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Sitting behind the wheel, makes you reach for a meal.

The effect of driving on taste perception and food consumption

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Abstract

In recent years, most people consume food while driving. However, people are not successful in dividing attention between multiple tasks and often one tasks suffers. We therefore studied the effect of driving on taste perception and food consumption and whether this differs between men and women. Participants were randomly distributed over two conditions (driving versus non-driving). All participants consumed a fixed quantity of potato chips in the driving simulator. Participants were asked about their taste perception and were invited to consume the remaining potato chips afterwards. The results showed that driving lowers people's perceived taste intensity. Additionally, the results showed that people consume significantly more potato chips after driving than after non-driving. The results did not show an effect for gender on taste perception. The results confirm that high cognitive load reduces taste intensity and increases food consumption, with the new extension that this effect also occurs while driving.

Keywords: cognitive load, taste perception, driving, consumption, gender differences

Sitting Behind the Wheel, Makes You Reach For a Meal: The Effect of Driving on Taste Perception and Food Consumption

Over the years our society has developed into a multitasking society. It has become increasingly common to carry out several tasks simultaneously (Kenyon, 2008). The 24- hour economy and the ever-increasing technological advances have made it possible, and desirable, to stay connected every hour of the day (Presser, 1999). Irregular work hours become more common and time is seen as something precious which must be used optimally, leading to multitasking (Presser, 1999; Robinson & Stubberud, 2012). At the same time, people are not successful at dividing attention between multiple tasks, therefore at least one task always suffers from performing several tasks at the same time (Lavie, 2010; Buser & Peter, 2012). Eating is an example of a task one easily gets distracted from (Ogden et al., 2013). Different factors distract one from eating, for instance watching television (Higgs and Woodward, 2009), listening to music (Stroebele & de Castro, 2006) or listening to a story (Bellisle & Dalix, 2001). A sufficient distraction from eating often leads to an increase of food intake, on the condition that there is enough cognitive capacity left to eat (Ogden et al., 2013); distraction also lowers one's taste perception (van der Wal & van Dillen).

A common place for people to get distracted is the car. Driving requires attention to focus on the road to be able to react to unexpected situations (Underwood, Chapman, Brocklehurst, Underwood & Crundall, 2003). However, most people do not only focus on the road but carry out multiple tasks while driving, with eating being one of the biggest distractions (Stutts et al., 2005). So far, the focus of research on distracted driving has mostly been on driving performance, for the obvious implications of road safety. However, eating while driving could reversely also affect consumption behaviour. We propose that due to the limited attention for food consumption more food needs to be consumed to have the same taste experience as when attention is unrestrained. Therefore, the current project will address the influence of driving on taste perception and food consumption.

Taste perception

The taste perception of food depends on multiple variables, for example texture, smell, colour and the actual taste. A small change in these sensory ques can influence how one perceives food (Pereira & van der Bilt, 2016). Several studies found that consuming food while performing another task influences one's food perception. When performing a highly demanding cognitive task the intensity of the perceived taste is weaker (van der Wal & van Dillen, 2013). When eating salty-buttered crackers, participants' perceived intensity of saltiness reduces under a high compared to a low demanding cognitive task (van der Wal & van Dillen, 2013). The cognitive load was manipulated by letting the participants memorize either a seven-digit number (high cognitive load) or a one-digit number (low cognitive load). Likewise, hearing noises while eating could also be considered a high cognitively demanding task. Listening and filtering noise requires attention, but attention is limited because it requires cognitive capacity. When listening to noise requires too much cognitive capacity, there is not enough left to perform other tasks. Therefore, you will perform worse on a task when listening to noise than performing it in silence (Cassidy & MacDonald, 2007). Research indeed shows that noise influences your taste perception; the louder the noise, the weaker your taste perception (Spence & Shanker, 2010).

Food consumption

Like the influence of distraction on food perception, distraction also influences the amount of food consumed. Research shows that eating in front of the television increases food consumption (Blass et al., 2006). This is in line with other research, which shows that under a high cognitive load you will consume more food than under a low cognitive load (Ward & Mann, 2000). Ward and Mann (2000) manipulated a high cognitive load by letting participants memorize slides and execute a reaction time test. Participants in the low cognitive load group only needed to execute the reaction time test. Memorizing slides requires cognitive capacity; combining this with another cognitive demanding task (the reaction time test), resulting in participants needing more cognitive capacity in the high cognitive load group than in the low cognitive load group. Cognitive capacity is limited, the more tasks you perform simultaneously, the more cognitive capacity is needed and the higher the cognitive load of that assignment/task is. After performing a high cognitive demanding task, less cognitive capacity is left for other tasks as Ward and Mann (2000) also found.

Besides multitasking affecting taste perception and therefore food consumption during a task, food consumption *after* a task is also affected. Higgs and Woodard (2009) found that participants, who watched television while eating lunch, consumed more cookies for the remaining hours of the day (see also Mittal, Stevenson, Oaten & Miller, 2011). This suggests that multitasking while eating increases food consumption afterwards.

Food choice

Performing a task while eating and drinking also influences one’s food and drink choices. Research shows that the more often one snacks while watching television, the higher the number of high-calorie snacks one will consume during watching (Gore, Foster, DiLillo, Kirk, & Smith West, 2003). Therefore, eating supper while watching television decreases the consumption of fruit and vegetables and increases the consumption of soft drinks (Liang, Kuhle & Veugelers, 2009). Shiv and Fedorikhin (1999) suggest that when one's cognitive resources are focused on one task, one is less likely to think food decisions through and the likelihood of eating high calorie snacks increases.

The above findings suggest that the more the mind is occupied, for example while watching television, more and unhealthier food will be consumed.

Gender difference in multitasking and driving style

Research suggests men and women differ in their multitasking skills. Although women are often believed to be better at multitasking than men (Pease & Pease, 2003), research shows the contrary. Mäntylä (2013) found that men are better at multitasking than women. Men are more accurate in their tasks while performing multiple tasks simultaneously compared to women. In addition to the differences between men and women in multitasking, research by Holland, Geraghty and Shah (2010) shows that women experience more stress during driving than men. Nevertheless, this difference in stress does not affect the driving skills; research shows that there are no gender differences in driving skills (Miller, Weafer, & Fillmore, 2009). Research does show that stress can lead to a lowered taste perception (Al'absi, Nakajima, Hooker, Wittmers & Cragin, 2012).

Together the above documented gender differences suggest that the capacity costs of multitasking and stress are higher for women than for men, which leads us to pose that women will dedicate more attention to driving and therefore have less cognitive capacity left to focus on other tasks, compared to men. As a consequence, while driving, women should have a lower taste perception compared to men.

Hypotheses

As mentioned earlier, most people multitask while driving, where consuming food is one of the biggest distractions (Stutts et al., 2005). Different research shows that a limited attention to consuming food will reduce your taste perception. The distraction can take different forms, like a high demanding task (van der Wal & van Dillen, 2013), noise (Spence & Shanker, 2010) or watching television (Ogden et al., 2013). This led to the first hypothesis: people who are driving have a lower taste perception in comparison to people sitting in the passenger seat.

Additional research shows that limited attention to consuming food will not only decrease one's taste perception, but also increase food consumption (Blass et al., 2006; Ward & Mann, 2000; Higgs & Woodard, 2009; Mittal, et al., 2011). This led to the second hypothesis:

people will consume more potato chips after driving in comparison to people sitting in the passenger seat.

Finally, research shows that men tend to be better at multitasking than women (Mäntylä, 2013). Also, women tend to experience more stress while driving than men (Holland, Geraghty & Shah, 2010), where more stress can lead to a significant lowered taste perception (Al'absi et al., 2012). This leads us to pose a third hypothesis, as an extension to the first hypothesis: the reduction of taste perception during driving will be stronger for women than for men and this effect will be enhanced by a higher level of stress.

Method

Participants and Design

In total 122 participants participated in the study. Due to incomplete questionnaires a number of 3 participants (all female) were excluded from the study and therefore the data of 119 participants, 88 females and 31 males, has been used. The recruitment of participants took place in the common areas of the University of Leiden. Participants could only participate if they had a driving license or were taking driving lessons. Participants were rewarded with 1 SONA credit or €3,50 for their participation. Participants were equally and randomly divided over two conditions, the experimental condition (containing 44 females and 16 males) and the control condition (containing 44 females and 15 males). Participants were randomised over the two conditions by putting all the uneven participant numbers in the experimental condition. Before the participants started with the experiment, they had to sign an informed consent form. The main dependent measures were the taste perception of the potato chips and the amount of potato chips consumed.

This study has been approved by the ethical committee of the University of Leiden.

Materials

Driving simulator. Participants in the experimental condition had to drive in a driving simulation. In a driving simulator the main features of real driving are created, without the actual risks of real driving (Contardi, Pizza, Sancisi, Mondini & Cirignotta, 2004). The simulator consisted of a car chair, pedals, steering wheel and a 32-inch television and represented an automatic car (Figure 1). For the simulator a PlayStation 3 was used, with which participants had to drive 3 rounds on the Twin Ring Motegi course of the game Gran Turismo® 6. The driving skills and the lap time of the participants were not recorded. Once the participants finished driving, the researcher noted how many rounds the participants actually drove. In the control condition participants were seated in the same driving set-up as the experimental condition and were shown a 3-minute pre-recorded video of the Twin Ring Motegi course of the game Gran Turismo® 6. In both conditions the participants were not exposed to sounds, the reason being that research showed that sound also influences your taste perception (Spence & Shanker, 2010).

Figure 1. Illustration of the driving simulation.

Taste perception. Natural ribbed potato chips was used for the study. Natural ribbed potato chips was chosen because of the exclusive salty taste. There is 1.3-gram salt in every 100 gram of natural ribbed potato chips. Plus, these potato chips are gluten free, resulting in the inclusion of gluten intolerant participants in the study. At the beginning of each session, a bowl containing 10 grams of potato chips was put next to the participants.

To measure participants' perceived taste of the potato chips, the participants had to answer six questions. The questionnaire was given after the driving simulation and consisted of the following questions 'How salty did you find the chips?' , 'How crunchy did you find the chips?', 'How sweet did you find the chips?', 'How sour did you find the chips?', 'What did you think about the quality of the chips?' and 'How tasty did you find the chips?' on a scale from 1 (not at all) to 7 (very). The questions about sweetness and sourness were added to mask the purpose of the study. The first question about saltiness indicates the taste intensity of the potato chips. The questions about crunchiness, quality and tastiness indicate the quality of the potato chips.

Stress. The participants had to answer four questions to measure their stress level during the driving simulation. The questionnaire was given after the questions about taste and consisted of the following questions: ‘How relaxed were you during the driving simulation?’, ‘How much did you have the feeling that you were in control during the driving simulation?’, ‘How rushed did you feel during the driving simulation?’ and ‘How nervous were you during the driving simulation?’. The questions ranged on a scale from 1 (not at all) to 7 (very). For all the stress items to indicate the same, that a higher score indicates a higher level of stress, the scores on how relaxed and in control participants felt were reverse coded to match the responses on the other items. This way, for all items regarding the indication of stress, a higher score indicates a higher level of stress.

Food consumption. After answering the second part of the questionnaire, participants were offered a bowl containing 15 grams of potato chips while waiting for the researcher to return. The potato chips were weighed on a small kitchen scale. The researcher noted how much grams of potato chips the participants had consumed during the waiting. This was used to analyse the relation between driving condition and food consumption. Other researchers conducting the same experiment focused on the influence of restrained eating and driving experience on this relationship; they were not included in this research.

Procedure

The researcher prepared the equipment needed for the study before starting the experiment. The researcher measured two bowls of potato chips, started the questionnaire and set-up the experimental or control condition in the driving simulator. Once the participants agreed to participate in the study and fitted the requirements, they were asked to fill in an informed consent. The participants were told the study was about multitasking while driving. After participants gave their informed consent, the participants were asked to take place in the lab and fill in the first part of the questionnaire. This first part of the questionnaire contained questions about restrained eating and their driving experience. Thereafter, participants in the experimental condition took place in the driving simulator. Participants in the experimental condition were told they had to drive three rounds, that time does not matter and that they had to consume all the potato chips during driving (10 grams of potato chips). After three rounds, the participants had to call the researcher to let them know they were finished, since the simulation did not stop automatically. The participants in the control condition were asked to take place in the passenger seat. They were told they were in the passenger seat, they did not need to drive and that during the ride they had to consume all the potato chips (10 grams of potato chips). Once the simulation was finished, they were asked to open the door to let the researcher know that the simulation ended.

The rest of the instructions were the same in both conditions. After the participants completed the simulation, they were asked to complete the second part of the questionnaire. The second part of the questionnaire contained questions about the taste of the potato chips and about one's stress level during the experiment. The participants got the specific instructions to stay seated after finishing the questionnaire and opening the door to let the researcher know when they had finished. Once the participants finished the second part of the questionnaire, the researcher excused himself stating that he still needed to collect the final debriefing form. The researcher placed a bowl containing 15 grams of potato chips in front of the participants and mentioned that they were free to eat some potato chips while waiting, since these were the leftovers from the earlier taste test. The researcher returned to the participants after waiting 3 minutes. The researcher gave the final debriefing form and had the participants sign for their compensation. In the final debriefing the participant could read the true purpose of the study, that we were interested in taste perception and food consumption instead of their multitasking skills. After the participants left, the bowl of potato chips was weighed to see how much potato chips was consumed. The duration of the study was approximately 20 minutes.

Statistical analyses

To test the three hypotheses SPSS version 24 was used. The first hypothesis: people who are driving have a lower taste perception in comparison to people sitting in the passenger seat was tested through an MANOVA. The driving condition being the independent variable and the perceived saltiness, crunchiness, quality and tastiness of the potato chips the dependent variables.

The second hypothesis: people will consume more potato chips after driving in comparison to people sitting in the passenger seat was tested through an independent sample t-test, with the driving condition as the independent variable and the amount of chips consumed as the dependent variable.

The last hypothesis, as an addition to the first hypothesis: the reduction of taste perception during driving will be stronger for women than for men and this effect will be enhanced by a higher level of stress was tested through several analyses. First an ANOVA was used to test main and interaction effects of gender and driving condition on saltiness, where gender and driving condition were the independent variables and the perceived saltiness of the potato chips was the dependent variable. Secondly an ANOVA was used to test the main and interaction effects of gender and driving condition on stress, where gender and driving condition were the independent variables and stress was the dependent variable. If both analyses would reveal interactions between gender and condition, it was next analysed if stress could explain the gender-dependent distraction effects of driving on taste perception.

For all tests $\alpha < .05$ is considered the threshold for a significant result.

Results

Lowered taste perception during driving

A multivariate analysis of variance (MANOVA) with driving condition as the independent variable, and the perceived saltiness, crunchiness, quality and tastiness as the dependent variables was conducted. Means and standard deviations are depicted in Table 1.

Using Wilks's Lambda, there was a non-significant multivariate effect of driving condition on the perceived saltiness, crunchiness, quality and taste, $\Lambda = .96$, $F(4,114) = 1.23$, $p = .301$. However, univariate tests on the outcome variable revealed that there was an effect of driving condition on perceived saltiness, $F(1,117) = 2.81$, $p = .096$, partial $\eta^2 = .02$. Because this study replicated earlier findings and we had specific expectations about the directionality of effects, the *p*-value can be divided by two, which would suggest that the driving condition has a significant effect on the perceived saltiness of potato chips, $F(1,117) = 2.81$, $p = .048$, partial $\eta^2 = .02$. Pairwise comparisons showed that in the driving condition the perceived intensity of potato chips was lower ($M = 4.40$, SD = 1.21) than in the non-driving condition ($M = 4.76$, SD 1.15; Figure 1). Univariate tests did not show an effect of driving condition on crunchiness, quality and tastiness (*p*s > .353 and *F*s < .87; Table 1), whether this was tested two-tailed or one-tailed.

Table 1. *Descriptives of the Various Taste Ratings as a Function of Condition.*

		Mean	*St. Dev.*
Saltiness	Driving	4.40	1.21
	Non-driving	4.76	1.15
Crunchiness	Driving	5.15	1.20
	Non-driving	5.22	1.12
Quality	Driving	4.88	1.15
	Non-driving	4.71	1.39
Tastiness	Driving	5.20	1.35
	Non-driving	4.97	1.39

Driving increases consumption

An independent t-test was conducted to compare the number of grams of potato chips consumed (dependent variable) after driving versus non-driving (independent). The results showed that after driving a car participants consumed significantly more potato chips (M = 6.77, SD = 6.12) than after non-driving (M = 4.29, SD = 4.83; $t(117) = 2.45$, $p = .016$, Cohen's $d = .45$; see Figure 2).

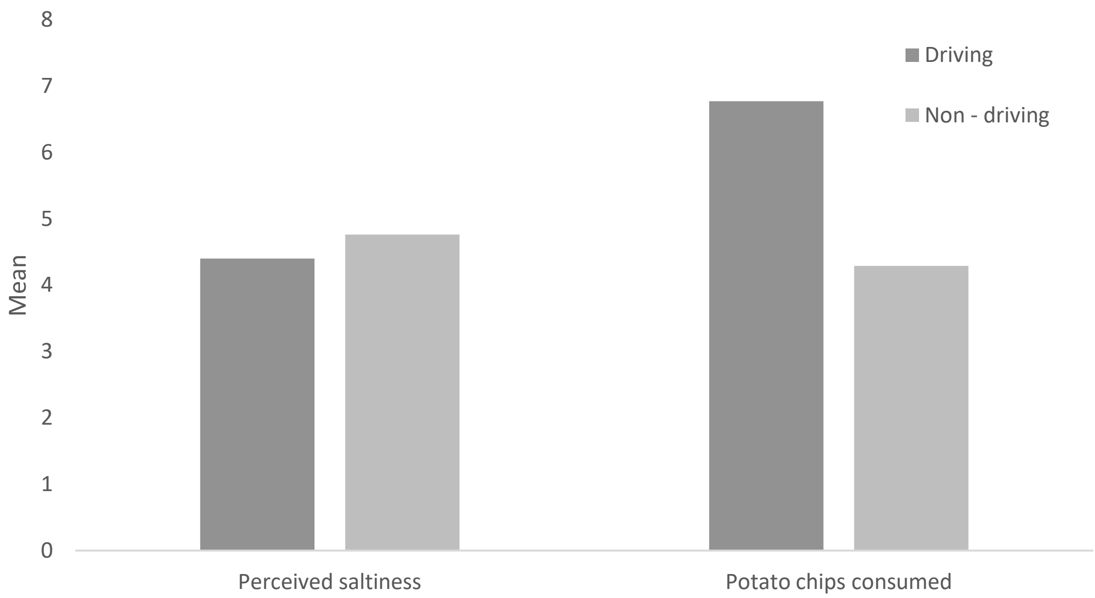

Figure 2. Means and standard errors of perceived saltiness and the amount of potato chips consumed. Perceived saltiness was measured on a scale ranging from 1-7, the total amount potato chips consumed was measured in grams ranging from 0 – 15.

Gender difference in taste perception

In addition to the first hypothesis, an analysis of variance (ANOVA) with gender and driving condition as the independent variables, and the perceived saltiness as the dependent variable was conducted. In the first hypothesis there was only an effect found of driving condition on saltiness, therefore only saltiness is taken into account in this analysis. The experimental condition consisted of 44 females and 16 males, the control condition of 44 females and 15 males. When including gender, the results showed a non-significant main effect of driving condition on saltiness, $F(1, 115) = 1.29$, $p = .259$. Furthermore, the results showed a non-significant main effect of gender on saltiness, $F(1, 115) = .29$, $p = .591$. At last, the results showed a non-significant interaction effect of driving condition and gender on saltiness, $F(1, 115) = .49$, $p = .486$. This suggests that the taste perception of men and women does not depend on the driving condition that they are in.

Additionally, the effect of gender and driving condition on stress has been looked at. The reliability of the four stress questions indicating stress during the driving simulator (nervous, rushed, relaxed and control) was low ($\alpha = .59$), but after removing the variable 'control' the reliability increased ($\alpha = .79$). Therefore, the stress indicator consisted of the items rushed, relaxed and nervous.

An analysis of variance (ANOVA) with gender and driving condition as the independent variable and stress as the dependent variable was conducted. The results showed a significant main effect of driving condition on stress, $F(1, 115) = 20,47$, $p < .001$, partial $\eta^2 = .15$, with participants experiencing more stress in the driving condition ($M = 11.70$, SD = 3.07) than in the non-driving condition ($M = 9.00$, SD = 3.58). The results also showed a significant main effect of gender on stress, $F(1, 115) = 18.03$, $p < .001$, partial $\eta^2 = .14$, where females experienced more stress ($M = 11.07$, SD = 3.41) than men ($M = 8.35$, SD = 3.33). The results showed a non-significant interaction effect between driving condition and gender on stress, $F(1, 115) = .48$, $p = .491$. This suggests that overall women experienced more stress than men, but this was not influenced further by the driving condition.

Taken both non-significant interaction effects together it was expected that there would not be a moderation effect of stress on the relationship between gender and driving on taste perception. Therefore, any gender-specific influences of stress on taste perception were not further examined.

Discussion

In this study the effect of driving on taste perception and food consumption was researched. Participants tasted natural ribbed potato chips while driving three rounds on the driving simulator or sitting in the passenger seat. Afterwards participants had to rate the potato chips and the participants got the opportunity to consume more potato chips. We found that participants rated the saltiness of the potato chips as less intense while driving than sitting in the passenger seat. Also, participants consumed significantly more potato chips after driving than after sitting in the passenger seat. We did not find any gender differences in the reduction of the taste perception of potato chips. However, we found that women experience more stress during the study than men, regardless of the driving condition.

The results showed that driving has an effect on the perception of saltiness, but not on the crunchiness, quality and the tastiness of potato chips. This is consistent with previous research, in which the perceived saltiness also decreases after a high cognitive task (van der Wal & van Dillen, 2013). Previous research of Rolls and Grabenhorst (2008) suggests that taste intensity and taste perception are two separate concepts. Rolls and Grabenhorst (2008) found that the focus on the intensity of food and the pleasantness of food activates different areas in the brain. These findings show that there is a distinction between the affective value and psychical properties. The affective value is related to the pleasantness and taste perception of your food, where psychical properties are related to the intensity of the flavours (Grabenhorst & Rolls, 2008). This could be an explanation as to why only an effect was found on saltiness and not on crunchiness, quality and taste.

Furthermore, the results showed that participants consumed more potato chips after driving than after sitting in the passenger seat. This is consistent with the idea that driving serves as a high cognitive task and reduces one's taste perception. To experience the same taste one has to consume additional food for the same taste experience. These findings are consistent with earlier work showing that under a high cognitive load there is a reduction of the intensity of taste and an increase in the consumption of the tested substances (van der Wal & van Dillen, 2013).

At last, in contrast to what was hypothesised, the results did not show an interaction effect of gender and driving condition on taste perception. We expected that men would have a significantly higher perception of taste intensity than women during driving. It was found that men are better at combining the two tasks of driving and eating (Mäntylä, 2013) and according to Holland, Geraghty and Shah (2010) women experience more stress and stress leads to a lowered taste perception (Al'absi et al., 2012). Research of Hyde (2005), however, suggests that men and women are not that different as we allegedly thought. Hyde (2005) did a meta-analyses on the differences between men and women of studies that included cognitive, social and personality variables. From these studies on gender differences, 78% of the effects sizes were small or close to zero. This leads us to think that the differences between men and women are not as big as initially thought. Taste perception is not one of the dimensions that is analysed by Hyde (2005). This could be because the majority of reported studies about distracted consumption is only focussed on women or did not report any gender differences. Mittal, Stevenson, Oaten and Miller (2011) for example mentioned that they chose to only include women in their study, because men tend to eat as much as they can. It makes it difficult to study differences between men and women on taste perception if most of the studies only include women. More research is needed to be able to state that there are not any effects of gender and driving condition on perceived taste perception.

Limitations and future directions

This study has a few limitations which might have influenced the results. For future research it is interesting to take these matters into account.

In this study more women participated than men (88 versus 31). Due to the small size of the male subgroups the power of the analysis to test whether men and women differ in their taste perception while driving is small. This influences the reliability of this research. For future research on gender differences it is preferable that both groups (men and women) are of equal size and are sufficiently powered.

Moreover, in this study we studied the effect of driving on taste perception and consumption of food, but we do not know what the participants ate before they participated, how much they ate and how hungry they were. Research showed that people consume more food when they are deprived in comparison to when they just consumed food (Herman, Polivy, Lank, & Heatherton, 1987). If participants just ate before they participated in the experiment, it could have influenced the data. Since the participants were randomly divided between both conditions and both conditions took place during the day, this should have a minimum influence on the results. However, we cannot rule out that the distribution was unbalanced. Thus, for future research it is advised to include questions about hunger.

Furthermore, as mentioned earlier, studies showed that the chances of eating unhealthy food increase when being distracted(in this case watching television; Liang, Kuhle & Veugelers, 2009; Shiv & Fedorikhin, 1999). We have taken this into account in our research by choosing unhealthy food as our consumption product, namely potato chips. Still, as we did not include a healthy control product, we cannot test the difference in consumption between the two groups. It is desirable to have a control group who would have gotten the opportunity to eat healthy food, for example grapes, instead of consuming potato chips. We did not have enough participants to divide the study into a potato chips and grapes group. For future research it is preferable to have a potato chips and a grapes (or other fruit) group and test if participants indeed consume more unhealthy food.

Lastly, it would be interesting to ask participants how they would rate the second bowl of potato chips. After the experiment, multiple participants asked if the first and second bowl contained different brands of potato chips, because they thought the potato chips of the two bowls tasted different. Hypothesised is that this difference in taste perception is due to the reduction of perceived intensity of the potato chips under a high cognitive load. Further research needs to be done to test this hypothesis.

Conclusion

The current findings show that the perceived intensity of food is reduced while driving and that the consumption of food increases after driving. This is an additional confirmation that high cognitive load reduces taste intensity and increases food consumption, with the new extension that this effect also occurs while driving. From the age of 18 people start driving and possible eat while driving. The current findings suggest that even when eating does not affect driving, driving may still affect eating. This may be harmless, but, be aware of what you do while driving, because this might influence how much food you will consume later.

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