What does current research tell us about why drivers engage with technological distractions: A Review.

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Abstract:

There has been extensive research into driver distraction in recent years that has aimed to measure the behaviour and its resulting effects. This has assisted in determining the capabilities of the driver to engage with secondary tasks while driving. Yet, as evidenced by the large number of reported incidents relating to driver distraction, drivers are still choosing to engage with distracting technologies. The factors influencing why drivers engage with distractions is a complex issue that requires an insight into the drivers own subjective opinions and interior thoughts. Therefore, in order to determine why distraction occurs, methods that are able to capture the drivers' perspective and the surrounding context of the behaviour are required. It is identified that subjective research is key in obtaining this data. In order to gain an insight into the current understanding of subjective research, a document analysis and review was conducted.

31 papers utilising subjective methods to study driver distraction from the drivers' perspective were found, compiling 14,140 participants across eight countries. The studies were reviewed to determine the methods that were used, the key themes that have been identified and the recommendations subsequently made by the authors. It was evident that subjective data has the potential to provide detail on the factors and context surrounding why drivers engage with technologies, which cannot be derived from objective methods. Current trends in subjective research into driver distraction from in-vehicle technology are highlighted, alongside future recommendations.

1. Introduction

Technological advancement is having a large impact on road safety [1]. Some technologies aim to enhance the safety of the driver and other road users, such us advanced warning systems, adaptive cruise control and hands-free technology [2]. Yet, other technological developments impede on the safe regulation of the driving task, predominantly portable devices that were not intended for use by drivers but are being brought into the vehicle, e.g. mobile phones [3], music players [4], and other smart technologies [5]. Distraction in the context of driving has been defined by Lee et al [6] as: attention directed away from activities that are "*critical for safe driving, towards a competing activity*" (p38). As drivers continue to rely on technology throughout their daily activities, its prevalence within the vehicle is set to increase [7], coinciding with the current upwards trend of death by dangerous driving

convictions [8, 9]. Research into the phenomenon of driver distraction from technology has thus tried to understand the behaviour and devise novel countermeasures

It is common for research into driver distraction from technological sources to objectively measure and observe the behaviour, using driving simulators and on-road studies. This has enabled an understanding of how drivers' behaviour is affected when interacting with secondary tasks. Reduced hazard detection [10], poor vehicle control [11], attention tunnelling [12], as well as identifying some compensatory mechanisms employed by drivers [13, 14] are examples of this objective measurement. Research has also quantified the duration of potentially distracting tasks to be those requiring more than 15 seconds in total, comprising no more than individual chunks of 2 seconds [15]. This quantification of distraction has highlighted the disruption of technologies such as mobile phones that allow the user to engage in calls, messaging, social media and even photo taking while driving and thus gratifying the ban on the use of the device while driving in many countries since its widespread use [3]. Yet, reports of engagement with such devices persist and reports of incidents continue to increase [8, 9]. Such research does not provide the context surrounding drivers' engagement with technology, it observes what happens when drivers are distracted rather than *why* they become distracted in the first instance. Alternative methods are required to gain an understanding for people's experience of distraction, their opinions, knowledge and perception of the behaviour [16]. Such approaches are associated with more qualitative and subjective research.

The distinction between quantitative and qualitative research is embedded within social science research, contributing to distinct research fields and methodologies [16]. However, the notion of a dichotomous relation between quantitative and qualitative is not always clear cut [17]. The notion of a second, objective/subjective, dichotomy adds another element to the distinction. Subjective data relates to the individual's personal judgements and opinions, whereas objective data involves impartial measurement of performance (or other metrics). Yet, the objective/subjective dichotomy features in both qualitative and quantitative research. Table 1 illustrates the distinction between qualitative/quantitative and subjective/objective data in relation to assessing distraction from text messaging while driving.

Table 1. Example of qualitative/quantitative and objective/subjective data relating to distraction from reading a text message.

	Quantitative	Qualitative
Objective	Reading a text took the drivers eyes away from the road for 4 seconds (e.g. eye tracking measurement)	Yes, I read text messages on my phone while driving (e.g. tick-box response to a survey).
Subjective	On a scale of 1-10, the driver rated reading a text while driving to be a 7 in terms of its distractive effects (e.g. Likert scale in questionnaire).	I only read a text while driving if my phone is placed in the phone holder, it is switched on to loud mode and I am driving on a quiet road because it grabs my attention (e.g. debrief interview).

Table 1 shows that both statements under the qualitative heading relate to data informed by the drivers' personal experiences. However, the statement that they have engaged in a distracting behaviour is an objective statement of fact, yet their reasoning and perception of the contextual elements informing the behaviour is subjective. Furthermore, the measurement of distraction on a Likert scale by the driver is a subjective assessment of the driver measured with quantifiable outcomes. Hence, in order to assess the drivers' perspective, both qualitative and quantitative can be utilised. To understand why drivers engage with distracting tasks, the subjective element of research needs to be assessed. While both qualitative findings include information on the driver, the subjective methods obtain information of the drivers' personal views. The utilisation of this to inform countermeasures should be considered alongside objective findings as it informs on the root cause of distraction, the *why*. However, its interpretive nature and deep connection to the wider context make subjective data less comparable than more objective measures, and so aggregation is less straight forward [18].

1.1 Aims

This paper aims, for the first time, to seek out the contribution of subjective methods in understanding driver distraction from technology in the vehicle. This sought to capture all current studies that have utilised subjective data collection via a document analysis and review. It explores the methodologies that have been applied, the types of technologies that have been researched, the key findings and recommendations made by the authors when studying the driver's perceptions, judgements and opinions on distraction caused by technological device use while driving.

2. Method

2.1. Document analysis

In order to obtain all relevant papers within the review, a document analysis was conducted. A comprehensive review of the scientific literature encompassing English-language

articles was undertaken using purposeful sampling to select items directly relating to the concepts under investigation.

2.1.1 Inclusion criterion: To provide a structured assessment of the literature an inclusion criteria was set. The main criteria and their justification is detailed in Table 2.

Table 2. Inclusion criteria for literature review

Criteria	Justification
Peer-reviewed research articles published within the last 10 years.	The pace of technological change and its impact on the driving domain has developed rapidly in the recent decade. High quality research that aligns with modern developments was required.
Methods obtain data that reflects the driver's subjective perspective.	This review discounted research looking to quantify and objectively measure driver distraction e.g. using driving simulators and road trials to measure performance metrics. It sought studies that focused on the drivers' perceptions of distraction, gathering data on their opinions, judgements and description of events.
Distraction references the technology as a competitive source of attention that detracts from the safe monitoring of the driving task.	A standardised definition of distraction was used to assess if the paper was denoting common distraction qualitied. The definition of distraction by Lee et al's [6] was used. This prevented the involvement of studies looking at technologies such as advanced warning systems and adaptive cruise control, which aim to assist the driving task, not compete with it.

The key aspects of the review were firstly that it was cemented in a singular theory of distraction, secondly that it sought data on the driver's subjective perspective on distraction as opposed to objective measurements and thirdly that it captured recent research on current technologies. It should be noted that articles that assessed technological as well as non-technological distractions were included where relevant, but only the technological distractions were focused upon.

2.2. Procedure

An initial search utilised 'Web of Science', a popular research platform which combines searches over multiple databases, to locate the literature of interest [21]. Papers found to meet the inclusion criteria listen in Table 2 in this initial search were used to find other relevant papers, using cited references in a snowballing method until all possible papers were deemed to be found at a point of saturation. The objectives, motivations, independent and dependant variables, findings and recommendations from each article were reviewed to determine if they captured subjective research on distraction from in-vehicle technology in line with the inclusion criteria. Those that met the criteria were then reviewed in further detail to determine

their key findings and contributions to the current understanding of driver engagement with technological devices. The iterative approach found 31 articles met the inclusion criteria, these are listed in the Appendix. The articles were reviewed to determine the methodologies used, the technological devices that were assessed, the key themes that were extracted from the results and the recommendations that were proposed by the researchers for mitigating driver distraction. This required reading through each article in fine detail and coding for each of the variables in an iterative manner. A flexible analysis was employed when reviewing the articles as the subjective nature of the findings make the methodologies employed, and the context of their employment, an important factor in their communication of findings [23]. Furthermore, it was important that the data utilised from the studies kept the same meaning derived from the context of the initial study they were extracted [22]. Inductive thematic analysis was performed to code for key themes that have arisen in the literature surrounding driver's subjective judgements of distraction from technological devices in the vehicle.

3. Results and Discussion

The 31 articles included within the review involved the assessment of 14,304 participants across eight countries. The geographical location of the studies was of interest as legislation relating to distraction from in-vehicle technologies differs across national governments and law regulators. A large number of the studies were run in the USA, this included states which have different legislations relating to device use while driving, such as Washington and Oregon which prohibit the use of all mobile phone functions, in contrast to Kansas and Iowa which permit all road users, apart from novice drivers, to use their phones while driving. A total ban on phone use was present in all other countries apart from Sweden, who state mobiles are banned only if they are causing detrimental effects on driving behaviour.

3.1 Methodology

As there is a broad range of methods available to assess subjective views, the review sought to identify the methods applied to driver distraction from in-vehicle technology and the data that this has revealed. Table 3 suggests that surveys were the most utilised method, with online application being the most popular method. The method was used to capture the drivers' subjective ratings of a number of qualities relating to their engagement with technological devices across Likert scales and open ended questions. Fewer studies utilised deeper qualitative analysis such as semi-structured interviews or focus groups which, although allow for more probing into the contextual factors surrounding engagement, are less pliable to producing

results of significant values or correlations [23]. An advantage of using online surveys is their facilitation of a sense of anonymity and confidentiality in the participant [24]. When discussion topics include mobile phone use while driving and other potentially illegal behaviours this is advantageous in encouraging more honest responses, compared to discussions with the researcher in person which may lead to response bias and social desirability bias [25]. Yet, more in depth probing and exploration of responses can be achieved through active communication between the researcher and participant [19].

Table 3. Methodologies and number of studies they were applied in.

Method		N
Survey		23
	Online	11
	In-person	8
	Telephone	1
	Unclear	3
Interview		3
Focus Group		2
Ethnography		3

Three studies cited the use of ethnography, two of which investigated satellite navigation devices (sat-navs) – the most common method to assess this type of technology. Both studies aimed to gain an understanding of the drivers' affective engagements with the device and allow participants to speak for themselves [26], which is not possible to do in constrictive surveys [23]. Its advantage in the analysis of sat-nav engagement is facilitating an insight into the drivers' reliance on the device in order to understand their environment [26,27]. One study into cell phone use also employed ethnography and, although it only utilised 4 participants, it produced a rich data set that captured the interaction between the driver, the device and the vehicle as well as the wider context. This is a finding that cannot be assessed through objective findings, or surveys completed outside of the context [25,26]. Schegloff [28] highlighted the importance of context when assessing new technologies, suggesting assessment out of context "yields only noise" (p298). Ethnography facilitates the qualitative assessment of devices within context and the findings in the ethnographic studies included within this review revealed novel methods that drivers employ when engaging with devices that were not found in objective assessments. Although the findings drawn from subjective research are rich, they are also somewhat limited to the context of their emergence and researcher interpretation [19]. In order to gain confidence in the findings, more in-depth research is required.

3.2 Technology Type

The variety of technological devices that have been explored within the literature was of interest to identify the extent to which different technologies have been assessed in relation to driver distraction. It was found that a large proportion of the studies targeted mobile phones (N=16). Many of these focused on general phone use (N=12), whereas others focused primarily on texting (N=3), and one on the specific use of smart phones. The prevalence of phone technology within the literature can be linked to the high degree of media attention surrounding mobile phone use while driving and the heightened laws in place in many counties specifically relating to hand-held phones [18]. Caird et al, states that the perceived importance of cell phone use has meant that the threshold of acceptance to papers within journals is lower for studies looking at the implications of phone use when driving [18], which would also contribute to the increased presence of their use in this review. This could, however, also be circular such that the disproportionate focus on phone use within driver distraction research suggests it to be more important than other technologies, which may then be deprioritised.

The only other device targeted specifically in subjective research was the sat-nav (N=4), the remaining studies looked at a range of different devices together (N=3) or distraction from devices alongside other distracting tasks (N=8). The technologies highlighted in these studies included adjusting integrated device controls (N=9), portable music players (N=5), portable TV/DVD (N=2), hands-free technology (N=2), and 'other nomadic devices' (N=3). Recent statistics from the UK state that 440 accidents resulting from distraction from mobile phones compared to 2,920 from distractions inside the vehicle and 1,526 from outside the vehicle [29]. This suggests that focusing on mobile phones will not curb all major sources of distraction and research into other sources should be targeted.

3.3 Key themes

Table 4 states the key themes that were identified from the literature with a description of each and the number of studies (N) that identifies them. These themes suggest the subjective reasoning currently associated with why drivers engage in potentially distracting technologies while driving. 'Perceived risk' and 'incidence of use' were found to be the most commonly occurring themes. Many surveys utilised Likert scales to analyse these themes, asking drivers to rate their response on a 3 to 10-point scale, depending on the study. Yet, such data does not allow us to identify the reasoning behind their 'perceived risk' or 'incidence of use'. Largely these studies combined other key themes to understand the rankings given. Three studies found

a significant interaction between 'incidence of use' and 'perceived risk', highlighting that drivers think about the riskiness of their actions in engaging with technologies before doing so. Furthermore, an additional six studies found a significant interaction between 'incidence of use' and 'task utility', suggesting that when drivers perceive the task to be useful to them while they are driving they are more likely to engage with it. These were the only significant interactions found across multiple studies, no other significant interrelations were found between the key themes.

Table 4. Key themes identified from subjective driver distraction research.

Key Themes	Description	N
Perceived Risk	Drivers state their views and judgement of the risk involved in engaging with the technology while driving	14
Incidence of use	Drivers state how frequently they engage with the task while driving and likelihood of engaging in different contexts	12
Compensatory strategies	Drivers state if they employ any mechanisms to manage engagement with technologies while driving	5
Engagement outside the vehicle	Drivers state their interaction with technology when they are not driving	5
Driving context	Factors within the context of driving that influence the driver's engagement the technology	5
Accident History	Drivers previous track record of their driving behaviour and the accidents they may have encountered	5
Task utility	Drivers state how useful engage with the technology would be when they are driving	5
Other risky behaviour	Any other risky behaviour that the drivers are likely to engage in, not necessarily related to driving	4
Physical characteristics of task	Description of the psychical features of the technological task in relation to its use	4
General Driving habits	Other driving behaviours the driver engages in	3
Driver perceived ability	Drivers view on their ability to drive	2
Perceived Responsibility	Drivers view on their responsibility for their actions when engaging in technological tasks while driving	2

3.4 Age effects

An initial review of the identified papers revealed that age was a variable of central importance. 20 studies referenced age as an important factor to consider in driver engagement with technologies while driving. 15 of these looked only at specific age groups, 4 looked at comparing age groups, 1 focused only on older participants and 10 focused specifically on younger users.

In a society where the population of older drivers is increasing [30], the proficiencies of these drivers in their use of technology and their utilisation of it while driving is important to consider. A deeper analysis of the methodologies used when specifically looking into age effects found that all those recruiting older participants used methods whereby they were requiring them to be there in person (e.g. interviews), whereas online surveys were reserved for looking at younger participants only. The reported digital divide between generations [31] suggests that online surveys may limit the accessibility to older members of society, although this divide is thought to be diminishing with older generations now willing to embrace new technologies [32]. However, there still exists a sampling bias towards those that are more technologically aware and possess the facilities and ability to complete the survey on an online platform. Such participants may be more predisposed to technology use in general, which may be inclusive of their use in the vehicle. This can, however, be said of both older and younger generations and therefore application of different methodologies across age groups will likely bias findings. The use of anonymous online surveys to target the younger generation should not be the only method through which this group is targeted. While it was stated previously that online surveys allow a sense of anonymity that may enable more truthful responses, they also prevent more probing questions of interest to be asked. It is suggested that studies should target a range of age groups utilising with consistent methodology, only one study in the review did this [33]. Lerner's focus group study involved face to face interaction between participants grouped in a range of age classifications [33]. Contrasts across age groups highlighted that teenage drivers saw technology use while driving as more of a challenge which related to their increased utilisation of devices while driving, a concept that was not included in any of the other surveys identified in the review. Meanwhile, older drivers were consistently the least willing group to engage in technologies while driving [33].

It is also important to note that the definition of age groups ranged considerably between groups. In addition to the twenty studies looking specifically at age effects, five studies investigated age as an additional construct, yet this resolved in mixed some finding (age effect found N=3, no age effect found N=2). NHTSA has set a standard age group range (18-24, 25-39, 40-54, 55+), but these were not widely utilised. Some studies noted young groups to include 18-25 year olds and middle age to include 26-54 year olds, whereas another stated young participants to be teenagers, and old drivers to range from 30-60 years. This may explain why some studies found age effects and some did not. The subjectiveness of the age categories used between studies makes it hard to attain exactly how and when age impacts on technology use by drivers. Not only are more established age divisions required within research, but the impact

of these divisions on the technological proficiency on these age groups needs to be understood. Age groups referencing people of similar technological use requires careful consideration as age effects in themselves appear to be not as clear cut as old versus young.

3.5 Recommendations

Research articles typically conclude with recommendations from the authors for further work that has emerged from their findings. These were of interest to the review to establish the future direction of the research field. The recommendations were collated into main themes through conceptual coding [21]. Three main categories were identified; social, design and policy categories (Table 5). Nearly half of the articles suggested recommendations of a social nature which related to concepts that required a change in the perspective, associations and awareness of distraction within wider society. Many highlighted the role of publicity and media campaigns to target the social perceptions of drivers towards technology use and driver distraction. Design recommendations related to those stating the need for alterations to technological interface and development at the design stage. Political recommendations included changes in the law and enforcement of distraction from technology. The use of design and policy changes to reduce distraction were minimal in contrast to social recommendations. Only seven studies recommended a holistic approach incorporating ideas from multiple areas.

Table 5. Recommendation categories and their citations count

Recommendations		N
Social		**20**
	Compensatory beliefs/strategies	2
	Reduce technology demand	4
	Increase emotionality	2
	Change social norms	3
	Increase Risk awareness	3
	Age specific approach	6
Design		**6**
	Disabling devices	2
	Intuitive design	4
Policy		**5**
	Enforcement	2
	Training	2
	Occupational use	1
Holistic		**7**

The high quantity of authors suggesting the need to target the social aspect of the behaviour over the more physical design based features highlights the current issues being faced in the area. The design of a device can only do so much to counteract its distractive effects, it is the wider societal views that need to be tackled in order to target the core of the issue [1]. An increasingly popular theory being applied to the decision and intent to be distracted is the Theory of Planned Behaviour (TPB) [34, 35, 36]. This links to the view that distracted driving should be seen disapprovingly by society [37]. There has been relatively little research into attitudes and beliefs surrounding driver distraction compared to other driving faux pas such as speeding [38,39] and drink driving [40].

4. Conclusion

This study has reviewed what has been established into driver distraction from in-vehicle technology to date using research that establishes subjective data. It has given an insight into the current methodologies used, the types of technologies that are being studied, the central themes that relate to the use of technology by drivers and the types of recommendations authors of subjective research have made. The use of mobile phones within subjective distraction research has been disproportionately researched compared to other technology, as it is in objective research. The high rates of distraction not relating to mobile phone use requires further research into other sources of technological distraction. Age is highlighted as a key factor that has been considered in many studies as influencing driver's perceptions and behaviours when interacting with technology. Yet, age is a complex factor and it has not yet been efficiently established how to categorise age groups with respect to technology use in the vehicle. To draw greater conclusions on the key themes, future recommendation and countermeasures from subjective research, more research of this kind is required.

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Appendix

Table 6. Articles meeting inclusion criteria and included in the review.

Reference	Author(s)	Year	Methodology	Participants (N)	Country	Technology type
[41]	Atchley, Hadlock, & Lane	2012	Survey (in-person)	160	America (Kansas)	Mobile phone (General)
[42]	Atchley, Atwood, & Boulton	2011	Survey (online)	401	America	Mobile phone (Texting)
[27]	Axon, Speake, & Crawford	2012	Survey (in-person)	46	UK	Navigation system
[43]	Donmez, Boyle, Lee, *et a*l	2006	Focus Group	N/A	America (Iowa and Seattle)	Range of technology and non-technology distractions
[44]	Esbjörnsson, Juhlin & Weilenmann	2007	Ethnography	4	Sweden	Mobile phone (General)
[45]	Fofanova & Vollrath	2012	Interview	414	Germany	Range of technology and non-technology distractions
[46]	Hafetz, Jacobsohn, Garcia-Espana, *et al*.	2010	Survey (unclear)	4269	America	Mobile phone (General)
[47]	Hancox, Richardson & Morris	2013	Survey (in-person)	20	UK	Mobile phone (General)
[48]	Horrey & Lesch	2008	Survey (in-person)	40	America	Range of technologies
[49]	Huemer & Vollrath	2011	Interview	289	Germany	Range of technology and non-technology distractions
[50]	Jamson	2013	Survey (online)	1500	Europe	Range of technologies
[51]	Kareklas & Muehling	2014	Survey (online)	357	America	Mobile phone (Texting)
[52]	Lansdown, Stephens & Walker	2009	Survey (online)	482	UK	Range of technology and non-technology distractions

[33]	Lerner, Singer & Huey	2008	Focus Group	45	America (Washington)	Range of technology and non-technology distractions
[53]	Leshed, Velden & Rieger	2008	Ethonography	N/A	America	Navigation system
[54]	McEvoy, Stevenson, & Woodward	2006	Survey (telephone)	1347	Australia	Range of technology and non-technology distractions
[55]	Musicant, Lotan & Albert	2016	Survey (online)	757	Israel	Mobile phone (Smart phone)
[56]	Nelson, Atchley & Little	2009	Survey (unclear)	279	America	Mobile phone (General)
[57]	Shi, Xiao & Atchley	2016	Survey (online)	414	China	Mobile phone (Texting)
[26]	Speake	2015	Ethnography	36	UK	Navigation system
[58]	Steelman, Soror, Limayem, *et al*	2012	Survey (online)	432	Unclear	Mobile phone (General)
[59]	Titchener, White & Kaye	2010	Survey (online)	84	Australia	Range of technology and non-technology distractions
[60]	Trisko & Ferraro	2014	Survey (in-person)	198	America	Mobile phone (General)
[61]	Vernon, Babulal, Head, *et al*.	2015	Survey (in-person)	100	America (Washington)	Range of technologies
[62]	Wang & Ju	2015	Interview	41	Korea	Navigation system
[63]	Weller, Shackleford, Dieckmann *et al*.	2012	Survey (online)	1006	America (Oregon)	Mobile phone (General)
[35]	White, Hyde, Walsh, *et al*	2010	Survey (in-person)	796	Australia	Mobile phone (General)
[64]	White, Walsh, Hyde, *et al*.	2012	Survey (in-person)	196	Australia	Mobile phone (General)
[65]	Young & Lenné,	2010	Survey (online)	287	Australia	Range of technology and non-technology distractions
[36]	Zhou, Wu, Rau, *et al*.	2009	Survey (unclear)	164	China	Mobile phone (General)
[66]	Zhou, Yu & Wang	2016	Survey (online)	140	China	Mobile phone (General)