A STATISTICAL ANALYSIS OF VISUAL DETECTION FAILURES FOR ACTIVE SAFETY FUNCTION EVALUATION

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1. ABSTRACT

The objective of this study is to understand the visual detection failure sequences that result in traffic accidents. An accident causation analysis was used to interpret and group causal factors for 5 distinct detection failure types that caused traffic accidents. Principal component analysis was used to interpret in-depth, on spot, accident causation data. Several scenarios were identified describing combinations of context, contributory and precipitating accident risk factors. These scenarios are discussed with regards to the functionality active safety technologies and automotive systems designs with special emphasis on the driver's needs, the safety functions needed to fulfil these needs and contextual constraints.

Keywords: accident causation, driver perception, active safety systems, vehicle design

2. INTRODUCTION

Research to improve road traffic safety and reduce casualties has historically concentrated on identifying single factors that cause accidents and their effects. This method places an emphasis on these individual factors (such as speed and alcohol) and is used in support of road safety countermeasure development. Road safety management in many countries is increasingly developed and a more in depth approach is needed to provide further reductions in traffic casualties. Vehicle and infrastructure based technologies are now considered to offer the opportunity to impact road casualties further provided they effectively address the key safety related functional requirements of drivers and other road users. Driving studies can identify some aspects of drivers needs however the functional requirements for safety technologies are best evaluated using detailed accident data. In order to identify solutions for failure sequences during road accidents, real life traffic accident data is needed to clarify the different factors that occur when a traffic accident takes place.

First introduced as a method for traffic accident studies during the 1970`s in-depth accident causation studies are routinely used to support improvements in traffic safety (Sabey, 1975, Treat et al, 1977). The aim of accident causation research is to identify the source of accidents and ultimately reduce or eliminate them (Lehto and Salvendy, 1991). In a traffic environment this includes looking at an accident from a holistic framework (with the traffic system as a whole) and establishing a causal link analysis which explains the accident occurrence starting from the start of any driving behaviour and continuing up to and after the accident event. These methods allow an interpretation of all of the relevant human, vehicular, environmental and infrastructure factors that occur between the pre-crash and crash events, which in turn allows for a preventive safety evaluation and a relevant function to be incorporated in the vehicle.

New intelligent technologies are rapidly being introduced to the road and vehicle environment with the purpose of improving safety and transport efficiency. The goal of these preventive safety functions, or advanced driving assistance systems (ADAS), is to prevent crashes from occurring and/or to reduce crash severity, by either alerting the driver to potential hazards or by taking over the driving task to some extent, using, for example, autonomous braking in emergency situations. (Ljung Aust, 2010). Examples of preventive safety systems include Electronic Stability Control, collision avoidance systems, and Brake Assist Systems. ADAS systems include Lane Departure Warning systems, Autonomous Cruise Control and advance hazard alert systems. With the increasing development and implementation of these systems within vehicles it is necessary to thoroughly understand the critical situations that can be addressed with the different current and emerging technologies. Accident causation research allows for this analysis by thoroughly identifying the key factors and the human functional failures that resulted in a traffic accident.

In the traffic environment there are many visual stimuli that a road user needs to perceive in order to correctly identify the traffic situation, make a decision and perform the required behaviour. Brehmer (1993) described driving as a self-regulated behaviour with two levels of control; (1) automated behaviour, which is learning to react to information and (2) deliberate behaviour which involves decision making. The deliberate behaviour decisions allow for the automated behaviour to take place but when the system is overloaded accidents may occur.

The visual sense is the main channel of sense in operation during a driving behaviour for the road user.(Peimersma, 1979). Drivers focus on objects in their visual field by routinely moving their eyes in order for that object to come onto the centre of the retina, (Herslund, 2003). In complex scenarios this may prove impossible and relevant information may not be perceived leading to an incorrect manoeuvre or behaviour and in turn to a potential crash situation.

There are several types of human functional failure that can lead to an accident. Van Elslande and Fouqouts (2007) classified these errors into the following groups: detection, diagnosis, prognosis, decisional or an actioning failure. Detection failures usually occur as a result of either non detection or late detection. Van Elslande and Fouqouts (2007) further separated the different types of detection failures into 5 distinct groups:

1. Non-detection in conditions of limited visibility,
2. Incomplete information acquisition from focusing on a part of the visual environment.
3. Cursory or hurried information acquisition.
4. Momentary interruption in information acquisition activity.
5. Neglecting the need to search for information.

The objective of this study is to understand the failure sequences that result in accidents where detection failures are the main cause and to identify the functionality of relevant active safety measures.

3. **METHOD**

In-depth accident causation data

Details of the causation factors relating to individual collisions were acquired using in- depth accident data methods on the spot by a group of accident researchers within an average time span of 20 minutes after an accident had occurred. The accident data were collected between 1999 and 2010 by two separate groups in the UK. The Vehicle Safety Research Institute (VSRC) investigated accident occurring within the South Nottinghamshire area of the East Midlands, England and the Transport Research Laboratory (TRL) covered the Slough, Reading, Henley on Thames and High Wycombe areas in the South East of England.

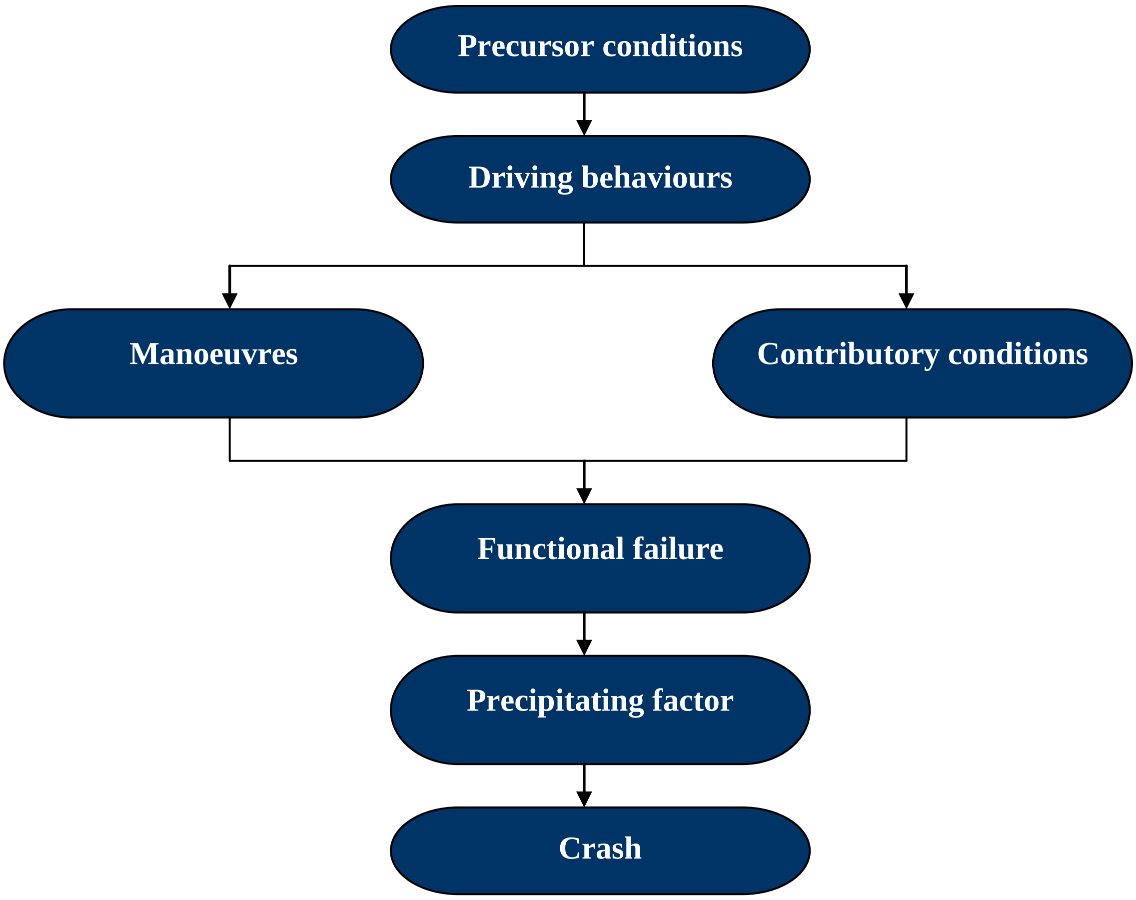
Case selection protocols involved rotating investigation periods during the week and over the duration of the study so that the data was representative of all police reported collisions. The results presented in this paper are based on 4,744 crashes involving a total of 12,749 vehicles and 527 pedestrians. Cases with detection stage failures were selected from this database for analysis (1651 cases).

Data recorded

Accident researchers reported all relevant data in terms of the vehicle, environment, infrastructure and human participant in relation to the accident. They also deduced and reported causal factors that were related to the formation of the accident process. The variable used in this study were classified as accident contributory causation factors, precipitating factors to the accident, and manoeuvre type. These factors are grouped according to the functional failure sequence model that can be seen in table 1.

Contributory causation factor: These are the factors that aided the failure occurring by being present though not the direct cause of the accident. They are interpreted on site from the available evidence by the accident investigators. These factors can be driver precursor condition (excess alcohol, drugs or fatigue) that are present before the driving behaviour occurs, driving behaviour factors (excessive speed), or contributory conditions which could be vehicle factors (worn tyres) or environmental/ infrastructure factors (road surface conditions, glare or line of sight obscuration). Further available contributory causation codes include, failure to look, look but did not see, carelessness, being in a hurry, inattention, aggressive driving and following the driver ahead too closely.

Table 1. Functional failure sequence model



Precipitating factors: These are the physical actions that directly lead to the accident occurring as judged by the investigator on the site of the accident (Hill and Cuerden, 2005). The failures can be; failure to stop, failure to give way, failure to avoid pedestrian, failure to avoid vehicle or object in carriageway, failure to signal/misleading signal, poor turn, poor overtaking, pedestrian entered carriageway without due care and loss of control of the vehicle.

Manoeuvre type: The traffic behaviour that occurred during the accident as observed by the investigator. Possible accident types are; Overtaking or lane changing, Merging, Right turn against, Manoeuvring, Pedestrians crossing road, Pedestrians other, Miscellaneous, Head on, Loss of control on Straight Road, Loss of control while cornering, Collision with obstruction, Rear end, Turning versus same direction, Crossing (vehicle not turning) and Crossing (vehicle turning).

Case types

5 groups of accidents were analyzed depending on the detection failure that caused an accident. These failures refer to the perceptive failure that a road user made during their driving behaviour. All 5 of the groups are taken from the Trace project (Traffic Accident causation in Europe) (Van Elslande and Fouqouts, 2007).

1.: Non-detection in conditions of limited visibility: Due to either an environmental or vehicular constraint limiting the driver's ability to detect an important object/situation during driving.(e.g. as a result of night or the vehicle infrastructure effecting visibility)

2. Incomplete information acquisition from focusing on a part of the visual environment. This type of failure occurs when a road user focuses their attention on a particular or complex problem (without a conscious choice) during the journey and so does not detect an object that needed to be detected (e.g. failing to detect a moving vehicle)

3. Cursory or hurried information acquisition: Insufficient time being given to the visual field resulting in a failure to detect a hazard. Factors could include a busy traffic environment or a rapidly changing traffic situation.

4. Momentary interruption in information acquisition activity: as a result of distraction from inside or outside the car but not related to the driving task, as a result of the monotonous nature of the driving task resulting in a loss of attention.

5. Neglecting the need to search for information: This failure is due to the road user not searching for information when it was required as they believe that it is not necessary, for example when the driver has the right of way or is familiar with the road.

The 1651 accident cases identified as having a detection failure were classified into each category by two accident investigators interpreting the causative factors scales and interpreting which factors were detection failure accidents

Statistical Analysis

The goal of this study is to identify the most relevant and significant combinations of manoeuvre types, precipitating factors and contributory causation factors when human functional failures occur at the information detection stage. The sample was analyzed by separating the different failure types that occurred at the information detection stage and identifying the key Human, Vehicular, Environmental and Infrastructure factors for each of the five failure types. A descriptive analysis was done to identify all of the manoeuvre types, precipitating factors and contributory causation factors that added up to 80% of each factor type.

As the dataset used consisted of more than 2,000 variables for each crash it was necessary to use an exploratory analysis tool to find significant factor groupings. Principal component analysis (PCA) is a statistical methodology that is used to reduce large and complicated multivariate datasets into a simpler form. This analysis allows multiple factors to be linked to a set of components that explain the variance in the group of cases, allowing for correlations between these factors to be analyzed and interpreted. Rather than using pre-conceived data chains to analyze the data this allowed for an exploratory analysis of the factors linking them to particular detection stage failures.

The main factors used for the analysis were chosen according to the contributory causation factors that were related to the accident, the precipitating factor (failure type) that the road user made that directly caused the accident, and the type of manoeuvres that occurred during the accident sequence. The purpose of the analysis was to identify the most relevant factors so the components selected for interpretation were those that collectively explained approximately 50% of the variance. In most cases the remaining components had a considerably lower explanatory power. The final factor solutions for the analyses met three criteria: (a) each one was based on factors with an eigenvalue >1 as this improved explanation of the variance in the data beyond the original variables themselves; (b) each individual item was correlated with the factor concerned at the 0.364 level or above, as the dataset was large (minimum 171 accidents for an analysis) this was a significant correlation for the components (c) only items with a communality of >0.5 were selected, as the analysis was conducted in order to find common patterns between different factors rather than singular factors within the different principal components. Factors that did not have a significant correlation with at least one of the four principal components for each of the five detection failure groups were extracted in the aid of clarity for tables 1-6.

4. **RESULTS**

The overall injury levels for the different detection failures are generally similar, as can be seen in Table 1. Fatal accidents account for between 2.5 and 4% of the data. Serious injury accidents were highest for information acquisition focusing on partial component of the situation failures and lowest for Momentary interruption in information acquisition activity failures. Slight injuries accounted for between 42 to 54 % of the data and were the injury group with the highest number of crashes. The accident cases that were analyzed are mostly slight and non-injury data which account for between 78.6% and 90.7% of the accidents for the 5 groups. Incomplete Information acquisition from focusing on a part of the visual environment failures had the highest rate of serious/fatal injuries with over 1/5th of these accidents causing a serious/fatal injury.

Detection failure type 1: Non-detection in conditions of limited visibility

Table 2 presents the analysis of causative factors relating to a non detection in conditions of limited visibility. The first component has a high correlation with excessive speed, with the nature of a non detection accident the road user is travelling at too fast a speed for there cognitive processes to take place accordingly. Surroundings obscured by a road with a bend and local infrastructure conditions are also correlated with this factor. Loss of control and failure to avoid also has a correlation with the first component and can be explained by the road user’s inability to act in a timely manner. The second components main factors are a failure to give-way in a crossing accident and an obscuration of the road user’s view. This component identifies a junction accident where the road user failed to see another approaching vehicle. The third component has four main contributory factors that are correlated carelessness, failure to look, being in a hurry and Inattention. Though there are no direct correlations with a specific accident type or main failure type these factors seem to demonstrate aggressive driving behaviours.

Table 1. Injury levels for detection failure types

Detection failure type	fatal	serious	slight	non-injury	unknown	total
Non-detection in conditions of limited visibility,	7(3.5%)	32(11.6%)	126(45.8%)	109(39.6%)	1(0.4%)	275
Incomplete information acquisition from focusing on a part of the visual environment.	9(4.0%)	36(16.4%)	118(53.9%)	54(24.7%)	2(0.9%)	219
Cursory or hurried information acquisition.	7(3.4%)	26(12.7%)	87(42.6%)	83(40.7%)	1(0.5%)	204
Momentary interruption in information acquisition activity.	6(3.5%)	14(8.2%)	78(45.6%)	72(45.1%)	1(0.6%)	171
Neglecting the need to search for information.	20(2.5%)	111(14.1%)	397(50.5%)	257(32.7%)	1(0.1%)	786

Table2. Correlation between Principal Components and causative factors for detection failure type 1: Non-detection in conditions of limited visibility

	Component order	1	2	3	4
factor type	Percentage of variance	11.90%	11.17%	8.43	6.33
contributory	Carelessness, reckless or thoughtless	0.104	0.008	**0.559**	0.191
	In a hurry	-0.088	0.203	**0.558**	0.137
	Failed to look	-0.363	-0.302	**0.457**	-0.203
	Inattention	-0.131	-0.087	**0.677**	0.054
	Excessive speed	**0.765**	0.312	0.111	-0.068
	Local infrastructure	**0.439**	0.165	-0.085	-0.109
	View obscured from window	-0.12	-0.334	-0.397	**0.435**
	Surroundings obscured by bend or winding road	**0.463**	0.349	-0.03	-0.101
	Surroundings obscured by buildings, fences, vegetation	-0.248	**0.512**	-0.136	-0.138
precipitating	loss of control	**0.473**	0.141	-0.125	-0.333
	failed to giveway	-0.554	**0.639**	-0.123	0.156
	failed to avoid	**0.369**	-0.185	-0.094	**0.615**
accident	Rear end	0.283	0.01	0.332	**0.404**
	Crossing (vehicle turning)	-0.425	**0.512**	-0.15	0.061

Bold numbers show significant linear relationship between PC and variable

The fourth component is a rear end accident where the individual failed to avoid the object in front. The view from the window being obscured was also correlated to this component.

Detection failure type 2: Incomplete information acquisition from focusing on a part of the visual environment.

Table 3 illustrates an analysis of causative factors and information acquisition focusing on partial component of the situation failures. The first component has a correlation with right turn against accidents (an accident where a right turn occurred across the path of another road user). Failure to give way was the failure that correlated with this component and failed to look, looked but did not see and in a hurry were the contributory factors that were correlated. This correlation suggest a situation where the road user concentrates on a particular component of the situation as a result being in a hurry. The second component has no main correlations. The third component has a correlation with a rear end accident, inattention and carelessness are the main contributory factors that are correlated. This gives an account of a situation where a driver fails to identify the speed of the road user in front due to not giving due attention to the driving task. The fourth component has a correlation with a right turn against scenario. Poor turn is the main failure identified, failure to judge other person’s path and lack of judgment of own path the main contributory factor. This correlation highlights a right turning vehicle that has not taken the other vehicle into account when making a decision to make a turn.

Table3. Correlation between Principal Components and causative factors for detection failure type 2: Incomplete information acquisition from focusing on a part of the visual environment.

	Component order	1	2	3	4
factor type	Percentage of variance	15.70%	12.54%	9.39%	8.80%
contributory	Carelessness, reckless or thoughtless	0.040	0.213	**0.399**	0.113
	In a hurry	**0.414**	0.253	0.323	0.332
	Failure to judge others persons path or speed	-0.245	-0.206	0.108	**0.380**
	Failed to look	**0.523**	0.161	0.310	0.142
	Looked but did not see	**0.403**	-0.294	0.034	-0.014
	Inattention	0.044	0.016	**0.636**	0.066
	Lack of judgment of own path	0.085	-0.081	0.258	**0.517**
Precipitating	failed to give way	**0.726**	-0.371	0.160	-0.301
	pedestrian entered carriageway	-0.014	**0.812**	-0.032	-0.003
	Poor turn	0.059	-0.132	-0.605	**0.478**
Manoeuvre	Rear end	-0.664	-0.277	**0.371**	0.064
	Right turn against	**0.497**	-0.290	-0.116	**0.463**

Bold numbers show significant linear relationship between PC and variable

Detection failure type 3: Cursory or hurried information acquisition

Table 4 presents an analysis of causative factors and type 3 detection failures relating to cursory or hurried information acquisition. The first component had a positive correlation with a rear end manoeuvre and both failure to avoid the other vehicle and a failure to stop. Following too close, failure to look, failure to judge the other road user's speed or path and distraction by a physical object outside the vehicle were the contributory factors for this accident type. This correlation suggests that a rear end accident happened as a result of a stressful traffic situation and the road user not being able to react in a timely manner. The second component did not have relevant correlations. The third component was a failure to stop with Inattention, carelessness and lack of judgment of own path being the causative factors. The correlation suggests that a critical situation occurred as a result of the road users' driving behaviours. The fourth component also did not have did not have relevant correlations

Detection failure type 4: Interruption in information acquisition

Table 5 illustrates an analysis of causative factors relating to type 4 detection failures, interruption in information acquisition. The first component had a positive correlation with both loss of control on a straight road and also while cornering. Loss of control was the precipitating factor and excessive speed for the conditions, panic behaviour and aggressive driving as the contributory factors. This suggests a situation where the road user lost control as a result of overaggressive driving for the road type.

Table 4. Correlation between Principal Components and causative factors for detection failure type 3: Cursory or hurried information acquisition

factor type	Component order / Percentage of variance	1 22.01%	2 11.81%	3 10.99%	4 7.84%
contributory	Distraction through physical object outside	**0.425**	-0.448	-0.332	-0.268
	Carelessness, reckless or thoughtless	-0.037	-0.257	**0.366**	**0.499**
	Failure to judge others persons path or speed	**0.538**	0.345	-0.239	0.157
	Failed to look	**0.364**	-0.521	0.222	0.262
	Inattention	0.176	0.059	**0.602**	0.319
	Following too close	**0.590**	0.227	0.241	-0.369
	Lack of judgment of own path	-0.177	-0.311	**0.390**	-0.193
precipitating	Failed to avoid	**0.533**	**0.605**	-0.276	0.264
	Failed to stop	**0.381**	-0.205	**0.614**	-0.343
Manoeuvre	Rear end	**0.718**	0.340	0.241	-0.202

Bold numbers show significant linear relationship between PC and variable

The second component had a positive correlation with loss of control while cornering with poor turn being the precipitating factor. Aggressive driving, being in a hurry and excessive speed were the contributory factors. This suggests that a loss of control as a result of a turn has possible differences than a loss of control on a straight trajectory. The third component had a positive correlation with a rear end accident and failure to stop, suggesting a typical rear end scenario when the road user diverts their attention away from the driving task. The fourth component had a positive correlation with loss of control, failure to stop and excessive speed. Though no manoeuvre types were positively correlated this suggests a combination of distraction and excessive speed causing an accident.

Table 5. Correlation between Principal Components and causative factors for detection failure type 4: Momentary interruption in information acquisition activity

factor type	Component order / Percentage of variance	1 18.87%	2 10.50%	3 9.98%	4 8.77%
contributory	Panic behaviour	**0.542**	-0.012	-0.197	-0.091
	In a hurry	-0.310	**0.654**	0.138	0.020
	Excessive speed	**0.450**	**0.413**	0.233	**0.427**
	Aggressive driving	**0.416**	**0.490**	0.226	-0.052
precipitating	Loss of control	**0.645**	-0.174	-0.415	**0.367**
	failed to stop	-0.046	0.020	**0.624**	**0.481**
	Poor turn	0.201	**0.430**	0.114	-0.553
manoeuvre	Loss of control on Straight Road	**0.460**	-0.408	-0.261	0.200
	Loss of control while cornering	**0.478**	**0.424**	-0.163	0.119
	Rear end	-0.081	-0.300	**0.542**	0.266

Bold numbers show significant linear relationship between PC and variable

Detection failure type 5: Neglecting the need to search for information

Table 6 presents the analysis of causative factors and detection failure type 5, neglecting the need to search for information failures. The first component had a positive correlation with a rear end scenario and failing to avoid the collision, the contributory factors following too close and panic behaviour were also positively correlated with this component. This suggests the driver panicked when he/she realized that an action needed to be made and could not avoid the crash as the vehicle in front was too close. The second component had a positive correlation with pedestrians crossing the road, with the pedestrian entering the carriageway, a rear end impact and failing to avoid the object also positively correlated. Following too close was the contributory factor. This suggests two types of accidents with a pedestrian entering the road as a result of familiarity with the road and not allowing the road user to react and a second weaker correlation with a similar rear end accident as component 1 though this time there is no positive correlation with panic behaviour.

The third component was correlated with rear end accidents and failure to give way. This would suggest by the nature of a neglecting the need to search for information failure over familiarity with the journey type and not being used to giving way. The fourth component had a positive correlation with crossing no turns and aggressive driving, excessive speed, carelessness and being in a hurry were correlated. This suggests that the road user was behaving overly aggressively due to familiarity with the journey and cause a critical situation.

Table 6. Correlation between Principal Components and causative factors for detection failure type 5: Neglecting the need to search for information

	Component order	1	2	3	4
factor	Percentage of variance	10.84%	8.35%	8.01%	6.59%
contributory	Panic behaviour	**0.364**	-0.144	-0.266	-0.093
	Carelessness, reckless or thoughtless	-0.094	0.042	-0.128	**0.366**
	In a hurry	-0.283	0.134	-0.059	**0.537**
	Excessive speed	0.346	-0.089	-0.178	**0.554**
	Following too close	**0.584**	**0.411**	0.294	-0.033
	Aggressive driving	0.190	-0.107	-0.071	**0.452**
precipitating	failed to give way	-0.396	-0.360	**0.509**	0.090
	pedestrian entered carriageway	-0.444	**0.609**	-0.473	-0.134
	failed to avoid	**0.479**	**0.380**	0.312	-0.033
	loss of control	0.367	-0.305	-0.517	0.089
Manoeuvre	Rear end	**0.572**	**0.471**	**0.385**	0.079
	Crossing (no turns)	-0.209	-0.066	0.147	**0.381**
	Pedestrians crossing road	-0.430	**0.610**	-0.454	-0.145

Bold numbers show significant linear relationship between PC and variable

5. **DISCUSSION**

This analysis has used in-depth accident causation data, derived from on-scene investigations of individual crashes, to investigate the factors relating to collisions where the road user functional failure concerned one of the five detection failures. A deep understanding of these collisions is essential to support the development of new technologies that will enhance the provision of information to road users to support them in the driving task. Without such an understanding it is completely possible that any new systems may address an irrelevant need or fail to take account of critical factors contributing to the crash. Principal Component Analysis has been used to identify groups of contributory and precipitating factors in conjunction with the relevant vehicle or pedestrian manoeuvres for each detection failure type. The results have shown several common factors that relate to the observed failures.

In relation to type 1 failures Non-detection in conditions of limited visibility the first two components had positive correlations with infrastructure factors. Solutions for this problem would be to alter the road infrastructure in areas where these accidents occur so as to either give a better view of the traffic site or to not allow road users to use excessive speed (e.g. using speed bumps if appropriate). The fourth component was a result of the vehicle’s window blocking the road users view and as such is a design issue in relation to the vehicle.

Type 2 failures Incomplete information acquisition from focusing on a part of the visual environment highlighted three types of accidents. The first type was a right turn accident was the road user did not see the other road user approaching as a result of being in a hurry. The second as a result of not paying attention to the vehicle in front and causing a rear end accident. The third as a result of a poor turn despite seeing the vehicle coming not being able to understand the speed that they were coming at. These behaviours occurred as a result of poor attention and solutions to these could be two fold. Either active safety systems that would direct the road users attention to the important objects around them or driver education to improve upon their attention levels.

Type 3 failures had two significant components the first type of accident was a rear end accident where the road user was distracted from an outside object and was following the vehicle in front too closely. The second accident was a result of the road user acting in a careless manner and not acting as they should of. This factor is related to the road users behaviour and as such driver education would be the key to addressing this.

Type 4 failures

All five types of detection accidents had at least one component with a positive correlation to rear end accidents. These types of accidents tend to be a result of following the vehicle in front too closely and as a result of inattention or a distraction through the environment or vehicle. Though the injury levels for these types of accidents are usually quite low the financial cost overall is quite substantial as rear end accidents are known to occur frequently compared to other accidents and may often involve long-term neck impairment from whiplash injury (Gkikas et al, 2007).

Possible solutions for this issue are brake assist measures, which are commonly used as an active safety measure for rear end accidents and have been made standard by the European Union during 2009 or rear end collision warning lamps which have been developed to sense deceleration of the lead vehicle and flash a warning strobe light to the road user to alert the road user of a potential stopping situation. Accidents where these active measures could not be used are also prevalent and future technologies may hinge on the ability to identify when a driver is not concentrating on the road by either possibly identifying situations where the road user is making incorrect adjustments or by identifying their eye scanning behaviours.

Overtaking accidents are the second most common group for detection failure accidents although the results for this study did not produce any significant component correlation for these types of accidents. This could be a result of the nature of different overtaking accidents. Clarke et al (1998) discovered ten types of overtaking accident when analysing different overtaking accident types so the component may have not been able to significantly group these types of accidents together. Thus further detailed analysis looking at these particular groups may be needed for interpretation.

Three of the components in the analysis identified traffic situations with pedestrians as important analysis groups. These components highlighted situations in which pedestrians entered the carriageway without due care and did not allow the road user to avoid them. Inattention, looked but did not see and being in a hurry were identified as contributory factors to these scenarios. A common example of these accidents is pedestrians entering the road next to a parked car and the vehicle driver not being given a chance to react. Possible solutions for the driver could be a system that enables static and moving objects to be distinguished from one another, allowing the identification of a possible pedestrian in time for a vehicle driver to have time to make a reactive behaviour to avoid a critical situation. Consequently for the pedestrian education could be a possibility or development of better pedestrian facilities with traffic calming could also be some measures taken. A better understanding of pedestrian's logic seems to be necessary in order to better avoid these accidents especially as a large number of pedestrians are individuals without access to cars (the young or elderly) and that are more susceptible to injuries.

Loss of control while cornering and on a straight road was identified in two components when an interruption in information acquisition was apparent. Excessive speed and overly aggressive driving behaviours were the contributory factors for these accidents thus not allowing for all the relevant information to be acquired by the driver. Solutions such as electronic stability control, a computerised technology that helps in stabilising the vehicle when it detects a loss of control situation, are available to tackle these problems. Thomas (2006) reported that overall vehicles with ESC were involved in 3% fewer crashes though this number rises to 25% for adverse weather conditions and this system also attributes to 15% less fatal accidents(when passive safety improvements are also taken into account)

A crossing situation had a high correlation on component 1 for non-detection in visibility constraint conditions. This was attributable to the surroundings being obscured and the road user failing to give way in a give-way situation. A possible system to help in overcoming these difficulties could help in either identifying the roadway or alerting the driver to possible visibility constraint conditions.

A crossing situation when the road user was not turning had a correlation as a component for neglecting the need to search for information, as a result of aggressive driving, excessive speed for the situation and being in a hurry. These situations occur when a road user is either in an area that he/she knows well or when confronted with a slower vehicle in front of them. A system that allows for identification of when a road user is overly aggressive for the specific road situation could be developed to tackle these issues.

In terms of the general population it is generally accepted that all human beings are affected by their different socioeconomic backgrounds, culture and other such factors thus with driving behaviours this will also come into account. For example if an individual driver is a more aggressive driver than the situations that he/she will possibly be involved in could differ from another type of driver. Thus all drivers' needs would be different according to these different outliers/expectations of the driver and active safety measures in the future could potentially take these into account. There is a safety potential for Advanced Driver Assistance Systems (ADAS), which support the driver in information assimilation and help to avoid distraction and reduced activity. The design of the ADAS is dependent on the specific influencing factors of the accident type (Staubach et al, 2009).

5. CONCLUSIONS

In this paper a statistical analysis of 5 specific detection failure types was done. Results showed the most common type of accidents were rear end accidents when the road user was following too closely and after making detection errors caused a crash to occur, Pedestrian accidents also were high in number and significant with the analysis most commonly caused by the pedestrian running into the road without due care and Turning/crossing accidents were also identified and had correlations with aggressive driving behaviours which shortened the time of reaction for the road user.

A further analysis considering all of the available national and international data could be carried out to control for any possible differences due to the area studied. An in depth analysis of cases where these failure types occurred could also be carried out in order to clarify both road user attributes and more complex roadside data in order to magnify some of the selected factors and also better take into account any differences between injury types and vehicle types when different crash groups are considered.

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