The Impact of Auditory Distractions on Cycling: Exploring the Role of Individual Differences in Immersion and Distraction

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Abstract

This study investigates the impact of auditory distractions on cycling behaviour, with a focus on individual differences in immersion and distraction susceptibility levels. The study examines the impact of listening to music, podcasts, or engaging in phone conversations on the frequency of head movements while cycling. The findings indicate no significant relationships between immersion, distraction susceptibility, and head movements among cyclists. Higher immersion scores do not necessarily correlate with increased distraction susceptibility, and higher levels of distraction susceptibility do not directly impact the frequency of head movements while cycling under auditory distractions. This suggests that distraction susceptibility alone does not directly impact head movement frequency. Additionally, it was found that higher immersion levels do not necessarily impact the frequency of head movements while cycling, suggesting that immersion levels may not directly influence head movement behaviour. Furthermore, the study emphasizes the need to consider attention allocation during cycling and explore how immersion impacts cognitive processing.

The Impact of Auditory Distractions on Cycling: Immersion and Distraction

It has become common for people to use mobile phones and other electronic devices while cycling and driving. However, using these devices irresponsibly while cycling or driving can be risky. Studies have shown that auditory distractions, such as listening to music, podcasts or engaging in hand free phone conversations, can compromise traffic safety.

Bellinger, Budde, Machida, Richardson, and Berg (2009) found that listening to music or telephoning while driving a car can lead to slower reaction times, potentially compromising traffic safety. Notably, talking on the phone while driving can lead to slower response times compared to listening to music. Moreover, Redelmeier and Tibshirani (1997) found that the use of a cellphone while driving increases the risk of a motor vehicle collision by four times compared to driving without a cellphone. The study suggests that this increased risk is not solely because of making or receiving calls at the moment of the collision. Instead, it is primarily due to the overall distraction caused by cellphone use while driving.

Other studies have demonstrated that listening to music or telephoning while cycling can negatively impact cycling behaviour. Engaging in a phone conversation, especially a demanding one, is associated with reduced speed and reduced peripheral vision performance (De Waard et al., 2010). Although the cyclists in the study who listened to music or made phone calls slowed down while cycling, they still reported more perceived mental effort and risk. This suggests that the cognitive demands of phone conversation while cycling can be distracting, potentially compromising traffic safety. Moreover, it was found that both handheld and hands-free use of mobile phones negatively impact perception (De Waard et al., 2010). The study found that hands-free phone calls are not necessarily safer than handheld calls, as both negatively impact cycling behaviour. Another study by De Waard, Edlinger, and Brookhuis (2011) found that listening to music worsens auditory perception, especially when in-earbuds are used. A significant number of participants failed to notice a stop signal, potentially posing a serious threat to traffic safety. Furthermore, another study found that the use of mobile phones while cycling significantly influenced head movement behaviour (De Waard, Westerhuis, Lewis-Evans, 2015). The study found that individuals using their mobile phones made fewer head movements to the right when approaching intersections, indicating a potential hazard to traffic safety.

In the Netherlands, it is illegal to hold an electronic device in your hands while driving a car while listening to music or making hands-free phone calls is permitted. Similarly, it is prohibited to use mobile phones, tablets, or music players while cycling. However, listening to music or hands-free telephoning while cycling is still allowed. Nevertheless, these studies suggest that these activities may act as distractions to cycling and have an adverse effect on cycling behaviour.

To better understand how these activities affect cycling behavior, it is important to consider individual personality differences. This can help identify those individuals who might be prone to risky or dangerous cycling behaviour. Consequently, this enables the development of interventions and educational campaigns that address the specific needs of different types of cyclists. Studies have shown has shown that personality differences can significantly influence cycling behaviour. For example, a study by O'Hern et al. (2020) found that extroversion positively correlated with both errors and violations in cycling behaviour. The study suggests that this positive correlation can be attributed to extrovert's tendency toward sensation-seeking, which leads them to take more risks while cycling. On the other hand, individuals with higher scores on conscientiousness and agreeableness are actually more likely to conform to road rules. These studies highlight the significant role of individual personality differences in cycling behaviour. Building upon this understanding, the current study takes into account another important factor: immersion.

Immersion is described by Oh, Herrera & Bailenson (2019) as: “the computer system’s technological capacity to deliver a vivid experience that removes the user from physical reality, and is measured by assessing the technical affordances provided by the system.” Immersive technologies like virtual reality have the ability to deeply engage people and absorb them in different activities or experiences. Cyclists with a tendency for immersion may be more susceptible to distractions such as music, telephoning, or podcasts. This might impact their ability to maintain focus and attention on the road, potentially creating an unsafe cycling environment.

Considering the concept of immersion, it is important to explore its relationship to distraction susceptibility and cycling behaviour. This can help identify potential dangers related to individual differences in immersion levels. By doing so, it will help the development of interventions and guidelines aimed at addressing the specific needs of individuals with varying immersion levels, ultimately contributing to a safer cycling environment.

During our study, we collaborated with Achmea, who coincidentally conducted their own research on traffic related topics. We suggested that Achmea include questions related to immersion in their questionnaire, that would line up with this field study. Achmea’s study (2023) found a positive correlation between higher immersion scores and perceiving headphones as distraction from traffic. Which means that cyclists who find themselves sensitive to being distracted by headphones also tend to have higher immersion scores. Additionally, the study found a positive correlation between higher immersion scores and whether participants found listening to music, podcasts, or watching navigation to be a distraction from traffic. These findings support the notion of a positive correlation between immersion and distraction.

Our study aims to further examine the relationship between immersion, distraction susceptibility, and cycling behaviour through experimental research. By conducting experiments, we can investigate how immersion influences cycling behaviour when engaging in potentially distracting activities.

In the current study, we propose that those with higher immersion scores may also score higher for distraction-related items, as compared to those with lower immersion scores. Earlier research (De Waard et al., 2015) showed that cyclists using a phone make fewer head movements, possibly because they are distracted. Therefore, in this research we will also study whether cyclists with higher scores for distraction-related items make fewer head movements while cycling. If immersion leads to distraction, and distraction in turn to fewer head movements, we may expect that people with higher scores for immersion also make fewer head movements while cycling, compared to those with lower scores for immersion.

In this study, our aim is to better understand how individuals with varying levels of immersion are affected differently by listening to music, podcasts, and engaging in conversation while cycling, and how this affects cycling behaviour. If our hypothesis is supported and we find that individuals with high immersion scores are more susceptible to auditory distractions, they might pose a higher risk in traffic situations. Guidelines and educational campaigns could then be implemented to provide information and help identify specific hazards for people with higher immersion scores. This would help these individuals to be more aware of their cycling behaviour and reduce potential risks on the road. Our goal is to provide insights that can support the development of such guidelines and campaigns, promoting safe cycling practices and creating a safer cycling environment.

Method

Participants

The participants of the research were recruited by word of mouth. Convenience sampling was used. Participation in this study was entirely voluntary and participants were not compensated. The study was successfully completed by 23 people. No participants were excluded from the study. This brings the number of valid participants to N = 23 The mean age of the participants was 24 years old (M = 23.61) with a standard deviation of 6 years (SD = 6.394) Of these participants, 10 were female and 13 were male.

Design and Procedure

The study used a within-subjects design, where each participant experienced four experimental conditions. The assignment of these conditions was randomized to ensure that any observed effects on cycling performance were not influenced by the order in which the conditions were presented. This random assignment balanced out potential sequence effects, minimizing its impact on the results. Every participant completed each of the four conditions once. The following conditions were included in the experiment: (1) control condition, which involved cycling without listening to music, a phone call, or podcast, (2) listening to music while cycling, (3) having a handsfree phone call while cycling, (4) listening to a podcast while cycling. During each of the non-control conditions, participants were instructed to use their earphones or headphones in the manner consistent with their customary usage to create a more ecologically valid and representative experimental condition.

At least a day before their participation, the participants received an email with general information such as location and time, an information form, a map and video of the route, and a reminder to bring a charged mobile phone and earphones with a working microphone. After the participants arrived, they were again informed about the procedure, and filled out an informed consent. The participants were told to cycle as they normally would do.

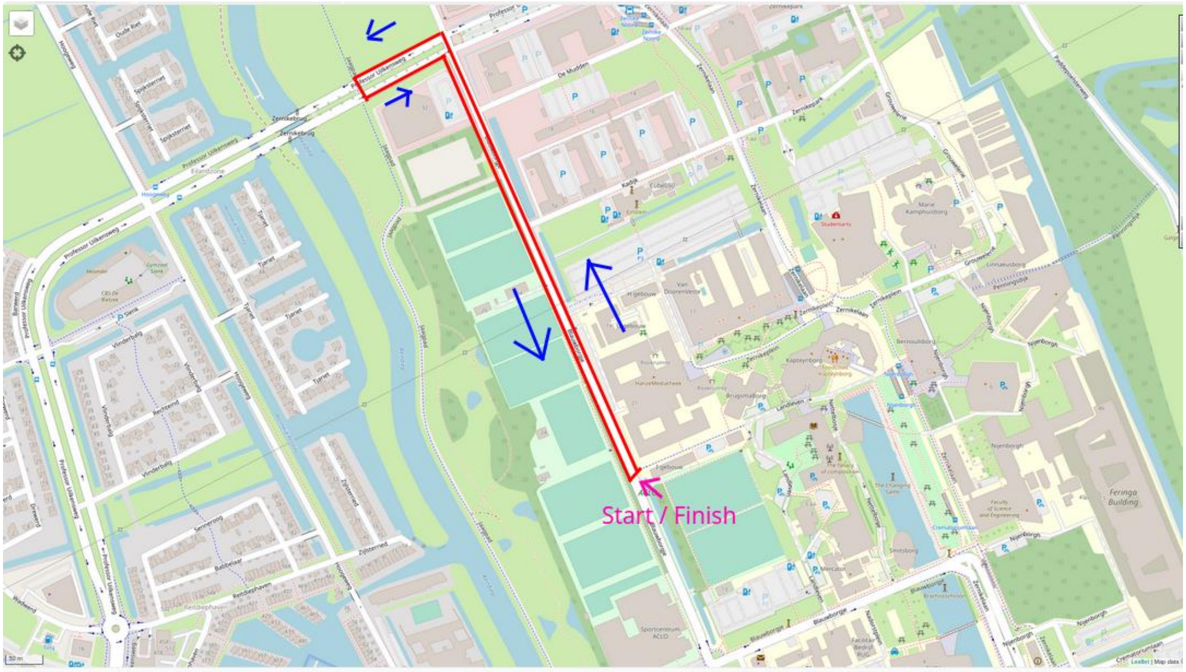
The participants then filled out a questionnaire, after which they completed the four conditions of the experiment in a random order. After each condition, they filled out a smaller questionnaire. After the experiment ended, a debriefing took place about the goals of the experiment, and the participants had an opportunity to ask questions. The experiment had a duration of approximately 45 to 60 minutes. The data were acquired in dry conditions during the end of May 2023.

Location

The experiment was carried out on a one-and-a-half kilometre long asphalted cycle path, in the north of Zernike Campus (see Figure 1). Most of the route was non-segregated, so cars and cyclists could be intertwined with each other. The cyclists followed the street on one side, turned left to cycle on a segregated path, crossed the street, and went left again to follow the non-segregated street until the end of the route. The cycling path itself was 1.5 kilometres long and the cycling path was 2.00 meters wide. The cycle path and the road where cars drive were not physically separated; instead, they were differentiated by distinct colours and dashed white lines.

Figure 1

Cycling route



Materials

The study utilized various materials containing an online questionnaire through the Qualtrics platform (a system in which questionnaires can be created and managed), an informed consent form, an information form, two GoPro cameras with handlebar mounts, and a calibration stick. Participants were instructed to use their own bicycle, mobile phone, and earphones or headphones as part of the experimental procedure.

Questionnaire. For the current research, data was gathered using an online questionnaire in the Qualtrics platform. The data collection process involved the implementation of two distinct questionnaires. The first questionnaire was administered before the experiment began, while the second questionnaire was administered during the intervals between the experimental conditions. Notably, the in-between questionnaire exhibited distinct variations corresponding to each specific experimental condition, featuring specific sections that were relevant to each experimental condition.

The first questionnaire consisted of a total of 21 questions that encompassed various aspects including demographic information, bicycle use, cycling behaviour, the use of electronic devices while cycling, immersion experiences, and two manipulation checks. The section of bicycle use and cycling behaviour included a combination of open-ended and Likert scale questions. An example item was: ‘’I feel confident in my cycling abilities, such as handling my bike in different conditions or situations’’, which was measured using a 5-point Likert scale (1 = ‘’strongly disagree’’ to 5 = ‘’strongly agree’’).

Regarding the use of electronic devices while cycling, participants encountered multiple-choice questions and Likert scale questions. Example items were: ‘’What kind of earphones/headphones do you use while cycling? (multiple answers are possible)’’ (answer options: ‘’noise cancelling headphones or earphones’’, ‘’non-noise cancelling headphones’’, ‘’non-noise cancelling earphones’’, ‘’other’’) and ‘’What do you usually do when you are cycling on an (electric) bike or moped/scooter and you receive a phone call?’’.

Immersion-related questions were answered using a 6-point Likert scale. An example item was: ‘’I often become completely engrossed in a movie or TV show’’ (1 = ‘’strongly disagree’’, 2 = ‘’disagree’’, 3 = ‘’not agree, not disagree’’, 4 = ‘’agree’’, 5 = ‘’strongly agree’’, 6 = ‘’don’t know / no opinion’’). To evaluate if the questionnaire was answered honestly by the participants, manipulation checks were incorporated within the questionnaire. One particular question, namely ‘’Answer ‘disagree’ on this question’’ served as a means to assess whether participants were responding honestly or randomly. This measure aimed to verify the participants’ engagement with the questionnaire. If a participant answered any other answer than ‘disagree’ their questionnaire would be excluded from the analysis due to the inability to ensure the accuracy and sincerity of their answers.

The in-between questionnaire consisted of four standard questions related to immersion, distraction, and working memory. These questions were: ‘’I was absorbed in my thoughts’’, ‘’I was aware of what was happening around me’’, ‘’My attention was on cycling alone (so no daydreaming and or being distracted by my surroundings)’’, and ‘’I used a lot of my working memory during the ride’’. All these questions were answered with a rating scale from 1 to 10, where 1 meant ‘’not at all’’ and 10 meant ‘’completely’’. The podcast and music conditions incorporated additional questions. In the music condition, participants were presented with an extra item regarding the genre of music they were listening to, utilizing a multiple-choice format that included various music genres as options. The podcast condition included several supplementary open-ended questions that focused on the content of the podcast.

The full questionnaire can be found in the appendix.

Measures

Head movements. Head movements were measured for all conditions. To measure head movements, a camera was mounted on the participant’s bike. The camera was securely attached to the bike using a stable and adjustable mounting mechanism. It was positioned in a way that provided a clear view of the participant’s head and upper body during the cycling session, as can be seen in Figure 2. In the current research, a head movement was measured as a visible shift from a neutral forward-facing position to a sideways movement (looking left or right). This included participant’s head motions for monitoring traffic as well as casual scanning of their surroundings. Subsequently, the amount of head movements made by the participants was manually counted at specific time intervals at two specific locations on the route. The analysis focused on two distinct segments: head movements on a straight road section and head movements at an intersection. The duration of the straight road segment was approximately 9 seconds, and the intersection segment was approximately 25 seconds for every participant.

Figure 2

Camera View for Head Movements

Immersion. Immersion was measured once for each participant prior to the start of the experiment. To measure immersion, we utilized the Immersive Tendency Questionnaire (ITQ), incorporating three questions that were adapted for this study. The ITQ is an 18 item-validated instrument and is widely used to assess individuals' tendency for immersion in various contexts. It encompasses three subdimensions: involvement, attentional focus, and tendency to play video games (Rósza et al., 2022). We selected three specific questions (question 18, 19 and 20 in our questionnaire) that specifically targeted the involvement and attentional focus dimensions to measure the participant's immersion. The questions were initially measured on a 6-point scale. However, to enhance clarity, the response ‘'don't know/ no opinion’' was removed. Consequently, a 5-point scale was utilized for the data analysis.

Distraction. Distraction was measured once for each participant. To measure distraction susceptibility, we used a questionnaire provided by Achmea, a company that concurrently conducted research on distractions and traffic behaviour. From their questionnaire, we selected two specific questions (question 14 and 15 in our questionnaire) to measure the level of distraction among the participants in our own study. The questions were initially measured on a 7-point scale. Similarly to the immersion questions, the response ‘’that never happens’’ was removed to enhance clarity for the data analysis. Consequently, a 6-point scale was utilized. The full questionnaire can be found in Appendix A.

Results

For immersion, the mean score was computed from three items that assessed participant’s immersion levels (M = 3.45, SD = 0.52) on a scale ranging from 1 to 5. Immersion was measured once for each participant individually. For the distraction variable, the mean score was calculated from two items assessing participant’s level of distraction. The mean score for distraction was (M = 4.35, SD = 1.10). Head movements were computed at the intersections, a straight road segment and the mean of both combined. Participants exhibited an average of 6.51 head movements (SD = 1.32) on the intersection and an average of 0.89 head movements (SD = 0.63) on straight road. Intersection and straight part combined; the participants exhibited an average of 3.70 (SD = 0.77) head movements. Additionally, the mean and standard deviation of head movements were computed per condition and presented in bar graphs (Figure 3 and Figure 4). Both figures indicate a relatively high amount of variance in head movements for all conditions.

Figure 3

Head Movements in Four Conditions: Straight Road Segment

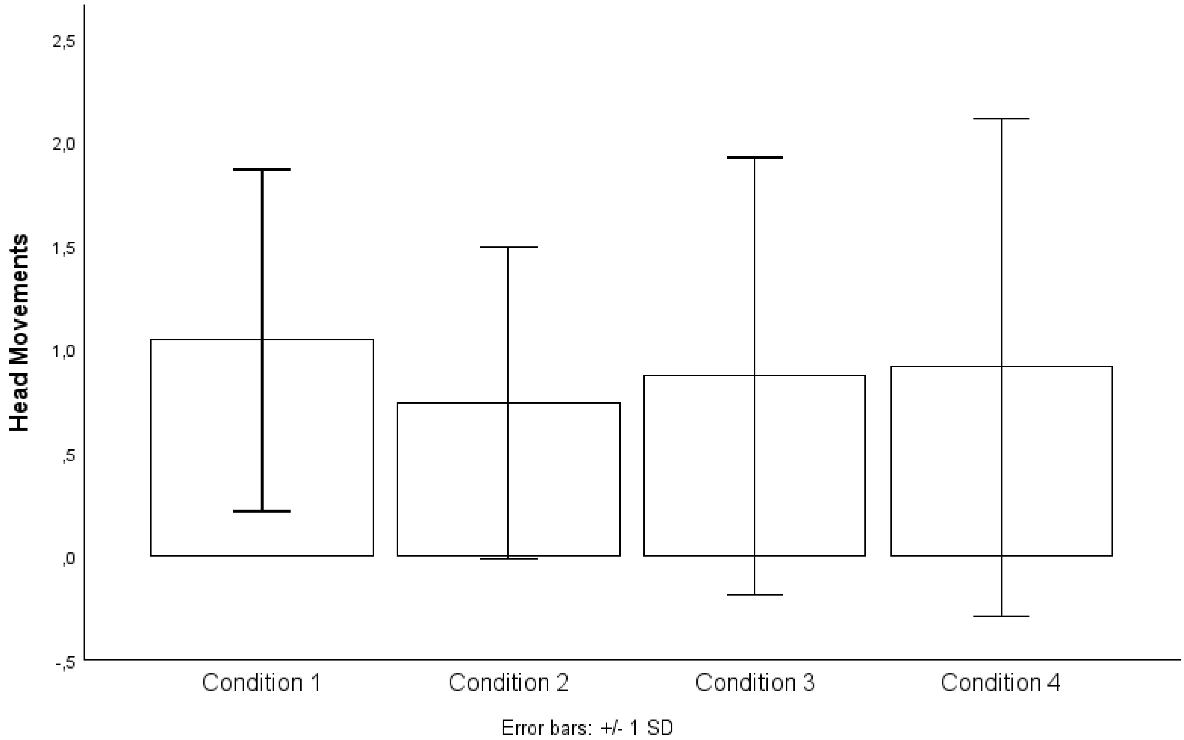


Figure 3. Head movements at the straight road segment across all conditions: Condition 1 (Control), Condition 2 (Music), Condition 3 (Phone call), and Condition 4 (Podcast). The error bars represent the standard deviation, and the bar height represents the mean.

Figure 4

Head Movements in Four Conditions: Intersections

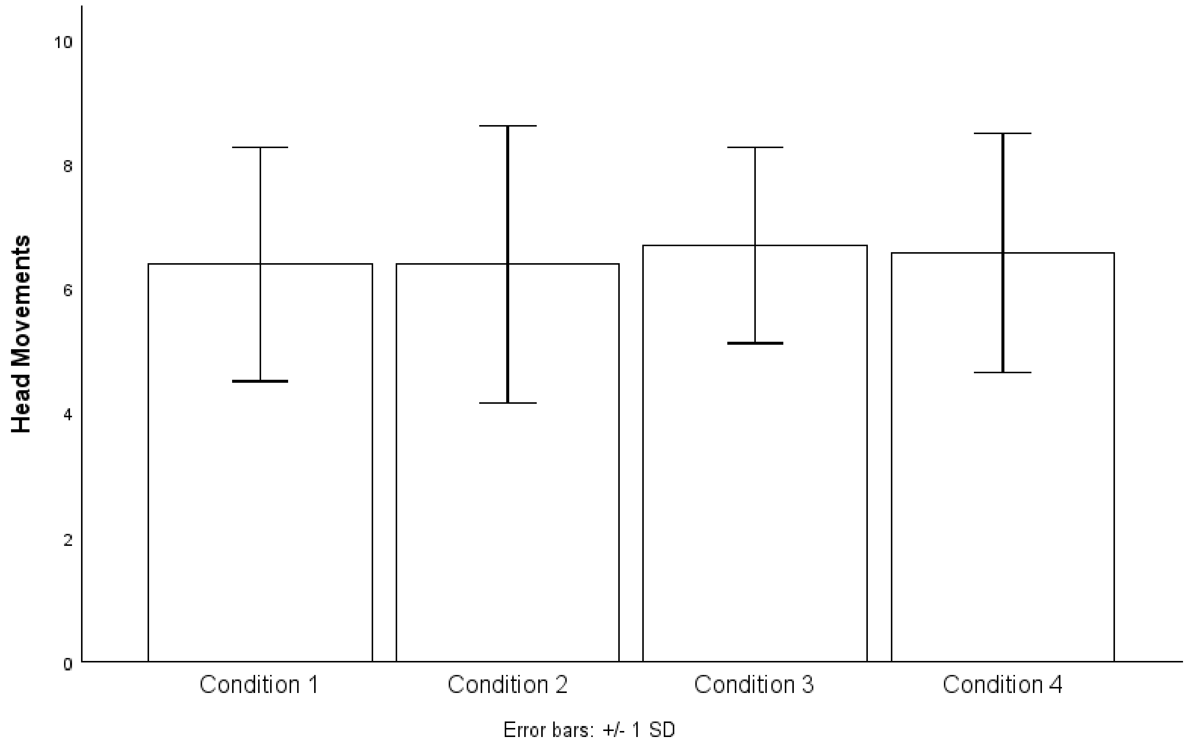


Figure 4. Head movements at intersections across all conditions: Condition 1 (Control), Condition 2 (Music), Condition 3 (Phone call), and Condition 4 (Podcast). The error bars represent the standard deviation, and the bar height represents the mean.

Immersion and distraction

To examine the relationship between immersion and distraction, a scatterplot was constructed to investigate the presence of a linear relationship between the variables. The scatterplot, which can be seen in Figure 5, showed no clear linear pattern or trend between immersion and distraction with the data used in this study. The data points appear scattered across the plot without any apparent relationship. Statistical analysis with a bivariate correlation analysis confirms the lack of a correlation between immersion and distraction ($r = -0.100$, $p = 0.651$).

Figure 5

Scatterplot illustrating a non-linear relationship between Immersion and Distraction

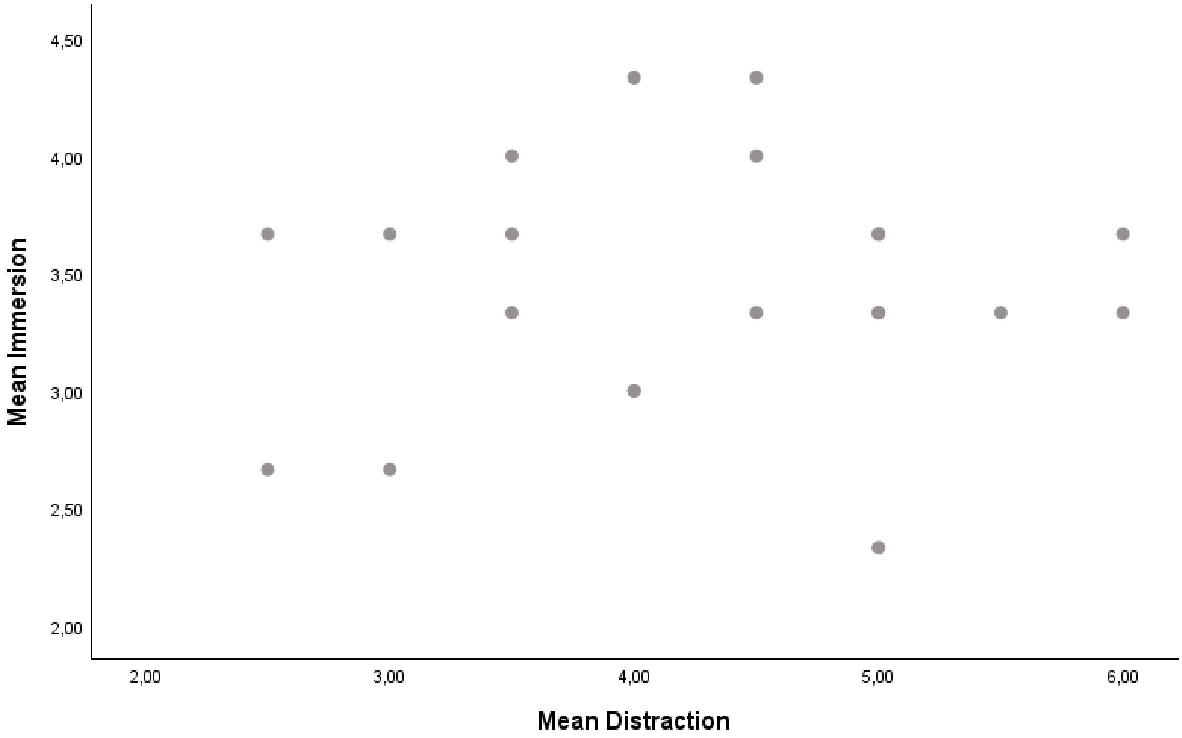


Figure 5. The scale for distraction ranged from 1 to 6, with 1 indicating high distraction and 6 indicating low distraction. The scale for immersion ranged from 1 to 5, with 1 indicating low immersion and 5 indicating high immersion.

Immersion and Head Movements, and Distraction and Head Movements

To examine the relationship between immersion and head movements, as well as distraction and head movements, linearity assumptions were evaluated. Scatterplots were inspected to assess the presence of a linear relationship between the variables. Because of violations of the linearity assumption for both the immersion-head movements and distraction-head movements relationships, linear regression analyses were not possible. Instead, bivariate correlation analyses were conducted to explore relationships between immersion and head movements as well as distraction and head movements. The analyses were conducted for head movements at intersections and head movements at straight road segments. Furthermore, a combined measure of head movements, compromising the mean of both conditions, was also examined.

Scatterplots illustrating the relationships between the variables can be found in Figure 6 and Figure 7.

Figure 6

Scatterplot illustrating the non-linear relationship between Immersion and Head Movements

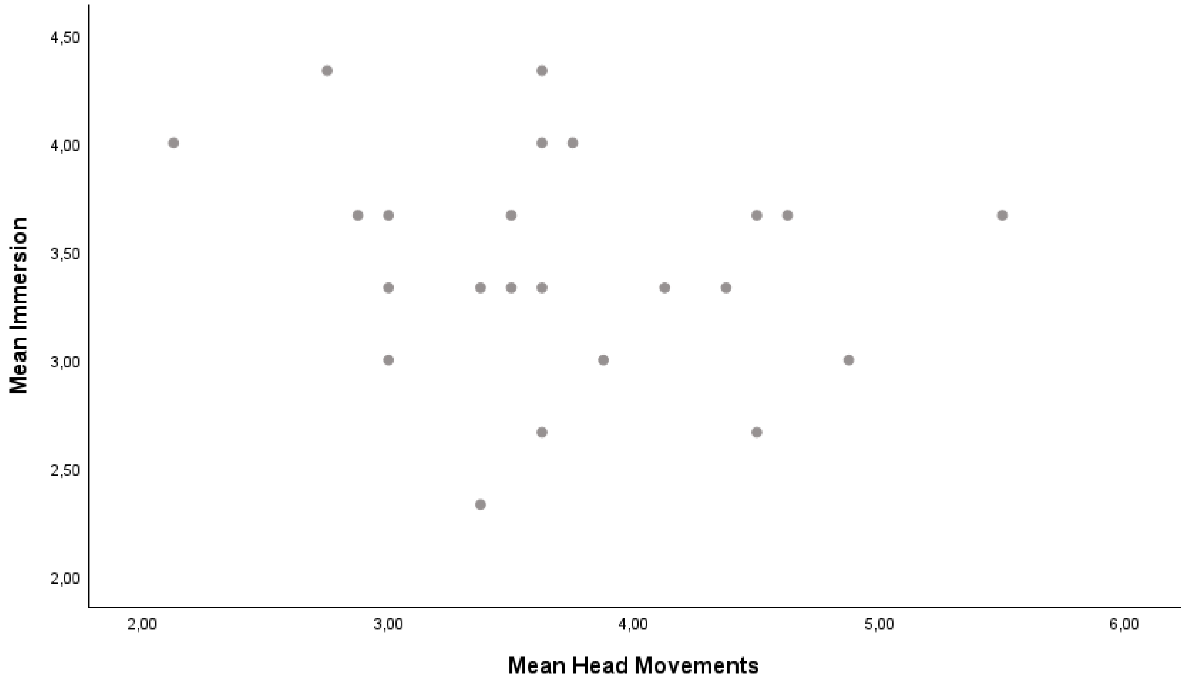


Figure 6. The mean amount of head movements made by participant's ranged from 1 to 6. The scale for immersion ranged from 1 to 5, with 1 indicating low immersion and 5 indicating high immersion.

Figure 7

Scatterplot illustrating the non-linear relationship between Distraction and Head Movements

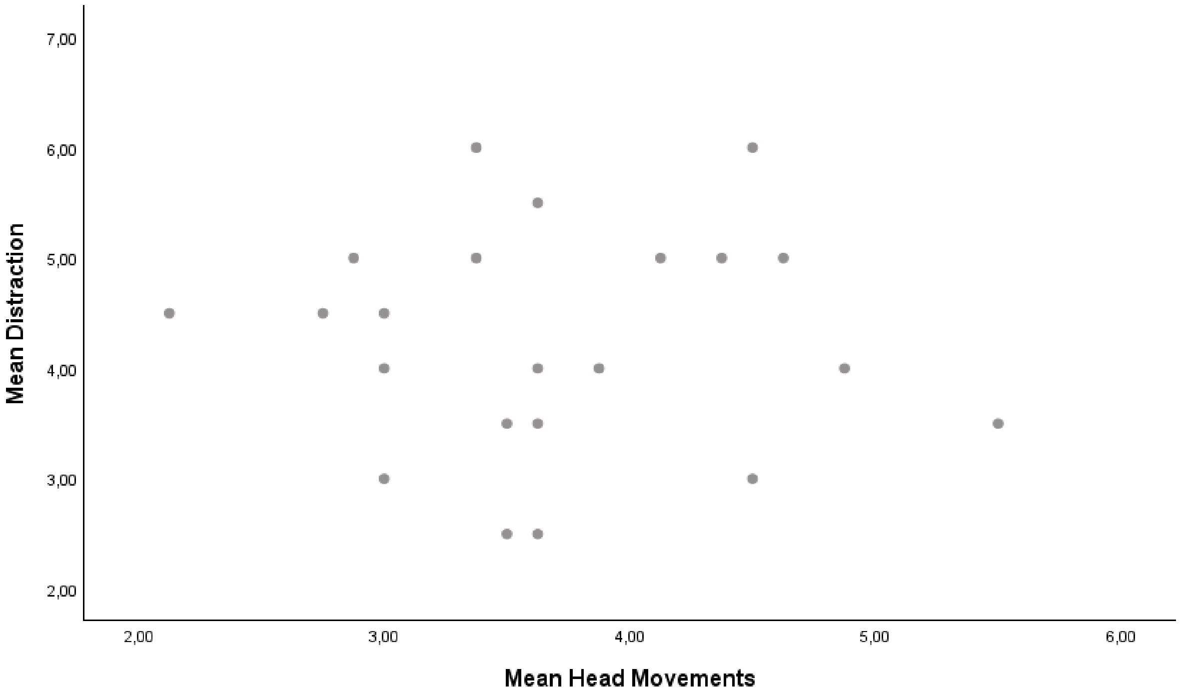


Figure 7. The mean amount of head movements made by participant's ranged from 1 to 6. The scale for distraction ranged from 1 to 6, with 1 indicating high distraction and 6 indicating low distraction.

Correlation Analyses

The correlation analyses did not reveal a significant correlation between immersion and head movements at straight road segments (r = -0.100, p = 0.651), not between immersion and head movements at intersections (r = -0.201, p = 0.357) and also not between immersion and mean number of head movements (r = -0.211, p = 0.334).

Similarly, no significant relations were found between distraction and head movements straight road segments (r = 0.049, p = 0.824), between distraction and head movements at intersections (r = -0.038, p = 0.864) and also not between distraction and mean number of head movements (r = -0.012, p = 0.955).

These non-significant results show that there is no correlation between head movements and immersion or distraction in this study. The results of the correlation analyses for immersion and head movements as well as for distraction and head movements can be found in Table 1.

Table 1

Correlation Matrix Immersion and Head Movements, and Distraction and Head Movements

		HMstraight	HMintersection	HMmean
Immersion	Pearson's r	-0,100	-0,201	-0,211
	p-value	0,651	0,357	0,334
Distraction	Pearson's r	0.049	-0.038	-0.012
	p-value	0.824	0.864	0.955

Note. The correlation coefficient represents the strength and direction of the linear relationship between the variables **p < 0.001 (two tailed) indicates a statistically significant correlation.

Discussion

The current research aimed to examine the relationship between immersion, distraction and cycling behaviour. The discussion section examines the findings and their relevance to the research objectives and hypotheses presented in the introduction.

The first objective of the study was to investigate the relationship between immersion and distraction-related items. We proposed that individuals who score higher on immersion items would also score higher on distraction-related items. Contrary to our hypothesis, the findings did not support a significant relationship between immersion scores and distraction-related items. This suggests that although immersion is often associated with a deep engagement and absorption in an activity, it does not necessarily imply an increased susceptibility to distractions.

The second objective was to study the relation between distraction scores and head movements among cyclists. In contrast to our hypothesis, the results did not show a significant relationship between distraction scores and head movements. This suggests that distraction susceptibility alone does not directly impact the frequency of head movements made while cycling. Cyclists with higher distraction scores were still capable of maintaining visual scanning and head movement behaviours.

Similarly, the third objective was to investigate the relationship between immersion and head movements. The findings did also not support a significant relationship between immersion scores and head movements. This suggests that immersion levels may not directly influence the frequency of head movements among cyclists, implying that cyclists can maintain their situational awareness and engage in necessary head movements regardless of their level of immersion.

The absence of significant effects suggests that people may not adjust their head movements in response to distractions while cycling. This implies that there may be no real-world effect on head movements caused by such distractions. While these findings are not line with our hypotheses, it shows that cyclists possess the ability to maintain their head movement and visual scanning behaviours during cycling, even in the presence of auditory distractions. This suggests that cyclists have the skills to maintain situational awareness and road safety. Considering these abilities, it appears that interventions or campaigns focused on immersion, distraction, and cycling behaviour may not be necessary. Instead, it is worth exploring other factors that contribute to safe cycling practices.

Interestingly, Achmea’s research on immersion and distraction yielded results that contradict our own findings. Their findings are in line with our first hypothesis, suggesting a positive correlation between immersion and distraction. As outlined in the introduction, they found a positive correlation between higher immersion scores and perceiving headphones as distraction from traffic (Achmea, 2023). Additionally, their study found a positive correlation between higher immersion scores and feeling like listening to music, podcasts, or watching navigation are a distraction from traffic. These findings support the notion of a positive correlation between immersion and distraction.

To address the different results between our study and Achmea's, potential explanations can be given. Firstly, our study measured individual differences in distraction levels objectively by using two items, whereas Achmea focused on individual's perception of being distracted by specific conditions. This difference in measurement may contribute to the contrasting findings. The contradicting findings might suggest a potential difference between individual's perception of the distraction posed by activities like music, conversation, or podcasts, and the actual impact they have on cycling behaviour.

However, the findings from Achmea's research are valuable and worthy of consideration. In comparison to our study's relatively small sample size (N = 23), Achmea's sample size was larger (N = 2077). Consequently, their results may possess greater reliability, validity, and generalizability. Therefore, the conflicting results might also imply that our study failed to detect relationships that may exist in reality. It is important to re-examine the results of our other hypotheses and examine potential explanations for the absence of significant effects among the variables.

Firstly, the measures to assess immersion, distraction and head movements should be considered. Achmea used four items to measure immersion, whereas our study used three items. This may have contributed to the validity of their findings and their statistically significant findings. Furthermore, we adapted three questions from the Immersive Tendency Questionnaire (ITQ) to measure participant's immersion levels. However, this adaptation may have potentially impacted the validity of the questions. Furthermore, it is important to consider that the original ITQ consists of 18 items. However, using only three items may limit the comprehensive measurement of individual immersive tendencies. Similarly, we selected two specific questions from Achmea's questionnaire to measure the level of distraction among the participants in our own study. However, using only two items may limit the comprehensiveness of measuring individual distraction levels as well.

Another important point to consider regarding head movements is the relatively high amount of variation observed in the frequency of participant's head movements. This variance can be attributed to individual differences in personality as well as contextual factors. For example, some people naturally look around more or less often than others, leading to instability and variation in overall head movements. Furthermore, contextual factors such as wind and traffic can introduce instability and variation, potentially influencing participant's scanning behaviour. While this variation might not be a problem in studies with a larger sample size, it becomes more significant in our study due to the relatively smaller sample size. The small sample size may have weakened the statistical power of the study, making it more challenging to identify any differences in head movements caused by auditory distractions. Future research should consider using larger sample sizes to gain a better understanding of the relationship between auditory distractions and head movements during cycling.

Furthermore, head movements were quantified and manually counted. However, the counting process was conducted by two researchers independently. Consequently, small variations in how head movements were defined could have affected the final count of head movements each researcher made. This possible measurement error could have potentially affected the accuracy of the head movements counts, and it may influence the reliability of the findings.

Another important aspect to consider is our interpretation that higher immersion scores correlate with an increased susceptibility to distractions, such as listening to music. However, another viewpoint challenges this interpretation by suggesting that higher immersion scores actually relate to a deeper absorption in the act of cycling itself. In a way, people would then be ‘’distracted’’ and engaged by the cycling experience, rather than by the music.

The various interpretations regarding the relationship between immersion and distraction highlight the importance of attention allocation. Individuals with higher immersion scores may pay greater attention to the road, while ignoring other relevant environmental stimuli. This selective attention may have a negative impact on cycling performance. On the other hand, individuals with higher immersion scores may pay greater attention to relevant stimuli that enhance safe cycling. This immersive experience could make people fully engaged in cycling, reducing the influence of external distractions like music. Although this interpretation is speculative, future research could explore how immersion impacts attention allocation during cycling.

Although this study did not find significant relationships between immersion on attention, auditory distractions and cycling behaviour, it is important for future research to address the limitations of this study. By doing so, researchers can work towards a more comprehensive understanding of the potential relationships among these variables.

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Appendix A: Questionnaire

Participant number: ______________________________

Cycling with headphones

Q1 How old are you?

____

Q2 How much sleep did you get last night?

- ○ less than 4 hours (1)
- ○ more than 4, less than 6 (2)
- ○ more than 6, less than 8 (3)
- ○ more than 8 (4)

Q3 What kind of earphones/headphones do you use while cycling? (multiple answers are possible)

- ☐ noise canceling headphones or earphones (1)
- ☐ non noise canceling headphones (2)
- ☐ non noise canceling earphones (3)
- ☐ other (4)

Q4 How many times per week do you cycle?

____

Q5 How many cycling accidents have you had in the last 2 years?

____

Answer This Question If:
The answer to the previous question is greater than 0

Q6 In how many of these accidents were you using earphones or headphones?

____

Q7 I feel confident in my cycling abilities, such as handling my bike in different conditions or situations

- ○ strongly disagree (1)
- ○ disagree (2)
- ○ neutral (3)
- ○ agree (4)
- ○ strongly agree (5)

Q8 I feel that I have good balance and coordination while cycling

- ○ strongly disagree (1)
- ○ disagree (2)
- ○ neutral (3)
- ○ agree (4)
- ○ strongly agree (5)

Q9 When you listen to music while cycling, do you change the way you ride your bike in any way? If you do, what do you do differently? (multiple answers are possible)

- ○ Cycling with one earbud (1)
- ○ Turning the volume down (2)
- ○ Cycling slower (3)
- ○ Cycling faster (4)
- ○ Making less head movements (5)
- ○ I don’t listen to music while cycling (6)
- ○ I do not change the way I cycle (7)

Q10 When you make a phone call while cycling, do you change the way you ride your bike in any way? If you do, what do you do differently? (multiple answers are possible)

- ◯ Cycling with one earbud (1)
- ◯ Turning the volume down (2)
- ◯ Cycling slower (3)
- ◯ Cycling faster (4)
- ◯ Making less head movements (5)
- ◯ I don't make phone calls while cycling (6)
- ◯ I do not change the way I cycle (7)

Q11 I feel that listening to music while cycling makes me less aware of my surroundings

- ◯ strongly disagree (1)
- ◯ disagree (2)
- ◯ neutral (3)
- ◯ agree (4)
- ◯ strongly agree (5)

Q12 I feel that calling while cycling makes me less aware of my surroundings

- ◯ strongly disagree (1)
- ◯ disagree (2)
- ◯ neutral (3)
- ◯ agree (4)
- ◯ strongly agree (5)

Q13 I feel that listening to music while cycling is distracting and negatively impacts my performance

- ◯ strongly disagree (1)
- ◯ disagree (2)
- ◯ neutral (3)
- ◯ agree (4)
- ◯ strongly agree (5)

Q14 What do you usually do when you are cycling on an (electric) bike or moped/scooter and you receive a phone call?

- I answer the phone while cycling (1)
- I stop immediately and answer the phone (2)
- I wait until it's quiet and call back while cycling (3)
- I wait until it's quiet and stop to call back (4)
- I ignore the ringing (5)
- I never hear it (6)
- That never happens (7)

Q15 What do you usually do when you are cycling on an (electric) bike or moped/scooter and you hear/feel that a new message has arrived on your phone or smartwatch?

- I message back while cycling (1)
- I stop immediately and message back (2)
- I wait until it's quiet and message back while cycling (3)
- I wait until it's quiet and stop to message back (4)
- I ignore it (5)
- I never hear it (6)
- That never happens (7)

Q16 Answer 'disagree' on this question.

- strongly disagree (1)
- disagree (2)
- neutral (3)
- agree (4)
- strongly agree (5)

Q17 I think I am able to hear traffic around me when cycling with music or while listening to a podcast

- strongly disagree (1)
- disagree (2)
- neutral (3)
- agree (4)
- strongly agree (5)

Q18 To what extent do you agree or disagree with the following statement:

When I am working on something, I easily lose track of time

- ○ Strongly disagree (1)
- ○ Disagree (2)
- ○ Not agree, not disagree (3)
- ○ Agree (4)
- ○ Strongly agree (5)
- ○ Don't know/ no opinion (6)

Q19 I can easily block out external distractions when I am focused on something else

- ○ Strongly disagree (1)
- ○ Disagree (2)
- ○ Not agree, not disagree (3)
- ○ Agree (4)
- ○ Strongly agree (5)
- ○ Don't know/ no opinion (6)

Q20 I often become completely engrossed in a movie or TV show

- ○ Strongly disagree (1)
- ○ Disagree (2)
- ○ Not agree, not disagree (3)
- ○ Agree (4)
- ○ Strongly agree (5)
- ○ Don't know/ no opinion (6)

Q21 Have you answered this questionnaire honestly?

- ○ No (1)
- ○ Yes (2)

Appendix B: Syntax

Correlations for Immersion, Distraction, and Head Movements

```
CORRELATIONS
  /VARIABLES=MEAN_distraction MEAN_HM
  /PRINT=TWOTAIL NOSIG FULL
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.

CORRELATIONS
  /VARIABLES=MEAN_distraction MEAN_HM MEAN_HMintersection
MEAN_HMstraight
  /PRINT=TWOTAIL NOSIG FULL
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.

CORRELATIONS
  /VARIABLES=MEAN_immersion MEAN_HM MEAN_HMintersection
MEAN_HMstraight
  /PRINT=TWOTAIL NOSIG FULL
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.

USE ALL.
COMPUTE filter_$=(Q0_14 < 7).
VARIABLE LABELS filter_$ 'Q0_14 < 7 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.
COMPUTE MEAN_distraction=MEAN(Q0_14,Q0_15).
EXECUTE.
CORRELATIONS
  /VARIABLES=MEAN_immersion MEAN_distraction
  /PRINT=TWOTAIL NOSIG FULL
  /STATISTICS DESCRIPTIVES
  /MISSING=PAIRWISE.
```

Graphs and Figures for Immersion, Distraction, and Head Movements

```
GRAPH
  /SCATTERPLOT(BIVAR)=MEAN_HM WITH MEAN_distraction
  /MISSING=LISTWISE.

GRAPH
  /SCATTERPLOT(BIVAR)=MEAN_HM WITH MEAN_immersion
  /MISSING=LISTWISE.

GRAPH
  /SCATTERPLOT(BIVAR)=MEAN_distraction WITH MEAN_immersion
```

```
  /MISSING=LISTWISE.

GRAPH
  /BAR(SIMPLE)=MEAN(head_turns_c1_i) MEAN(head_turns_c2_i)
MEAN(head_turns_c3_i)
    MEAN(head_turns_c4_i)
  /MISSING=LISTWISE
  /INTERVAL SD(1.0).

GRAPH
  /BAR(SIMPLE)=MEAN(head_turns_c1_s) MEAN(head_turns_c2_s)
MEAN(head_turns_c3_s)
    MEAN(head_turns_c4_s)
  /MISSING=LISTWISE
  /INTERVAL SD(1.0).
```