions of aggressive driving	N = 193 drivers, 17–36 years	DAS	Responses to 8 scenarios adapted from Propensity for Angry Driving Scale (PADS)	Paper survey (participants randomly assigned to role of perpetrator or victim, responded to 8 scenarios of driver aggression)	Consistent with actor-observer bias, recipients significantly more likely than instigators to endorse inadequacies in instigator's driving skills as cause of driver aggression; focused on safety implications. Perpetrators (a) more likely to attribute behaviours to external but temporary causes (lapses in judgement/errors); (b) focused on degree of intentionality of driver in making assessments; and (c) reported greater emotional impact of driving aggression on recipients
Abdu et al. (2012) Israel	Cause-and-effect relationship in state anger and driving behaviour	N = 15 male students, licensed drivers, 22–27 years	Mood Check (short 6-item questionnaire e.g., "I am happy", "I am angry")	3 situations: light changes green to yellow, option to stop or speed & pass; car suddenly weaves in, time to brake; fast-walking pedestrian enters road, avoidance	Driving simulator (twice) following 1 of 2 emotion inductions based on event recall: angry and neutral (driving behaviours, reaction time)	Following anger induction, drivers crossed more yellow traffic lights and drove faster. However, performance on emergency manoeuvres remained unaffected. Appears state anger affects driving by increasing risk taking, without necessarily compromising skilled behaviours
Delhomme et al. (2012) France	Investigate effect of driving sensation seeking and driver anger on speeding	Study 1 N = 143, Study 2 N = 2038, 19–28 years	Driving Related Sensation Seeking Scale, DAS	Scenario-based speeding intentions; driving experience, mileage, driving fines, involvement in car crash	Study 1: computer aided interview. Study 2: longitudinal three-phase survey	Driving sensation seeking is a better predictor of speeding than driving anger or either of its factors
González-Iglesias et al. (2012) Spain	Relationship between driving anger and various dangerous and risky behaviours including violations and by gender	N = 541 drivers, males and females, 20–73 years, licensed more than 2 years	Reduced versions of DAS and DAX	Traffic Violations in Driver Behaviour Questionnaire (DBQ)	Paper survey collected by researchers at driving assessment centres	Gender differences in driving behaviour Males – greater number of fines and accidents, and more prone to violating traffic regulations; angrier at police presence Females – angrier at traffic obstructions; more adaptive attitude (anger expression forms)

Nesbit and Conger (2012) United States	Evaluate anger experience and expression, and cognitive distortions, of individuals who self-report higher and lower levels of driver aggression	N = 130; Higher aggression (n = 57), lower aggression (n = 73), Intro Psych students, M age = 18.85 years, driving M = 3.64 years	Trait Anger Scale, Hostile Automatic Thoughts Scale, DASA, Modified Dysfunctional Attitudes Scale, Driving Angry Thoughts Questionnaire	Driving survey (driver aggression subscale of the Driving Survey), Anger Expression Scale	Survey	Higher aggression drivers demonstrated a different pattern of affective experience, problematic cognitive tendencies, and subsequent negative outcomes in comparison to those reporting lower levels of aggression
Beck et al. (2013) United States	Relationship between hurried driving and distress tolerance (individual's capability to experience and endure negative emotional states)	N = 769 college students, 18–23 years and older (95.7% aged 18–22 years)	Driver dispositions (3 negative, 3 positive), driver anger (short DAS), 15-item distress tolerance scale	Risky driving, aggressive driving, self-reported traffic citations and crashes	Web-based survey	Hurried driving was significantly associated with lower distress tolerance. Hurried drivers reported greater frustration and impatience with other drivers, suggesting difficulty in withstanding or coping with negative psychological states when driving
Berdoulat et al. (2013) France	Combined effect of 3 predictors of aggressive and transgressive driving: driving anger, aggressiveness, and impulsiveness	N = 455, males and females, 18–81 years	Impulsivity (UPPS Impulsivity Behaviour Scale), DAS, Instrumental/Emotional Aggressive-ness Questionnaire (QAIE)	DBQ, DBQ Transgression Subscale	Survey (online and paper versions)	(1) A significant gender effect for almost all variables; (2) Gender was involved in the prediction of Lapses and Errors (as measured by DBQ); (3) Driving anger, impulsiveness and aggressiveness involved in a complimentary manner in prediction of aggressive and transgressive driving; (4) Aggressiveness and Impeded Progress were best predictors of violations and aggressive violations
Blankenship and Nesbit (2013) United States	Driving stimuli as triggers for aggression-related concepts for individuals predisposed to becoming angry while driving (high in self-reported trait driving anger)	Study 1 N = 131 (M age = 19.45 years, M driving exp. = 4.14 years). Study 2 N = 165 (M age 19.41 years); Introductory Psychology students	DAS, Trait anger (TAS), Prime (pretesting (N = 63) revealed that all stimuli were similar in eliciting low levels of negative emotion)	Study 1 and 2: Reaction time to word/non-word judgment	Study 1 – computer based prime and questionnaires (exposed to 1 of 6 photos of driving-related or 1 of 6 photos of driving unrelated stimuli), letter string (24 aggressive words, 24 nonaggressive words). Study 2 – questionnaires, exposed to Study 1 prime and string, included driving condition (randomly assigned to read 1 of 2 driving scenarios)	Study 1: Participants high in trait driving anger responded more quickly to aggressive words when paired with driving than neutral stimuli. No differences in primes for nonaggressive words and non-words Study 2: For participants high in driving anger, increased accessibility of aggressive words following driving primes predicted self-reported anger in a provoking driving scenario
Blankenship et al. (2013) Iowa	Self-validating role of anger within provoking driving situations	N = 1444 Introductory Psychology students (M age = 19.26 years, M years driving = 3.81 years)	Thoughts (reported as read scenario), thought confidence measures, level of state anger, rage, irritation	DAS	Scenario method Study 1 – role of thought confidence in anger experience Study 2 – whether thought confidence mediates relation between anger and behavioural intentions	Study 1: Participants higher in driving anger more confident in thoughts in provoking situation and thought confidence mediated effect of trait driving anger in response to provocation. Study 2: Thought confidence mediated influence of anger on aggressive driving intentions, but only for individuals higher in driving anger

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Table 3 (continued)

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
Roidl, Siebert, Oehl, and Höger (2013) Germany	A multivariate model for predicting driving performance: the role of driving anger and personal characteristics	Study 1 N = 74 (60% female, 18–31 years, M licensed 3.12 years). Study 2 N = 80 (60% female, 18–52 years, M driving exp. 6.49 years)	Emotions via adjusted Geneva Emotion Wheel questionnaire, German version of DAS, Motivation	Driving patterns (mean velocity (km/h), acceleration (m/s ²), lateral acceleration (m/s ²)); speeding violations	Study 1 – Induced emotions with short video clips. Study 2 – Confronted participants with potentially anger-inducing traffic situations during simulated drive	Participants who experienced high levels of anger drove faster and exhibited greater longitudinal and lateral acceleration. Highly motivated male drivers displayed same behaviour independent of emotional state
Wickens et al. (2013) Canada	Developed 10-category offensive driver behaviour coding scheme; developed coding scheme to characterise perceptions of why offensive driver behaviours occurred	N = 199 (58 males, M age 23.2 years, M licensed 6 years)	Driving diaries (4 online, once every 2 days to record negative driving event involving motorist), critical incident description, perceived cause	Driving diaries include both emotion measures and behaviours	Content analysis; Offensive driver behaviour coding scheme (diary entries coded), Perceived cause of the offensive behaviour coding scheme (possible causes identified by participants for offending driver's behaviour)	Most frequently reported driving behaviour – weaving and cutting (33%). Slow driving (20%), speeding (13%), perceived hostile driver displays (13%), and tailgating (11%). Inter-rater reliability of coding of 3 causation categories (retaliation, time urgency, and negligence) within acceptable range and improved when applied exclusively to critical diary entries identified by each participant as most negative and upsetting. Application of the behaviour coding scheme to Ontario Principal Police (OPP) records provided information concerning daily, weekly, and seasonal variations in risky and aggressive driving behaviour that could be used to more efficiently target problem drivers
Aniței et al. (2014) Romania	Utility of Big Five personality factors in predicting aggressive driving behaviour	N = 100 (64 females), 2nd year Psychology and Science Education students, 18–25 years	International Personality Item Pool (IPIP)	Assessment of Aggressive Driving Behavior (AVIS)	Questionnaire	Aggressive driving behaviour predicted by low emotional stability. The other personality factors predicted dimensions of aggressive behaviour: extraversion predicted increased enjoyment of violence; openness to experience predicted negativism in traffic; low agreeableness predicted enjoyment of violence; and low conscientiousness predicted driving anger
Beck et al. (2014) Washington D.C.	Relationship between distress tolerance and risky and aggressive driving	N = 796 college students, 18–23 years	15-item distress tolerance scale	Risky driving behaviour, aggressive driving	Web-based survey	Distress tolerance significantly inversely related to risky driving and aggressive driving: Participants with diminished capacity to endure frustration without experiencing negative emotional states (i.e., low distress tolerance) tend to drive aggressively and in a risky manner
Rosenborough and Wiesenthal (2014) Canada	Effect of punishment of road rule violators on feelings of anger and happiness in witnesses and victims	N = 279, 17–43 years	How happy or angry behaviours made them feel; again after being informed violator had been punished	NA	Exposed to 4 animated unjust driving behaviour simulations (written vignette/animated video)	While inconsistent, analyses generally indicated perceived punishment reduced feelings of anger and increased feelings of happiness

Wan et al. (2014) Wuhan, China	Electro-encephalogram (EEG) characteristics in angry driving conditions	N = 10, male professional taxi drivers, 22–40 years	Self-report driver anger	EEG recordings	Drive along a real and particularly busy route (driving task had to be completed within a limited period of time and encountered anger inducing special traffic events such as waiting at a red light, traffic congestion, offensive lane merging, and illegal pedestrian roadway crossings)	Amplitude of EEG signal and mean value of frequency percentage of β waves is significantly larger, and frequency percentage of δ waves is much smaller, under angry driving conditions compared with normal driving conditions Compared with subjects' self-assessment for emotion recognition, the physiological signals are a more objective method for determining emotion. The results may provide theoretical support for designing emotion recognition equipment in the future
Chraif, Aniței, Burtăverde, and Mihăilă (2015) Romania	How personality factors, aggressive driving, and risky driving outcomes interact	N = 293 (252 male, M licensed = 14.34 years)	International personality item pool questionnaire	AVIS, risky driving outcomes (crashes, traffic tickets, licence suspensions)	Computerised questionnaires	Aggressive driving negatively related to emotional stability, agreeableness, and conscientiousness and positively related to risky driving outcomes. Agreeableness was negatively related to accidents, tickets, and licence suspension. Conscientiousness negatively related to tickets. Structural model was supported by data in which agreeableness predicted risky driving outcomes. Emotional stability, agreeableness, and conscientiousness predicted aggressive driving, which in turn predicted risky driving outcomes. Aggressive driving was shown to be a mediator in the relationship between agreeableness and risky driving outcomes
Chraif et al. (2015) United Kingdom	Psychometric properties and discriminant validity of English version of AVIS	Study 1 N = 229 men, 25–40 years. Study 2 N = 226 men (M age = 33.07 years)	AVIS and DAX	NA	Online survey	The results showed good discriminant validity, the dimensions of the two instruments being uncorrelated. The English version of AVIS is a valid instrument that can be used successfully in assessing driving aggression in future research projects and psychological assessment, while at the same time contributing to the development of the construct of driving aggression
Oliver et al. (2015) United States	Relationship among ADHD symptoms, negative emotions, emotion control, driving anger, safe driving	N = 246, college students (M age = 18.7 years)	ADHD Current Symptoms Scale; STAXI; Emotional Intensity Scale (EIS)	Driving outcome measures (DAS, Driving Behaviour Survey (DBS))	Survey	Both negative emotions and emotion control were significant mediators of relationship between ADHD symptoms and driving anger, but not safe driving behaviour. Mediation was stronger for ADHD-Hyperactive/Impulsive symptoms than for ADHD-Inattention symptoms
Svetieva et al. (2015) Australia	Mediating effect of ostracism-induced anger on risk-taking and risky driving	Study 1 – N = 52 (M age = 19.35 years, 35 females). Study 2 N = 72 (M age = 22.04 years, 45 females) Introductory Psychology students	Ostracism manipulation check (12-item self-report primary needs questionnaire), Anger affect	Risk-taking (modified version of the Evaluation of Risks Questionnaire)	Study 1 – Ostracism manipulation (Cyberball paradigm – virtual ball-tossing game online), questionnaire (affect, risk-taking). Study 2 – Driving task (PC-controlled driving simulation/gaming consoles – driving game <i>Burnout Paradise</i>), Ostracism manipulation, Questionnaire	Study 1: Ostracism increased self-reported risk-taking inclinations, and relation between ostracism and risk-taking was mediated by feelings of anger, but not control Study 2: Ostracism increased risky driving during a driving video game. Effect of ostracism on risk-taking again mediated by post-ostracism anger (but not control or ostracism-induced sadness) Suggests that anger elicited by ostracism may increase risk-taking

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Table 3 (continued)

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
<i>Distraction and inattention</i>						
Briggs et al. (2011) United Kingdom	Effects of varying participants' level of emotional involvement in conversation	N = 26, half spider-phobic, males and females, 19–55 years	Spider Phobia Questionnaire, The State-Trait Anxiety Inventory – form Y1	Heart rate monitoring (cognitive workload), eye tracking, driving errors	Driving simulator, either undistracted or while conversing on subject of spiders	Spider-phobic (more emotionally involved in conversation) significantly higher cognitive workload (heart rate), more driving errors, and demonstrated significant decline in range of visual fixations, showing pattern of visual tunnelling; the more emotionally involving a conversation, the greater the potential for distraction
Chan and Singhal (2013) Canada	Driver distraction from emotional information presented on roadside billboards	N = 37, 18–30 years, University students	Priming with emotional words	Driving performance (mean speed, lane position, steering wheel rate/angle), response rates and error rates, proportion of words recalled	Driving simulator, 3 types of emotional information (neutral, negative emotional, and positive emotional words). Responded to target words while driving, surprise free recall task (all words) at end of drive	Driving performance differentially affected by valence (negative vs. positive) of emotional content. Lower mean speeds when there were emotional words compared to neutral words, and this slowing effect lasted longer when positive. When required to process non-emotional target stimuli, drivers had faster mean speeds in conditions where targets were interspersed with emotional words compared to neutral words, and effects lasted longer with positive words. Negative information led to better memory recall
Serrano et al. (2014) Spain	Affective sound effects on driving behaviour	Study 1 (n = 19), 18–27 years Study 2 (n = 20), 18–27 years	Emotional warnings (auditory stimuli: baby's scream and baby's laugh)	Reaction time	Computer-based reaction time task (4 naturalistic road pictures presented): 2 risky and 2 non-risky situations. Emotional warnings (3 auditory stimuli)	Participants quicker to evaluate whether a traffic scene was risky or not after hearing an emotionally-charged auditory stimulus than after a neutral one. However, urgent (braking) responses to same scenes were not affected by emotional quality of auditory signal
Qu et al. (2015) China	Analyse relationship between mind wandering in daily life and dangerous driving	N = 295 drivers, 19–55 years	Dula Dangerous Driving Index (DDDI)	Mind Wandering Scale (MW)	Survey	Frequency of mind wandering positively correlated with risky driving (including self-reported crashes and offences), aggressive driving, negative cognitive/emotional driving, and drunk driving. In 'high mind wandering' group, male drivers reported more risky and negative emotional driving behaviours than females

America and Europe/the United Kingdom, 3 papers emerged from Asia, and 2 papers each emerged from the Middle East and Australia. Ninety-two percent of papers were published in 2010 and later, consistent with the increasing interest in the relationship between driving emotions and the driving behaviour of adolescents observed in Sections 3.1 and 3.2. As noted in Section 3.2.2, methodological advances were also apparent within the literature in Table 2, with [Chraif, Dumitru, Aniței, Burtăverde, and Mihăilă \(2015\)](#) validating an English version of an aggressive driving self-report scale.

While the experience of anger when driving appears to differ around the world, with drivers in America and Australia reportedly experiencing more driving anger than drivers in Britain and Japan (see [McLinton & Dollard, 2010](#), 18–73 years), greater anger has consistently been found to be predictive of a breadth of risky driving behaviours including speeding (e.g., 18–52 years, [Roidl et al., 2013](#)), tailgating and weaving through traffic (average age 23.2 years, [Wickens, Roseborough, Hall, & Wiesenthal, 2013](#)). There also appears to be some evidence of the differential experience of contributors to driving anger by driver sex, with males experiencing greater anger in the presence of police while females experience greater anger in response to traffic obstruction (20–73 years, [González-Iglesias, Gómez-Fraguela, & Luengo-Martín, 2012](#)). In addition, there appears to be a complex interrelationship evident among individual traits (i.e., stable qualities such as personality), states (i.e., transient characteristics such as anger), the driving context (e.g., congestion, impeded progress), and angry and aggressive driving behaviour which is relatively robust.

At the simplest level, traits, states, and context can impact upon angry and aggressive driving behaviour directly. To illustrate, research has demonstrated that Type A personalities exhibit more aggressive driving behaviour (e.g., 18–58 years, [Hui et al., 2011](#)), that persons higher on trait anger recall aggressive words faster in discussing provoking driving scenarios (average age 19.26 years, [Blankenship & Nesbit, 2013](#)) and that these drivers and drivers lower on agreeableness report more aggressive driving (e.g., 18–60 years, [Jovanović, Lipovac, Stanojević, & Stanojević, 2011](#)), driving anger is predicted by lower levels of driver conscientiousness (18–25 years, [Aniței, Chraif, Burtăverde, & Mihăilă, 2014](#); licensed average 14.34 years, [Chraif et al., 2015](#)), and that sensation seeking propensity is a strong predictor of speeding ([Delhomme, Chaurand, & Paran, 2012](#)), risky and aggressive driving violations (21–51 years, [Schwebel, Severson, Ball, & Rizzo, 2006](#)). There is also consistent research from around the world supporting the finding that lower emotional stability predicts aggressive driving behaviour ([Aniței et al., 2014](#); [Chraif et al., 2015](#)), such that adolescent driver anger precedes angry and aggressive driving (e.g., [Jovanović et al., 2011](#)), with drivers higher on state anger engaging in more risky driving behaviour (e.g., 22–27 years, [Abdu, Shinar, & Meiran, 2012](#); 18–25 years, [Villieux & Delhomme, 2010](#)) but not displaying any deficits in performing emergency manoeuvres during driving simulation ([Abdu et al., 2012](#)). Furthermore, there is evidence that context plays an important role in angry behaviour, with adolescents deliberately excluded from a game (i.e., ostracised) experiencing greater anger and reporting more risk-taking and risky driving behaviour specifically (average age 22.04 years, [Svetieva et al., 2015](#)). Within the driving context, impeded progress has been found to predict aggressive violations (18–81 years, [Berdoulat, Vavassori, & Sastre, 2013](#)) and hurried driving contributes to reduced distress tolerance and coping and increased frustration (18–24 years, [Beck, Daughters, & Ali, 2013](#)), culminating in more aggressive driving and risky driving behaviour (18–23 years, [Beck, Ali, & Daughters, 2014](#)).

However, as evidenced in the social-cognitive model of driving aggression – in which cognitive, situational, and dispositional factors are more fully considered ([Dula, Geller, & Chumney, 2011](#)) – these relationships are complex: for example, angry and aggressive driving has been found to increase sensation seeking propensity, anger and anxiety, which leads to risky driving behaviour (e.g., 18–30 years, [Alsaleh, 2006](#)). As noted in Section 3.1 in which changes in brain function were apparent in drivers who could not regulate their emotions, changes in EEG signals have been found for adolescents in angry driving conditions (22–40 years, [Wan, Wu, & Ma, 2014](#)). In addition, for drivers with ADHD, negative emotions mediated (and increased) the influence of hyperactivity and impulsivity symptoms upon driving anger, while emotion control mediated (and decreased) the influence of hyperactivity and impulsivity symptoms upon driving anger (average age 18.7 years, [Oliver, Han, Bos, & Backs, 2015](#)). The influence of anger upon aggressive driving intentions has also been found to be mediated by confidence in thoughts ([Blankenship, Nesbit, & Murray, 2013](#)), with persons who engaged in more aggressive driving have been found to have distorted cognitions and affective experiences compared to drivers who engaged in less aggressive driving (average age 18.85 years, [Nesbit & Conger, 2012](#)). Finally, if the driver perceives that another road user has ‘done something wrong’, any anger they feel in response to this action is reduced – and happiness increased – through the observed punishment of that other road user (17–43 years, [Roseborough & Wiesenthal, 2014](#)), further demonstrating the complex intricacies of driving anger and driving behaviours.

3.3.2. *Distraction and inattention*

Of four papers only exploring the relationship between emotions, distraction and inattention for adolescent drivers, two papers comprised simulator-based research, and one paper each operationalised survey research and computer-based reaction time testing. Papers were again published recently, with publications in 2011, 2013, 2014, and 2015, and papers emerged from the United Kingdom, Spain, China and Canada. Regarding inattention, drivers (including adolescent drivers) who reported mind-wandering also reported more risky driving behaviour, more emotional driving, and more aggressive driving, particularly males (19–55 years, [Qu et al., 2015](#)). Similar to the lack of influence of emotions upon emergency driving manoeuvres (see Section 3.3.1), emotionally-charged auditory stimuli did not influence reaction time in a computer-based task, while emotionally-charged auditory stimuli resulted in faster appraisal of the riskiness of the presented traffic scene (18–27 years, [Serrano, Di Stasi, Megías, & Catena, 2014](#)). In contrast to the influence of fear discussed in Section 3.1.2, drivers who were negatively-emotionally aroused due to a discussion of spiders experienced increased heart rates, more driving

errors, and visual tunnelling in a simulator driving task (19–55 years, Briggs, Hole, & Land, 2011), while drivers who recalled emotional words (both negative and positive valence) related to roadside billboards during a driving simulator task drove at slower speeds, if the words were positive. Interestingly, drivers had better recall of negative words (18–30 years, Chan & Singhal, 2013), suggesting that drivers may pay greater attention to negative cues.

3.4. *Emotions, the adolescent, and road safety interventions*

Table 4 summarises the literature regarding emotions, the adolescent, and road safety interventions. Of these six papers, two papers comprised survey research, and one paper each comprised motivational interviewing/relaxation training, interviews, priming, and watching commercials. Papers emerged from North America (3), Europe (1), the Middle East (1), and Australia (1), and publication dates were relatively consistent with one each in 2006, 2007, 2010, 2011, 2012, and 2015.

While it appears that there is no immediate negative effect of brief exposure to an emotionally-evocative risky driving commercial upon young driver behaviour (18–64 years, Vingilis et al., 2015), the ‘real world’ – characterised by repeated exposure via different mechanisms and in different contexts – impact remains unknown at this time. Interestingly, an investigation of the texting and driving behaviour of young drivers revealed that the behaviour was associated with less mindfulness, and, consistent with earlier findings regarding the need for and the difficulties associated with emotion regulation during adolescence, that texting while driving served an emotion regulation purpose (average age 19.74 years, Feldman, Greeson, Renna, & Robbins-Monteith, 2011). Moreover, unless adolescent drivers believed that the behaviours portrayed in positive-focused intervention advertising (i.e., that they had response efficacy) there were unlikely to accept the message within such interventions (17–60+ years, Lewis, Watson, & White, 2010).

Interventions targeting two problematic groups have further highlighted the inescapable young driving problem/problem young driver dichotomy previously raised in Section 3.1.1. Accordingly, intervention regarding emotion-related risky driving behaviour should consider not only the young driver problem (as argued in the introduction all young drivers are adolescents and thus are emotionally-vulnerable developmentally), intervention should consider specific sub-populations of young drivers based on a growing body of evidence which suggests heterogeneity among this at-risk population (e.g., Scott-Parker et al., 2013). To illustrate, teen male incarcerated juvenile offenders who participated in a motivational interviewing intervention reported less drinking and driving, and being a passenger of a drinking driver, than males who participated in a relaxation training intervention, particularly if they were experiencing lower levels of state depression (Stein et al., 2006). In addition, in-depth interviews with seven young male ‘excessive speeders’ revealed that interventions should consider evoking the emotional aftermath of a serious crash caused by such drivers (Falk & Montgomery, 2007). These intervention-related findings speak to the complexity of intervening in emotion-related young driver behaviour, including operationalising emotion-related interventions themselves.

4. General discussion

4.1. *Synthesis of findings*

Operationalising the Transportation Research Board guide for conducting literature searches and literature reviews within the domain of young (adolescent) drivers, emotions, and driving behaviour, during just over a 10-year period has revealed a wealth of peer-reviewed literature best conceptualised within the domains of emotions and the adolescent (44 papers), emotions, the adolescent, and driving risks (23 papers), emotions, the adolescent, and risky driving behaviour (30 papers), and emotions, the adolescent, and road safety interventions (6 papers). A breadth of research methodologies were operationalised within the literature, ranging from self-report techniques such as interviews and surveys, simulator-based studies including computer-based priming studies, and naturalistic studies. In addition, while not a specific focus of this literature review, it is noteworthy that while some theory was applied within the context of this research, particularly within the domain of angry and aggressive driving, much of this work was atheoretical (i.e., no theoretical framework guided the research into risk factors, relationships, and/or intervention).

A synthesis of the findings summarised thus far reveals the complex interrelationship between the adolescent driver, their emotions, the driving context, and their driving behaviour. Regarding the characteristics of the adolescent driver, similar to other non-emotion-related peer-reviewed literature, the characteristics of the young driver appeared influential in understanding the impact of emotions upon risky driving behaviour. To illustrate, personality traits such as ‘Type A’ personality, decreased agreeableness, and increased sensation seeking corresponded to greater speeding behaviour. Similarly, various driver states, including anxiety, depression, and anger, corresponded to more risky driving behaviour. In contrast, greater self-regulation of emotions (i.e., emotion regulation), corresponded to less risky driving behaviour, and less angry driving behaviour when driving with peers as passengers, with greater emotional intelligence leading to fewer emotion regulation difficulties. It is noteworthy however that developmental delay in emotion regulation during adolescence is normative, and contributes to risky driving behaviour by adolescent drivers, such that reduced regulation and increased emotionality is associated with more aggressive driving behaviour and decision-making difficulties, which are impacted further upon by the driving context (including social influences, the purpose of driving, and time pressure) and the personal characteristics of the driver. For example, pre-teen emotional problems were found to indicate that the teen was likely to

experience greater emotional problems, while sleep deprivation, insomnia, and ego-depletion (emotional fatigue) contributed towards difficulties with emotion regulation. Ego depletion also decreased distress tolerance and increased frustration which further contributed towards ego depletion, while increasing reaction time, sensation seeking propensity, and risk taking propensity. Furthermore the heterogeneity of 'adolescent drivers' per se merits further consideration, particularly the problem young driver within the larger young driver problem, and adolescent drivers with ADHD, as research suggests that increased emotional control decreases the influence of hyperactivity and impulsivity on driving anger.

Regarding the characteristics of the driving context, driving exposure characterised by the external driving environment (e.g., impeded traffic) which can and does interact with the behaviour of the driver (e.g., hurried driving), and the internal driving environment (e.g., vehicle passengers) play an important role in both the direct and mediated impact of emotions on adolescent driver behaviour. Passengers in particular are a salient, immediate source of reinforcement via social rewards which are emotionally-pleasant for the adolescent driver who is developmentally increasingly-sensitive to social and emotional cues. Regarding the driving behaviour itself, which can comprise intentionally or unintentionally risky driving behaviour, emotions were found consistently to affect mood, and mood was found consistently to affect driving behaviour, such that the adolescent driver experiencing strong emotions (and moods) was more likely to *engage* in risky driving behaviour such as speeding, and to *not engage* in protective driving behaviour such as wearing seatbelts. The adolescent driver is still developing cognitively, and as such may have distorted cognitions *before* entering the vehicle and experiencing strong emotions (Path A, Fig. 1) or experiencing strong emotions before entering the vehicle (Path B, Fig. 1), and while such cognitive distortions are associated with angry and aggressive driving behaviour, there is a growing body of research which reveals that the adolescent driver is still capable of accurate emergency manoeuvres. Emotions were also found to impact upon decision-making, which can be unconscious or conscious, and decision-making also impacted upon driving behaviour. To illustrate within the context of risk and hazard perception, emotional contexts were found to decrease sensitivity to hazards (positive affect was found to decrease risk perception and increase risky driving behaviour, while negative effect delayed hazard perception), while neutral contexts increased sensitivity to hazards while adolescent drivers were most risk averse when no emotional responses evoked.

Regarding intervention in adolescent emotional driving, it appears that the relationship between emotions, adolescence, and risky driving behaviour merits further consideration, particularly as we intervene in adolescent road safety as if the population is homogeneous when it clearly is heterogeneous. In addition, while distracted driving such as driving while texting or while ruminating is associated with emotional and angry driving, further explication of factors contributing to this risky driving behaviour reveals that using a mobile phone while driving served an emotion regulation purpose for the adolescent driver. This finding suggests that adolescents themselves have elucidated ways in which to regulate emotions in a developmentally-hindered context, albeit through the engagement in risky secondary tasks such as texting (e.g., [Klauer et al., 2014](#)). Further, social norms were found to mediate the influence of the adolescent's sensation seeking propensity upon driving after drinking, consistent with recent applications of systems thinking that asserts that multi-faceted interventions should consider the larger young driver road safety system, rather than simply targeting the young driver themselves (see also [Scott-Parker, Goode, & Salmon, 2015](#); [Scott-Parker, Goode, Salmon, & Senserrick, 2016](#)). In addition, while the presentation of emotionally-charged stimuli was found to lead to faster riskiness appraisal, consistent with the findings regarding emotionally-charged stimuli discussed above, negative stimuli (in this case, spiders) led to driving errors and visual tunnelling in adolescent drivers. Notwithstanding this finding, better recall of negative words was found in an emotional auditory task, raising the question: Are adolescent drivers (and arguably all drivers as fundamentally-emotional human beings) cued, given the potential life and death consequences, to pay attention to negative cues?

4.2. Directions for future research

The literature review and the synthesis of findings has revealed a plethora of research directions. Clearly we do not yet understand fully the impact of emotions – negative, neutral, and positive – upon driving behaviour, and conversely the impact of driving behaviours upon emotions. In addition, as represented in Fig. 1, we do not fully understand the synergies between emotions, the personal characteristics of adolescent drivers, the driving context, and driving behaviours through the complex pathways depicted. Given the predominantly recent emotion-adolescent driver-driving behaviour literature reviewed, and the recent development and application of a breadth of innovative methodologies, a wealth of research can be undertaken within key domains. Such research is fundamental for guiding effective intervention, and it is noteworthy that – where possible – application of relevant psychosocial theory should be considered ([Scott-Parker, 2012](#)). It is also noteworthy that much of the research identified in this systematic literature review operationalises methodologies in which diverse participant samples are included, with some research including participants as old as 76 years. While the inclusion of participants in different developmental periods such as early adulthood (20s and early 30s; and for the purposes of young-driver related research could comprise samples aged 25–35 years), middle adulthood (late 30's to mid 60's) and late adulthood (65 and older) is important for comparative purposes and can reveal important distinctions in characteristics, experiences, and behaviours, these comparisons and differences and/or similarities were not readily apparent in all of the reviewed literature.

Moreover, the influence of a breadth of developmentally-normative – and arguably developmentally-critical – social influences merits further consideration. For example, the influence of friends during adolescence, and in particular their impact upon driving behaviour through the experience of and/or the manifestation of various emotions before the drive (thus Path B, Fig. 1) or during the drive (thus Path A, Fig. 1). Perhaps of greater interest, given their pervasive influence

Table 4

Emotions, the adolescent, and road safety interventions.

Author, Publication year, Jurisdiction	Context	Participants	Emotion measure(s)	Behaviour measure(s)	Methodology	Main findings
Stein et al. (2006) Rhode Island	Motivational interviewing/relaxation training to reduce driving under influence of drugs/alcohol	N = 105, 90% male, aged 14–19 years	Alcohol/marijuana dependence: Clinical Interview, DSM-IV (SCID-I); depressive symptomology via Centre for Epidemiological Studies-Depression Scale (CES-D)	Risky behaviours (Risky Behaviours Questionnaire, RCQ)	Interventions (Motivational Interviewing and Relaxation Training), 3-month follow up interview	When compared to Relaxation Training (RT), adolescents who received Motivational Interviewing (MI) had lower rates of drinking and driving, and being a passenger in a car with someone who had been drinking at follow-up. Effects were moderated by levels of depression: At low levels of depression, MI evidenced lower rates of these behaviours; at high levels of depression; effects for MI and RT were equivalent. Similar patterns found for marijuana-related risky driving
Falk and Montgomery (2007) Sweden	Informing design of road safety interventions	N = 7, males, aged 20–23 years	N/A	Frequently, substantially, deliberately exceeding the speed limit when driving (habits and motives)	In-depth interviews; eliciting tasks: (1) free associations for "risks in traffic"; (2) scenario technique – imagine visualise and verbalise a serious accident and its aftermath; (3) open-ended questions on risk-taking beliefs	(1) Self-image as a good driver brings self-esteem; (2) Commanding high speed is associated with pleasurable sensations; (3) Drivers are aware of risks, but serious outcomes are not salient; (4) Imagined crash scenarios evoke outcome conceptions; (5) Perceived cause of crash influences anticipated affective reactions. Conclusion: interventions based on imagining emotional aftermath of being the perpetrator of a serious crash should be developed and tested
Lewis et al. (2010) Queensland	Improve understanding of persuasive process of emotion-based appeals in relation to negative fear-based appeals and positive emotions	N = 406 (268 females), aged 17 + (age distributions: 17–24 years (42.9%), 25–34 years (23.4%), 35–44 years (18.2%), 45–54 years (11.8%), 60 + years (0.7%))	Responses to message assessed on 7-point likert scale (response efficacy, emotional responses, message acceptance, message rejection)	N/A	Online survey Emotional appeals (one negative, fear-based and two positive emotion-based messages, one pride- and the other a humour-based appeal). Messages pre-tested with focus groups of drivers	Confirmed importance of emotional and cognitive components of persuasive health messages, identified response efficacy as key cognitive construct influencing the effectiveness of both negative and positive emotion-based messages. Response efficacy's influence on message effectiveness may differ for positive or negative emotion-based appeals such that significant indirect (and mediational) effects were found with both acceptance and rejection of positive appeals yet only with rejection of negative appeals
Feldman et al. (2011) Boston	Examined mindfulness in relation to texting while driving	N = 231 undergraduate students, females M age = 19.74 years	Cognitive and Affective Mindfulness Scale	Frequency of texting while driving	Survey	Individuals lower in mindfulness reported more frequent texting-while-driving – mediated primarily by emotion-regulation motives (i.e., texting to ameliorate negative emotional states)

Taubman-Ben-Ari (2012) Israel	Impact of positive priming on willingness to drive recklessly	S1: N = 114, 17–22 years; S2: N = 135, 17–18 years, S3: N = 103, 17–19 years; S4: N = 104, 18–22 years; S5: N = 115, 17–22 years	Emotion priming manipulation check (rate degree to which they were feeling each of the 10 emotions)	Studies 1, 2, 3, 4 & 5: self-report scale (proneness to reckless driving) Study 3 & 5 also included Multidimensional Driving Style Inventory (MDSI)	Participants exposed to 1 prime of positive affect: positive mood story; happy memories; exciting film; relaxing film; thoughts on meaning of life; then reported on willingness to drive recklessly. Responses compared to others exposed to neutral affect, another kind of positive affect, or negative affect priming	Positive affect (especially in the form of arousal) was related to higher willingness to drive recklessly Men tended to report higher intentions to drive recklessly, however men and women did not react differently to the emotional induction Positive emotions of a relaxing nature, as well as thinking about the meaning of life, lowered the willingness to engage in risky driving
Vingilis et al. (2015) Canada	Explored impact of risky driving in television commercials on attitudes, emotions, and risky driving inclinations	N = 175 undergraduate Students, aged 18–64 years, driver's licence (M licensed = 4.3 years), M driving = 9.3 h/week	Implicit Attitude Test (IAT) – risk-positive attitudes; Driver Thrill Seeking Scale (DTSS) – risk positive emotions; Vienna Risk Taking Test – Traffic (WRBTV) – risky driving inclinations	NA	Participants randomly assigned to 1 of 3 conditions (risky driving motor vehicle commercial, non-risky driving motor vehicle commercial, non-motor vehicle commercial)	Type of commercial watched did not affect performance on the IAT, DTSS, or WRBTV The main effect of heightened risk-positive emotions and risky driving inclinations was found for males Despite public and governmental concern that risky driving motor vehicle commercials may increase the likelihood that people exposed to these commercials engage in risky driving, this experimental study found no immediate effect of brief exposure to a risky driving motor vehicle commercial on risk-positive attitudes, emotions or risky driving inclinations

throughout the lifetime of the adolescent, including the development of emotion regulation capacities, and their modelling of driving behaviours and attitudes, long before the adolescent is seated behind the steering wheel, then their capacity to regulate driving behaviours and to assist their adolescent to develop emotion regulation capacities behind the road through reinforcement during driving supervision is the seemingly undervalued and underexplored influence of parents. In addition, it is noteworthy that future research specifically within the domain of emotion-adolescent drivers-driving behaviours should operationalise best practice methodology and reporting practices (Scott-Parker & Senserrick, 2013, in press) including reporting response rates and recruitment practices to inform generalisability of findings and further guide intervention development, application and evaluation. It is notable that, while the publication date was the indicator of the 'recency' of the research/review, this indicator may have obscured the actual period during which the research was undertaken due to the idiosyncrasies that is the nature of peer-reviewed dissemination of research findings. While some relevant research may not have been identified as it did not fit within the search parameters (i.e., published before the search period, or did not feature the word 'adolescent'), this literature review had clearly identified parameters in addition to resolving some of the terminology- and reporting-related issues associated with young-driver-related research. Accordingly, some research questions are posed (note, this is not an exhaustive list, and indeed addressing one or more of these research questions will subsequently pose additional research questions derived from the research therein).

Regarding the adolescent driver themselves, does the impact of emotions – and thus the capacity to intervene, and the nature of the intervention to ameliorate or mitigate the impact of these emotions – differ according to whether the adolescent driver becomes emotional *before* they enter the car or *after* they enter the car? Does it differ if they become more emotional while they are driving after entering the car in response to an initial emotional trigger? Does the emotional response differ in the short term and the long term related to the driving context (e.g., greater mileage) or the adolescent driver's characteristics (e.g., psychosocial maturation), suggesting that the intervention may need to differ according to these variables? Are there other as yet unidentified influential emotion-related factors pertaining to the adolescent driver? How heterogeneous/homogeneous are adolescent drivers? How heterogeneous/homogeneous are emotional triggers for adolescent drivers? How heterogeneous/homogeneous are emotional responses pre/post entering the car (c.f. Fig. 1) by adolescent drivers? How does the adolescent's behavioural response to an emotional trigger differ according to the differential influence of peers, vis-à-vis Path A and Path B? How does the adolescent's behavioural response to an emotional trigger differ according to the differential influence of a breadth of parenting-related factors, including but not limited to parenting style, pre-driving modelling, learner driving instruction, and driving regulation, vis-à-vis Path A and Path B?

Regarding the driving context, does the driving context impact upon these emotional triggers and these emotional responses, and in what way? What role does the purpose of driving play in the triggers for emotional responses and responses to these emotional triggers? What role does car ownership play in the triggers for emotional responses and responses to the emotional triggers? Regarding their driving behaviour, do emotions play a role in learning to drive, learning to drive safely, and learning to drive while minimising the negative impact of emotions and maximising the positive impact of emotions? What is the balance between paying attention to negative cues, positive feedback, and safety? What is the differential impact of emotion on emergency and other manoeuvres? Is there an influence of automaticity in an emergency despite the core human characteristic of emotion? Can this influence be transferred to non-emergency driving contexts? Regarding intervention, can interventions such as GDL target emotional triggers and emotional responses more specifically? Can we intervene pre-licensure to assist adolescents in developing emotion/self-regulation skills in other high risk contexts and transfer these skills to the driving context? What do interventions that recognise the crash risk-critical influence of emotions upon adolescent driver behaviour actually look like? What do interventions that target problem young drivers actually look like? Do emotion-focused interventions need to be developed for drivers of all ages and experience levels?

5. Concluding remarks

To the author's knowledge, this is the first literature review which explicitly followed transportation-specific best practice in conducting literature reviews, and synthesised the findings relevant to adolescents, emotions, and driving behaviour. Moreover, the recent application of systems thinking within the road safety context, and within the domain of young driver road safety specifically, coupled with the increasing recognition that young drivers are a heterogeneous cohort of adolescents experiencing a breadth of safety-related developmental issues, supports assertions that current road safety interventions do not adequately address the complex interrelationships among adolescent characteristics and their emotions, the driving context and their driving behaviours. The research questions posited subsequent to the synthesis of the literature from 103 relevant articles published over more than a decade will yield invaluable insight into these interrelationships and thus yield invaluable guidance for effective and efficient intervention development, application, and evaluation.

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