Fail to notice or distracted?

An empirical study of hazard perception among adolescent cyclists

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Abstract

This study examined the difference in hazard perception and visual search between adolescent and adult cyclists, as well as the impact of distraction hereon. This because previous car research showed that young-inexperiened drivers compared to adult-experienced drivers, are worse in hazard perception and scan traffic less widely. Previous research also showed that visual search of car drivers is impaired by distraction. In this study, adult and adolescent cyclists completed a hazard perception test, which consisted of traffic videos from the perspective of a cyclist, in a control and distraction condition. Participants were asked to press a button whenever they thought a situation was hazardous, eye movements were analyzed using an eye tracker. Results showed that overall, adults pressed the button more often during the hazard perception test than adolescents. Besides that, in the control condition, adults pressed the button more for hazardous situations and therefore scored higher on this aspect of the test than adolescents. There was no difference between age groups in terms of fixations on hazardous situations. However, there was an effect of distraction, when distracted by a secondary task, both groups fixated less in hazardous areas. Surprisingly, results of visual search showed that in the distraction condition adolescents scanned the videos more broadly from side to side compared to adults, in the control condition no difference emerged. The results suggest that on some points, adolescents have poorer hazard perception skills than adults and that distraction has an impact on hazard perception of both groups. Limitations and implications are discussed.

Keywords: adolescent cyclists, hazard perception, distraction, eye tracking

Contents

Relevance of this research

In the Netherlands, cycling is a popular way of transport. The bicycle is used for more than a quarter of all journeys and for distances up to 7.5 km, the bicycle is the most favored way of transport (Ministry of Transport, 2009). Besides the facts that cycling, in comparison to other ways of transport, reduces air pollution, congestion, noise and the benefits for people's health, it also has a downside. Because of lack of protection, cyclists are vulnerable road users and therefore run a higher risk of getting injured in a crash. For each car casualty (fatalities & severely injured) there are 150 bicycle casualties in car-bicycle crashes (Wegman, Zhang & Dijkstra, 2012). Additionally, of all the serious road injuries in the Netherland, cyclists contribute to the largest group of the injured road participants: more than half of the total in 2009 (SWOV, 2013).

What stands out is that especially young adolescents in the age of 12 to 14 years are frequently involved in traffic crashes while cycling. In 2014, 13 out of 19 fatal traffic accidents among people younger than 15 years happened while they were traveling by bike (CBS, 2015). Besides these fatalities, the amount of seriously injured adolescent cyclists is another noteworthy problem. As can be seen in Figure 1, which presents the number of seriously injured cyclists per 100 000 citizens, the amount of seriously injured cyclists is especially high in the age group 12-15 years old (SWOV, 2013).

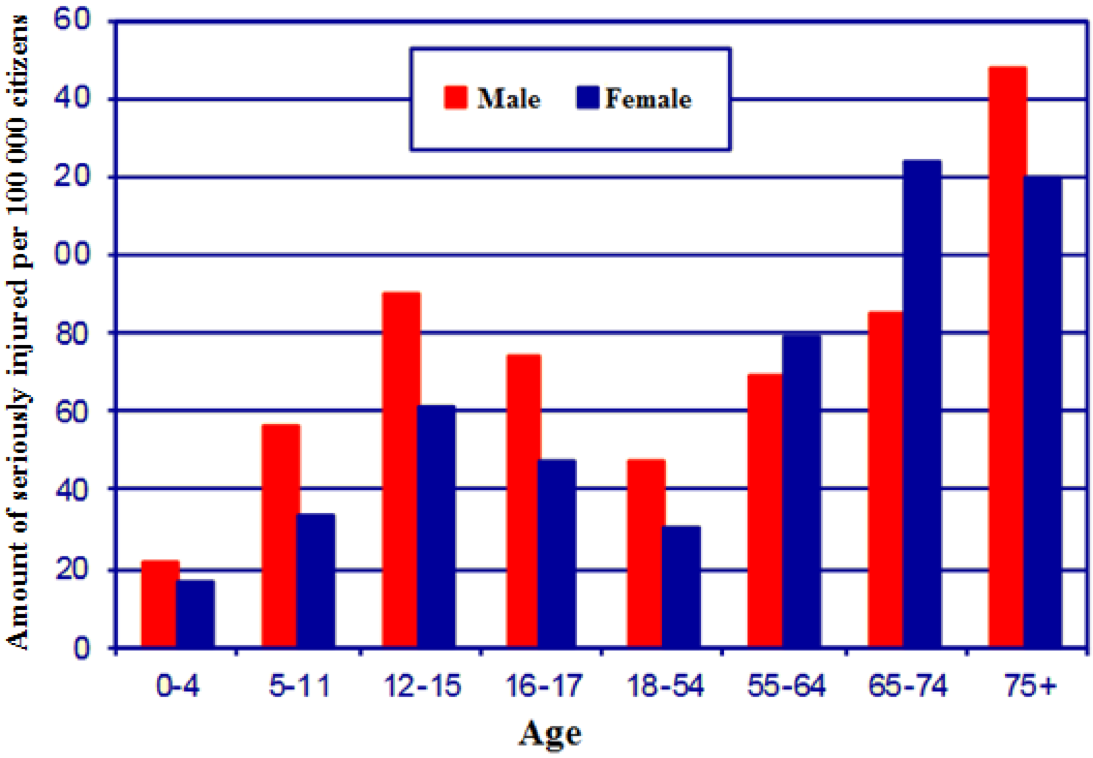

Figure 1. The amount of seriously injured cyclists per 100 000 citizens by gender and age category in 2005-2009 (LMR-DHD; CBS). Adapted from "SWOV Factsheet on Cyclists' by SWOV institute for road safety (2013). Copyright 2013 by the American Psychological Association.

This high amount of seriously injured cyclists among adolescents can be attributed to the fact that this age group travels a lot by bike (more than any other age group), because it is their main means of transport. However the fact remains every year a lot of adolescents get injured while traveling by bicycle, and some of them will have to live with an injury or trauma the rest of their lives.

The road risk of adolescents is thought to be relatively high due to several causes. One of these causes is thought to be their developmental stage, which is associated with risk taking, novelty seeking and inexperience (Steinberg, 2004). Also, considering cycling, the exposure to longer and more complicated school routes of adolescents to their secondary school is thought to play a major role in higher crash risk (Chinn, Elliott, Sentinella &

Williams, 2004). The Dutch Association of Insurers (2015) also detected an increased amount of collisions between cars and cyclists/pedestrians in the first six weeks after summer holidays when schools start again, which supports the view of Chinn et al. (2004).

So far, besides the previously mentioned developmental stage, inexperience and exposure, there is a relatively poor understanding of the role of other risk factors of adolescent cyclists. In terms of skills, such factors might be poor hazard perceptions skill or the division of attention in combination with distraction. Therefore, this research will focus on these other factors influencing adolescents cyclists in the age of 12-14 years, in which the transition to secondary school takes place.

Aim of this research

The aim of this research is to examine if hazard perception differs between adolescent and adult cyclists. Additionally, the influence of distraction on hazard perception of cyclists is examined. If this research shows that adolescents, compared to adults are worse in hazard perception and are more affected by distraction, traffic education programs could be adjusted to these findings. Questions that will be explored in this research are:

- Are adults better than adolescents in recognizing dangerous situations when completing a hazard perception test?
- Are adolescents more affected by distraction while completing a hazard perception test than adults?
- Is there a difference in scanning patterns between adults and adolescents while they look at videos of someone cycling through traffic?

Previous research on hazard perception

Hazard perception is considered to be an important factor in traffic (accidents), and is generally defined as the ability to anticipate to traffic situations and to recognize hazardous situations (Sagberg, 2006). Because so far, very little research has been done on hazard perception of cyclists, previous research of the difference between novice and experienced car drivers in hazard perception and visual search will be discussed. Mourant & Rockwell (1972) found in their research that young, novice drivers fixate longer on irrelevant traffic information and move their eyes less frequently than experienced drivers. Vlakveld (2011) stated that in all studies carried out in real traffic, it was found that young novice drivers scan traffic less broadly from side to side compared to more experienced drivers. Chapman & Underwood (1998) also stated that novices and experienced drivers differed in their visual search. Novices had longer fixation durations especially in dangerous situations.

According to Miltenburg & Kuiken (1990) the longer fixation durations of novice drivers can be explained in the following way: experienced drivers already have more knowledge and formed schemata to deal with dangerous situations which allows them to process a scene faster than novices. Therefore, a longer fixation duration of a participant could be interpreted as having more difficulty with processing visual cues.

However, the research about fixation duration is inconclusive, Huestegge, Skottke, Anders, Müsseler & Debus (2010) did not find a difference in fixation duration between novice and experienced drivers. But in their research, they made use of static scenes, instead of video-based material, which could be the reason their results differed from video-based research.

Pradhan et al. (2005) found in their research that young novice drivers often failed to look at potential hazardous situations. According to Borowsky, Shinar & Oron-Gilad (2010) driving experience improves drivers' awareness of potential hazards and guides drivers' eye movements to locations that might enclose potential risks. In their study, experienced drivers, compared to young-inexperienced drivers, reported more hazardous situations of the traffic scenes they were showed in the experiment. Young-inexperienced drivers were less aware of the potential hazards in the traffic scenes. This supports the finding of Pradhan et al. (2005)

that novice drivers seem to have poorer hazard perception skills and are less aware of potential hazards than experienced drivers.

Consequently of these previous findings, in this current study, scan patterns of adolescents and adults who are watching traffic videos from the perspective of a cyclists will be compared, using an eye-tracker. It is expected that the same visual search difference between inexperienced and experienced car drivers, that was found in previous car research, also emerges between adult and adolescents cyclists. It is also expected that adolescents have poorer hazard perception skills compared to adult cyclists, which will be tested with a hazard perception test.

Adolescence as a period of risk taking

Besides hazard perception, the following factors could also be contributing to the higher crash risk of adolescents: risk taking, novelty seeking and heightened sensitivity to social influences. These factors are all associated with adolescence. Several researchers state there is a maturational gap between cognitive control and affective processes in the brain of adolescents, which may explain adolescents increase in engaging in risky situations and impulsive and dangerous behavior (Somerville, Jones & Casey, 2010 ; Steinberg, 2008). The social-emotional system changes substantial around the time of puberty, whereas the cognitive control system develops gradually over the course of adolescence and young adulthood. This gap causes increased reward-seeking and risk-taking because the cognitive control system which enhances self-regulation is not yet fully developed.

In addition, adolescence is a period in which the social environment changes and gets more and more important. Chein, Dustin, O’Brien, Uckert & Steinberg (2011) showed that adolescents, more than adults, were susceptible for social context while driving a simulated car. Adolescent took more risks while driving when they were observed by peers. The adolescents showed an exaggerated neural responses in the ventral striatum and orbito frontal cortex, which are reward-related regions of the brain, during risk-taking when they believe they were being observed by peers, compared with when they believed they were not being observed by peers. Cascio et al. (2015) found similar results, elaborating on the research of Chein, et al. (2011). They stated that social cues probably play a significant role in how risky decisions are processed by adolescents. Adolescents took more risky decisions in the presence of a peer, compared with solo driving, regardless of the norms the peer embodied. O'Brien, Albert, Chein & Steinberg (2011) suggest that peers probably serve as a social cue for adolescents that primes reward sensitivity and hence adolescents are more likely to take risky short-term decisions rather than safer long-term benefits of decisions.

Hazard perception of adolescent cyclists

Previous studies examined risky decision making and hazard perception of young car drivers. More recently similar studies were carried out on young cyclists. Strijker (2015) conducted a research on the topic hazard perception of adolescent cyclists. She studied whether adolescents cyclists perceived danger in traffic videos differently than adult cyclists and if adolescents were slower in responding to dangerous situations. Participants watched traffic videos from the point of view of a cyclists, in which they had to indicate, by pressing on a button, when they thought a situation was dangerous. Participants received points if they pressed the button for the right hazard. No significant difference in scores on a hazard perception test between adolescents and adults emerged. Additionally, there was no significant difference in reaction time in hazard detection between adolescents and adults. However, there was a significant difference between adults and adolescents in fixation-response time. Adolescents looked earlier at the hazard than adults but pressed the button to mark a situation as hazardous at the same time. Apparently, it took longer for the adolescents to mark a situation as dangerous.

The same kind of phenomenon was found by Baird, Fugelsang & Benett (2005). In their research of risk taking of adolescents they discovered that adolescents took significantly longer than adults to respond to questions like: ‘Is it a good idea to swim with sharks?’. Elaborating on the research of Baird et al. (2005), Feenstra, Ruiter & Kok (2011) also found that adults were faster than adolescents in responding to risky, traffic related, questions. They concluded that adults probably use gist-based intuition instead of considering the pros and cons of a situation and therefore are faster than adolescents in deciding whether a situation is dangerous or not. The rationale behind this is that adults base their decisions more on intuition and schemata they have formed, while adolescents make a rational consideration before deciding whether a situation is dangerous or not.

In this current study on adolescent cyclists, which elaborates on the study of Strijker (2015), again differences in hazard perception will be tested, as well as scanning patterns and fixation duration using an eye tracker. This eye tracker will analyze visual search of participants while they watch short clips of someone who is cycling through traffic. As mentioned before, other research showed a difference in hazard perception between novice and experienced car drivers. Therefore we expect to see this difference also among cyclists of difference age groups.

The impact of distraction on hazard perception

Besides differences in hazard perception and scan patterns between adolescent and adult cyclists, in this study the influence of distraction on hazard perception was also examined. Distraction is thought to be an important risk factor in traffic, road users can be distracted visually, manually and cognitively (Strayer, Watson & Drews, 2011). Visually because drivers take of their eyes of the road for example to grab something in the car, manually because a driver has to type something into the navigation system and cognitively, because the attention of the driver is impaired. In this research we concentrated on the impact of cognitive distraction on hazard perception of cyclists.

According to Stelling & Hagenzieker (2012), who made a literature report solely about distraction in traffic, cognitively distracted road users miss all kinds of visual information because they have to divide their attention to multiple tasks. For example, calling drivers , both handheld and hands-free, have a narrowed visual view, and remember fewer details of traffic situations. Strayer & Johnston (2001) examined the impact of hands-free and handheld cell phone use on detection of traffic signals. Participants drove in a driving simulator and had to break when they saw a red light. Both hands-free and handheld cell phone use caused participants to detect less red lights and caused slower breaking response to the red lights that were detected.

Amado & Ulupinar (2005) explored to which extent it mattered if drivers had a conversation on the phone, or with a passenger in the car. Participants had to complete a primary visual task whilst driving in a simulator; they had to indicate when a light appeared in the peripheral visual field, whether it came from left, right or both sides. Amado & Ulupinar (2005) found that both having a conversation on the phone and with a passenger had a negative effect on attention and the primary visual task.

Some researchers explored the effects of cognitive distraction on cyclists. De Waard, Edlinger & Brookhuis (2011) explored the effects of handheld and hands-free telephone use on cyclists, and found that both had a negative effect on visual peripheral detection. Calling cyclists, performed worse on naming the signs which they detected while cycling, compared to cyclists who were just cycling without calling on the phone. Terzano (2013) found in a field study that bicyclists, who used a cell phone, listened to music or were conversing with other bicyclists more frequently exhibited unsafe behaviors compared to bicyclists who did not perform a secondary task. They also found that bicyclists who performed a secondary task created more situations where other road users had to evade them to avoid an accident.

In this study, we explored the impact of distraction on hazard perception in the form of a captivating secondary task. This secondary task was a guessing game, in which participants simultaneously had to guess animals and complete the hazard perception test. Participants completed the guessing game with another participant; a peer, who was in the same room. This task was based on the guessing game in the research of Horrey, Lesh & Garabet (2009) and was chosen because it simulates a way in which people can be cognitively distracted while cycling in the real world. It's kind of like having a conversation with someone or calling on the phone.

The guessing game required participants to formulate questions to determine which animal they were guessing. Participants had to integrate and remember all the information they gathered during the game. For example: which questions did they ask, what were the answers and what is the best question to ask next in order to determine the animal? Therefore this task utilizes problem solving skills, strategic planning and information integration, which are all three features that are expected to be harder for adolescents, because their brain isn't fully developed yet. Hence, it is hypothesized that adolescents suffer more from doing this distracting secondary task than adults. Additionally, as previous mentioned adolescents respond slower than adults when they have to indicate if they think a situation is dangerous (Baird et al. 2005 ; Feenstra et al., 2011), because they seem to make a rational assessment instead of using gist-based intuition and therefore are already using more of their working-memory. This could also be a reason adolescents are more affected by the guessing game than adults.

Participants were, as a social incentive, told that the duo that guessed the most animals, would win a prize. As mentioned earlier, peers trigger the reward-related regions of the adolescent brain (Chein et al. 2011) and adolescents take more risks when peers are present Cascio et al. (2015). Therefore it is possible adolescents find it more important to do well on the guessing game which they performed with a peer, than to perform superb on a hazard perception test. Another probability is that adolescents are less inclined to mark a situation as hazardous in the presence of a peer, because they think it is not 'cool' to notify a situation as dangerous.

This study

In summary this study examined the difference in hazard perception and visual search between adolescent and adult cyclists, as well as the impact of distraction hereon. All participants completed a hazard perception test, which consisted of traffic videos from the perspective of a cyclist. Participants were asked to press a button whenever they thought a situations was hazardous. Every participant completed half of the hazard perception test alone without distracting task (control condition), and half of the test while simultaneously doing a guessing game with a peer (distraction condition). Total amount of button presses were measured and button presses during hazardous situations. An eye tracker was used to see if participants looked at hazardous situations and to analyze scan patterns

In this study the following hypotheses were tested:

The hypothesis is that adolescent cyclists, compared to experienced cyclists, have poorer hazard perception skills. Hazard perception of both groups is expected to deteriorate by distraction , but this deterioration is expected to be greater among adolescent cyclists.

In line with the first hypothesis, the second hypothesis states that adolescent cyclists, are expected to scan the traffic videos less widely compared to adult cyclists. Both groups are expected to stare more and scan traffic videos less when distracted, but this effect is expected to be bigger among adolescent cyclists.

Method

Participants

In total 63 people participated in this study, consisting of two groups. The first group consisted of 29 adolescents in the age of 12 to 14 (*M* = 12.2, *SD* =.41) and were all first year students of a secondary school. Seventeen of the adolescents were male (58,6%) and twelve of them were female (41,4%). The secondary school students were recruited at the Northgo College in Noordwijk via their teachers. The second group consisted of 34 adults in the age of 19 to 62 (*M* = 32.4, *SD* = 13.3). Ten of the adults were male (29,4%) and 24 of them were female (70,6%). The adults were recruited by hanging up flyers in the local supermarket, via companies in the vicinity of SWOV or were acquaintances of researchers of SWOV. Both groups cycled frequently, the adults reported to cycle 5.06 days a week (*SD* = 1.54) with an average of 49.12 minutes a day (*SD* = 19.42). Adolescents reported to cycle 5.66 days a week (*SD* = .86) with an average of 45.83 minutes on the days they cycled (*SD* = 20.61). All participants voluntary participated in the experiment and signed an informed consent. The adolescents were only allow to participate if their parents also signed the informed consent. This experiment was approved by the ethical committee of SWOV.

Mixed-model design (SPF 2.2 design)

This study used a mixed-model design. The independent between group variable was age (adults and adolescents) and the independent within group variable was condition (control and distraction). Participants completed half of the hazard perception task while a peer was in the same room, with whom they had to complete a guessing game. They completed the other half of the hazard perception test without performing a secondary task or the presence of a peer.

The dependent variables were fixation duration, scan patterns of the x- and y-axis, score on hazard perception task, total amount of button presses, button presses during areas of interest and number of areas of interest in which participants fixated.

Materials

Questionnaire

A short questionnaire was used to gather some background information about the age, sex and bicycle behavior of the participants. Two questionnaires were used, one for the adolescents and one for the adults. Both questionnaires can be found in Appendix A.

Hazard perception test.

A hazard perception test was developed which consisted of two parts, A and B, both consisting of 11 videos displaying the view of someone cycling through traffic with a timespan between 30 and 60 seconds. Consequential, the test in total consisted of 22 videos. To prevent order effects, of both parts a reversed version was used, resulting in four versions: A, A reversed, B and B reversed. These versions were counterbalanced to prevent order effects and were offered according the following schema: ABBA, BAAB, ABBA (reversed), BAAB (reversed).

Participants were instructed to press the spacebar each time they detected a hazard or thought a situation could become dangerous. Previous to the test, two practice videos were displayed so participants could get familiar with the test.

All videos used in the hazard perception test had been recorded with a GoPro Hero 3 Silver Edition Camera. This camera was attached to the bicycles of two interns, who filmed traffic while they were cycling through Leiden and Amsterdam. No situations were planned or set up. Three employees of SWOV decided which timeframes of the film footage could be used to compose 22 videos for the hazard perception test. The aim was to form a test with a wide range of hazards. There were no acute hazards in the videos, only possible hazards that could develop into an immediate threat. These kind of hazards are in literature also referred to as latent hazards (Vlakveld, 2011). A distinction was made between overt and covert hazards, according to the research of Vlakveld (2011), who explains the difference between these types of hazards as follows: ‘Covert latent hazards are possible other road users on collision course that are hidden from view, overt latent hazards are visible other road users that, due to evolving circumstance in the environment, might act in such a way they could move into a drivers pathway’. This distinction between the two types of hazards according to the relationship between precursor and hazard is also made by Crundall et al (2012). The type of hazard (overt or covert) and clip location (Amsterdam or Leiden) were balanced between part A and B of the hazard perception test.

For each video an Area of Interest (AOI) was determined and consisted a time frame and target area in which it was important to be aware of the latent hazard. In this way, it was possible to calculate a hazard perception test score after participants finished the test.

Secondary task : Guessing game

All participants of each age group completed half of the hazard perception test while doing a distracting, secondary task with a peer and half of the hazard perception test alone, without secondary task. This secondary task, called the guessing game, was based on the task used in the research of Horrey, Lesh & Garabet (2009). Participants completed the guessing game with another participant; a peer, who was in the same room. Participants had to ask questions which could be answered with ‘yes’ or ‘no’ to discover which subject, in this experiment different types of animals, their peer saw on cards, which they received from the researchers. An example of the cards can be found in Figure 2.

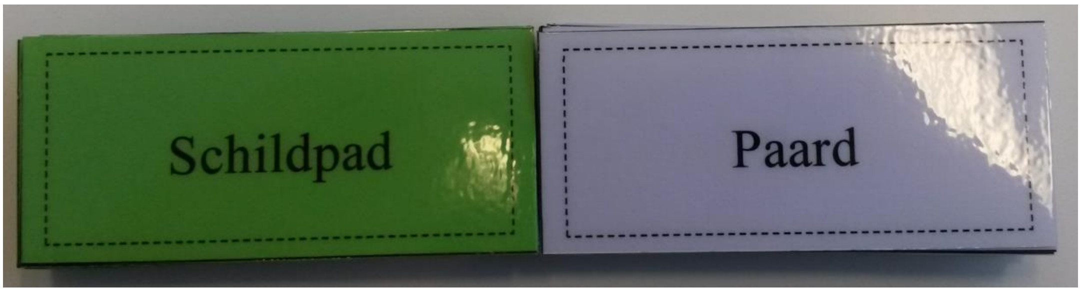

Figure 2. The animal cards which were used for the animal guessing game

The peer was only allowed to answer with 'yes' or 'no' until the participant guessed the animal right. Participants could also pass, then the card moved to the bottom of the pile and they could guess a new animal. For the animal guessing game two stacks each containing 27 cards with animal species on it were used. The instructions of this game can be found in Appendix B.

Eye-tracking equipment

During the hazard perception test the Gazepoint GP3 Eye Tracker was used to register the eye movements of participants. The Gazepoint software was used to run the calibration. The clips were played within the Gazepoint software. With this software, fixation duration, scan patterns and button presses could be analyzed.

Other equipment.

The videos were displayed a 21,5 inch flat screen monitor (aspect radio 16/9) which was placed at 60 centimeters distance of the eyes, because this was the ideal distance for the eye tracker to measure the eye movements. A chinrest was used to prevent participants from moving too much with their head. Participants had a wireless keyboard in front of them, on which they could press a button when they considered a situation as hazardous. An example of the test set-up can be seen in Figure 3.

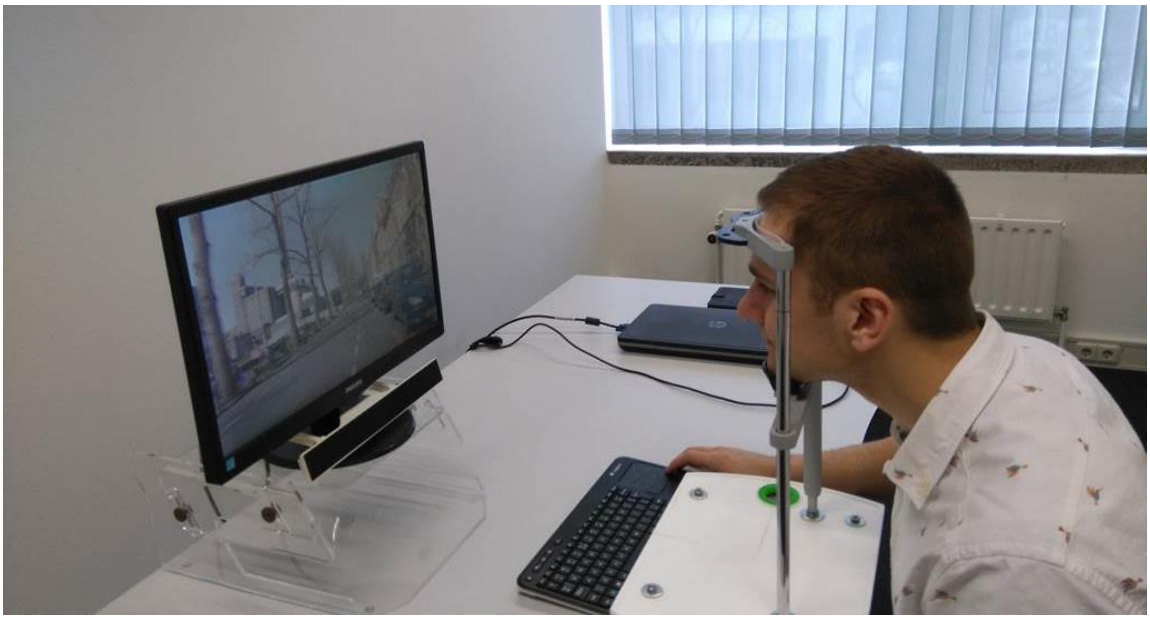

Figure 3. The test set-up

Procedure

Testing of adolescents took place at their school. Testing of adults took place at SWOV and in a room of the house of one of the researchers. Participants were tested in duo’s. The first participant of every duo watched the instruction video first and thereafter started with the first part of the hazard perception test. After completing the first part, the second person of the duo entered the room with whom they had to do the guessing game. Participants were told that the duo that guessed the most animals, would win a prize. So in this way the participants had to work together to guess as many animals as possible. The first person of the duo had to guess the animals while simultaneously completing the second part of the hazard perception test. After completing the second part, participant switched places and the person who so far only had to answer the questions in the guessing game with yes or no, now watched the instruction video while the first participant filled in a short questionnaire. After that, the second participant started with the first part of the hazard perception test while simultaneously guessing animals. After the second participant completed the first part of the test, the first participant left the room. Then the second participant completed the second part of the hazard perception test alone, without executing an extra task.

Afterwards this participant also filled in a short questionnaire. All participants received a voucher worth 10 euro's to thank them for participating in this experiment.

Variables and data analysis

Five mixed between-within subjects analysis of variance were conducted to examine the difference between adolescents and adults within the control and distraction condition on the following dependent variables that were measured during the hazard perception test:

1) Total number of button presses during the test in the control and distraction condition
2) Areas Of Interest (AOI) in which was fixated longer than 200 ms. Participants received one point each time they fixated more than 200 ms in the AOI. The maximum score was 22 for the whole test and 11 for each part of the test. It was chosen to take 200 ms as cut off point, because according to the research of Velichkovsky, Rothert, Kopf, Dornhöfer & Joos (2002), 200 ms is the minimum duration required for focal vision and to detect and recognize hazards in traffic.
3) Standard deviation of scanning the x-axis
4) Standard deviation of scanning the y-axis
5) Mean fixation duration in seconds during the whole hazard perception test.

The fixation duration and standard deviations of scanning the x- and y-axis were derived via the Gazepoint analysis software. This software provided the users point-of gaze (POG) as determined by the internal fixation filter. The X- and Y-coordinates of the fixation POG were determined as a fraction of the screen size, where (0,0) was seen as the top left, (0.5,0.5) as the screen center, and (1.0,1.0) was bottom right.

The difference between adult and adolescent cyclists in button presses during the presence of AOIs was also measured. Participants received one point each time they pressed the button when an AOI was present, the maximum score was 22 for the whole test and 11 for each part of the test. Because the data was skewed (a lot of participants scored 0 on this aspect of the test), a Wilcoxon Signed Rank test was performed to test the within-subjects difference in control and distraction condition in button presses during the AOI. The between group differences in button presses during AOI was tested with the Mann-Whitney U test because of skewness.

Participants were labeled as an outlier if their score was more than three standard deviations below or above the mean score of all participants. Outliers were not included in the analyses. Ten participants of the adolescent group and 5 participants of the adult group were not included in the analyses of the eye tracking data, because the eye tracker did not correctly track the eyes, but tracked their ears instead. For all the statistical tests an alpha level of .05 was used.

Results

Total number of button presses

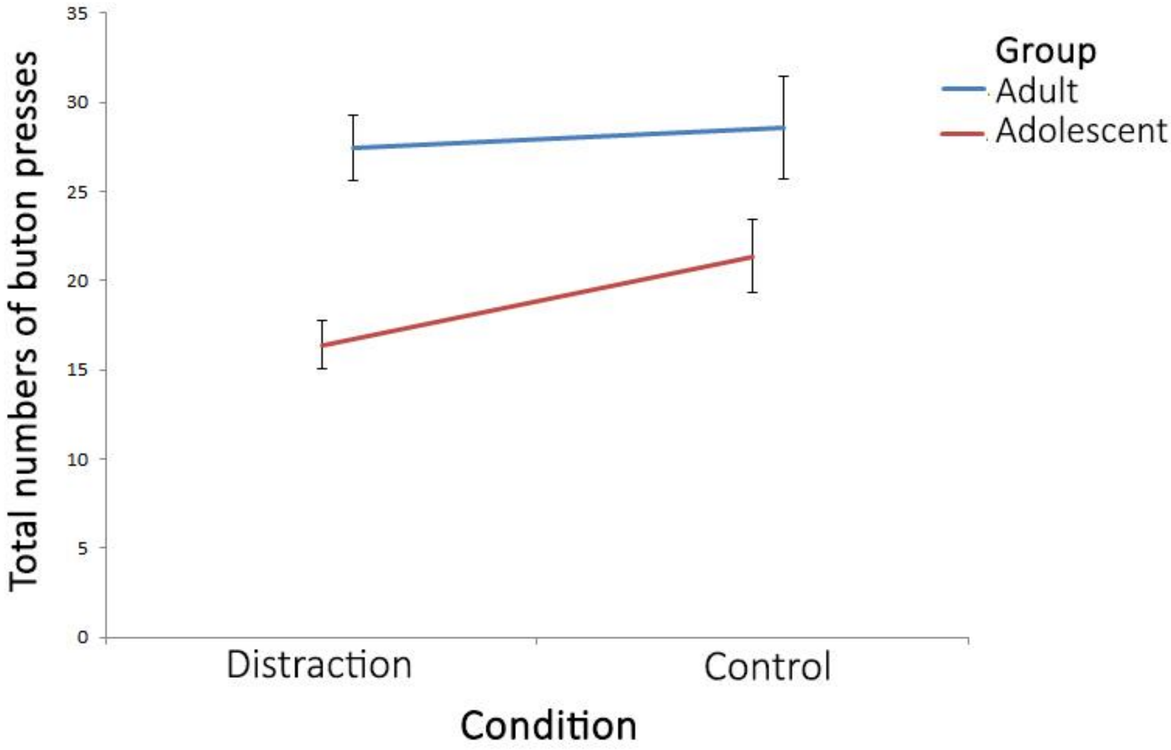

Figure 4. Total number of button presses for hazardous situations during the hazard perception test. Error bars represent +/- 1 SE.

Figure 4 shows the difference between groups on total number of button presses in the control and distraction condition. Because Levenes test of equality of variances was violated, the scores were transformed with log(10). The interaction effect was significant, $F(1, 61) =$ 4,239, $p = .044$, $\eta^2 p = .065$. Adults showed a small difference in button presses between control (M = 28,59 presses , SD = 16.73 presses) and distraction condition (M = 27.47, SD = 10.57), Adolescents, compared to adults, showed a bigger difference in button presses between the control (M = 21.38, SD = 11.09) and distraction condition (M = 16.41 , SD =7.23). The main effect for condition was significant, $F(1, 61) = 4.920$, $p = .030$, $\eta^2{}_p = .075$, as well as the main effect for group, $F(1,61) = 13.85$, $p = .001$, $\eta^2{}_p = .185$.

Number of fixations in AOIs

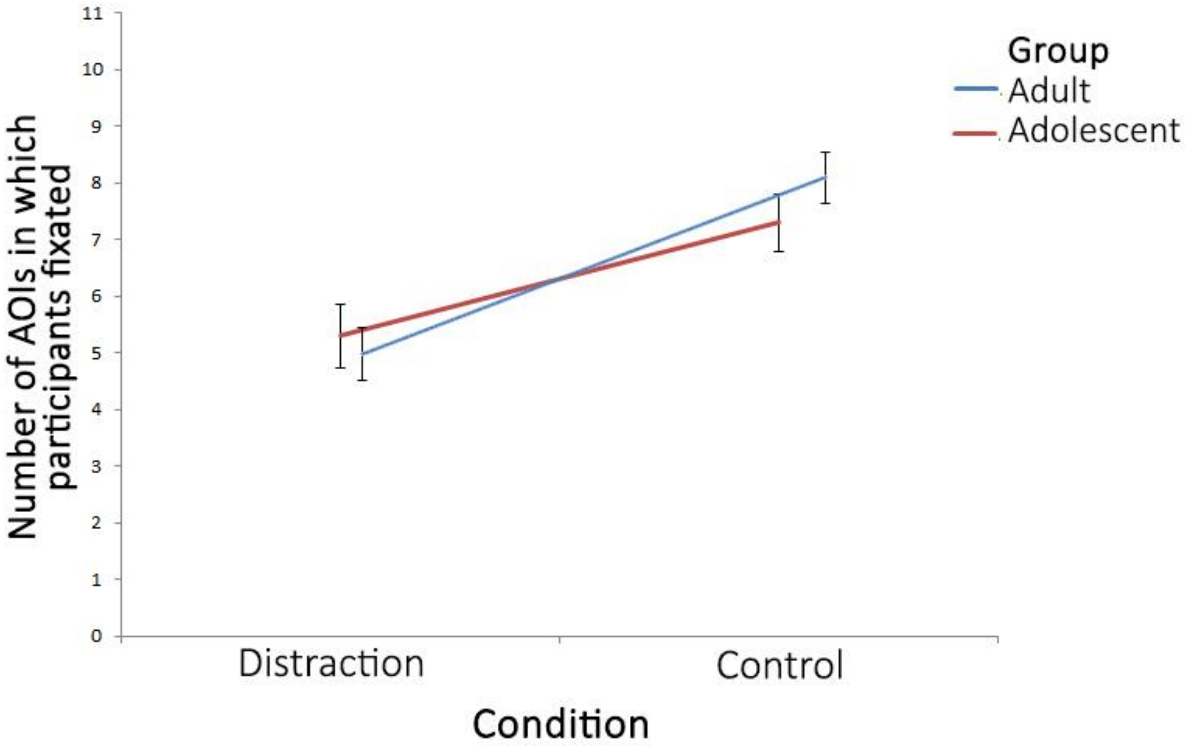

Figure 5. Total number of AOI's in which participants fixated longer than 200 ms. The maximum score per condition was 11. Error bars represent +/- 1 SE.

Figure 5 displays in how many of the 11 areas of interest per condition participants fixated longer than 200 ms. The main effect for condition was significant, $F(1, 47) = 32.438$, $p = .001$, $\eta^2 p = .480$. Both adults ($M = 8.10$, $SD = 2.40$) and adolescents ($M = 7.30$, $SD = 2.25$) looked in more AOIs in the control condition, compared to the distraction condition (*M adults* = 5, $SD = 2.46$; *M adolescents* = 5.3, $SD = 2.52$). There was no main effect for group, $F(1,47) = 0.218$, $p = 0.643$. The interaction effect was not significant, $F(1, 47) = 1.516$, $p = .224$.

Button presses during AOIs

It was also tested whether participants pressed the button to indicate they thought a situation was dangerous, while an AOI was present in the videos. The results are visualized in Figure 6. Because the data was skewed, no interaction effect between groups and condition can be interpreted.

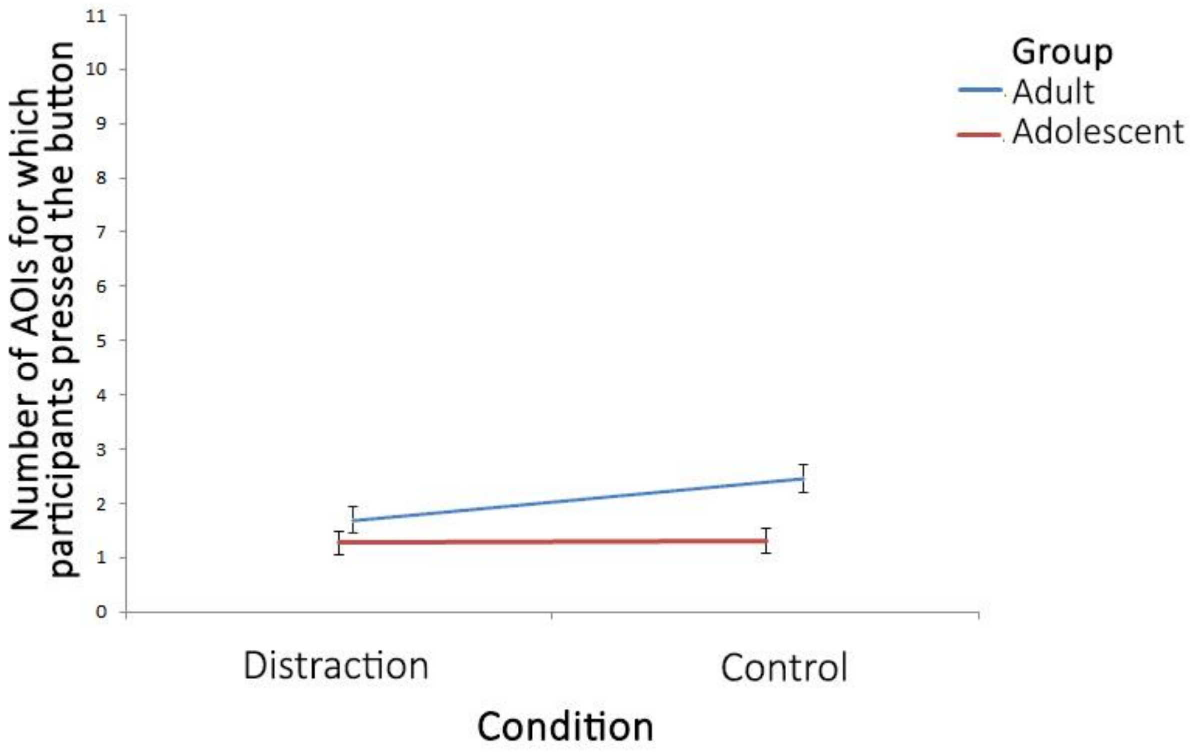

Figure 6. Number of AOI’s during which participants pressed the button to indicate they thought the situation was dangerous.

To test the within-group difference between control and distraction condition the Wilcoxon Signed Rank test was performed. Adults pressed the button more during AOI’s in the control condition (M = 2.47, SD = 1.46) compared to the distraction condition (M = 1.71, SD = 1.40). This effect was significant, T = 293, p = .03, r = .363. Adolescents however, did not press the button significantly more often while an AOI was present in the control condition (M = 1.31 , SD = 1.20) compared to the distraction condition (M = 1.28 , SD = 1.13), T = 130.5, p = .89, r = *.025*.

The difference between the two groups within the two conditions in pressing the button during an AOI was tested with the Mann-Whitney U test. In the control condition, adults scored better than adolescents, they pressed the button more often during the AOI's, U = 711.5, p = .002, r = .388. No difference between adults and adolescents emerged in the distraction condition, U = 576, p =.239, r = .148.

Scan pattern of the x-axis

The results of the analysis of scanning the x-axis are displayed in Figure 7. Because Levenes test of equality of variances was violated the scores were transformed with log(10).

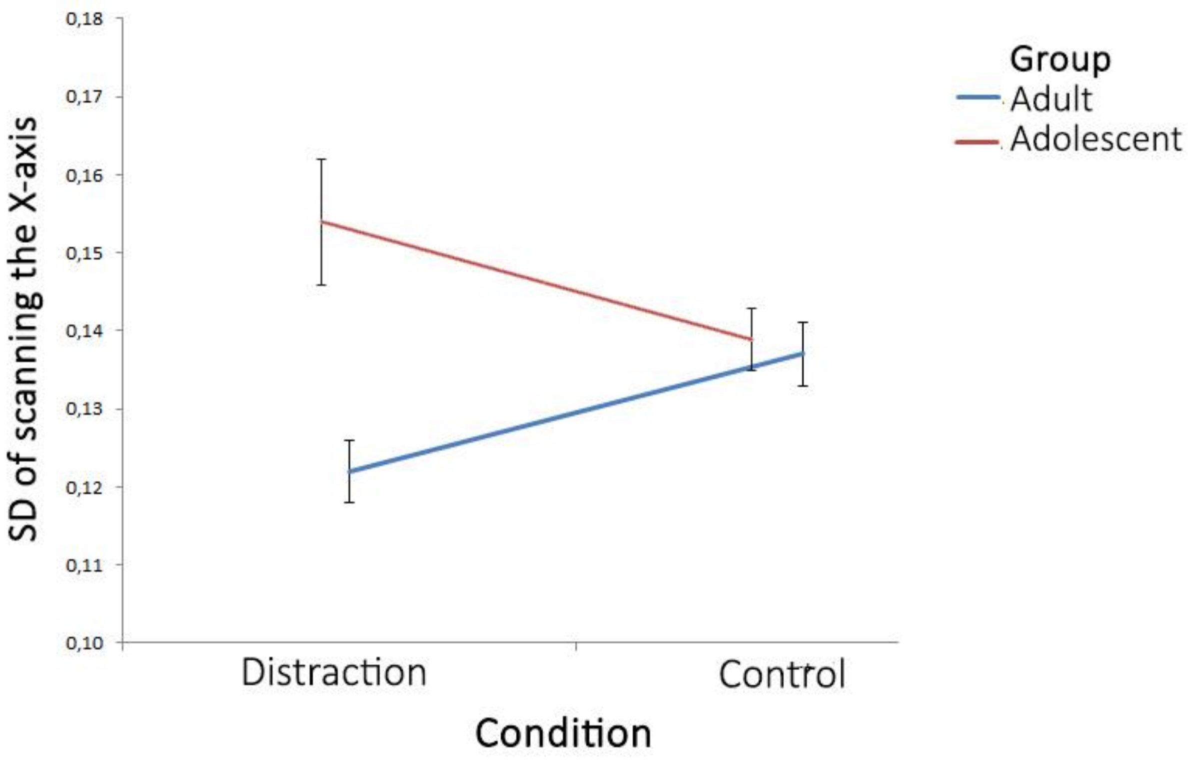

Figure 7. Mean values of the standard deviation of scanning the x-axis in the hazard perception videos. Error bars represent +/- 1 SE.

The interaction effect between group and condition was significant, $F(1, 45) = 18.027$, p =.001, $\eta^2 p$ = .286. There was also a main effect for group, $F(1,45) = 5.895$, p = .019, $\eta^2 p$ = .286 . Adults scanned the x-axis a bit less thoroughly in the distraction condition (M = .12, SD = .02) compared to the control condition (M =.14, SD = .02). On the contrary, adolescents scanned the x-axis more extensively in the distraction condition (*M* = 0.15, *SD* = .04) compared to the control condition (*M* = .14, *SD* = .02). No significant main effect for condition was found, *F*(1, 45) = 0.262, *p* =.611.

Scan pattern of the y-axis

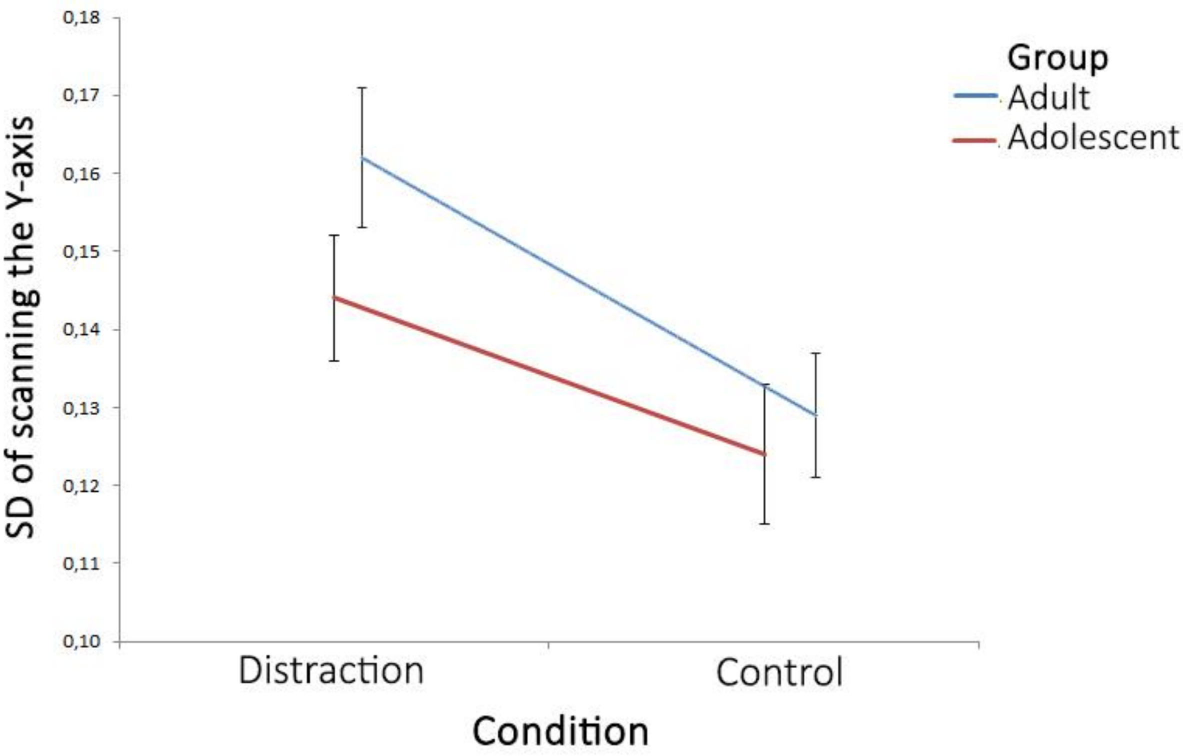

Figure 8. Mean values of the standard deviation of scanning the y-axis in the hazard perception videos. Error bars represent +/- 1 SE.

Figure 8 shows the difference in scan pattern on the y-axis between groups in the two conditions. The main effect for condition was significant, F (1,46) = 14,213, *p* = .001, $\eta^2 p$ = .236. In the control condition both adults (*M* =.13, *SD* =.04) and adolescents (*M* = .12, *SD* =.04) scanned the y-axis less, compared to the distraction condition (*M adults* = .16, *SD* =.05; *M adolescents* =.14, *SD* = .04). There was no significant main effect for group, *F* (1, 46) = 1.215, *p* = .276. There was no significant interaction effect between group and condition, *F*(1, 46) = .822, *p* =.559.

Fixation duration

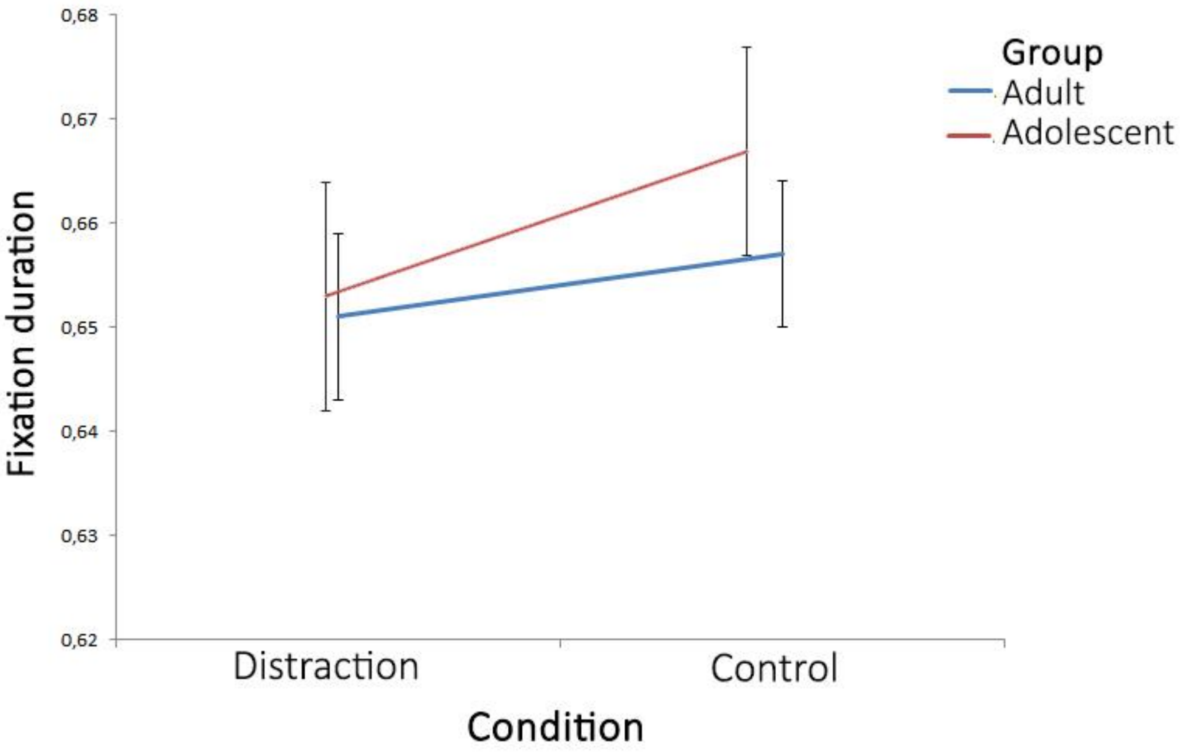

Figure 9. Mean fixation duration in seconds during the hazard perception test. Error bars represent +/- 1 SE.

Figure 9 shows the mean fixation duration of both groups in both conditions. Because Levenes test of equality of variances was violated scores were transformed with log(10).The main effect for condition was not significant, $F(1,44) = 2.513$, $p = .120$, neither the main effect for group $F(1,44) = .322$, $p = .573$. In the control condition, on the average, the fixations of adults lasted .657 seconds ($SD = .04$) and the fixations of the adolescents lasted .667 seconds ($SD = .04$). In the distraction condition the mean fixation duration of adults was .651 seconds ($SD = .04$) and the mean fixation duration of adolescents was .653 ($SD = .05$). There was also no significant interaction effect , $F(1, 44) = .256$, $p =.615$.

Subjective ratings of attention

Participants had to indicate in the short questionnaire to which of the tasks they paid the most attention to; the hazard perception test, the animal guessing game or to both tasks the same amount of attention. Of the adults, 18 participants (52,9%) indicated they paid the most attention to the animal guessing game, 9 (26,5%) indicated they paid the most attention to the hazard perception test and 7 participants(20,6%) said they divided their attention between both tasks. Of the adolescents, 13 participants (46,4%) indicated to pay the most attention to the animal guessing game,10 participants (35,7%) indicated that they paid the most attention to the hazard perception test and 5 adolescents (7,9%) indicated that they divided their attention between the two tasks. Thus, more than half of all the participants indicated to have been more focused on the guessing game than on the hazard perception test.

Discussion of results

One of the goals of this research was to test whether adolescent cyclists, compared to experienced adult cyclists, have poorer hazard perception skills. The impact of distraction on hazard perception was also examined. We expected hazard perception of both groups to deteriorate by distraction, but this deterioration was expected to be greater among adolescent cyclists. To test this we looked at button presses during AOIs and fixations in AOIs. Participants could score a maximum of 11 in each condition for both button presses and fixations in AOIs. The higher the score, the better the performance was on the hazard perception test.

Results showed that in the control condition, adults pressed the button significantly more during the AOIs (M = 2.47, SD = 1.46) compared to adolescents (M = 1.31, SD = 1.20). So in the control condition adults performed better in terms of button presses during AOIs compared to adolescents. However in the distraction condition no significant difference between the two groups emerged, adults pressed the button on the average 1.71 times during AOIs (SD = 1.40) and adolescents pressed the button on the average 1.28 times (SD = 1.13). It should be noted that both groups did not score high on this aspect of the test if you keep in mind that the maximum score could be 11.

When looking at the impact of distraction on button presses during AOIs, distraction had no influence on adolescents, there was no significant difference in button presses during AOIs between the distraction and control condition within this group. However, it should be noted that the scores of adolescents in the control condition were already so low, possibly a floor effect occurred. Their score could hardly be affected by distraction. Adults were influenced by the distraction task, there performance of button presses during the AOIs was significantly worse in the distraction condition compared to the control condition. This finding corresponds in some way to the research of Mckenna & Farrand (1999), in which experienced drivers also showed to be affected by a secondary task while performing a hazard perception test. In their research, participants had to push a button as fast as they could whenever they detected a hazard. Experienced drivers were significantly faster on the hazard perception test compared to the novice drivers without secondary task. However, in the secondary task condition, this difference disappeared and experienced and novice drivers score the same on the hazard perception test. Thus in their research only the adults were impaired by a secondary task.

When looking at hazard perception skills in terms of fixations in AOIs, no significant difference between the two age groups was found. The groups did not differ in their scores on looking in the AOIs in both condition. Thus, concerning this variable, adolescents did not score worse than adults on the hazard perception test and the hypothesis could not be confirmed. Distraction affected both age groups in the same way, both groups looked in significantly less AOIs in the secondary task condition compared to the no secondary task condition. Thus, adults were as much distracted by the secondary tasks as adolescents were.

We also looked at hazard perception in general during the whole hazard perception test. What was the total number of button presses of participants? In other words: how often did participants thought a situation was hazardous enough to press the button? And was the total number of button presses affected by distraction? Results showed that, where adults barely differed in number of button presses between the distraction and control condition, adolescents were more affected by distraction. Adolescents pressed the button far less in the distraction condition, compared to the control condition. In this case, adolescents were more affected by distraction than adults. This result could also be interpreted as adolescents being less concerned with the hazard perception test while guessing the animals, they suddenly indicated less situations as hazardous while doing the guessing game. What stands out is that adults overall pressed the button significantly more than adolescents, apparently they considered more situations as hazardous than adolescents.

Furthermore we also compared the visual search of adolescent and adult cyclists. We expected adults to scan the videos more extensively than adolescents. We also expected both groups to scan the videos less and to have longer fixation durations in the distraction condition compared to the control condition, but we expected this effect to be stronger for the adolescents.

The hypotheses on visual search were not confirmed. Adults showed the expected pattern, they scanned the x-axis significantly less in the distraction condition compared to the control condition. Whereas adolescents showed the opposite pattern, they scanned the x-axis significantly more in the distraction condition compared to the control condition.

Additionally, when looking at the scan pattern of the y-axis also an unexpected pattern came up. Both adolescents and adults scanned the y-axis significantly more in the secondary task condition then in the no secondary task condition. When looking at the footage of the eye tracker, this pattern can be explained. While guessing the animals, a lot of participants looked up to think about what kind of question to ask or what kind of animal they were guessing. So they were not paying more attention to their surroundings, instead they were more concerned with the guessing game. This was also evident from the subjective ratings of the participants.

More than half of the adults (52,9%) declared to have paid the most attention to the animal guessing game in the distraction condition, as well as the adolescents, of whom 46,4% indicated to have paid the most attention to the animal guessing game

We also looked at fixation duration and expected participants to stare more while being distracted during the hazard perception test. No significant main or interaction effect was found. Participants did not have a longer fixation duration in the distraction condition compared to the control condition. This could be explained by the fact that people, while guessing for example looked up to think and therefore did not stare. Something to bear in mind is that, because the scan patterns that were found were not as hypothesized, also the results of fixation duration were different than expected. It should be noted that the standard error of fixation duration was large, apparently there were large individual differences.

General discussion

In summary, some hypotheses were (partly) confirmed, where others were not. Results showed that adults, compared to adolescents, had better hazard perception skills in terms of button presses during AOIs in the control condition. This finding is in line with the research of Borowsky et al. (2010). Their research revealed that experienced drivers reported significantly more hazards than inexperienced drivers, which suggested that young-inexperienced drivers were less aware of potential hazards. The fact that in the distraction condition no between groups difference in button presses during AOIs was found, could have been caused by a floor effect. Adolescents already scored so low, distraction could barely affect their scores.

Based on the research of Borowsky et al. (2010) and the research of Pradhan et al. (2005) we also expected adolescents to perform worse on the hazard perception test in terms of fixations in AOIs. This hypothesis was not confirmed. Adolescents and adults did not significantly differ in fixations in AOIs in control or distraction condition. This might be due to not picking the right moments for the AOIs or the videos did not contain good latent hazards to distinguish between adult and adolescent cyclists.

In terms of visual search, none of the hypotheses were confirmed. Both groups did not have longer fixation durations while they were distracted. In the control conditions, adolescents did not scan the x-axis of the traffic video's less than adults. On the contrary, in the distraction condition they scanned the videos even more broadly from side to side compared to adults. These finding were not in line with previous research of Mourant & Rockwell (1972) and Vlakveld (2011) which showed that novice drivers have longer fixation durations, move their eyes less frequently and scan traffic less broadly from side to side than experienced drivers.

Both groups scanned the y-axis of the traffic videos more in the distraction condition, but as earlier mentioned that could be explained by looking at the eye tracking footage. This footage revealed that participants looked up to think of questions during the guessing game. Therefore, the results of visual search must be interpreted with caution. A higher standard deviation on the x-axis or y-axis does not necessarily mean participants consciously scanned the traffic videos more. There is also a possibility that they were elsewhere with their thoughts, for example they could be with their thoughts at the guessing game.

Future work and limitations

It is possible the hypotheses on hazard perception skills were not confirmed because not the right moments for the AOIs were picked, maybe they were not hazardous enough. It turned out that it was difficult to define the most hazardous situation in the videos. For the videos made in Leiden, a panel of 20 adults watched the videos who verbally had to indicate when they thought a situation was hazardous. From this method, it was not possible to choose one hazardous situation in each video, because everyone of the panel came up with different hazardous situations. Therefore it was chosen to let researchers of SWOV pick the moments for the AOIs. Further research on how to determine the most distinctive latent hazards to make a good hazard perception test is recommended.

Something else to bear in mind for future research, is that participants indicated they found it difficult to imagine they were the cyclists in the videos, and they had problems with the fact they could not decide how fast or slow to cycle. For a follow-up study it is recommendable to use a more realistic setting to test hazard perception. Perhaps using a kind of bicycle simulator, so participants can determine their own pace while cycling and can also brake and stop when they think a situation is hazardous (instead of pushing a button). In this way it can be measured if, even when a hazard is seen, participants would still take a dangerous decision.

Something else to be noted is that some of the participants indicated to recognize the traffic situations in the videos, because they lived in Amsterdam or Leiden. This could have affected their scan patterns and performance on the hazard perception test in two ways. Some participants indicated that they paid more attention because they knew the traffic situation in question was dangerous, where other indicated they paid less attention because they already knew nothing hazardous could happen at that particular traffic situation.

Conclusion

Although not all the hypothesis could be confirmed, this research is a first step in the right direction to gather more information and knowledge about hazard perception of cyclists in general and about adolescent cyclists in specific. The results definitely showed that distraction plays an important role in hazard perception of cyclists. Results on hazard perception skills were inconclusive, but on some points adolescents were worse in hazard perception than adults. Hopefully, other researchers will pick up this research and will continue on conducting research of hazard perception among cyclists, so in the future the amount of adolescents cyclists which are involved in traffic accidents can be reduced.

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Appendix A

Questionnaires Adults

Introductie:
Deze vragenlijst is bedoeld om algemene informatie te verzamelen en wordt *anoniem* gekoppeld aan de informatie die is verzameld met de fietsvideo's. Deze informatie hebben wij nodig om de resultaten beter te begrijpen. Het invullen duurt ongeveer 5 tot 10 minuten.

1. **Wat is uw geslacht?**

   Man ☐ Vrouw ☐

2. **Wat is uw leeftijd?**

   ☐☐ jaar

3. **Wat is uw woonplaats?**

   ☐

4. **Wat is uw huidige werksituatie?**

   Werkende ☐ Werkloos ☐ Huisvrouw/man ☐ Student ☐ Anders namelijk: ☐

5. **Gaat u (gedeeltelijk) met de fiets naar uw werk?**

   Ja ☐ Nee ☐ Niet van toepassing ☐

6. **Hoeveel dagen in de week fietst u gemiddeld?**

   ☐ dag(en)

7. **Op de dagen dat u fietst, hoeveel uur fietst u dan gemiddeld per dag?**

   ☐ uur ☐ minuten

8. **Bent u de afgelopen 12 maanden betrokken geweest bij een fietsongeval?**
Men spreekt van een ongeval wanneer u botst met iemand. Het kan zijn dat hierbij iets kapot gaat of dat iemand zich pijn doet. Uw fiets kan kapot zijn gegaan of u kunt uzelf pijn hebben gedaan. Maar het kan ook zijn dat bij degene waar u tegenaan bent gereden iets kapot is gegaan of dat diegene zich pijn heeft gedaan. Ook als er geen anderen waren,(u bent bijv. in een sloot gereden) dan bestempelen wij dat als een ongeval.

Ja	Nee
☐	☐

<u>De volgende vragen gaan over de fietsvideo's en daarbij behorende taken</u>

9. **Hoe duidelijk was het voor u wat u moest doen tijdens de fietsvideo's?**

Heel erg onduidelijk	Onduidelijk	Neutraal	Duidelijk	Heel erg duidelijk
☐	☐	☐	☐	☐

10. **Hoe moeilijk vond u het om de gevaren in de fietsvideo's te herkennen**?

Heel erg moeilijk	Moeilijk	Neutraal	Makkelijk	Heel erg makkelijk.
☐	☐	☐	☐	☐

11. **Hoe moeilijk vond u het om dieren te raden?**

Heel erg moeilijk	Moeilijk	Neutraal	Makkelijk	Heel erg makkelijk.
☐	☐	☐	☐	☐

12. **Hoe moeilijk vond u het om tegelijkertijd naar de filmpjes te kijken en dieren te raden?**

Heel erg moeilijk	Moeilijk	Neutraal	Makkelijk	Heel erg makkelijk.
☐	☐	☐	☐	☐

13. **Aan welk van de twee taken heeft u voor uw gevoel het meest de aandacht besteed?**

De gevaarherkenningstaak	de dierenraadtaak	aan beide taken evenveel
☐	☐	☐

14. **Heeft u nog overige vragen of opmerkingen over dit onderzoek?**

Dit is het einde van de vragenlijst, bedankt voor uw deelname aan dit onderzoek

Appendix A

Questionnaire adolescents

Introductie
Deze vragenlijst is bedoeld om algemene informatie te verzamelen en wordt *anoniem* gekoppeld aan de informatie die is verzameld met de fietsvideo's. Deze informatie hebben wij nodig om de resultaten beter te begrijpen. Het invullen duurt ongeveer 5 tot 10 minuten.

1. **Wat is je geslacht?**

   Man ☐ Vrouw ☐

2. **Wat is je leeftijd?**

   ☐☐ jaar

3. **Wat is je woonplaats?**

   ☐

4. **Welk niveau doe je op dit moment?**

   VMBO ☐ HAVO ☐ VWO ☐ Gymnasium ☐

5. **Hoe ging je naar de basisschool?**

   Te voet ☐ Fietsend ☐ Met de auto ☐

6. **Ga je met de fiets naar de middelbare school?**

   Ja ☐ Nee ☐

7. **Hoeveel dagen in de week fiets je gemiddeld?**

   ☐ dag(en)

8. **Op de dagen dat je fietst, hoeveel uur fiets je gemiddeld per dag?**

   ☐ uur ☐ minuten

9. **Ben je de afgelopen 12 maanden betrokken geweest bij een fietsongeval?**
Een ongeval is als je botst met iemand. Het kan zijn dat hierbij iets kapot gaat of dat iemand zich pijn doet. Jouw fiets kan kapot zijn gegaan of jij kan jezelf pijn hebben gedaan. Maar het kan ook zijn dat bij degene waar je tegenaan bent gereden iets kapot is gegaan of dat diegene zich pijn heeft gedaan. Ook als er geen anderen waren,(je bent bijv. in een sloot gereden) dan noem je dat een ongeval.

Ja	Nee
☐	☐

<u>De volgende vragen gaan over het onderzoek zelf</u>

10. **Hoe duidelijk was het voor jou wat je moest doen tijdens de fietsvideo's?**

Heel erg onduidelijk	Onduidelijk	Neutraal	Duidelijk	Heel erg duidelijk
☐	☐	☐	☐	☐

11. **Hoe moeilijk vond je het om de gevaren in de fietsvideo's te herkennen**?

Heel erg moeilijk	Moeilijk	Neutraal	Makkelijk	Heel erg makkelijk.
☐	☐	☐	☐	☐

12. **Hoe moeilijk vond je het om dieren te raden?**

Heel erg moeilijk	Moeilijk	Neutraal	Makkelijk	Heel erg makkelijk.
☐	☐	☐	☐	☐

13. **Hoe moeilijk vond je het om tegelijkertijd naar de filmpjes te kijken en dieren te raden?**

Heel erg moeilijk	Moeilijk	Neutraal	Makkelijk	Heel erg makkelijk.
☐	☐	☐	☐	☐

14. **Aan welk van de twee taken heb je voor je gevoel het meest de aandacht besteed?**

De gevaarherkenningstaak	De dierenraadtaak	Aan beide taken evenveel
☐	☐	☐

15. **Heb je nog vragen of opmerkingen over dit onderzoek?**

Dit is het einde van de vragenlijst, bedankt voor je deelname aan dit onderzoek!

Appendix B
Instructions guessing game

Instructie dieren raadspel voor de persoon die raad

Tijdens het bekijken van de fiets video's ga je ook nog een raad spelletje spelen met een leeftijdsgenoot. Het doel van het spel is om zoveel mogelijk dieren te raden die op de kaartjes staan.
Door het stellen van vragen kun je er achter komen welk dier er op het kaartje staat. De vragen moeten door jou leeftijdsgenoot met een ja of nee kunnen worden beantwoord.
Stel er staat op het kaartje hond, en je vraagt heeft het dier haren dan antwoordt jouw leeftijdsgenoot dus met ja. Er kunnen allerlei soorten dieren worden gevraagd van insecten tot circusdieren. Er zullen geen specifieke rassen van dieren worden gevraagd. We zullen dus niet vragen naar een labrador, maar naar een hond.
Als je een dier goed hebt geraden, gaan we door naar het volgende dier. Probeer zo veel mogelijk dieren te raden want het duo dat de meeste dieren raad, wint een prijs!

Lukt het niet om een dier te raden of vind je het te lang duren dan mag je pas zeggen en ga je door naar het volgende dier.

Hieronder vind je een aantal voorbeeldvragen als hulp:
1) Heeft het dier 4 poten?
2) Kan het dier zwemmen/vliegen/lopen?
3) Is het een huisdier/dierentuindier?
4) Leeft het dier in een warm gebied?
5) Heeft het een staart?

Succes!

Instructie dieren raadspel voor diegene die de vragen moet beantwoorden met ja/nee

Je krijgt zo kaartjes met daarop dieren te zien, bijvoorbeeld vogel, hond, wesp, etc. Jouw leeftijdsgenoot gaat vragen stellen om erachter te komen welk dier jij op je kaartje hebt staan. Je mag alleen antwoorden met ja of nee. Het doel is om samen zo veel mogelijk dieren te raden.
Staat er op het kaartje hond en vraagt de ander: Heeft het dier haren? Dan antwoord je dus met ja. Is het dier geraden dan mag je zeggen dat het klopt en pak je het volgende kaartje van de stapel.
Het duo dat uiteindelijk de meeste dieren raad wint een prijs! Succes!