# THE TIMECOURSE OF DRIVER VISUAL ATTENTION IN NATURALISTIC DRIVING WITH ADAPTIVE CRUISE CONTROL AND FORWARD COLLISION WARNING

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## ABSTRACT

Adaptive Cruise Control (ACC) and Forward Collision Warning (FCW) have been shown to have a positive effect on safety-related measures *despite* a general increase in secondary task involvement. To understand this effect, this study examined the relationship between drivers glance locations and ACC hard braking or FCW events when ACC is active. The study analyzed naturalistic driving on motorways where the car remained in the same lane. Four subsets of driving segments were included: ACC braking (peak deceleration ≥ 3 $m/s^2$), FCW+ACC (driving with ACC when a forward collision warning was issued) ACC maintaining speed, and Driver braking without ACC or FCW. The results indicate that although drivers do take their eyes off path more when using ACC, this conclusion seems to be valid only in non-critical (baseline-similar) situations. Drivers showed a steady increase in %EyesOnPath well before critical situations, resulting in 95% EyesOnPath both at the onset of ACC braking and at the onset of driver braking, and 98% when FCW were issued. At braking onset, headway was significantly longer when ACC braked compared to when the driver braked.

## INTRODUCTION

Adaptive Cruise Control (ACC) supports the driver in selecting and maintaining an appropriate speed and time-headway depending on chosen preferences. Forward Collision Warning (FCW) is intended to improve driver response times to lead vehicle critical situations by issuing a warning. An FCW can be issued in various critical situations, including when the ACC is active and the driving situation exceeds the braking capacities of the ACC because of a highly decelerating vehicle in front. The ACC and FCW functions are frequently offered together as bundled functions (referred to as FCW+ACC) and are intended to have a positive effect on both driving comfort and safety (Malta, et al., 2012).

In an analysis of the largest naturalistic driving dataset including FCW+ACC (EuroFOT), Malta et al (2012) concluded that when drivers use FCW+ACC, there is a positive effect on safety-related measures. When drivers used FCW+ACC, the number of critical time gaps (time headway<0.5 sec) to the leading vehicle was reduced by 63-82% and average time headway was increased by 16%. As ACC time-headway settings can never be lower than the legally prescribed limit this indicates that safety margins are improved by ACC. It logically follows that the need for harsh braking maneuvers should decrease and the number of high decelerations was reduced (e.g. 69% on motorways). In addition, the number of critical incidents was reduced (e.g. 82% on motorways). Further, Malta et al (2012) demonstrated that the highest reduction of harsh braking events can be found in phases where the ACC was active (ACC active + FCW on, and ACC active + FCW off) rather than when just the FCW was active (ACC off + FCW on).

These field data results (Malta et al, 2012) can be contrasted with experimental data, which largely have been collected in driving simulators (for a review see De Winter et al, 2014; Young & Stanton, 2007). Concerns about harmful effects of increasing automation such as ACC have been raised, largely based on these driving simulator studies. A number of experiments have found that ACC drivers can be slower to respond to critical events compared to manual drivers, while many studies show faster reactions to artificial visual stimuli (De Winter et al, 2014). Slower response has been measured as reactions to automation failure (Rudin-Brown & Parker, 2004; Strand et al 2014; De Winter et al, 2014), reaction time to artificial visual stimuli, and tests of object detection and comprehension (De Winter et al, 2014). Of the various measures of slower response, it is perhaps the slower driver brake reactions to conflicts that are most concerning (Young & Stanton, 2007; Stanton et al 2001; Larsson et al., 2014). However, Larsson et al. (2014) argue that an increased brake reaction time during ACC control is not necessarily a disadvantage of the system, as experienced drivers clearly trust it to perform its task appropriately and only intervene at the last second. Further, Victor et al (2015) showed, in naturalistic rear-end crashes and near-crashes, that reaction times are driven by lead-vehicle looming and not brake light onsets as for instance reported by Young and Stanton (2007). Further research is needed to understand whether experimental reaction time data transfer into field effects (Merat & Waard, 2014). Malta et al (2012) is to our knowledge the only long term field study of FCW+ACC use so far.

In a meta-analysis of primarily simulator experiments, De Winter et al (2014) concluded that a lower level of workload is experienced by drivers using ACC than manual driving. However, results for situation awareness vary between studies. ACC use can result in deteriorated situation awareness when engaged in secondary tasks but improved situation awareness if attending to the driving task. De Winter et al (2014) concluded that ACC typically does increase secondary task engagement. Malta et al (2012) also investigated hypothesized negative side effects of FCW+ACC in terms of increased secondary task engagement, attention to forward roadway, and drowsiness in the EuroFOT study. FCW+ACC presence did not seem to affect the amount of drowsy driving. They found that during normal driving, drivers were in general more likely to engage in secondary tasks when using FCW+ACC, and three times more likely to engage in visual secondary tasks (e.g., reading maps, looking at passengers or objects in the car) compared to driving without advanced driver assistance systems. However, during crash relevant events, no such increase in secondary task engagement was found. During crash relevant events, driver's attention towards the forward roadway was actually higher in FCW+ACC driving than in manual driving. This suggests that FCW+ACC is successful in redirecting driver attention toward the forward roadway when needed.

## Aim

In naturalistic driving data, the combination of ACC and FCW appears to have a positive effect on safety-related measures (Malta et al, 2012) *despite* a general increase in secondary task involvement. This positive effect was attributed to increased safety margins (headway) while driving with active ACC and FCW. To shed more light on these issues, this study examines the relationship between drivers glance locations and ACC hard braking or forward collision warning events when ACC is active.

This study examines the time course of driver visual attention before, during, and after (1) ACC braking (peak deceleration ≥ 3 $m/s^2$) or (2) FCW warnings while ACC is engaged (FCW+ACC). Comparisons are made with (3) ACC maintaining constant speed (no braking or warning) and (4) driver braking without ACC or FCW. Several hypotheses for the safety benefit of ACC despite an increase in secondary task involvement are examined in this paper. Here, we examine glance locations (e.g. windshields, phone) and EyesOffPath as measures of inattention. These measures are thereafter discussed in relation to secondary task involvement.

The main hypothesis is that *off-path glances are reduced by ACC braking and forward collision warnings.*

Another hypothesis is that *ACC braking has an attention orienting effect that causes drivers to look towards the forward path* because they sense ACC braking in lead-vehicle closing or cut-in situations. Thus, when drivers are inattentive, ACC may help drivers to redirect their attention the forward path and respond earlier to decreasing headways than they would in manual driving.

Further, we hypothesize that *FCW has an attention orienting effect towards the forward path in lead-vehicle closing and cut-in situations (threat period) and away from the road after the threat-*

*period in order to understand the circumstances of the warning, in line with results from Wege, Will & Victor (2013).*

# METHOD

## The EuroFOT database

The data analyzed in this study was retrieved from a database containing driving data from 100 Volvo cars driven in normal day-to-day traffic for one year. The data was collected in the EuroFOT-project (Kessler & Etemad 2012, Malta et al. 2012) and contained 3-4 months of driving without access to advance driver assistance systems (baseline), and the remaining time with access to systems such as adaptive cruise control, forward collision warning, and lane departure warning (treatment). The data was recorded at 10Hz and contained video (driver view, forward view, rearward view, feet view) and recorded signals (e.g., speed, brake pressure, distance to lead vehicle, state and settings of advanced driver support systems).

## Data selection

### General inclusion criteria

Four samples of driving segments were retrieved from the database. The inclusion criteria for all driving segments were: motorway driving, speeds above 30 km/h, and mainly straight road segments (curve radius > 1000m, estimated by yaw rate and maps as described in Tivesten and Dozza (2014)). Segments were included in the analysis only if the front view and driver video were available, and the drivers' eyes were clearly visible. Additional criteria were selected for each sample as described below.

### Sample 1: ACC braking

This sample included driving segments where ACC was braking with a deceleration of 3 $m/s^2$ (approx. 0.3g) or more. In addition, 15 s of driving before and 15 s after the onset of ACC braking (determined by the onset of brake pressure) was included in each segment. A segment was not included if the driver changed set speed, or performed a lane change or overtaking in the 5 s interval before or during the ACC braking. Also, a segment was included if the car was in car-following mode at the onset of ACC braking (i.e., car regulating speed based of time gap to lead vehicle), the ACC was on and active, the time gap to the lead vehicle was set to 1.0 s or 1.4 s. In total, there were 50 valid segments that fulfilled all the criteria in the database and these were all included in the analysis. There was a brake capacity warning (visual only in the head up display) in 7 out of the 50 segments, but there were no instances of a FCW (visual and auditory warning).

### Sample 2: ACC maintaining speed

This sample contained driving segments at constant speed with ACC. Each driving segment contains 5 seconds of driving where the driver was going at constant speed with ACC active/on and a lead vehicle was present within 150 m of the subject vehicles. All the same selection criteria as in sample 1 was also applied for this sample, except for the deceleration. Instead the filtered[1] deceleration should not to deviate more than +/-0.2 $m/s^2$ and the change in speed should be less than 2 km/h during the 5 second interval. Each segment was matched by selecting the same driver, set time gap, and speed within +/- 15 km/h as a segment in sample 1 at the onset of the ACC braking, resulting in 50 segments.

[1] 5th order low pass Butterworth filter with normalized cut off frequency of 0.1

### Sample 3: Driver braking

This sample was also matched to Sample 1 and contained 50 driving segments from EuroFOT baseline where no advanced driver support systems such as ACC or FCW were available. This sample included events where the driver was braking with a deceleration of at least 3 $m/s^2$. In addition, 15 s of driving before and 15 s after the onset of driver braking (determined by brake pressure and brake pedal position) was included in each segment. Only eleven segments were possible to match by driver ID, and the remaining samples were matched by +/- 10 years of driver age. All segments were matched by the speed within +/- 15 km/h, and fulfilled the general inclusion criteria described above. There was no matching based on time gap (i.e., time headway) for this sample since the time gap was varying over each segment.

### Sample 4: FCW + ACC

This sample is independent from the previous samples but fulfilled the general inclusion criteria. The sample included driving segments where a FCW was issued while driving with ACC. In addition, 15 s of driving before and 15 s after the onset of FCW was included in each segment. The segment required that before and at the onset of FCW the ACC was on and active, a lead vehicle was within 150 m and the time gap was set to 1.0 s or 1.4 s. A segment was not included if, in the 5 seconds interval before the onset of FCW, the driver changed either the ACC set speed or the FCW settings (e.g. the modality of warning), performed a lane change or overtaking. Moreover, the segment was also discarded if a LDW was triggered prior to the onset of FCW. In total, there were 21 valid segments that fulfilled all the criteria in the database and these were all included in the analysis. The FCW modality was visual and auditory according to the specifications described by Coelingh, Jakobsson, Lind, & Lindman (2007).

## Coding

The video segments from sample 1-4 were viewed, and several recorded signals were reviewed, to verify that each segment fulfilled the inclusion and matching criteria. Drivers gaze direction was coded based on driver and forward video. Gaze direction was coded frame by frame for each segment by using the following categories: On path, Centre stack, Driver Information Module (DIM), Phone, Interior object, Passenger, External non-driving related attention (External NDR), Eyes closed, Other NDR, Rear view mirror, Left side mirror, Right side mirror, Left window, Right window, Left windscreen, Right windscreen, Left over shoulder, and Right over shoulder. Short blinks where the driver had his/her eyes closed during one frame was ignored in the coding, while eyes closed for at least two frames was coded as Eyes Closed.

## Analysis

A time vector was created for each segment to make it possible to compare all segments within a sample to a specific reference time set to 0 seconds. For each sample, the reference time was set to the onset of ACC braking in sample 1, the beginning of the constant speed interval in sample 2, the onset of driver braking in sample 3, and the time when the forward collision warning was issued in sample 4.

### Gaze direction

The distribution of gaze direction was plotted across the time vector to get an overview of what the driver was looking at before, during, and after the onset of braking or warning (illustrated in figure 1).

### %EyesOnPath

A binary EyesOnPath variable was created based on the coded gaze direction. EyesOnPath was set to 1 for gaze direction equal to On Path and 0 for all other gaze directions.

The time vector at 10Hz was collapsed into 2-second bins for sample 1, 3, and 4. For instance time stamps -0.9 through 1.0 seconds were assigned to time equal to 0 seconds, 1.1 through

3.0 seconds were assigned to the time +2 seconds, and so on. For sample 2 (ACC constant speed), the complete 5-second interval was collapsed into one single bin. The %EyesOnPath was then calculated for each bin for every individual driving segment. The mean and standard error were then computed for each sample.

## Time Headway

The time headway to the lead vehicle was computed to be able to compare any differences between samples 1-4 in car-following behavior. Time headway was computed as distance to lead vehicle in meters divided by subject vehicle speed in meters per second. All time intervals and segments with valid measurement of distance to lead vehicle by the forward radar was included in this analysis. In addition, maximum inverse time to collision (Max(1/TTC)), corresponding to lead-vehicle looming, was retrieved for each segment to provide descriptive statistics on event severity for the different samples.

## Analysis of driving with and without ACC

The distribution of %EyesOnPath in each 2 second bin was typically not normally distributed since several segments had 100% EyesOnPath. The 2 second bins within the same sample was considered as related samples since they were part of the same driving segments. Furthermore, sample 1-3 were considered as related samples since they were matched according to the criteria previously described. Therefore, Wilcoxons signed rank test (non-parametric test for related samples) was used to compare differences in % EyesOnPath between different 2 second bins within the same segments, and to compare differences between matched samples. Wilcoxons signed rank test was also used to compare differences Time Headway within the same sample and between matched samples.

## Analysis of FCW events when driving with ACC (FCW+ACC)

Sample 4 (FCW+ACC) was analyzed in a similar way as Sample 1-3 with the exception that sample 4 was treated as independent to the other samples. The Mann-Whitney U test was used to compare differences between a 2 second bin in sample 4 with sample 2 (ACC maintain speed), while the Wilcoxons signed rank test was used to compare 2 second bins within sample 4. All statistical tests were adjusted for multiple testing using the Benjamini and Hochbergs false discovery rate (Benjamini & Hochberg, 1995). The adjusted p-values were considered statistically significant at 0.05.

 

# RESULTS

## Driving with and without ACC

The drivers directed their gaze towards the forward path most of the time. The distribution of gaze directions for all segments in sample 1-3 is shown in Figure 1 below, where the white area represents on path gaze direction. A large portion of the off-path glances were directed to other parts of the road environment as indicated by blue colors (through mirrors and windows). The driver information module (DIM) also attracted a large amount of the off-path glances, suggesting that the driver frequently checked the speedometer, fuel, or other information messages displayed in the DIM. In sample 1 (ACC braking), the drivers frequently checked the rear view mirror and the DIM a few seconds after the onset of ACC braking (Figure1a), while this type of check after braking was less prevalent when driving without ACC (Figure 1c). Non-driving related glances, such as looking at passengers or interior objects, were less common and only observed in a few segments. The black curves in Figure 1 shows the corresponding mean %EyesOnPath for the 2 second time intervals (Figure 1a, 1c) and the 5 second segments where ACC was maintaining speed.

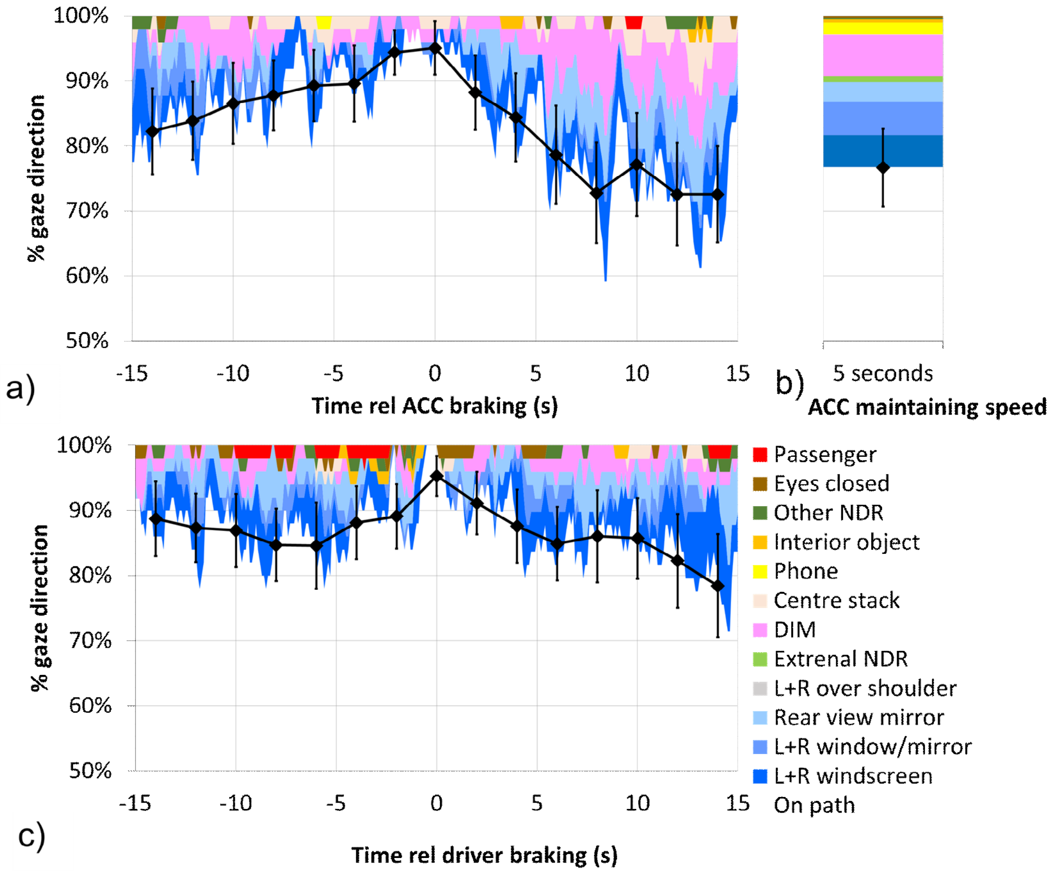


***Figure 1: The distribution of gaze direction as a function of time: a) Sample 1 (ACC braking), b) Sample 2 (ACC maintaining speed), c) Sample 3 (Driver braking). The black curve indicates the mean %EyesOnPath for the 2 second intervals with 95% confidence intervals.***

The driving segments in Figure 1b) ACC maintained speed had a mean 77% EyesOnPath, while Figure 1a) ACC braking segments had a 95% EyesOnPath at the onset of ACC braking (p<0.001, z=-4.89) as shown in Figure 2a. The segments with ACC braking show a steady increase in %EyesOnPath from 82% to 95% when comparing 14 seconds before the onset of ACC braking and the onset of ACC braking ($p<0.01$, $z=-3.09$) (Figure 1a). The difference in %EyesOnPath was not statistically significant when comparing 14 seconds before the onset of ACC braking compared to ACC maintaining speed ($p>0.05$, $z=-1.43$).

The segments including driving without ACC where the driver was braking (Figure 1c) show a slightly different pattern, where the %EyesOnPath varies between 85% and 89% prior to the onset of driver braking. The moderate increase from 89 %EyesOnPath at 14 seconds prior to braking to 95% at the onset of driver braking is not statistically significant ($p>0.05$, $z=-2.02$).The %EyesOnPath was significantly higher when comparing 14 seconds before the onset of driver braking compared to the segments where ACC maintained speed ($p<0.01$, $z=-2.80$).

The mean time headway is consistently higher in the ACC braking segments compared to the segments where the driver is braking while driving without ACC (Figure 2b). This difference is statistically significant at the onset of braking ($p<0.05$, $z=-2.46$) and at 14 seconds after the onset braking ($p<0.01$, $z=-3.00$), but not at 14 seconds before braking ($p>0.05$, $z=-1.76$).

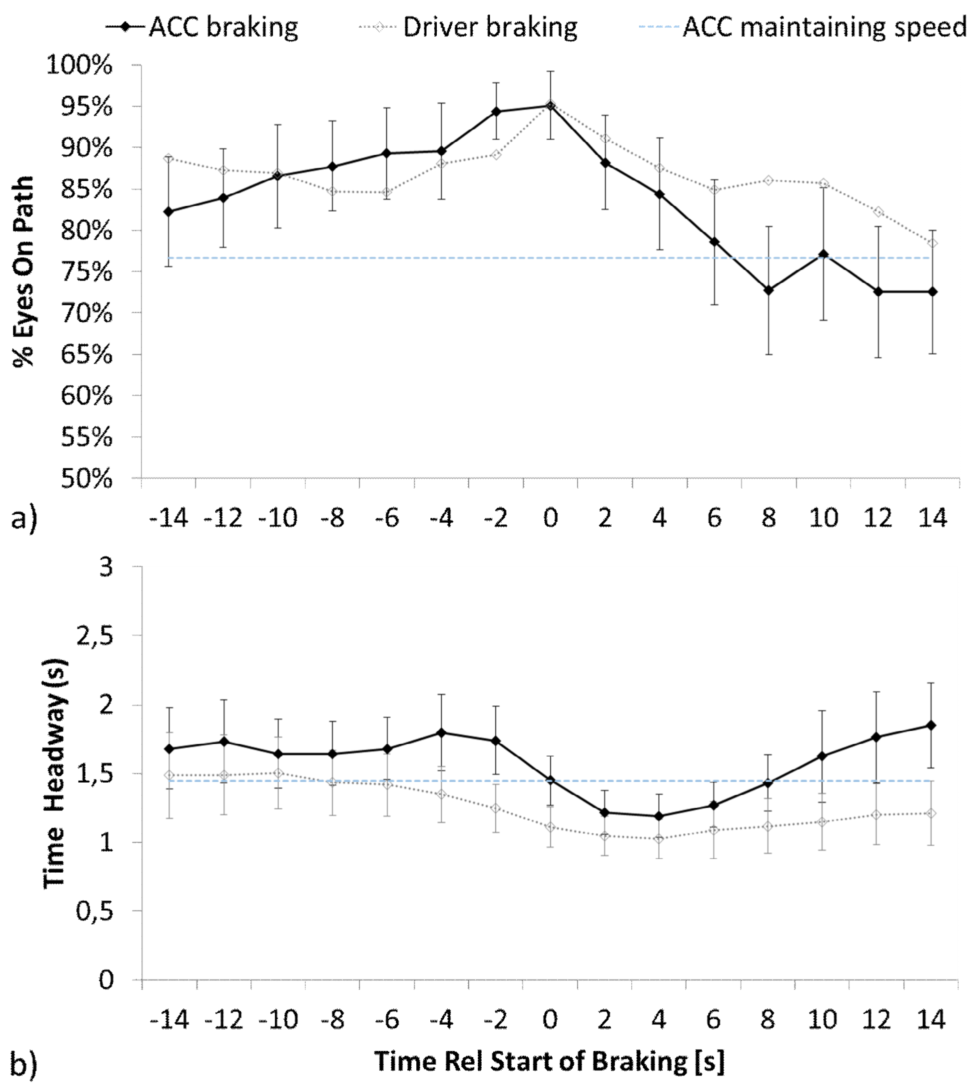


***Figure 2: The y-axis shows a) Mean percent eyes on path, and b) Mean Time headway. The x-axis shows 2 second time intervals relative to the onset of ACC braking or driver braking. The bars indicate 95% confidence interval for the mean values.***

## FCW when driving with ACC (FCW+ACC)

The distribution of gaze directions for all segments in sample 4 is shown in Figure 3, where the white represents on path gaze. As in case of samples 1-3, the drivers directed their gaze towards the forward path most of the time, and they had a similar distribution of off-path gaze directions. Similarly to sample 1 (ACC braking), the drivers frequently checked the rear view mirror and the DIM for a few seconds after the onset of FCW.

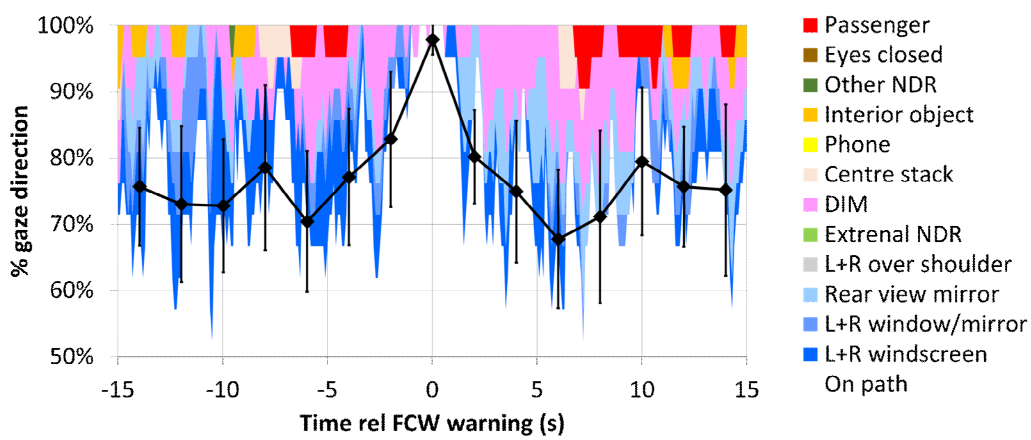


***Figure 3: The distribution of gaze direction as a function of time for Sample 4 (FCW+ACC) as a function of time relative the FCW warning. The black curve indicate the mean %EyesOnPath for the 2 second intervals with 95% confidence intervals.***

The black curve in Figure 3 and 4a shows the mean %EyesOnPath based on the 2 second time intervals. Whereas driving segments where ACC maintained the speed had an average value of 77% (Figure 1b), segments with FCW+ACC had the maximum value of 98% at the onset of FCW ($p<0.001$, U=170.5, r=-0.55). The segments with FCW+ACC show a symmetrical pattern whereby, there was an increase in %EyesOnPath from 76% to 98% when comparing 14 seconds before and at the onset of FCW ($p<0.01$, z=-3.39), and a decrease of equal value 14 seconds after the FCW was issued ($p<0.01$, z=-3.02). This trend was particularly evident in the 2 seconds interval before and after the onset of FCW. Before the warning %EyesOnPath rises from 83% to 98% ($p<0.05$, z=-2.58) and it drops after to 80% ($p<0.01$, z=-3.31).

Figure 4b indicates that the time headway in FCW+ACC segments before the onset of the warning, and the time headway where ACC was maintaining speed were similar (Figure 1b). This was expected, since the set time gap was similar in both samples. After the FCW was issued, mean time headway increased dramatically and had a large standard deviation compared to ACC maintaining speed. The difference in time headway was significantly higher in the FCW+ACC sample at 10 seconds after the warning compared to when ACC was maintaining speed ($p<0.05$, U=339.0, r=-0.25).

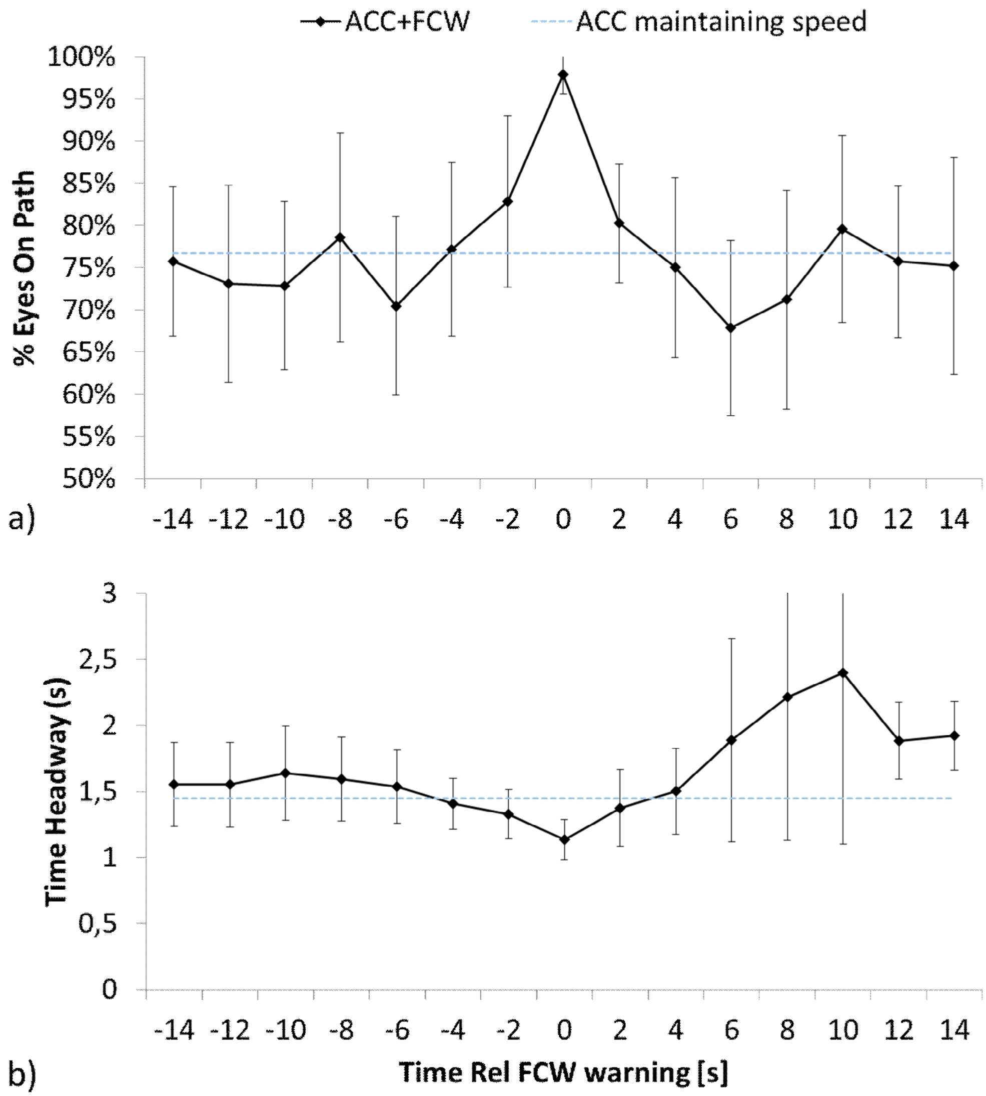


***Figure 4:  The y-axis shows a) Mean percent eyes on path, and b) Mean Time headway. The x-axis shows 2 second time intervals relative to the onset of the FCW warning. The bars indicate 95% confidence interval for the mean values.***

The maximum value of inverse time to collision (Max(1/TTC) , i.e. looming) was slightly higher in the ACC braking sample (M=0,22 s-1, Mdn=0,22 s-1, SD=0,06 s-1) compared to the Driver braking sample (M=0,20 s-1, Mdn=0,21 s-1, SD=0,08 s-1) while a much larger standard deviation was noted for the Driver braking sample. The Max(1/TTC) was, as expected, higher in the FCW+ACC sample (M=0,32 s-1, Mdn=0,26 s-1, SD=0,10 s-1) compared to the other samples.

# DISCUSSION AND CONCLUSIONS

14 seconds prior to braking, driver's eyes were directed more towards the road when driving without ACC (89% EyesOnPath) than 14 seconds prior to ACC braking (82% EyesOnPath). These levels can be compared with EyesOnPath results from previous naturalistic driving baselines (80-83% EyesOnPath in SHRP2 and 100-car baselines, see Victor et al, 2015). Notably, there was an average of 77% EyesOnPath in the ACC maintaining speed segments. These results indicate that drivers do take their eyes off path more when using ACC. However this conclusion seems to be valid only in non-critical (baseline-similar) situations. These results seem to support previous conclusions that drivers are more likely to engage in secondary tasks (Malta et al., 2012, De Winter et al 2014) when driving with ACC, however it is important to note that we focused the analysis on eyes off path and not secondary task engagement. Eyes off path towards, for example the DIM or windows, could be related to the primary task of driving or a secondary task. The proportion of secondary task engagement was typically low in the present study and there were no clear difference in Driver braking and ACC braking conditions with respect to secondary task engagement. This result is In line with Malta et al (2012)'s results that showed no increase in secondary task engagement in crash relevant events.

Interestingly, the results indicate that drivers anticipated critical situations by directing their eyes proportionally more towards the developing situation well before it becomes critical. The average amount of EyesOnPath increased steadily over time before the ACC initiated braking, before the drivers themselves braked, and shortly before the FCW was issued. Because drivers seem to react to external stimuli (e.g. approaching a vehicle) and anticipate braking, there is little to improve upon, at least in the situations examined here. An additional positive effect from ACC and FCW would have to improve from this level. In real crashes and when performing secondary tasks, there could be a stronger attention orienting effect of ACC and FCW. This anticipatory eyes on road response makes it difficult to examine the main hypothesis that *off-path glances are reduced by ACC braking and forward collision warnings,* because the effect of ACC and FCW would have to come *in addition to* this anticipatory effect. However, we can conclude that the anticipatory eyes on road response to a critical braking situation is not significantly different as there was an average of 95% EyesOnRoad both at the onset of ACC braking and at the onset of driver braking. Similarly, when forward collision warnings were issued there was 98% EyesOnPath.

When using ACC drivers seem to look more at the Driver Information Module (DIM), perhaps to monitor the ACC display, and look towards other parts of the road environment through mirrors and windows (Figure 1a). There was no strong indication of increased distraction towards secondary tasks such as phone, interior objects etc during hard braking although this was slightly more prominent in ACC maintaining speed.

Regarding the hypothesis that *ACC braking has an attention orienting effect that causes drivers to look towards the forward path*, the anticipatory eyes on road response to a developing situation also leads to an unexpected conclusion. Drivers already have an average of 95% EyesOnPath at the onset of brake pressure by the ACC, making a further increase difficult to detect. It is possible that deceleration caused by ACC throttle control may provide a cue to look ahead. For example, Lee et al (2007) found that drivers are sensitive to ACC decelerations as low as 0.015g under ideal conditions in a driving simulator, and that this sensitivity varies dependent on both maximum deceleration and brake duration. In naturalistic driving, these levels may differ due to noise and vibrations from the road and speed. It is possible that there would be different results regarding an attention orienting effect if crashes with ACC active could be analyzed. A large proportion of the off-path glances were related to the driving task, which may explain the anticipatory gaze behavior in the present study. Other results could be expected if specifically selecting drivers that were engaged in a secondary task at the onset of ACC braking and/or FCW warning. It is possible that ACC braking would show a clear attention orienting effect for drivers engaged in a visual secondary task.

A strong attention orienting effect from the FCW was found, supporting the hypothesis that *FCW has an attention orienting effect towards the forward path in lead-vehicle closing and cut-in situations (threat period) and away from the road after the threat-period in order to understand the circumstances of the warning.* There was 98% EyesOnRoad at the onset of FCW, with a particularly evident increase from 83% the 2 second interval before the onset to 98%. After the warning the %EyesOnPath returned to the same level as before the warning (about 76% EyesOnPath). This similar pattern of results was shown by Wege, Will & Victor (2013).

Another unexpected interesting result was the post-threat-period response after braking (Figure 2a, from 0 to +14s). It appears that drivers look around more to orient themselves with the traffic situation (e.g. improve situation awareness) after ACC braking or Driver brakng. These after-threat glances were frequently directed to the rear-view mirror and the DIM. This might correspond to a need to check for potential threats from following vehicles, and to monitor the change is speed a consequence of driver and/or ACC braking.

Malta et al (2012) concluded that due to the predefined settings of the ACC time-headway, the frequency of close approaching events is highly reduced compared to manual driving. However, when these events do occur, and the time course of headway is examined (Figure 2b and 4b), a general pattern can be observed. In line with Malta et al (2012), the mean time headway is generally longer in the ACC braking segments compared to the Driver braking segments. Thus, at braking onset, headway was significantly longer when ACC braked compared to when the driver braked. Headway decreased somewhat when the FCW was issued and then increased markedly afterwards, perhaps because drivers initiated braking. The slightly higher maximum value of inverse TTC (maximum looming) in FCW+ACC than Driver braking is likely an effect of data selection as FCW is only issued in critical situations. Thus, when driving with ACC the frequency of FCWs by generally providing an increased headway.

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