The impact of movie soundtracks on the estimation of driving speeds

Coen Dekker
Graduation Thesis
Media Technology MSc Programme, Leiden University, The Netherlands
Supervisors: Edwin van der Heide, Cynthia Liem
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***Abstract*— Music can be experienced in a variety of ways and it can lead to a number of different effects on us while listening to it. We have researched up to what extent certain movie soundtracks impact the estimation of a car's driving speed. We have done this by combining video recordings shot from the driver's perspective and combined them with different soundtracks. The experiment used video recordings of three different driving speeds (40, 60 and 80 km/h). Each of these was presented in four different ways: without a soundtrack, with a soundtrack scoring high on anger, a soundtrack scoring high on happiness or a soundtrack scoring high on sadness. The order of the video sets was shuffled per participant. A total of 96 participants took part, half of them offline and the other half online. The results of our research show that all three soundtracks significantly raised the speed estimation of the video recording with a driving speed of 40 km/h. The estimations of the other two driving speeds were not significantly influenced by a soundtrack. Another effect that was observed is that the overall influence of the anger and happiness soundtracks tended to converge the speed estimates towards a central speed, instead of giving an overall increase or decrease for the estimated speed.**

***Index Terms*— Effect of Soundtrack; Simulated driving; Speed estimates;**

I. Introduction

Nowadays there is an great amount of information processing taking place. We perceive the world using our human senses, usually without much mental effort. Each sense gives us a specific frame. We can control seeing, hearing, feeling and more whenever we want. Hearing someone directly talk to you or eavesdropping on a distant conversation, our senses allow us to focus. All senses together assist in our perception of the world. But what if these senses are conflicting? For each case there is a dominant sense which usually overrules the other senses' conflicting information.

A traditional scientific example is the McGurk effect, discovered by McGurk and MacDonald in 1976. The effect describes two conflicting stimuli: the first being video material of a person pronouncing "va", the other being audio material of that person pronouncing "ba". Observers of this experiment mostly heard "va", indicating that the visual material changed the perceived sound [McGurk, 1976]. This effect can be described as visual dominance [Posner, Nissen & Klein, 1976]. It has been an idiom recorded all the way back in 1639: "Seeing is believing", indicating the visual sense is dominating the other senses.

On the other hand there is also research that indicates that hearing can be dominant over seeing. In 2000 Shams at al. experimented with flashes accompanied with one or two auditory beeps. The observers reported that they saw two flashes when the sound beeped twice, while there was only one flash in the visual material. So by changing the amount of beeps, the observers perceived more flashes [Shams, Kamitani & Shimojo, 2000]. The examples show that hearing can in fact overrule seeing, meaning visual dominance is not a rule of thumb. It can still be true, but surely not in all cases.

In daily life we usually perceive far more than one sense at a time. From this we can argue that more than one sense is used when perceiving the world. We would like to research what impact hearing, specifically hearing music, has on visual perception.

In 2007 Dibben and Williamson conducted a survey of 1780 British drivers suggesting that approximately two-thirds of the participants listen to recorded music or music radio while driving. Music was reported to be less distracting than a human conversation. Most participants found listening to music relaxing while driving. Participants also tend to sing along and turn on the volume when driving alone, in the hope that it will help against driving fatigue and drowsiness [Dibben & Williamson, 2007]. Based on this research we can assume that it is common to listen to music while driving. During an activity like car driving, we would like to investigate if the estimation of speed is influenced by the presented music. This in turn could lead to a change in driving experience, which is not yet fully tested.

Our aim is to research the impact that instrumental music has on speed estimation. Thus we focused on movie soundtracks, which are instrumental and bear narrative value. We have chosen to use movie soundtrack fragments originating from a music dataset by Eerola and Vuoskoski in 2010. We would like to use this music dataset to experiment if music can be influencing the perception of driving speeds. The established research question is: To what extent do movie soundtracks impact the estimation of driving speed?

II. Related Work

As mentioned in the introduction, the McGurk effect is a classical example where visual and auditory stimuli conflict, resulting in visual overruling of the auditory stimuli (visual dominance). When conflicting information from two different sensory modalities are perceived with one being vision, the visual information would dominate. The classical example of visual dominance is reported by Gibson in 1933. Gibson experimented with subjects wearing prism spectacles that made straight edges appear curved. When subjects watched their hands move along an objectively straight edge, visual information demonstrated it to be curved, although kinesthetic information suggested that the edge was straight. The result was that subjects experienced no conflict; the edge felt curved. The visual input dominates perception [Gibson, 1933]. Rock and Victor reported in 1964 that visual dominance hold true in judgments of size. Their subjects looked at a square object through a minimizing lens but were not told of the visual distortion. In one condition they were asked to grasp the object and then to reproduce or match either its visual or felt size. The result was that both judgments, depend on the perceived visual size of the object and not upon its actual size [Rock & Victor, 1964].

"Seeing is believing", the idiom recorded in 1639 seems to be correct in the research above. But as mentioned previously, other research indicates that the visual sense can also be overruled, showing that visual dominance is only true in some cases. Shams et al. published a research in 2002 where auditory stimuli overrules visual stimuli. The experiment consisted of a flashing gabor patch accompanied with an audio beep. When observers were presented one flash accompanied with two beeps they reported seeing two flashes as well [Shams,, Kamitani & Shimojo, 2000]. The result indicates that visual dominance is not always applicable. The results is accompanied by another study published in 2002 by Berger. Berger experimented with a similar setup, but used multiple flashes instead of one. Berger's results support the idea that audio beeps change the number of flashes that are reported by observers [Berger, 2002].

With our research we aim to go more into sound than just beeps. Music is commonly around us, used to set a mood, convey a message or set the context of visual information. Music is composed to fit in the specific situation it is being used. In a study done by Cohen in 1993 it is suggested that sound can transform the visual interpretation of a movie. A musical piece of a movie is able to bear narrative functions on its own. In the study three experiments were presented. Firstly, an auditory pattern varying in tempo and height altered the happiness/sadness judgments of a bouncing ball. Secondly, contrasting music influenced semantic differential judgments about a simple animation overall and for the three geometric film "characters". Thirdly, different music in some instances shifted both the affective and denotative meaning of the film [Cohen., 1993]. Cohen's study shows that music can change the interpretation of an image or video. Even if music does not overrule the visual information, it can still fill in otherwise emotionless things.

In our research we focus on car driving while listening to music and what impact the music might have. A study done by Hennessy in 2000 suggests that listening to music while driving is an important mechanism for coping with driver stress. In rush hour, it was observed that the participants listening to music experienced lower stress than those who did not [Hennessy, 2000].

Another study in this field by Brodsky in 2001 researched the influence of music tempo on car driving. The first main finding was that as the tempo of music increased, so did simulated driving speed and speed estimate. Without music subjects accelerated to moderately quick speeds, while they perceived their velocity to be slow (i.e., speed estimates were most inaccurate without music). The second main finding of the study was that the tempo of music consistently affected the frequency of traffic violations. Vehicular collisions, lane crossings, and disregarded red traffic lights were most frequent during simulated driving with fast-paced music. Subjects in the fast driving group demonstrated significantly more at-risk simulated driving behaviors with fast-paced music [Brodsky, 2001].

In 2012 van der Zwaag et al. researched if music changed the speed participants drove on two lane widths. The participants in this research rated 60 sample songs on valence and energy levels. Based on the ratings, van der Zwaag et al. selected a personal 'positive' and 'negative' song for each participant. The selected songs, along with no music at all, were used in a simulated driving sequence. Results present that negative music raised the driving speed on the wide lane roads, while positive music decreased it. In the narrow road both positive and negative music decreased the driving speeds, indicating the urge to drive pay more attention. Another finding was that both no music and 'negative' music had the same recorded driving performance, while 'positive' music increased driving performance significantly [van der Zwaag et al., 2012].

The last two studies seem to be in conflict. Brodsky implies that driving performance is lower when fast-paced music is present, whereas van der Zwaag et al. imply that as long as the music is rated positive it increases driving performance. From this we can conclude that the impact of music can be very different for each person, as it is perceived differently.

A relevant study done by Horswill and Plooy in 2008 presents that there is another factor we use to estimate driving speeds. Horswill and Plooy present the improvement of car technology resulting in cars getting quieter in each iteration. This development affects the auditory feedback that the car gives the driver. The results from this study demonstrates that reducing the auditory feedback of the car engine has a significant impact on estimating simulated driving speeds. Overall, the participants rated the simulated driving speeds lower when the auditory feedback was reduced [Horswill & Plooy, 2008]. We can assume that auditory feedback of a car is a crucial factor in the process of estimating driving speeds.

As stated earlier, our research focuses on the influence of soundtracks on speed estimation. Drawing from earlier mentioned research we conclude that it is possible, but it is not always the case. We also found that music can bear information on its own. One of the most common places to listen to music is in the car. There is already some research done on music influence on car driving, indicating that fast-paced music results in more traffic violations. However, if a specific song is experienced positive, it can also lead to an

increase in driving performance. We are taking this into account when designing our own experiment. We would like to know if soundtracks can significantly impact the estimation of driving speed.

III. Method

An experiment was created by recording real-life car driving scenes and presenting them accompanied with movie soundtracks. What we needed was video material and auditory material.

1) Video material

Video footage is specially recorded for this experiment. We chose to take a piece of daily life and use that in the experiment because in that manner we ensured that the setting was common for our participants. Video recordings were made in and around Hazerswoude, Netherlands. Initially, driving speeds between 20 and 120 km/h were recorded, each segment lasting at least 20 seconds on the same speed. We used a camera on top of the dashboard of a Citroën Berlingo. The recording setup with the rough viewing angle is displayed in Fig. 1.

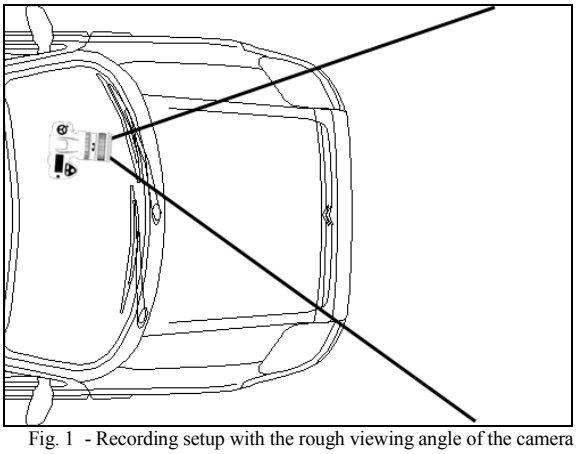

Fig. 1 - Recording setup with the rough viewing angle of the camera

We should mention that the recording setup that was used resulted in a zoomed-in view of the car. This will differ from driving in a car in real-life, where the viewing angle is much wider. The zoomed-in perspective could have a slightly negative impact on the perception of speed. Upon researching this effect we came across an illusion which is well explained on oneyetricks.com. This illusion seems to closely resemble our perspective of the video. The illusion is animated using moving dots from the center to the corners. The illusion works as follows: as the dots in the center are covered, the dots in the corner appear to be moving faster. The reverse is true when covering the corner dots, the center dots appear to move slower. We think this resembles how we take our perspective in the car, which could result in speeds being perceived slower than they actually are [Online Source, 2015].

Nonetheless we think this perspective can be used for speed estimation, but we will need results without soundtracks to compare with. Figure 2 illustrates how this perspective is seen on video.

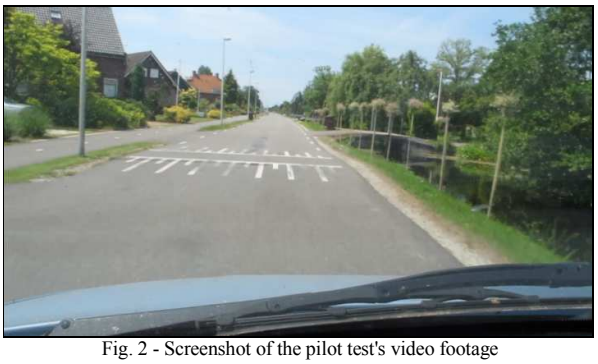

Fig. 2 - Screenshot of the pilot test's video footage

The recorded videos were cut in segments of 20 seconds each using Sony Vegas Pro 13. Auditory feedback of the car was maintained in the videos. We used the common MP4 format on 1280 by 720 pixels. We recorded around 25 videos of varying speed to be used in the pilot test.

2) Auditory material

When we searched for audio footage we required movie soundtracks. We excluded vocal music. We understand that vocals could be a big part of music, but we would like to use music that can be experienced universally. Also, vocal music could have obvious impact on the observer, for example talking about fast or slow topics. Instead, we would like to explore the possibilities of instrumental music. An aspect of music which is already researched by Brodsky in 2001 is music tempo. According to Brodsky a simulated driving video accompanied by high tempo music resulted in observers estimating speed higher as well [Brodsky, 2001].

For our research we would like to experiment with movie soundtracks and the mental states they might invoke on the listener. Movie soundtracks are suitable since they have composed narrative in them. A viewer of a movie has to feel happy, mad or sad, which the soundtrack could stimulate. The drawback of this idea was that music could be beautiful for one and sad for the other. At this point we do not know what impact a specific piece of soundtrack has. We would like to have a music set which is tested among multiple participants.

The set that got our attention was a music set by Eerola and Vuoskoski which consists movie soundtrack fragments. Each fragment is around fifteen seconds long and is tested among 116 participants. Test categories were valence, energy, tension, anger, fear, happiness, sadness, tenderness, beauty and liking [Eerola, Vuoskoski, 2010]. Eerola and Vuoskoski conducted this research to find systematic way to group movie soundtracks. We found this music dataset interesting since it had the same aim as we did, and it provided us with the auditory material we needed. Even though earlier discussed work from van der Zwaag stated that music is experienced in a highly personal way, we would like to test music in a more uniform experiment. This is done because a significant finding in a uniform experiment is way more applicable in daily life, compared to a highly personal experiment. We favored this view, hence we decided to take this approach.

We chose to select three pieces from Eerola and Vuoskoski's set based on their ratings. Since we are not sure if there is an influence, we selected three categories that we think could the biggest chance to show an influence. The first

category is anger, which we chose for its high ratings in energy, tension and anger. The second category is happiness, which we chose for its high ratings in energy, valence and happiness. The final category is sadness, which we chose for its high ratings of beauty, sadness and liking. In our opinion these are quite different and might invoke different emotions, which makes them the most interesting to experiment with. Furthermore, we would like to take extreme measurements in each category because we are not sure if there is a significant influence. Taking the extreme would further ensure to show this influence, if it is there. Using Adobe Audition we recorded the beats per minute per soundtrack so we could use it later on in the results.

An overview of the audio material ratings is displayed in Table i. Eerola and Vuoskoski's used a scale of 0 to 10 for ratings. The values we selected the music on is highlighted.

TABLE i. AUDIO MATERIAL FROM EEROLA AND VUOSKOSKI'S MUSIC DATASET INCLUDING ALL THEIR RATINGS

	Target	*Valence*	*Energy*	*Tension*	*Anger*	*Fear*	*Happy*	*Sad*	*Tender*	*Beauty*	*Liking*	*BPM*
1	Anger	2.56	**7.73**	**8.38**	**6.39**	4.4	1.21	1.75	1.01	4.71	4.97	40.68
2	Happy	**8.27**	**8.54**	4.46	1.04	1.03	**8.21**	1.10	1.45	4.35	4.85	124.29
3	Sad	4.38	2.48	3.27	1.07	1.78	1.12	**7.18**	3.03	**6.73**	**5.83**	86.96

A. Experiment I - pilot test

The video material and auditory material were combined in a pilot test to review our testing setup. The aim of this test was to thoroughly examine the current footage and find aspects we could improve before carrying out the full experiment. Speeds between 20 and 120 km/h were recorded, we selected three speeds for the pilot test. In a quick selection we already noticed that 10 km/h differences might be hard to tell apart, so we decided to select three speeds which were at least 20 km/h apart. The speeds were 40, 60 and 80 km/h. This was done because the speeds could be recorded on most roads with the exception of highways and urban areas. We excluded these roads because they already hint the observer the most accepted speeds and since we are not editing the speeds afterwards. This way we preserved a neutral starting point that does not bias the observer. The three speeds were combined with each of the three selected soundtracks in Sony Vegas Pro 13. The only adjustment was a little lower volume in each soundtrack so they blended more natural in the videos. It should be mentioned that the sound of the camera while recording was maintained in the videos. According to Horswill and Plooy the internal sounds of a car engine also contribute greatly to the estimate of speed [Horswill & Plooy, 2008]. We constructed nine unique scenes for the pilot, presented in Table ii.

TABLE ii. DATA SETUP FOR THE PILOT TEST DISPLAYING THE NINE UNIQUE VIDEOS

	Soundtrack 1 - Anger	*Soundtrack 2 - Happiness*	*Soundtrack 3 - Sadness*
Video A - 40 km/h	A1	A2	A3
Video B - 60 km/h	B1	B2	B3
Video C - 80 km/h	C1	C2	C3

The pilot test is carried out with 10 participants. Each participant only got each testable object once in shuffled combinations and in shuffled order. For example: participant 1 got A2, C1, B3 while participant 2 got C1, B3 and A2. This way the participant perceived each video and each piece of soundtrack once. We chose this way of testing to make sure that the order will not play a huge role in the total results. The pilot test was conducted using a Macbook Pro 15" running QuickTime video software while using a Sennheiser HD 439 as headphone.

The pilot test left us with some points of critique:

Firstly, the recorded footage varied in traffic and sort of roadways. Upon executing the pilot we got the impression that differing roads might still hint the participant on what kind of road it is and what speed is acceptable. We want the observer to primarily focus on the driving and the speed.

Secondly the current videos had several bumps in the road, which resulted in the camera swayed the view more and less violently depending on the speed. This was intended to help the observer in getting a feel of the speed, but ended up being way more impactful than expected.

Thirdly, even though we selected parts of roads which avoided most of the traffic signs, we still had sources that gave away too much in our opinion. One example are traffic signs with a distance indicating a traffic light or turn. These could be used for speed estimating, while we would like the observer to perceive the road, instead of the traffic cues.

Fourthly, we found that the soundtrack fragments did not blend very naturally into the video. The issue was that the soundtracks were high quality while the video was recorded using the camera microphone. This resulted in the soundtrack sounding too different from the sound of the video, which made the whole experiment feel fake.

Lastly, we realized we were working with estimates. For this reason we also would like to test the videos without added soundtracks so we could check what the soundtrack actually influenced.

After the pilot test we came to the conclusion that to redo the recording of speed on the same road. The speeds of 40, 60 and 80 km/h still felt suitable for this experiment. The recording should avoid any traffic signs, while traffic lines and hectometer signs are present. We also want to remove the noise of other traffic, so we strived to avoid as much oncoming traffic as possible.

3) Updated material

A second recording was made to improve the video footage. The recording was done on one specific street: Broekweg, Hazerswoude. This road allowed for speeds of 40, 60 and 80 km/h, it was low on traffic and avoided traffic signs. All footage was at least 15 seconds long and excluded oncoming traffic. All video featured a flat road ending just before a bump in the road. Again the Canon G13 Bridge camera was used for the recording, this time recording in a slightly higher angle to focus on the road and avoiding visual material of the car itself. Figure 3 is a screenshot of the updated footage. The selected scenes were again edited using Sony Vegas 13.

Fig. 3 - Screenshot of the updated footage

Footage of 50 km/h was the last addition to the visual material to serve as an introduction. Since the viewing angle is highly specific towards the only allowed to watch in the front of the car we figured it would be good to add a reference video as introduction to the experiment. The updated set included four video's of 40, 50, 60 and 80 km/h respectively.

For the soundtracks we decided to play them on the car radio while recording them with the camera. This ensured that the sound quality of the sound in the video and the soundtracks were of the same quality, which blended better. Table iii has an overview of each video that will be used in the experiment.

TABLE iii. OVERVIEW OF THE UPDATED MATERIAL

	Soundtrack 0 - Silence	*Soundtrack 1 - Anger*	*Soundtrack 2 - Happiness*	*Soundtrack 3 - Sadness*
Video R - 50 km/h	Reference	-	-	-
Video A - 40 km/h	A0	A1	A2	A3
Video B - 60 km/h	B0	B1	B2	B3
Video C - 80 km/h	C0	C1	C2	C3

B. Experiment II - full scale test

With the material above we conducted an experiment to answer the question: *Do movie soundtracks influence speed estimation?*

1) Participants

A total of 96 humans participated in the experiment [average age 22.95 years (SD 3,19); 36 females and 60 males; 60 participants had a driver's license and 36 did not].

2) Material

The updated material, as discussed earlier, was used in experiment II. We avoided a fixed order by shuffling the combinations and order of the videos. With only presenting each video and soundtrack once we got six setups, combined with six possible orders for each setup we got a total of 36 unique experiments. We created six possible orders of videos without soundtracks. All 42 videos were made in a format where the start had some introductory information, accompanied with a reference video of 50 km/h. Next the shuffled videos were shown, each with fifteen seconds in between to ensure the participant had enough time to write down a speed estimate. The 36 combinations were shuffled between the first 36 participants.

3) Procedure - Offline

The first 36 participants did the experiment in an offline and fixed test setup. Once again each unique video is shuffled between participants so all 36 get a random video in the test set. First the participant got a pen and a paper handout, introducing the experiment. Next the participant sits down on a table and puts on the Sennheiser HD 439 headphone. The specific video was opened using QuickTime software on a Macbook Pro 15". Participants looked perpendicular at the screen at a distance of approximately 45 centimeters. When the participant was ready the experiment begun and we ran the video. The video also introduces the experiment and shows the

reference video of 50 km/h. After that the participant starts with the experiment, answering the speeds of all three videos on the handout. Afterwards the participants adds their name, age, gender, driver's license and if they want more info, an e-mail address on the handout. The handout is collected and serves as the result for that specific video.
The next twelve participants got the experiment with no soundtracks, exactly the same way as the one above. This resulted in 48 handouts filled in by different people.

4) Procedure - Online

The same as the offline test, the online test was first done with 36 participants in an online setting to raise the overall amount of participants. This time, the participants got a specific Dropbox folder consisting of a video and a Microsoft Word document. The participants were instructed to first open the Word document, which was the handout. This handout also included the requirement to put on sound of the computer and turn off any music or other sound that might be playing at that point. When the participant was ready they could open the video, which was the same as the offline test. During the experiment the participants were encouraged to write their answers on a sticky note so they could run the video full screen. After the test the participants had to fill in the Word document, which also asked the same as the offline handout. The participants are done with the experiment when they send back the filled handout.
The next twelve participants got the experiment with no soundtracks, exactly the same way as the one above. This resulted in 48 handouts filled in by different people.

In the end a total of 96 handouts are collected. With the design of our experiment we ensured the same number of results per combination of video with soundtrack, presented in Table iv.

TABLE iv. OVERVIEW OF THE NUMBER OF RESULTS OF EACH COMBINATION

	Soundtrack 0 - Silence	*Soundtrack 1 - Anger*	*Soundtrack 2 - Happiness*	*Soundtrack 3 - Sadness*
Video A - 40 km/h	24	24	24	24
Video B - 60 km/h	24	24	24	24
Video C - 80 km/h	24	24	24	24

II. RESULTS AND EVALUATION

First the results were collected from the handouts of both the offline and online experiments. The results that were collected consisted of: id, experiment number, set number, age, gender, license b, video id, soundtrack id, estimation given and a yes/no to indicate if the test was done online or offline. We maintained the order of each participant by grouping the ids. To give a more clear idea of the results the first three results are presented in Table v.

TABLE v. FIRST THREE ANSWERS IN EXCEL FORMAT

Id	*Experiment number*	*Set number*	*Age*	*Gender*	*License*	*Video*	*Sound*	*Answer*	*Online*
1.1	1	28	23	f	b	C	2	80	No
1.2	1	28	23	f	b	A	3	40	No
1.3	1	28	23	f	b	B	1	60	No
2.1	2	21	20	m		B	2	50	No
2.2	2	21	20	m		C	1	60	No
2.3	2	21	20	m		A	3	40	No
3.1	3	23	22	f		B	3	60	No
3.2	3	23	22	f		C	1	80	No
3.3	3	23	22	f		A	2	40	No

For the analysis we start with comparing the offline results to the online results. To get an overview of both sets of results we generated boxplots of each set. For the first comparison we only used data from the last four columns. Both sets of the experiment are evenly weighted since there are 48 participants in each set. When generating the boxplots we included all data and did not make a selection of outliers. The boxplots are shown in Fig. 4 and Fig. 5.

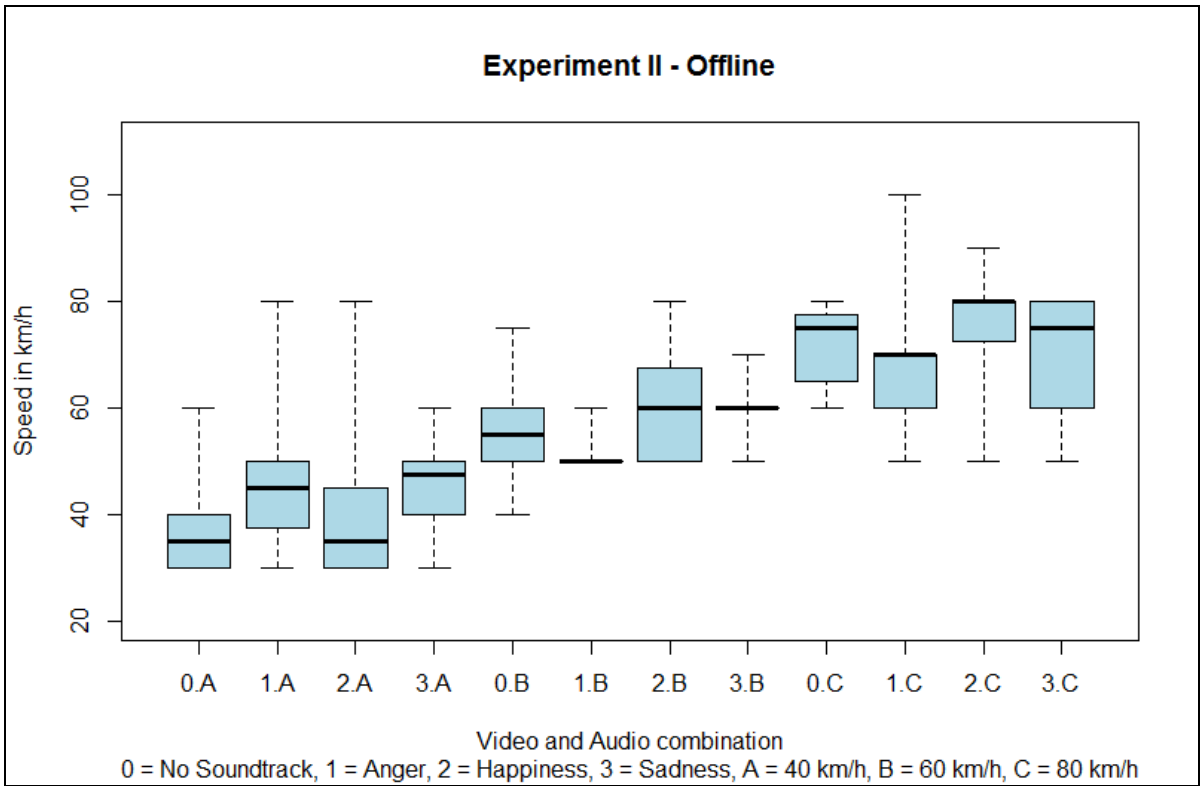

Fig. 4 - Experiment II offline results for each combination of video and soundtrack. n= 48

Upon inspecting the non soundtrack results we can see that consistently most of the estimations are below the actual speed of the video. This is what we somewhat predicted, with the optical illusion mentioned earlier. The slightly zoomed-in perspective could be the reason why speed estimations were a bit lower for most participants. When comparing the non soundtrack to the soundtracks we can see that the anger soundtrack has an interesting impact. In video A and B the estimates are considerably higher, while in video C the results are lower. Also, it should be mentioned that the anger soundtrack had the highest peak estimation of speed in video C with 110 km/h.

When comparing the happiness soundtrack with non soundtrack group we can see a small effect. In video A the estimates are a quite high but are still averaging around the estimation of the non soundtrack. In video B the estimations of happiness are averaging a bit higher than the non soundtrack, which is in line with the actual speed of the video. Also, the results are varying a lot more. In video C we can see that happiness estimations are higher than non soundtrack, which again is more in line with the actual speed of video C. Once again the results are varying much more compared to the non soundtrack.

When comparing the non soundtrack with the sadness soundtrack we can see a another effect. In video A we can observe that the estimates average is a lot higher than the actual speed of the video. In video B the estimations of sadness are really narrow and averages on exactly the speed of the video. In video C we can see that the sadness soundtrack is around the same as the non soundtrack estimates, which is a little below the actual speed of 80 km/h.

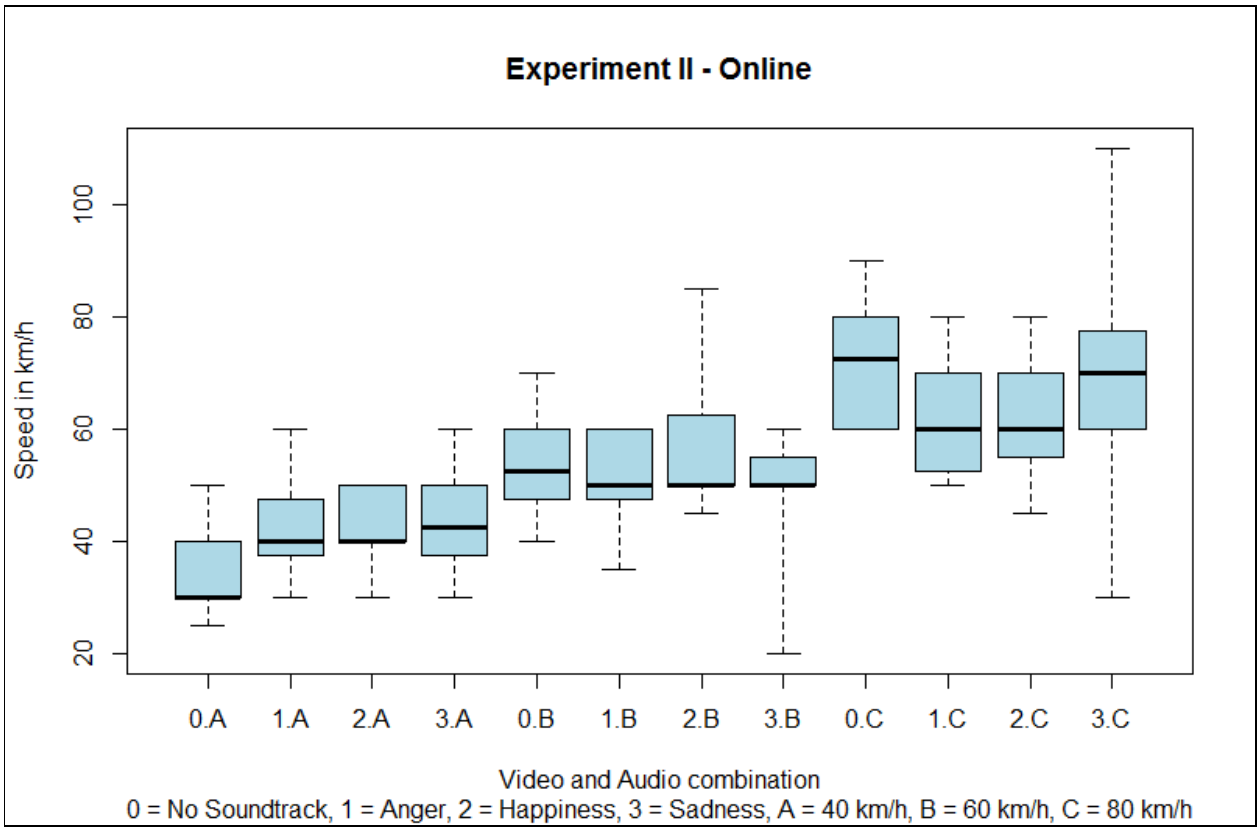

Fig. 5 - Experiment II online results for each combination of video and soundtrack. n= 48

When comparing the offline with the online test we can see that the non soundtrack results around the same as the offline results. The results of the anger soundtrack are around the same. The results of the happiness soundtrack demonstrate little differences, especially in video A and C. The online results for the happiness soundtrack in video A is considerably higher, there the results of video C are considerably lower. The results of the sadness soundtrack are arguably the most different. In video A there are comparable with the offline results, but in video B and C the results are quite far apart, with the lowest estimate of 20 km/h in video B and the highest estimate in video C with 120 km/h.

Since most the averages of both sets of data are still quite in line with each other we decided to combine both sets for further analyzing. The combined plot, which will be our main overview, is illustrated in Fig. 6.

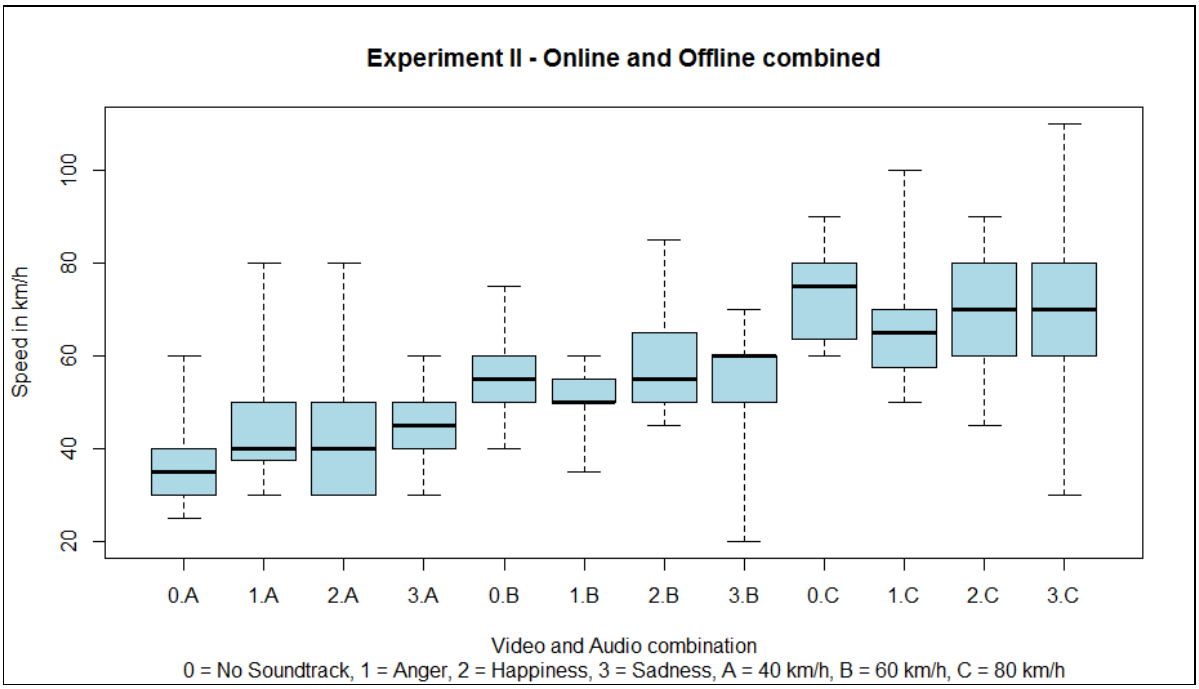

Fig. 6 - Boxplot of all data. vertical axis is km/h. Horizontal is the video with sound. n= 96.

The boxplot above provides a decent overview of all the data. When we look at the 40 km/h video (the first 4 boxplots), we can see that the non soundtrack estimates are quite below the actual speed of 40 km/h. Also, the speed estimates with soundtrack are a bit higher than the one without a soundtrack. The highest estimates were found with the happiness soundtrack, but the overall highest estimates were given with the sadness soundtrack. When we look at the 60 km/h video (the middle 4 boxplots), we can see that the non soundtrack estimates are a little below the actual speed of 60 km/h. Also, the speed estimates with soundtrack are both higher and lower than the one without a soundtrack. The anger soundtrack is considerably lower than the non soundtrack estimates. The happiness has extremely high estimates but still averages around the non soundtrack estimates. The sadness soundtrack is overall a little bit higher than the non soundtrack estimates.

When we look at the 80 km/h video (the last 4 boxplots), we can see that the non soundtrack estimates are again quite below the actual speed of 80 km/h. Also, the speed estimates with soundtrack are lower than the one without a soundtrack. The anger soundtrack is considerably lower than the non soundtrack estimates. The happiness soundtrack has some high and low estimates but still averages around the non soundtrack estimates. The sadness soundtrack is all over the place with the same average around the happiness soundtrack.

To get a clear overview of the impact that soundtrack had on the estimates of speed we performed a two way analysis of variances (two way ANOVA). We calculated the interaction between the soundtracks and speed estimates, presented in Fig. 8.

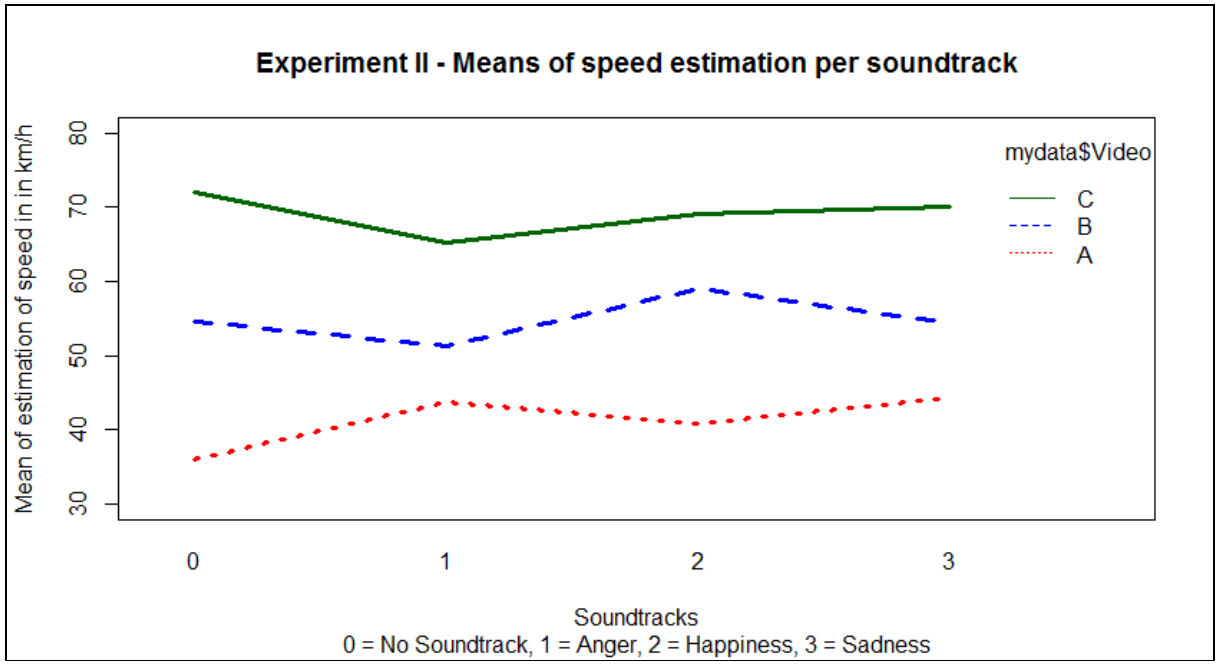

Fig. 7 - Interactions for each soundtrack on each video. For A p = 0.016, for B p = 0.426 and for C p= 0.274, n=24

Figure 7 shows the means of all speed estimations. First of we would like to point out that the influence of soundtrack was only significant on video A, with a p value of 0.016. The p values of videos B and C are greatly higher than 0,05 and therefore not significant. Next we can see that all the non soundtrack estimations are under the actual speed. The anger soundtracks show an interesting impact. On video A the estimations are higher, while video B and C show a decrease in estimation speed. The happiness soundtrack is a little higher on both videos A and B, while it is lower on video C. Finally the sadness soundtrack is close in line of the non soundtrack in video B and C, while it is considerably higher in video A. An overview of the impact is presented in Table vi.

We would like to mention that the beats per minute did not seem to influence the estimations of speed significantly. That being said we should also add that especially the anger and sadness had low beats per minute, while happiness had a high beats per minute.

TABLE vi. MEANS OF SPEED ESTIMATION PER VIDEO AND SOUNDTRACK IN THE COMBINED DATASET. N= 96

	Soundtrack 0 - Silence	*Soundtrack 1 - Anger*	*Soundtrack 2 - Happiness*	*Soundtrack 3 - Sadness*	*Significance Level (P)*
Video A - 40 km/h	35.96	43.75	40.83	44.38	0.016
Video B - 60 km/h	54.58	51.25	58.96	54.38	0.426
Video C - 80 km/h	71.96	65.21	69.17	70.00	0.274

With the current data we analyzed a more features that might hold relevance for this research: license vs. no license and females vs. males.

A. License vs. no License

First we compiled two groups of the participants with and without a driver's license. A total of 60 participants with a license and 36 without were registered. We should mention that comparing this data is possible but might lead to misleading data since both groups are not equally weighted. Visual overviews of this comparison are presented in Appendix C.

When looking at the means of speed estimations per video and soundtrack we can see that the non soundtrack was consistently higher at the non license group. Since the means of all data was below the actual speed of each video, we can suggest that the non soundtrack group without a driver's license was closer to the actual speed than the no soundtrack group with a driver's license. Another thing to note is that the

non license group consistently showed more varying estimations of speed. Since the estimations were the most varying in the soundtrack groups, we could say that the addition of soundtrack had more influence on participants without a driver's license. for the non license group, the anger soundtrack greatly raised the estimation of speed in video A, while reducing it considerably in videos B and C. The happiness soundtrack averaged around the same as the non soundtrack, while showing a lot more extreme estimations both above and below the non soundtrack. The sadness soundtrack showed higher estimates in video A, little lower estimates in video B and C, with the most varying data being in video C.

B. Females vs. Males

Next we compiled two groups of participants, female and males. A total of 36 females and 60 males were registered. We should mention that comparing this data is possible but might lead to misleading data since both groups are not equally weighted. Visual overviews of this complaisant are presented in Appendix D.

When looking at the results of the non soundtrack we can clearly see that the females are averaging on the actual speed of the video. Males seem to estimate the speed of the videos a bit lower. When looking at specific soundtracks we can see the following. The anger soundtrack raised the estimation in video A and lowered the estimation in video B and C for both groups. The happiness soundtrack consistently raised the estimation of speed for males in video A and B, while it seems to have a mixed result for the females. The sadness soundtrack raised the overall estimation of speed, with the exception of video C, where it was mixed for males and which lowered the estimation for females.

We considered using the participants' age to filter the data, but we realized that the groups would be too different to compare. a considered group of age 21 to 25 would consist of 62 participants 18 participants are under this group and 16 are above. Results of this filter would be unreasonable to include.

We would also like to summarize the responds we got from the participants, either filled in on the handout, or mentioned after the experiment.

Firstly, around one third of the participants in the soundtrack group reported that the speed appeared the same in all of the videos. No matter the order, the reference video seemed to be repeated, with each video being 50 km/h. It should be noted that only 10 participants actually answered 50 km/h in all videos. We would also like to point out that this did not occur in the non soundtrack group.

Secondly some participants in both the non soundtrack and soundtrack groups reported that they used the hectometer signs as a way of perceiving speed.

Thirdly, a handful of participants pointed out that they had the idea that each video started and ended on the same place. In reality only the end position was close each time, ending just before a bump in the road. This resulted in some participants thinking that both the start and ends were the same, giving them the idea that the speeds were the same on all videos.

Lastly two participants indicated that the online test was uneven for all participants since the background noise and screen size were uncontrolled. Both the impact of soundtrack and the perception of speed could be varying for the participants online, which resulted in different experiment per participant.

Since one third of the participants in the soundtrack group reported that the videos appeared to have the same speed, we would like to see what would happen if we would filter these answers from our analysis. We filtered a participant's estimations if they were all 50 after being rounded to dozens. This left 86 results, meaning there are 10 participants that answered 50 on all three videos. A visual representation of the data of this group, titled "no 50/50/50", is presented in Appendix E. There is no change in the non soundtrack estimates, since there was no participant who reported the same speed of 50 km/h for each video. For the soundtrack group there is a decent change in results, mostly closer to their actual speeds. The specific influence of each piece of soundtrack obviously got larger, with a p value of 0.08, which is still not significant.

III. Discussion

The first and largest potential issue with our approach was the addition of the online experiment. The online experiment could lead to misleading results because it did not have the same levels of control over the setup as the offline did. This is because we instructed participants to avoid background noise and run the video full screen, but there was no way to check if the instructions were actually followed. When analyzing the data we saw that there were no significant differences between the two groups. For this reason we merged the data for further analyzing. The addition of an online experiment also allowed us to do the exact same experiment online which doubled our participants number for the limited time.

Another thing we would like to point out is the perspective of the recorded videos. As mentioned earlier, as a result of our experimental setup the perspective of the videos is zoomed-in. We presume that the video footage is enough to estimate speed, but the perspective closely resembles a visual illusion: The video appears slower as the corners are covered. For this reason we believe that most of our recorded estimates are under the actual speed of the video. In our experimental setup this was not necessary a problem since we got reference material without soundtracks that could be related to the soundtrack material. In the end we found that the estimates were indeed lower than the actual speed.

A third aspect of this study is that we focused on soundtracks, specifically soundtracks from Eerola and Vuoskoski. We based our selection of music solely on the values of their study, to find tested extreme musical examples to experiment with. We found these examples suitable for this experiment since they were tested on emotional energy.

IV. Conclusion

In this research we featured the question: To what extent do movie soundtracks impact the estimation of driving speed? We approached this question with a realistic experiment of driving videos with the addition of soundtracks. A total of 96 participants joined, half offline and half online. The experiment consisted of three videos (40, 60 and 80 km/h) presented in four ways: with no soundtrack or with either anger, happiness and sadness soundtrack. We found that for our 40 km/h video the influence of soundtrack was significant (p=0,016), the impact of the soundtrack overall increased the speed estimates, with the highest being the sadness soundtrack. The addition of soundtrack did not leave a significant impact on the other two videos (p=0.426 for B and p= 0.274 for C).

The first interesting finding is that the anger soundtrack did not seem to have a linear effect on speed estimation, instead the effect was a little bit more complicated. On the slower video, the soundtrack increased speed estimations, while the two faster videos had the reversed effect. As a result the anger soundtrack seemed to draw the estimations to a central point instead of just raising or lowering it consistently. The same seemed to be true on with happiness soundtrack, but the effect was smaller.

A second finding was that the most mixed results came from the sadness soundtrack. The non soundtrack did not show values as varying as the sadness soundtrack, which indicates that the sadness soundtrack had a considerable influence, but is experienced differently per participant.

A third finding is that with the experimental setup we gave around one third of the soundtrack group the idea that all videos were the same speed. When performing the experiment we did not state that soundtrack would be tested, only that videos would be used to estimate speed. When the soundtrack finally emerged with the experimental videos, some participants got the idea that the music was the thing that was playing tricks on them. This resulted in participants answering 50 km/h on all three videos.

A fourth finding is that high beats per minute of a soundtrack did not raise the speed estimate, as was indicated by Brodsky in 2001.

Another interesting find is that the non soundtrack group consistently underestimated the actual speed of the video, although this might be a result of our experimental setup. We used a zoomed-in view in a car, which limited our participants' view of the driving car, only showing the front. The underestimation of speed was more applicable on the male participants.

A final finding is that participants with a driver's license seemed to agree more on the speeds estimation compared to participants without.

We can conclude that in our study music does in fact influence the driving speed estimations. Music generally increased the speed estimations, although some varying results occurred, presenting a more complex influence.

V. Future Work

With the executing of this experiment we cannot do but wonder about the impact that other soundtracks could have on speed estimation. Looking back upon this research we would like to improve the initial setup by broadening the viewing angle, which would be more in line with actually driving a car.

If a new experiment is done we would like to do it with a more fixed participants group. Our data showed that the most varying data was given by participants without a driver's license, which could be inexperience of perceiving driving speeds.

This research gives a starting point to research the influence that music has on the estimation of driving speeds. Further research might lead to a universal effect that music can have on speed estimation. A way to implement this could be in a car radio. It would be a system that adjusts the music which aids the driver in estimating speeds for specific traffic situations. A system like this would be helpful for car drivers. Also, it would be interesting to experiment further with the influence that music has on human perception in general. Examples like the influence of music on sense of scale or sense of depth.

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Appendix A - Offline handout

Participant ID:

Welcome! This is the handout for Coen's Experiment. The handout is used to register answers as well as providing additional information after the experiment. All answers are completely anonymous and are strictly used for this research.

Question 1:
How fast is the car driving in video 1?

Question 2:
How fast is the car driving in video 2?

Question 3:
How fast is the car driving in video 3?

Additional info

Name:			
Age:	*Gender:*	*Do you have a driver's License B?*	*Yes / No*
E-mail:		*Want to be added to the mailing list of results?*	*Yes / No*
Comments:			

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Appendix B - Online handout

Welcome! This is the handout for Coen's Experiment. The handout is used to register answers as well as providing additional information after the experiment. All answers are completely anonymous and are strictly used for this research. Please answer honestly.

Before starting:
Please turn off any music or other sound source and make sure the sound of the computer is on.

The experiment:
You have a video file attached with this handout. Please open it using a video player. The video will provide additional information. After the test video three videos will play after each other. After each video you will be asked to answer one of three questions. Please fill your answers in below.

Note: At the start there will be a test video, which you do NOT have to answer here, it is just used as introduction.

Question 1: How fast is the car driving in video 1? Answer 1: .....km/h

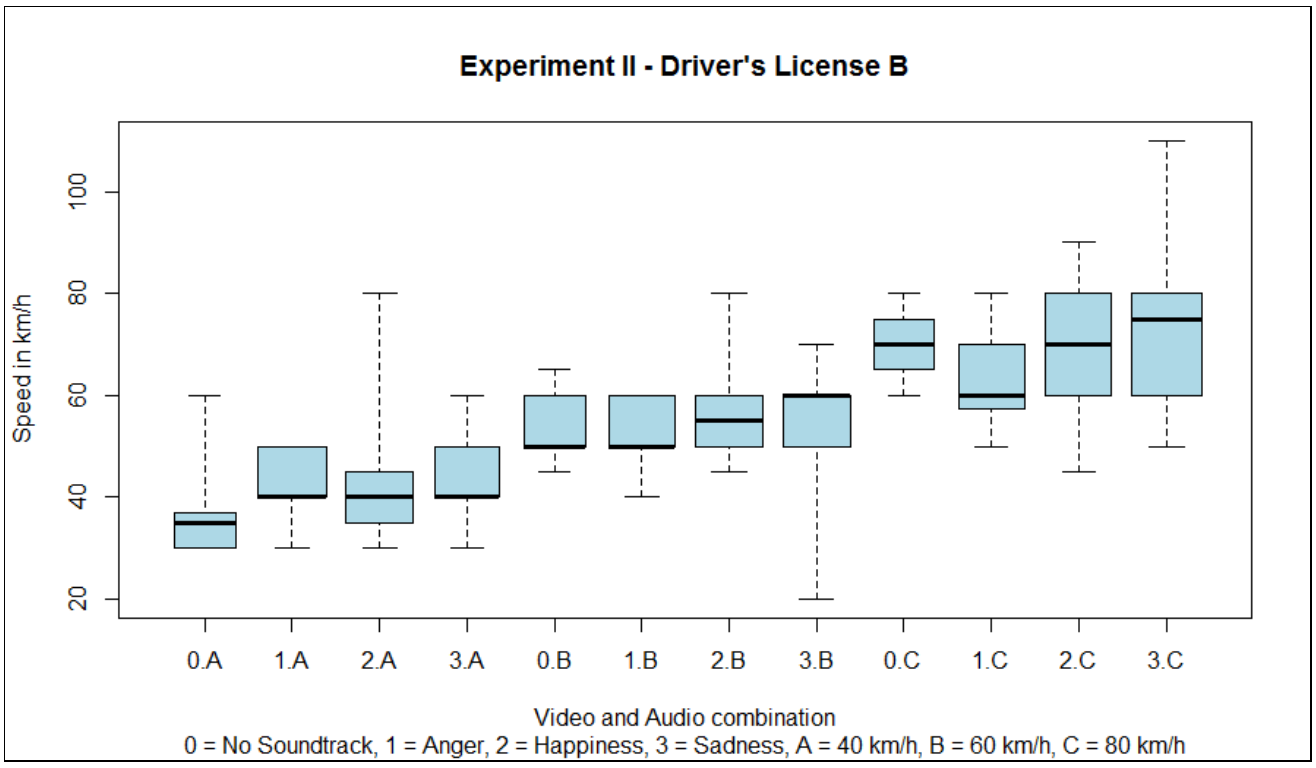
Question 2: How fast is the car driving in video 2? Answer 2: .....km/h

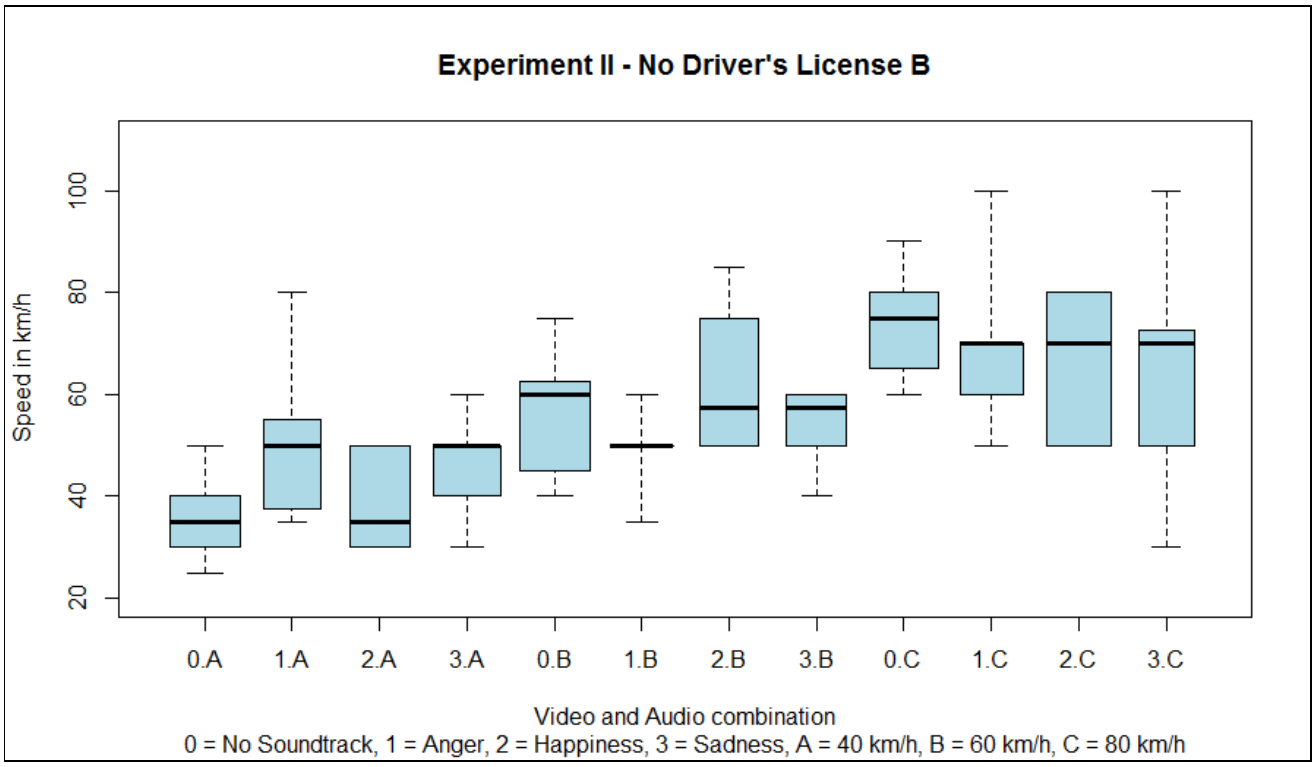
Question 3: How fast is the car driving in video 3? Answer 3: .....km/h

Additional Info:

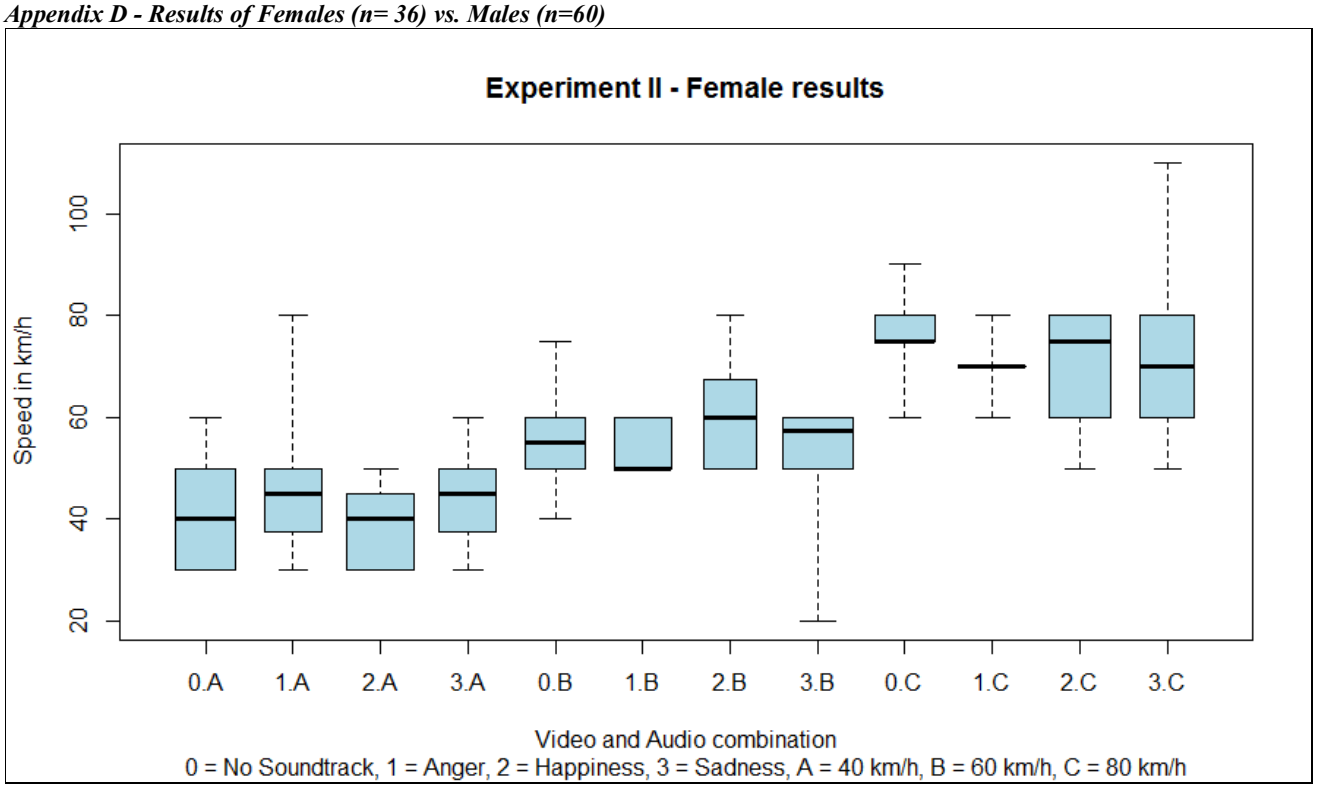
Name:	
Age:	
Gender:	
Do you have a driver's License B?	Yes / No
Email:	
Do you want to be added to the mailing list with results of this study?	Yes / No
Any additional comments?	

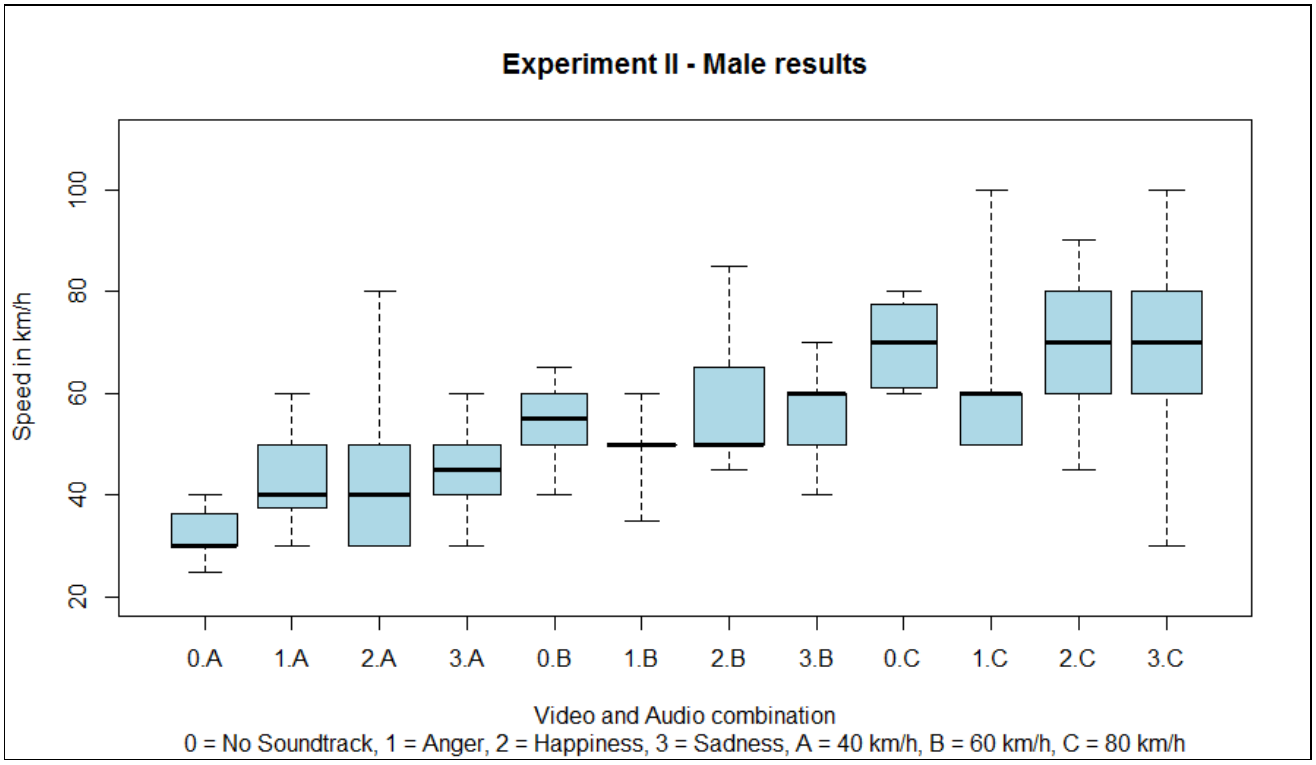
Appendix C - Results of License (n=60) vs. No License (n= 36)





Appendix D - Results of Females (n= 36) vs. Males (n=60)





Appendix E - Combined results (filtering 50/50/50, n = 86)