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As a manuscript

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Neurocognitive mechanisms of social influence on decision-making through narratives

Dissertation Summary

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This dissertation was prepared at the International Laboratory of Social Neurobiology, Institute of Cognitive Neuroscience, National Research University Higher School of Economics. The Ph.D. thesis consists of three studies that correspond to the following articles published in first-tier journals[1]:

1. Efimov, K., **Ntoumanis, I.**, Kuskova, O., Kadieva, D., Panidi, K., Kosonogov, V., Kazanina, N., Shestakova, A., Klucharev, V., & Jääskeläinen, I. P. (2022). Impact of induced moods, sensation seeking, and emotional contagion on economic decisions under risk. Frontiers in psychology, 12, 796016. https://doi.org/10.3389/fpsyg.2021.796016

2. **Ntoumanis, I.**, Panidi, K., Grebenschikova, Y., Shestakova, A. N., Kosonogov, V., Jääskeläinen, I. P., Kadieva, D., Baran, S., & Klucharev, V. (2022). "Expert persuasion" can decrease willingness to pay for sugar-containing food. Frontiers in nutrition, 9:926875. https://doi.org/10.3389/fnut.2022.926875

3. **Ntoumanis, I.**, Davydova, A., Sheronova, J., Kosonogov, V., Shestakova, A., Panidi, K., Jääskeläinen, I.P., & Klucharev, V. (2023). Neural mechanisms of expert persuasion on willingness to pay for sugar. Frontiers in Behavioral Neuroscience, 17:1147140. https://doi.org/10.3389/fnbeh.2023.1147140

The results were also presented at the following conferences:

1. 2nd International conference on social neuroscience in ecologically valid conditions (Oct 2022, virtual). Speaker. How expert persuasion can decrease the willingness to pay for sugar-containing food. **Ntoumanis, I.** [link]

[1] First-tier publications include papers indexed in the Web of Science (Q1 or Q2) or Scopus (Q1 or Q2) databases, as well as peer- reviewed collections of conferences that appear in CORE rankings (ranks A and A*).

1. Introduction

1.1. Research problem

Our everyday life is full of decisions. What to cook for dinner, whether or not to take a financial risk, whether or not to do a PhD in Cognitive Science - with a little bit of reflection, it is easy to realize that this list grows long. Importantly, the majority of our decisions are influenced by a variety of factors. In fact, it is rather hard to imagine an example of a decision that is not influenced by cognitive biases, past experiences, genetics, social norms or emotions. Narratives can apply most of these factors at once, making them a particularly effective means of social influence (Shiller, 2017). Thus, it is important to understand how narratives influence decision-making at the behavioral level, but also, how compliance or defiance with narratives is represented in the human brain.

Emotions have been characterized in the past as "agents of social influence" (van Kleef, 2014). They have been shown to regulate neural circuits associated with proactive or passive behavior, and as a result, influence risk assessment and decision-making under risk (Engelmann and Hare, 2018). However, the literature offers inconsistent findings about whether positive or negative emotions increase or decrease risk-taking (Schulreich et al., 2014; Stanton et al., 2014; Raghunathan and Pham, 1999; Yuen and Lee, 2003). One reason for this heterogeneity in previously reported results may be the fact that individual differences are often neglected. Among the goals of the current investigation is to explore how emotions modulate decision-making under risk, taking into consideration the personality of individuals. I explored this in the domain of financial decision-making, since monetary decision-making tasks offer a straightforward way to measure risk (i.e., in monetary units).

In addition to emotions, social norms are another category of social influence that can shape decision-making (e.g., McDonald and Crandall, 2015). Social norms can be defined as "implicit codes of conduct that provide a guide to appropriate action" (Higgs, 2015). The role of social norms in decision-making is present in many disciplines (Lipari,

2018) and it has extensively been studied in the domain of food choices (e.g., Higgs, 2015; Robinson et al., 2013). The findings of these studies suggest that norms may affect food choices by altering self-perceptions of foods (Higgs, 2015). In my research, I aimed to alter self-perceptions of a particular unhealthy food ingredient (i.e., sugar) through the opinion of an expert and to investigate whether and how this intervention can modulate food decision-making.

Finally, apart from exploring the sole behavioral effect of emotions, personality traits and social norms on decision-making, I also conducted an electroencephalography (EEG) study to examine whether neural responses to a means of social influence can predict the efficacy of persuasion. Neuroeconomics, i.e., the application of neuroscience tools and methods to study decision-making, is a growing scientific field, due to the vastness of its applications. Analyzing one's brain activity during exposure to a social influence prior to decision-making can help us to distinguish between successful and unsuccessful social influences, and potentially apply the former in order to improve society. Hence, following my investigation on how social norms can shape unhealthy food decision-making, I investigated whether neural responses to a social norm message can predict whether this message will have a behavioral effect or not.

1.2. Dissertation objectives

1. To investigate how narratives can affect decision-making by inducing emotions and how this effect depends on personality traits;
2. To investigate how narratives can affect decision-making by conveying a social norm;
3. To elucidate neurophysiological markers of effective social influence by narratives;
4. To devise a novel methodological approach for predicting the efficacy of a social influence, based on brain responses to the narrative that conveys it;

1.3. Research methodology

Overall, 180 participants were included in the three investigations. For each of the three studies, participants signed informed consent before taking part in the experiments. All experiments were approved by the Institutional Review Board of the Higher School of Economics.

Studies 1 and 2 were behavioral, employing a within-subjects and a between-subjects experimental design, respectively. For the data analysis, we used repeated-measures or mixed ANOVA, one- or two-samples t-tests and linear mixed-effects models with subject-level random effects. The data and code used in both studies have been made publicly available for reproducibility (Study 1: https://osf.io/7nxce/, Study 2: https://osf.io/894mk/).

Study 3 deployed electroencephalography (EEG) to measure electrical activity in the brain. Subjects were fitted with a standard, 64-electrode cap following the international 10-10 system, and the EEG was recorded at a sampling frequency of 500Hz. Signal processing and artifact correction was performed in MNE Python (Gramfort et al., 2013). Specifically, the EEG data were down-sampled at 250Hz, high-pass filtered at 0.5Hz and notch-filtered at 50Hz and 100Hz, in order to remove drift and power line noise, respectively. Afterward, noisy channels were detected by visual inspection and the samples of these channels were interpolated based on the signals of the good sensors around them (Ki et al., 2016). Eye-movement artifacts were removed by Independent Component Analysis (ICA) using the infomax algorithm (Bell and Sejnowski, 1995). Samples exceeding 3 SDs of the mean of their respective channel were replaced with 0, and so were the samples 40 ms around such outliers (i.e., before and after; Cohen et al., 2016; Ntoumanis et al., 2023).

A key role in my methodology played the neural similarity of EEG activity among participants, also known as intersubject correlation (ISC). This neural index was hypothesized, and later confirmed, to be a marker of effective expert persuasion. ISC was

estimated via a correlated components analysis (CorrCA; Dmochowski et al., 2012; Cohen and Parra, 2016). In general, the goal of this analysis is to find linear combinations of electrodes that are maximally correlated between subjects. Each such linear combination projects the data from an (N subjects × D electrodes × T time points) space to an (N × T) space, where the intersubject correlation is calculated. Let R_b denote the between-subjects covariance and R_w denote the within-subjects covariance. Then, the component projections that achieve the maximal ISC are the eigenvectors of the matrix ${R_w}^{-1} \cdot R_b$ with the strongest eigenvalues (Parra et al., 2019). The ratio of the between-subjects covariance and the within-subjects covariance of the projected data is considered the ISC. The ISC analysis was performed in Matlab.

In Study 3, I also conducted a multivariate pattern analysis (MVPA) of the EEG responses to the expert's narrative. MVPA is typically used to decode the difference between conditions or groups of subjects, based on the spatiotemporal patterns of brain activity. In our study, we used it to decode the difference between those participants who were highly influenced by the expert and those who were not. Specifically, a machine learning logistic regression classification model was trained to predict, based on distributed patterns of EEG activity evoked by the healthy eating call, whether or not a participant was highly influenced by the narrative. This was done repeatedly in time windows of 1 second length. The features of this classifier were the mean EEG signal of each channel within the corresponding time window. To avoid overfitting, a 5-fold cross-validation was performed and the classification accuracy for each time window was calculated as the average percentage of correct guesses across all the cross-validation runs in the corresponding time window. Statistical testing was performed by comparing the classification accuracy to an empirical chance distribution, and a cluster-based correction for multiple comparisons was employed. The MVPA analysis was performed in Python, using the Scikit learn package (Pedregosa et al., 2011).

1.4. Scientific novelty

1.4.1. Theoretical novelty

Earlier research has provided inconsistent results in terms of how emotions influence decision-making under risk. This inconsistency likely lies in the fact that previous studies have not accounted for the intersubject variability, e.g., related to personality differences. In Study I, we overcame this challenge by investigating how certain personality traits moderate the effect of emotions on decision-making. In Studies II and III, we also examined the potential moderating role that certain personality traits may have on the observed main effects. We therefore strongly recommend adopting this approach to other scientists in the field of decision-making.

Another major novelty introduced by the research summarized in this dissertation constitutes the utilization of a healthy eating call by an expert (i.e., expert persuasion) as an effective nudge intervention against sugar consumption. Previous studies investigating interventions against sugar consumption have so far been limited to visibility enhancements and nutrition labeling. However, these types of interventions are, in general, half as effective as healthy eating calls (Cadario and Chandon, 2020). In fact, not only we used a more promising intervention (i.e., a healthy eating call), but we even communicated it through an expert. The idea behind this was to maximize the persuasion, because communicators with high expertise are particularly persuasive (e.g., Deutsch and Gerald, 1955). Given that Studies II and III highlight the effectiveness and robustness of this intervention, this novelty may pave the way for an avenue of innovative marketing strategies to support individuals in their food choices related to sugar.

1.4.2. Methodological novelty

Although the EEG responses to nudge interventions have been studied before (e.g., Schubert et al., 2021), these responses have rarely been used to predict the nudges'

effectiveness. Notwithstanding its practical significance, a “pathognomonic” link between neuroimaging and decision-making is still scarce in research related to unhealthy food choices. In this dissertation, I account for this link. Specifically, I present two distinct neurophysiological indices that can be used to predict the effectiveness of healthy eating calls.

The first index is the neural similarity of EEG responses to the healthy eating call, or ISC. Although ISC has been proved to be a promising tool in neuroforecasting for movie and music popularity (Christoforou et al., 2017; Leeuwis et al., 2021), my Study III is the first to apply it in neuroforecasting of healthy eating advertisements. Given that this novel application was successful (i.e., it provided significant results), it is likely to inspire future neuromarketing research.

A second aspect of methodological novelty is the use of MVPA to predict the efficacy of expert persuasion. I discovered that spatiotemporal patterns of EEG responses to the healthy eating call contain predictive information in terms of whether a persuasion was successful or not. Indeed, such a multivariate approach is unprecedented in the neuromarketing research that employs such ecologically valid stimuli as videos and narratives.

1.5. Theoretical and practical significance

The results of the research presented in this dissertation, especially those presented in Studies II and III, hold the potential to make concrete beneficial contributions to society.

Inside a grocery store, consumers are often surrounded by high-calorie, sugary food which is just irresistible. Such an obesogenic environment makes it difficult for consumers to maintain their healthy eating goals. Public health measures have failed to provide such support, since obesity rates are rising rapidly with far-reaching health consequences (Dixon, 2010; Kelly et al., 2008). Although sugar is a key cause of obesity (Yu et al., 2022), there is limited research exploring what can influence individuals to consume less sugar. Our research introduces a novel way to influence individuals against sugar-

consumption: a healthy eating call by an expert. This or a similar healthy eating call could easily be implemented in television advertisements to assist individuals in reducing sugar consumption.

Importantly, we offer a tool to design and assess such healthy eating advertisements before they are released to the public. In Study III, we demonstrate that when the brains of different people respond similarly to a healthy eating call, then this healthy eating call is likely to be successful in influencing its audience. In fact, the higher the neural similarity it provokes, the more successful it will be. Hence, this tool can be used to directly compare multiple healthy eating advertisements and suggest which of them is the most promising candidate.

1.6. Key ideas to be defended

1. The effect of mood on decision-making under risk depends on personality traits of individuals;
2. A healthy eating call by an expert is an effective way to influence individuals against sugar-consumption;
3. The intersubject correlation of EEG responses to a healthy eating call can predict its efficacy;
4. Spatiotemporal patterns of EEG signals while listening to a healthy eating call contain predictive information about its efficacy;

1.7. Author contribution

Study I: Stimulus presentation code, data analysis, interpretation of the results, manuscript draft and revision.

Study II: Study conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing—original draft, writing—review and editing, visualization, and project administration.

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2. Summary of the dissertation

The word *narrative* is often synonymous with story, but a modern definition of the word also refers to video clips, jokes and even theories (Shiller, 2017). All these forms of narratives can be considered social influences that widely shape decision-making (Shiller, 2017; Jääskeläinen et al., 2020). In the research summarized in this dissertation, I investigated how narratives can shape decision-making by inducing emotions or by conveying a social norm. I also explored how individuals with different personalities might be differently influenced by such narrative content.

2.1. Study I. Impact of induced moods, sensation seeking, and emotional contagion on economic decisions under risk

In addition to probabilities of monetary gains and losses, emotions and personality traits influence financial decision-making (Kahneman and Tversky, 1979; Kusev et al., 2017). However, how exactly emotions affect decision-making under risk is still under question. For example, some studies suggest that sadness increases risk-taking (Raghunathan and Pham, 1999), whereas others suggest that sadness decreases risk-taking (Yuen and Lee, 2003). A possible explanation why earlier research has provided

inconsistent results on this topic is that they did not account for the heterogeneity of individuals. For example, personality traits, such as sensation seeking and emotional contagion, might moderate the effect of mood on decision-making. In the present study, we used emotional video clips to induce joy, sadness and neutral emotions to 88 participants (60 females, aged 16-45 years; mean 22.7 years) and then, we investigated the impact of these emotions on risk-taking behavior in a financial decision-making task. We did so by also accounting for participants' sensation seeking and emotional contagion personality traits, which were measured based on participants' responses to the corresponding questionnaires (Zuckerman, 1979; Doherty, 1997).

Participants watched four emotional video clips of the same condition (i.e., joyful, sad, or neutral). Once they watched the video clips of each condition, they performed 48 trials of the decision-making task, where at each trial, they had to choose between a safe and a risky option. This procedure was repeated three times, one for each emotional condition, the order of which was randomized.

Participants' self-reported valence ratings after watching each video clip showed that the mood induction was successful (i.e., joyful videos increased individuals' valence, sad videos decreased it, and neutral videos did not affect it). However, we did not observe a significant main effect of induced moods on decision-making. Sad mood only resulted in a slight non-significant trend of risk aversion compared to a neutral mood. However, when limiting our analysis to participants with low emotional contagion score, we found that the sad mood provoked a statistically significant risk-aversion compared to a neutral and a joyful mood (Figure 1).

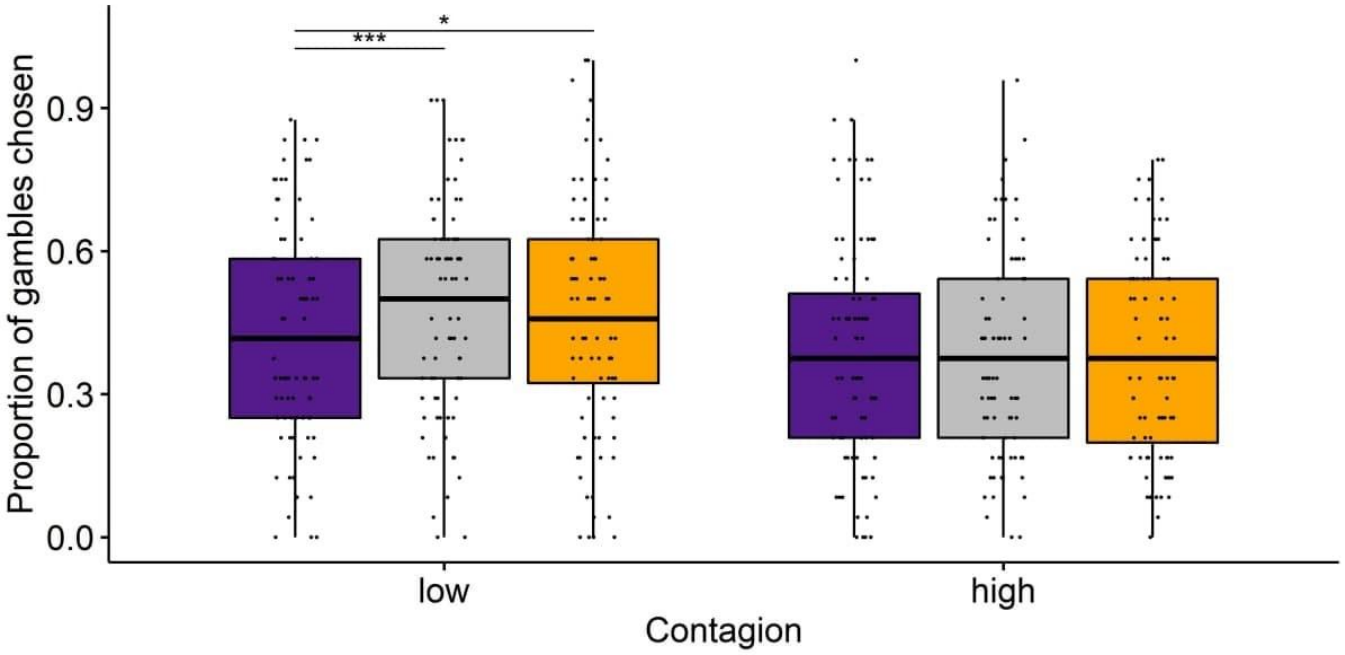

Figure 1 *| The effect of mood induction on risk taking (proportion of gambles chosen), separately for individuals with low and high emotional contagion. Dots represent individual subjects. Purple represents sad mood, gray represents neutral mood, and yellow represents joyful mood. *p < 0.05, ***p < 0.001.*

Overall, our results demonstrate that sadness-inducing video clips can influence decision-making under risk, in a pronounced way in individuals with low levels of emotional contagion. A possible interpretation of this finding is that the emotional contagion trait influences how one processes emotional naturalistic stimuli, which in turn, influences how these stimuli alter one's behavior. Moreover, our study highlights the importance of including measures of personality traits in future studies of induced mood states effects on decision-making. Finally, our findings suggest that emotional narratives may not necessarily have a population-wide impact on decision-making under risk, but instead, their impact may vary significantly between individuals.

2.2. Study II. Expert persuasion can decrease willingness to pay for sugar-containing food

Inside a grocery store, we are surrounded by unhealthy, sugary food, which is just irresistible. Such obesogenic environments make it difficult for the consumers to maintain their healthy eating goals. Thus, consumer researchers have started to investigate which nudge interventions can influence individuals against sugar consumption. However, these interventions have, so far, been limited to visibility enhancements (e.g., placing sugar-free food at eye level counts) and nutritional labeling (e.g., providing information about the ingredients), with the results being inconsistent (e.g., Shin and Kim, 2022; Bialkova et al., 2016; Thiene et al., 2018). Critically, visibility enhancements and labels are, in general, half as effective as healthy eating calls (Cadario and Chandon, 2020). Thus, the goal of our study was to examine whether a healthy eating call by an expert can effectively decrease the willingness to pay for sugar-containing food products.

Forty-six participants performed two blocks of a bidding task, in which they had to bid on sweets labeled either as “sugar- free” or as “sugar-containing”. In-between the two blocks, half of the participants listened to an audio narrative by a dietary specialist emphasizing the health risks of sugar consumption (experimental group), whereas the remaining participants listened to a control narrative irrelevant to food choices (control group). Each block of the bidding task consisted of 60 trials: 30 products labeled as sugar-containing, and 30 products labeled as sugar-free. The Becker-DeGroot-Marschak auction was used in order to measure individual preferences and each participant’s exact WTP for every product (Plassman et al., 2007; Becker et al., 1964).

To test our hypothesis, we conducted a two-way mixed ANOVA with Delta of WTP (i.e., the WTP for each product in the second block subtracted by the WTP for the same product in the first block) as a dependent variable, Condition (two levels: sugar-containing, sugar-free) as a within-subjects factor and Group (two levels: experimental, control) as between-subjects factor. The results showed a significant interaction of Group and Condition on the Delta of WTP ($p = 0.028$). Post-hoc tests showed that the Delta of WTP

for sugar-containing products was significantly lower for the experimental group as compared to the control group (p = 0.0003), but the delta of WTP for sugar-free products was not statistically different between the two groups (p = 0.578). Figure 2 illustrates these results.

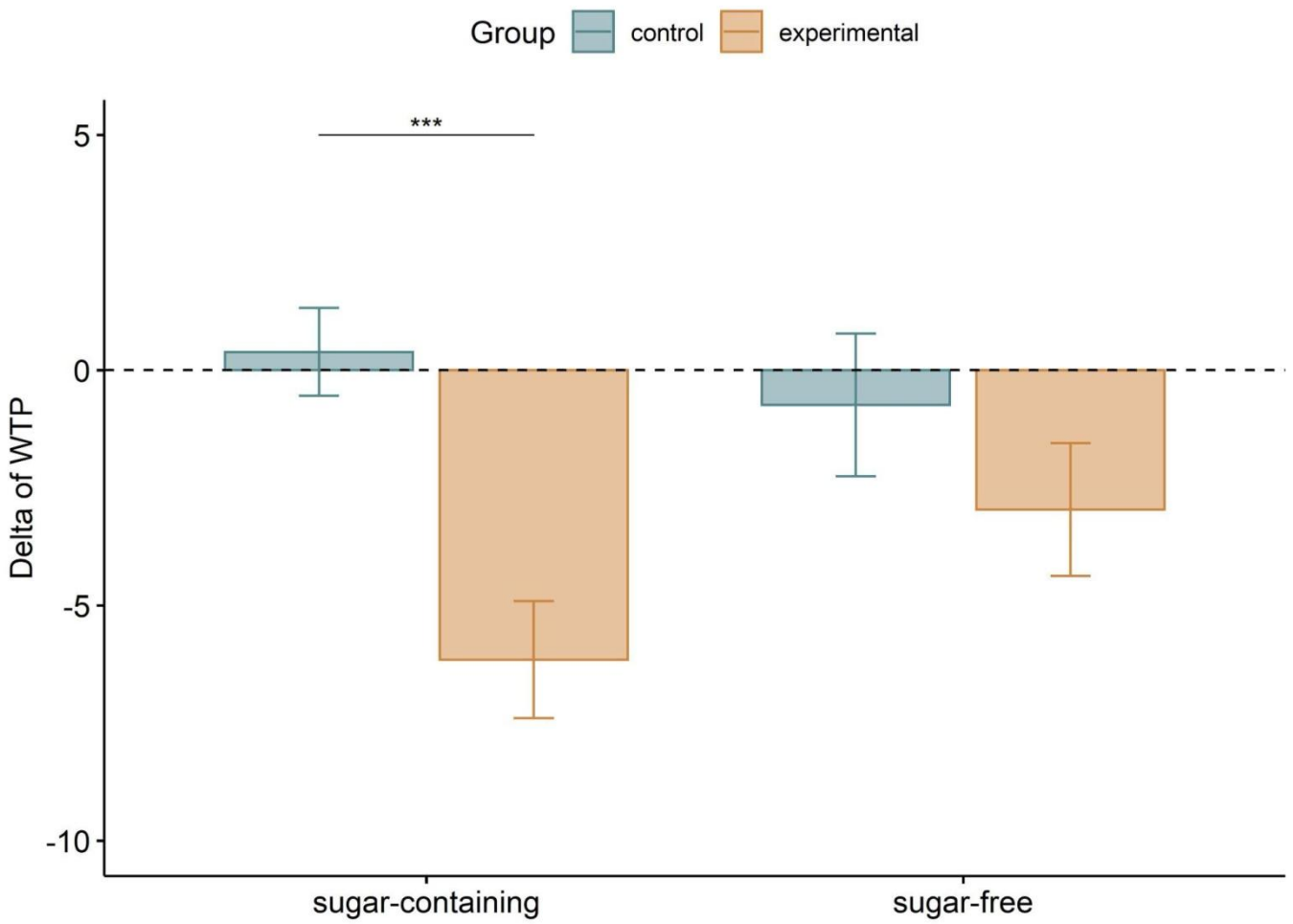

Figure 2 *| Delta of WTP by group and condition. Error bars denote mean ± standard error (SEM), after averaging the data within each participant. The delta of WTP for sugar-containing products was significantly lower for the experimental group as compared to the control group, but the delta of WTP for sugar-free products was not statistically different between the two groups.*

Moreover, in order to speculate whether the effect of the healthy eating call was due to certain emotions it induced, we recruited an independent cohort of 49 participants, who

rated their emotions after listening to the experimental or the control narrative. This independent analysis revealed that the experimental narrative induced higher levels of fear and sadness relative to the control narrative. While asking the participants of the main study to rate their emotions after listening to the narratives would better address the role of emotions in the observed effects, our findings suggest that the pronounced fear and sadness the expert's narrative induced may have contributed to the reduction of WTP for sugar-containing food. This speculation is supported by a previous field experiment, where graphic warning labels (e.g., tooth decay photos) decreased the share of sugar-containing drinks purchased in a cafeteria (Donnelly et al., 2018). Therefore, similarly to Study I where sadness slightly decreased financial risky decisions, Study II moderately suggests that sadness may also decrease risky (e.g., unhealthy) food choices.

In conclusion, our study extends previous work on influencing individuals against sugar-containing food by using an expert's healthy eating call as a nudge intervention. Earlier investigations have shown that, in general, nudge interventions are more effective at reducing unhealthy eating than at increasing healthy eating (Cadario and Chandon, 2020). This is supported by our findings, since the healthy eating call decreased the WTP for sugar-containing food, but did not increase the WTP for sugar-free food. Moreover, the present study contributes to the debated topic of how emotions affect eating behavior, by suggesting that unhealthy eating might be susceptible to alteration by fear and sadness. Overall, our findings may stimulate novel marketing approaches aiming at assisting consumers in their food choices.

2.3. Study III. Neural mechanisms of expert persuasion on willingness to pay for sugar

After demonstrating that a healthy eating call by an expert can significantly decrease the WTP for sugar-containing food (Study II, Ntoumanis et al., 2022), we aimed to investigate the neural correlates of this phenomenon. Thus, we conducted a follow-up EEG

study to examine which aspects of neural responses to the same healthy eating call can predict the efficacy of expert persuasion. The study design was slightly different from that of study II: instead of having a control group, we had a control condition of non-edible products. Therefore, all participants (N = 45) listened to the same audio narrative - the healthy eating call used in Ntoumanis et al. (2022) - but this time, they had to bid on three product categories before and after the narrative: 30 sugar-containing, 30 sugar-free and 30 non-edible products. Another difference between study II and study III is that in the latter, participants' brain activity was recorded with EEG during the entire duration of the experiment.

At the behavioral level, the results replicated the findings of study II, that is, the healthy eating call decreased individuals' WTP for sugar-containing food, while it did not affect their WTP for sugar-free or non-edible products. Further, we found that the delta of WTP for sugar-containing food was negatively correlated with the Conformity personality trait of the participants, which was measured prior to the EEG data collection (Mehrabian and Stefl, 1995). The Conformity scale measures the reliance on others for decision-making, in a variety of social contexts (Mehrabian and Stefl, 1995). Martinelli and De Canio (2021) have previously illustrated the moderating role of Conformity in inducing non-vegan consumers to buy vegan food.

Further, we examined two aspects of participants' EEG responses to the healthy eating call that could possibly predict its behavioral effect. The first was the EEG ISC, which is a measure of engagement and attention (Hasson et al., 2004; Dmochowski et al., 2012; Ki et al., 2016). We chose this measure because in the past, it has successfully been used to predict population-wide music popularity (Leeuwis et al., 2021), movies' box-office performance (Christoforou et al., 2017) and individual preferences for television ads (Dmochowski et al., 2014). Hence, we hypothesized that high ISC during listening to the healthy eating call would result in a large decrease in the WTP for sugar-containing products. Our data confirmed this hypothesis (Figure 3).

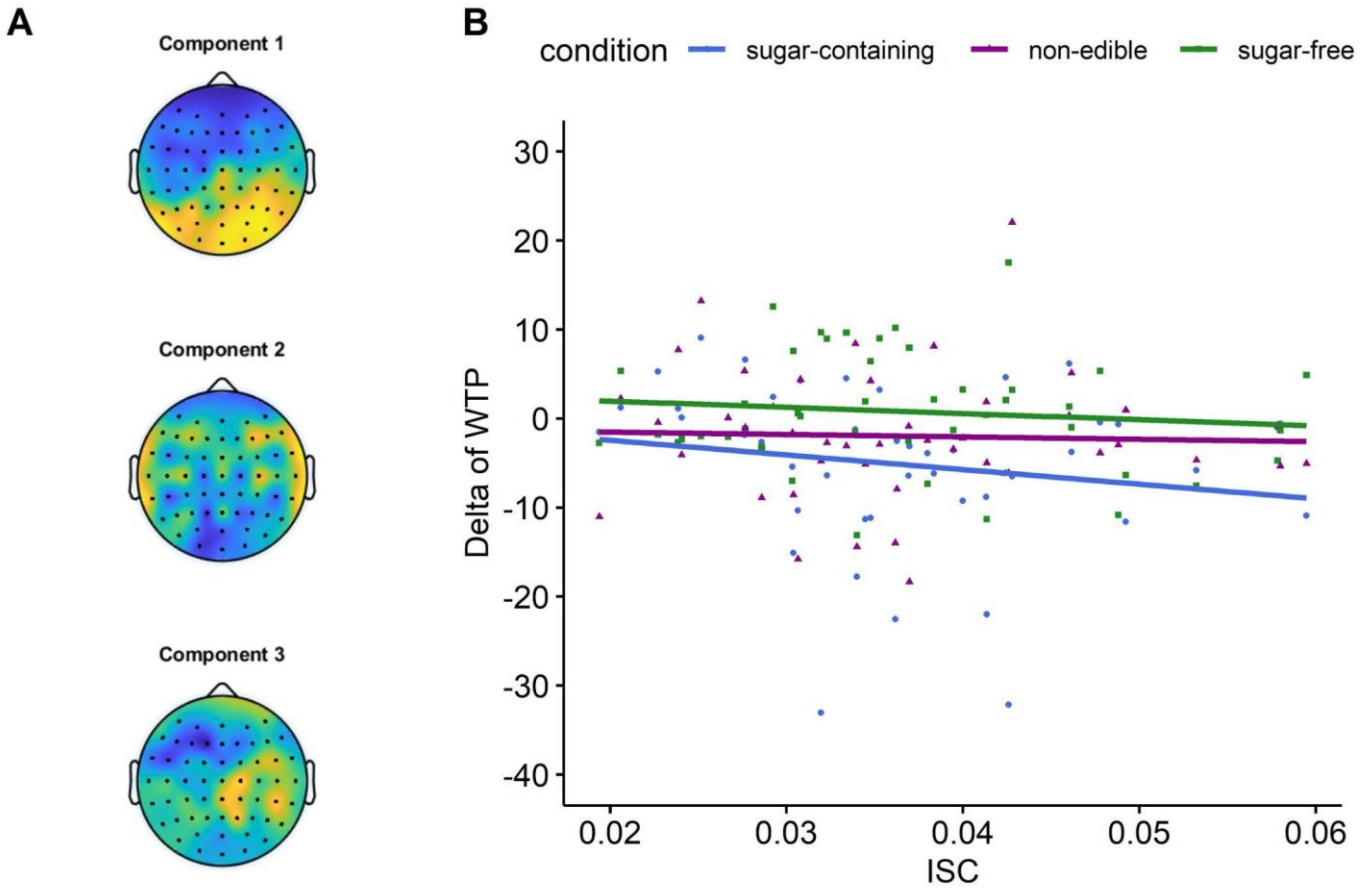

Figure 3 *| The results of the ISC analysis. (A) Scalp projections of the three strongest correlated components. (B) The relationship between the ISC during listening to the healthy eating call and the delta of WTP for different product categories. For the category of sugar-containing products, the correlation was r = -.29, with a significant p-value = .027.*

The second aspect of participants' EEG responses to the healthy eating call that was tested in terms of its predictive ability regarding the efficacy of expert persuasion was the spatiotemporal patterns of EEG signals. Specifically, we trained a machine learning classification model to predict the decrease in the WTP for sugar-containing products from patterns of EEG responses to the healthy eating call. To that end, we first labeled half of the participants as "highly-influenced" and the other half, "not highly-influenced" by the healthy eating call, based on the median delta of WTP for sugar-containing products. Then, we conducted the MVPA in 1-second time windows. The classification accuracy was statistically significant in 22.25% of the time windows. As a control analysis, we repeated exactly the same MVPA for non-edible and sugar-free products, and the

corresponding accuracy was significant only in 6.75% of the time windows for non-edible products and in 4.00% of the time windows for sugar-free products. Extracting the feature weights of the machine learning algorithm revealed that electrodes at the temporal and frontal sites were the main contributors of the significant classification accuracy for the efficacy of expert persuasion.

This study presents a first attempt to link, on the one hand, the behavioral effect of a healthy eating by an expert on the WTP for sugar-containing food and, on the other hand, the neural responses to this healthy eating call with the use of EEG. At the behavioral level, the results illustrated a successful persuasion by the health expert. This behavioral effect was associated with two neurophysiological indices, namely, (i) the group-level ISC of EEG responses to the healthy eating call and (ii) the subject-level spatiotemporal patterns of EEG responses to the healthy eating call. Taken together, by using EEG, we elucidated the neural mechanisms by which the brain responds to persuasive messages by experts. From a broader perspective, our results demonstrate that EEG is a powerful tool that can be used to predict the efficacy of health-related advertisements before they are released to the public.

3. Conclusion

The three studies' joint results shed light on the psychophysiological mechanisms of social influence on decision-making through narratives.

Study I investigated how narratives can affect decision-making by inducing joyful or sad emotional states. Based on our findings, sadness appears to provoke risk-aversion, especially in individuals with low levels of emotional contagion. Studies II and III investigated how narratives can affect decision-making by conveying a social norm. Based on our findings, an expert's negative opinion about sugar consumption can effectively decrease individuals' WTP for sugar-containing food. The effect was found to be particularly significant in individuals with high levels of social conformity. This result, in

combination with the results of Study I, indicate that personality traits may play a significant moderating role in the efficacy of social influence on decision-making in various domains (e.g., financial decisions, food choices). Study III offers a robust methodological approach to link, on the one hand, the behavioral effect of a narrative on decision-making, and, on the other hand, neural responses to the narrative. Our analysis posits that EEG offers a powerful tool to design narratives so that their social influence is maximized. Specifically, the novel methodological approach discussed in the current dissertation could be used to predict the behavioral effect of a narrative based on individuals' EEG responses to it. This could be used, for example, in order to design and assess health-related advertisements before they are released to the public. Future studies could replicate this methodological approach to other neuroimaging methods offering higher spatial resolution, such as functional magnetic resonance imaging (fMRI).

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