Journal of Cognitive Psychology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/pecp21

The combined effect of music-induced emotions and neuromodulation on economic decision making: a tDCS study

Barbara Colombo & Paola Iannello

To cite this article: Barbara Colombo & Paola Iannello (2022): The combined effect of music-induced emotions and neuromodulation on economic decision making: a tDCS study, Journal of Cognitive Psychology, DOI: 10.1080/20445911.2022.2084546

To link to this article: https://doi.org/10.1080/20445911.2022.2084546

Published online: 08 Jun 2022.

JOURNAL OF COGNITIVE PSYCHOLOGY
https://doi.org/10.1080/20445911.2022.2084546

Routledge
Taylor & Francis Group

Check for updates

The combined effect of music-induced emotions and neuromodulation on economic decision making: a tDCS study

Barbara Colombo [a] and Paola Iannello[b]

[a]Behavioral Neuroscience Lab, Champlain College, Burlington, VT, USA; [b]Psychology Department, Catholic University of the Sacred Heart, Milan, Italy

ABSTRACT
Literature highlights how decision makers' behaviour is not driven by pure self-interest but also by emotions. Recent studies have refined these results by including the role of neurological basis. This study aimed at investigating the effect of music-induced emotions and tDCS (transcranial Direct Current Stimulation) neuromodulation of the DLPFC (Dorsolateral Prefrontal Cortex) on the decision-makers' behaviour when playing the Ultimatum Game (UG). 108 participants were randomly assigned to: (i) a tDCS condition; (ii) a music-elicited emotion condition. After receiving the tDCS stimulation and listening to music, participants played the role of proposer in four rounds of UG. Responders were presented as more or less likely to accept an unfair offer. Results suggest that inducing emotions through music affects economic decision-making, in particular when combined with neuromodulation of the DLPFC. After cathodal stimulation participants tended to be more strategic when making decisions, differentiating their offers depending on the responder's characteristics.

ARTICLE HISTORY
Received 14 June 2021
Accepted 26 May 2022

KEYWORDS
Decision making; ultimatum game; tDCS; emotions; music

Introduction

Contemporary models of decision making acknowledge the fact that humans are not consistently rational decision makers (Ariely & Jones, 2008; Bhui et al., 2021; De Martino et al., 2006; Kahneman, 2011). This is partly based on the assumption that decision-making is thought to involve two distinct types of processes (Evans, 2008; Evans & Stanovich, 2013; Sloman, 1996; Stanovich, 2004). According to parallel-competitive accounts within dual-process theories, intuition and analysis can be conceived as two distinct coexisting systems that may interact but remain independent at the same time (Barbey & Sloman, 2007; Epstein, 1994; Sloman, 1996; Smith & DeCoster, 2000; Wang et al., 2017). Whereas literature has traditionally focused on the shortcomings of intuition in decision-making processes (e.g. Kahneman (2011)), the focus has more recently shifted towards the benefits of intuition, assuming that intuition may be (at least) as good as analytical thinking (Aczel et al., 2011; Dane, 2011; Dane & Pratt, 2007; Julmi, 2019), and highlighting that strategic decision-making may require the involvement of both systems (Elbanna & Child, 2007; Hodgkinson et al., 2009). Analytical thinking can be considered as primarily cognitive and affect-free, whereas intuition has been defined as an affectively charged process (Adam & Dempsey, 2020; Dane & Pratt, 2007; Sinclair & Ashkanasy, 2005). Affect seems to be related to intuition both as its antecedent: i.e. mood has been found to trigger or reinforce intuitive processing (Epstein, 2011; Sinclair et al., 2002) and an inherent component of the intuiting process itself, the "affect-based" intuition, (Sadler-Smith et al., 2008).

Affect has been widely recognised as having a profound influence on decision making (Bechara et al., 2000; George & Dane, 2016; Treffers et al., 2020; Wray, 2020), thus highlighting the effects of emotions both on intrapersonal (see the affect-as-information model, Schwarz and Clore (1983)) and interpersonal decision-making (see the emotions as social information—EASI- model, Van Kleef (2009)). Specifically, in social decision-making, people are found to use both their partner's and their own emotions to inform their behaviour and

CONTACT Barbara Colombo bcolombo@champlain.edu 163 S. Willard Street, Burlington, VT 05401, USA
Supplemental data for this article can be accessed online at https://doi.org/10.1080/20445911.2022.2084546.

make strategic decisions (Van Kleef, 2009). Even though the effect of emotions on social decision-making has been largely recognised, the question of whether emotions arise during social decision making (integral emotions) or propagate from other situations (incidental emotions; Lerner et al. (2004)) is little explored yet. This is particularly true in interdependent decision-making, which requires decision-makers making a series of moves until a common agreement is reached. Examples of such agreement-games include the Ultimatum Game, in which two players are tasked with splitting a designated amount of money (Güth et al., 1982; Koenigs & Tranel, 2007). Many studies, using modifications of the Ultimatum Game, provide evidence that participants' behaviour is particularly affected by emotions. Specifically, findings have revealed that when playing as the proposer (i.e. they can decide how to split the money), most people offer even equal split of the total amount of money (Iannello & Antonietti, 2008), as well as the evidence that responders typically reject lower and unfair offers (Iannello & Antonietti, 2008; Van't Wout et al., 2006; Yamagishi et al., 2012). This trend highlights that different factors, other than self-interest and reward gain only, may affect the players' decisions (Fehr & Camerer, 2007). Empirical evidence has highlighted that players' emotional states and perceptions of fairness are important factors in ultimatum game behaviour (Forgas & Tan, 2013; Gilam et al., 2019; Grecucci et al., 2020).

The evidence related to the effect of incidental emotions on decision making stress the relevance of using music-induced emotions (Hart et al., 2010) to study the effect of emotion on decision making (Engelmann et al., 2018; Qiao-Tasserit et al., 2017). Emotional priming involves administering stimuli with the purpose of evoking a specific emotion, or combination of emotions, which is intended to have some effect on the participant's behaviour and thoughts (Hart et al., 2010). Emotion inducing can be conceived differently and many forms involve visual imagery. Yet other forms such as music and speech have also been used (Chen et al., 2008; Tay & Ng, 2019). Music in particular serves as an interesting way for inducing emotions since it's neither visual nor verbal, and it has potential to manipulate emotion in a very strong way (Koelsch, 2018; Konečni et al., 2007) given its connection with several brain structures that are linked to and affect the affective–attentional network, as well as support and guide social functions (Koelsch, 2014). Emotions elicited by music have also been classified as incidental emotions in several experimental studies linked to judgment and decision making (Enachescu et al., 2020; Gawronski et al., 2018; Schulreich et al., 2014).

Although there is a significant body of research surrounding both the role of emotion on economic decision-making behaviour and the relationship between emotion and music, there is very little which connects all three concepts together. A recent study (Chung et al., 2016) explored the effects of mood (manipulated by music induced emotions) on socio-economical decision making, by using the Ultimatum game. Results showed how people tended to reject unfair offers less often after listening to music eliciting a more positive mood. These results are promising and show an effect of mood in response to perceived fairness and how this affects behaviour. Yet, it would also be interesting to see if a music-induced mood could affect not only the response to a fair vs. unfair offer, but also the formulation of the offer, which potentially involves a more involved strategic planning (Iannello & Antonietti, 2008).

Another interesting aspect that the recent paper by Chung et al. (2016) has not explored is the role of possible neurological basis in charge of controlling decision making under the influence of emotions. Our study aims at adding this additional aspect to the experimental conditions. In order to achieve this goal, we decided to focus on the role of the Dorsolateral Prefrontal Cortex (DLPFC). It was once thought that primary function of the prefrontal cortex was reasoning and problem solving, while emotion processing was left to the amygdala, hippocampus, and other parts of the limbic system. Advances in research have demonstrated that many structures within the limbic system have important connections to the frontal lobe, and thus the prefrontal cortex (Banks et al., 2007; Barbas & García-Cabezas, 2017; Rolls, 2019). Specifically, the DLPFC has been shown to increase cognitive control where emotion processing tasks are concerned, because of the connections between the limbic system and frontal lobe (Balzarotti & Colombo, 2016; Barbas & García-Cabezas, 2017; O'Reilly, 2010). According to the valence-specific hypothesis, the left side of the brain controls positive emotions, while the right is responsible for negative emotions (Balzarotti & Colombo, 2016; Prete et al., 2019). The stimulation of the left DLPFC (lDLPFC) has also been proved to affect the emotional processing (Allaert et al., 2019; Balzarotti & Colombo, 2016; Martínez-Pérez et al., 2019). Anodal stimulation of the same area increases the recall of positive emotional stimuli but not negative ones (Balzarotti & Colombo, 2016), and also reduces the allocation of cognitive resources when examining emotional stimuli, while cathodal stimulation increases the allocation of resources but only for negative emotions (Allaert et al., 2019), supporting the role of lDLPFC in managing mainly positive emotions.

The effect of tDCS (transcranial Direct Current Stimulation) on left DLPFC has been recently proved to affect risky decision making and cognitive flexibility in both pathological gamblers (Soyata et al., 2019) and healthy adults (Huang et al., 2017). In these experiments, cathodal stimulation of the lDLPFC resulted in more advantageous decision making, and showed that people tend to be more risk-averse when they think they can gain something easily after receiving left anodal tDCS of the DLPFC.

It is hence reasonable to assume that manipulating the activation of the left DLPFC would affect both emotion regulation (for positive emotions) and a more risky behaviour while individuals are engaged in a task as the UG. For this reason, in our study we used transcranial direct current stimulation (tDCS), to alter the activation of the lDLPFC in our participants. Using this design, we aimed at exploring both factors together, by adding music induced emotions to the effect of brain stimulation on a risky economical decision-making task.

Starting from the evidence discussed in previous literature, we conjectured that cathodal brain stimulation would lead participants to better differentiate their offers depending on the responders' characteristics (meaning they would offer less money to players described as more likely to accept an unfair offer and offer more money to players described as more likely to refuse an unfair offer) when compared to sham and anodal condition (HP1). We also expected that the positive effect of cathodal stimulation on offers would be further enhanced by music (HP2). Finally, we expected music to have a positive effect *per se*, meaning that in the sham condition participants would better differentiate their offers after listening to music (HP3).

Methods

This study has been granted approval by the IRB at Champlain College (COA IRB000143).

Participants

108 participants (F = 68; Age range: 18–22; M = 19.58 SD = 1.25) joined the study and were randomly assigned to one of the tDCS conditions (anodal, cathodal or sham) and to the music condition (music induced condition vs. control). Participants were balanced among conditions. Participants has been recruited through flyers available in different areas of the Campus and in the students' dorms. Some professors shared the info about the experiment in their classes and encouraged students interested in seeing how noninvasive brain stimulation work to take part in the experiment.

Instruments

Music

To select the music to use to induce emotions, we collaborated with a professional composer, who highlighted how in music, most often, several factors combine to create an emotional effect. In the case of evoking a feeling of generosity, there are several common factors in classical music: An arching, lyrical melody whose profile traces slowly climbing phrases, which resolve to the tonic. A slow tempo, often in 3/4 time, whose pulse helps to bolster feelings of sympathy and emotional warmth. Choices of instrumentation, register, and orchestral techniques that emphasise feelings of emotional connectedness. For example, a slow melody played in the upper range of the violin might express sorrow or longing; the same melody played in the lower register of the tuba would sound ironic and lampoon a sense of longing or sorrow. Starting from these indications, we selected four pieces of classical music who met these criteria: the second movement from Beethoven's Sonata No. 8 (the Pathetique); the second movement from Beethoven's Sonata No.7; The Intermezzo from Mascagni's "Cavalleria Rusticana", and the 4th movement (Adagietto) from Mahler's Symphony No. 5.

We explored individuals' emotional reactions to these pieces by having a sample of 79 college age participants' (to match the age of our intended sample) listen to them and rate their emotional responses to each individual piece of music using the GEneva Music-Induced Affect Checklist (GEMIAC), a brief instrument for the rapid assessment of musically induced emotions (Coutinho & Scherer, 2017). The presentation order for the pieces of music has been counterbalanced to avoid any effect due to the order of presentation.

We run repeated measures ANOVAs for four emotions reported in the GEMIAC, identified as useful for our study: being interested, feeling hostile towards others, feeling inspired, and feeling focused. We used the four pieces of music and within subjects' variables. Most of the considered variables showed no difference among the pieces in participants' ratings (see mean scores and SD reported in the Table added as supplementary materials), which was not surprising, since we selected pieces with very similar harmonic and melodic characteristics. Yet, one of the pieces emerged as different from the others on some key variables. The Mascagni piece had the lowest score in response to "feeling hostile" ($F_{3;\ 186} = 5.80$, $p = .001$), the highest score for "feeling inspired" ($F_{3;\ 186} = 5.16$, $p = .002$). It also recorded an average score for feeling "concentrated" ($F_{3;\ 186} = 6.12$, $p = .001$), which was optimal since we were not trying to lead participants to focus more after listening to the music.

The Mascagni *Intermezzo* also fits the criteria listed by the composer well. Its expansive, poignant melody unfolds very slowly and resolves to the tonic: creating both a sense of pathos and also connection. The slow tempo and 3/4 pulse have a calming and emotionally entwining effect on the listener. Last, the subtle orchestration, with its countermelodies of sighing wind instruments, expertly reinforces the emotional character of the music. These three predominate features of the music, working together, greatly help to emphasise sentiments of generosity.

Because of these results and considerations, we choose the Mascagni Intermezzo as our music stimulus.

Ultimatum Game

The Ultimatum Game has been used in the past for exploring the divide between a participant's desire for fairness and their desire for personal gain in conjunction with brain stimulation (Iannello et al., 2014). It has also been used, as discussed in the introduction, to explore the impact of emotion on decision making (Riepl et al., 2016; Van't Wout et al., 2006).

In our study participants were presented with a computer-based version of the Ultimatum Game (Iannello & Antonietti, 2008). Playing the role of proposer, participants were asked to complete four rounds of one-shot UG with four different responders. Each fictitious player was introduced to the participants by providing information about their job, lifestyle, and values. These descriptions were crafted in order to imply that two of the participants were more likely to accept an unfair offer (the "acceptors"), while the other two were more likely to reject an unfair offer (the "rejectors"). Players were balanced by gender (two males and two females) and age (two younger and two older). The order of presentation of the participants was counterbalanced. After reading the description of each responder, participants were asked to make their proposal to each of them and, then, received feedback about which of their offers have been accepted or rejected.

In this version of the ultimatum game (Iannello & Antonietti, 2008) participants were not incentivised, and a subtle form of deception was used because the feedback provided to the players (accepted vs. rejected offers) was randomly generated by the computer. Participants were debriefed at the end of the experiment, and the reasons for this form of deception (Hertwig & Ortmann, 2008) was explained.

The instruction provided to the participants before they started to play the UG are available as supplementary materials.

tDCS

In this study we used 1300A 1 × 1 Transcranial Direct Current Low-Intensity Stimulator by Soterix Medical to deliver brain stimulation to our participants. This device has been FDA approved for research investigation. The PI of the study has been certified to been authorised to use and supervised the use if tDCS equipment and underwent specific first-aid training in order to be able to address any possible adverse event. She was in the room at all times when the tDCS device was used, and provided extensive information about the equipment and the possible risks to each participants. Participants were also given a phone number that they could use to get in touch with the PI in case of any symptoms they might experience in the hours following the experiment. We used two 5 × 5 cm rubber electrodes enveloped in saline-soaked sponges covered with conductive gel. For the two experimental conditions (anodal and cathodal lDLPFC), the stimulation was set at 1.5 mA (current density: .02857 mA/cm^2) for 20 minutes. In the control (sham) condition, the equipment started the stimulation

Figure 1. Procedure.

normally and ramped up to the target intensity of 1.5 mA—then it ramped down to 0 mA just a few seconds. This gives participants the impression of actually receiving stimulation, when in reality the stimulation lasts less than 5 seconds, thus having no actual effect on brain functions.

Procedure

After reading and signing the consent form, researchers asked any questions participants might have, before starting the experimental procedure (See Figure 1).

The tDCS electrodes were placed on the lDLPFC (F3) (active electrode) and on the right forearm. After starting the tDCS stimulation (either actual stimulation or sham) and waiting 60 seconds to be sure that the equipment was functioning properly and no side effects were reported, participants were instructed either to close their eyes and relax listening to music (experimental condition—music induced emotions) or close their eyes and relax for a few minutes (control condition). After that, participants were asked to open their eyes, and to play the Ultimatum Game using a Mac Computer. The rounds were presented using a timed Power Point presentation, in order to keep the time for reading the information about the other player and make the offer.

After playing the four rounds, participants were told which of their offers have been accepted (this feedback was randomly selected). After that, electrodes were taken off, participants were asked if they had any questions, debriefed and thanked for their participation.

Results

We run a GLM Repeated Measure ANOVA, using the two experimental conditions (tDCS and music) as independent between-subjects variables and the offers as dependent variables. The responders (people who our participants offered money, and who were described as more likely to accept an unfair offer—Acceptors—or more likely to reject and unfair offer—Rejecters) where the within subject variable.

Mean scores for the different conditions are reported in Figure 2.

An interaction effect between the type of responder and tDCS condition emerged: $F_{2;101} = 4.67$; $p = .01$, $\eta^2 = .08$. The model also returned a significant interaction between the type of player and the music condition: $F_{1;101} = 4.14$; $p = .04$, $\eta^2 = .04$. And also a three-way interaction among the type of player, tDCS condition and music condition: $F_{2;101} = 4.77$; $p = .01$, $\eta^2 = .08$.

Looking at the mean scores, we can notice how in sham condition people tended on average to offer more to participants who were described as more likely to refuse an unfair offer, but they would be even more generous to them after listening to music. On the other hand, they would offer less money to people who were more likely to accept even un unfair offer.

After receiving cathodal stimulation, people tended to offer more money to participants described as more likely to refuse an unfair offer after the control condition, hence being less generous with them after listening to the music—

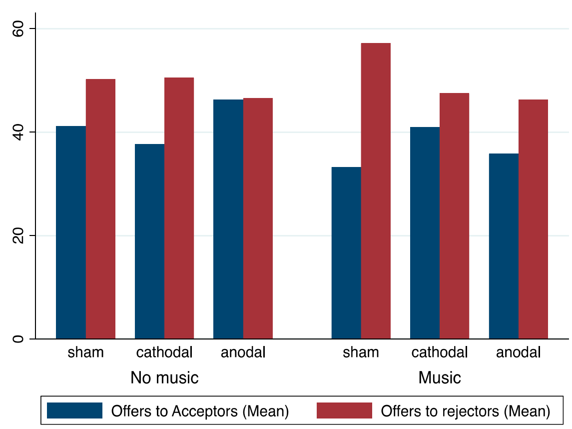

Figure 2. Mean Scores for acceptors and rejectors under the different conditions. (To view this figure in colour, please see the online version of this journal.)

showing an opposite effect when compared to sham.

The anodal condition appeared the most interesting, with participants offering much more money to every participant regardless of the likelihood of them accepting or refusing an unfair offer after the control condition. Listening to music lead them to behave more strategically and be more conservative in their offers, when playing against players described as more likely to accept unfair offers.

Discussion and conclusions

The main aim of this study was to explore the effect of music induced emotions to affect economic decision making, especially when combined with neuromodulation of the DLPFC.

Our first hypothesis partially was confirmed. After cathodal stimulation, our participants tended to be more strategic when making decisions, as indicated by the result that they tended to offer less money to players described as more likely to accept an unfair offer and more money to players described as more likely to reject an unfair offer. This finding confirms the results previously reported by Huang et al. (2017). Quite interestingly, music seems to lessen the effect of the tDCS, thus going against our second hypothesis. This apparently paradoxical effect can be explained by the notion that music induced emotions have been reported to affect response to similarly emotional stimuli, but not non-affectively connotated stimuli (Goerlich et al., 2012). In our case, the effect of cathodal tDCS seems to affect participants by making them more rational and less emotive in their decision-making behaviour—so results suggesting that the music seems to counter the effect of the tDCS seems to be easily explained. This explanation is supported by the data suggesting that after anodal stimulation, where participants were made more impulsive (as supported by the result that after anodal stimulation participants would offer less money to players who were more likely to reject un unfair offer) but also more emotional. This effect was noticeable when positive emotions were involved (Balzarotti & Colombo, 2016), in this case supporting our second hypothesis: music improved the decision-making strategies but only with players introduced as more likely to accept a lower offer, hence most likely triggering a positive emotional response in participants within the scope of the Ultimatum Game ("I can get more money here"). This interpretation is in line with the EASI model (Van Kleef, 2009) and supported by some literature on the Ultimatum Game, reporting how offers tend to be guided by the emotions that proposers anticipate when contemplating their offers (Nelissen et al., 2011).

Finally, our third hypothesis focused on the effect of music on decision making in the control (sham) condition—when no interference from neuromodulation was in place. This hypothesis was confirmed, since participants in the sham condition tended to act more effectively in their decision making after listening to music (i.e. they offered more money to players described as more likely to refuse an unfair offer, and less money to those described as more likely to accept an unfair offer). This finding confirms the preliminary results reported in the study by Chung et al. (2016), already discussed in the introduction.

The findings reported in this study seem to depict an interesting if complex relationship among music, economic decision making, emotions, and impulsivity. Music induced emotions seems to affect decision making, by helping individuals to be more efficient when making economic based decision making. Yet, when individuals are already being more analytical (e.g. from the effect of neuromodulation) the effect of the music is lost because the emotional activation seems to conflict with the less emotional process triggered by neuromodulation. The opposite happens when the emotional processing mode is triggered by tDCS: in this case when there is a match between the emotions elicited by the music and the emotions anticipated by the players as a consequence of their decision, then the positive effect of the music induced emotions is boosted.

To our knowledge, this study is the first one to explore this complex relationship, which could lead to possible interventions aimed at improving impulsive decisional making in clinical populations based on the combined use of musical priming and neuromodulation. If the present study doesn't have relevant data that allow deriving any conclusions about specific clinical effect of this procedure, future studies should investigate possible benefits with clinical populations, adding the effect of music to the already explored effects of neuromodulation (Gilmore et al., 2018). Specific interventions could focus on individuals with an addiction to gambling or an alcohol addiction—

who share similar patterns in impulsive decision making (Lawrence et al., 2009). Other clinical populations who could potentially benefit from this approach are Parkinson's (Djamshidian et al., 2012) and ADHD patients (Patros et al., 2016).

There are also some limitations that need to be addressed by future studies: even if we carefully selected the music to be used as a way to induce emotions, the effect of different types of music should be explored. Also, the effect of music induced emotions and neuromodulation on participants playing the Ultimatum Game as respondents should be explored. As an additional point, we didn't measure the perception of fairness of the game—which could have been an interesting variable to add as a moderator in our analyses.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The data that support the findings of this study are openly available by emailing the corresponding author. Due the IRB specific approval for this research, authors were not authorised to make the dataset openly available in a public repository.

ORCID

Barbara Colombo http://orcid.org/0000-0002-4095-9633

References

Aczel, B., Lukacs, B., Komlos, J., & Aitken, M. R. (2011). Unconscious intuition or conscious analysis? Critical questions for the deliberation-without-attention paradigm. *Judgment and Decision Making*, *6*(4), 351.

Adam, F., & Dempsey, E. (2020). Intuition in decision making-risk and opportunity. *Journal of Decision Systems*, 1–19. https://doi.org/10.1080/12460125.2020.1848375

Allaert, J., Sanchez-Lopez, A., De Raedt, R., Baeken, C., & Vanderhasselt, M.-A. (2019). Inverse effects of tDCS over the left versus right DLPC on emotional processing: A pupillometry study. *PloS one*, *14*(6). https://doi.org/10.1371/journal.pone.0218327

Ariely, D., & Jones, S. (2008). *Predictably irrational*. Harper Audio New York, NY.

Balzarotti, S., & Colombo, B. (2016). Effects of unilateral transcranial direct current stimulation of left prefrontal cortex on processing and memory of emotional visual stimuli. *PloS one*, *11*(7). https://doi.org/10.1371/journal.pone.0159555

Banks, S. J., Eddy, K. T., Angstadt, M., Nathan, P. J., & Phan, K. L. (2007). Amygdala–frontal connectivity during emotion regulation. *Social Cognitive and Affective Neuroscience*, *2*(4), 303–312. https://doi.org/10.1093/scan/nsm029

Barbas, H., & García-Cabezas, MÁ. (2017). Prefrontal cortex integration of emotion and cognition. In M. Watanabe (Ed.), *The prefrontal cortex as an executive, emotional, and social brain* (pp. 51–76). Springer.

Barbey, A. K., & Sloman, S. A. (2007). Base-rate respect: From ecological rationality to dual processes. *Behavioral and Brain Sciences*, *30*(3), 241–254. https://doi.org/10.1017/S0140525X07001653

Bechara, A., Damasio, H., & Damasio, A. R. (2000). Emotion, decision making and the orbitofrontal cortex. *Cerebral Cortex*, *10*(3), 295–307. https://doi.org/10.1093/cercor/10.3.295

Bhui, R., Lai, L., & Gershman, S. J. (2021). Resource-rational decision making. *Current Opinion in Behavioral Sciences*, *41*, 15–21. https://doi.org/10.1016/j.cobeha.2021.02.015

Chen, J., Yuan, J., Huang, H., Chen, C., & Li, H. (2008). Music-induced mood modulates the strength of emotional negativity bias: An ERP study. *Neuroscience Letters*, *445*(2), 135–139. https://doi.org/10.1016/j.neulet.2008.08.061

Chung, H., Lee, E. J., Jung, Y. J., & Kim, S. H. (2016). Music-induced mood biases decision strategies during the ultimatum game. *Frontiers in Psychology*, *7*, 453. https://doi.org/10.3389/fpsyg.2016.00453

Coutinho, E., & Scherer, K. R. (2017). Introducing the Geneva Music-Induced Affect Checklist (GEMIAC): A brief instrument for the rapid assessment of musically induced emotions. *Music Perception: An Interdisciplinary Journal*, *34*(4), 371–386. https://doi.org/10.1525/mp.2017.34.4.371

Dane, E. (2011). Capturing intuitions 'in flight': Observations from research on attention and mindfulness. In *Handbook of intuition research* (pp. 217–226). Edward Elgar Publishing.

Dane, E., & Pratt, M. G. (2007). Exploring intuition and its role in managerial decision making. *Academy of Management Review*, *32*(1), 33–54. https://doi.org/10.5465/amr.2007.23463682

De Martino, B., Kumaran, D., Seymour, B., & Dolan, R. J. (2006). Frames, biases, and rational decision-making in the human brain. *Science*, *313*(5787), 684–687. https://doi.org/10.1126/science.1128356

Djamshidian, A., O'Sullivan, S. S., Sanotsky, Y., Sharman, S., Matviyenko, Y., Foltynie, T., … Doherty, K. M. (2012). Decision making, impulsivity, and addictions: Do Parkinson's disease patients jump to conclusions? *Movement Disorders*, *27*(9), 1137–1145. https://doi.org/10.1002/mds.25105

Elbanna, S., & Child, J. (2007). Influences on strategic decision effectiveness: Development and test of an integrative model. *Strategic Management Journal*, *28*(4), 431–453. https://doi.org/10.1002/smj.597

Enachescu, J., Žiga, P., Bauer, C. M., Olsen, J., Kirchler, E., & Alm, J. (2020). *Incidental emotions, integral emotions, and decisions to pay taxes*. Routledge.

Engelmann, J. B., Hare, T. A., Fox, A. S., Lapate, R. C., Shackman, A. J., & Davidson, R. J. (2018). Emotions can bias decision-making processes by promoting specific behavioral tendencies.

Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist*, *49*(8), 709. https://doi.org/10.1037/0003-066X.49.8.709

Epstein, S. (2011). The influence of valence and intensity of affect on intuitive processing. In *Handbook of intuition research* (pp. 37–51). Edward Elgar Publishing.

Evans, J. S. B. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology*, *59*(1), 255–278. https://doi.org/10.1146/annurev.psych.59.103006.093629

Evans, J. S. B., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science*, *8*(3), 223–241. https://doi.org/10.1177/1745691612460685

Fehr, E., & Camerer, C. F. (2007). Social neuroeconomics: The neural circuitry of social preferences. *Trends in Cognitive Sciences*, *11*(10), 419–427. https://doi.org/10.1016/j.tics.2007.09.002

Forgas, J. P., & Tan, H. B. (2013). Mood effects on selfishness versus fairness: Affective influences on social decisions in the ultimatum game. *Social Cognition*, *31*(4), 504. https://doi.org/10.1521/soco_2012_1006

Gawronski, B., Conway, P., Armstrong, J., Friesdorf, R., & Hütter, M. (2018). Effects of incidental emotions on moral dilemma judgments: An analysis using the CNI model. *Emotion*, *18*(7), 989. https://doi.org/10.1037/emo0000399

George, J. M., & Dane, E. (2016). Affect, emotion, and decision making. *Organizational Behavior and Human Decision Processes*, *136*, 47–55. https://doi.org/10.1016/j.obhdp.2016.06.004

Gilam, G., Abend, R., Shani, H., Ben-Zion, Z., & Hendler, T. (2019). The anger-infused Ultimatum Game: A reliable and valid paradigm to induce and assess anger. *Emotion*, *19*(1), 84. https://doi.org/10.1037/emo0000435

Gilmore, C. S., Dickmann, P. J., Nelson, B. G., Lamberty, G. J., & Lim, K. O. (2018). Transcranial Direct Current Stimulation (tDCS) paired with a decision-making task reduces risk-taking in a clinically impulsive sample. *Brain Stimulation*, *11*(2), 302–309. https://doi.org/10.1016/j.brs.2017.11.011

Goerlich, K. S., Witteman, J., Schiller, N. O., Van Heuven, V. J., Aleman, A., & Martens, S. (2012). The nature of affective priming in music and speech. *Journal of Cognitive Neuroscience*, *24*(8), 1725–1741. https://doi.org/10.1162/jocn_a_00213

Grecucci, A., Giorgetta, C., Lorandini, S., Sanfey, A. G., & Bonini, N. (2020). Changing decisions by changing emotions: Behavioral and physiological evidence of two emotion regulation strategies. *Journal of Neuroscience, Psychology, and Economics*, *13*(3), 178. https://doi.org/10.1037/npe0000130

Güth, W., Schmittberger, R., & Schwarze, B. (1982). An experimental analysis of ultimatum bargaining. *Journal of Economic Behavior & Organization*, *3*(4), 367–388. https://doi.org/10.1016/0167-2681(82)90011-7

Hart, S. J., Green, S. R., Casp, M., & Belger, A. (2010). Emotional priming effects during Stroop task performance. *Neuroimage*, *49*(3), 2662–2670. https://doi.org/10.1016/j.neuroimage.2009.10.076

Hertwig, R., & Ortmann, A. (2008). Deception in experiments: Revisiting the arguments in its defense. *Ethics & Behavior*, *18*(1), 59–92. https://doi.org/10.1080/10508420701712990

Hodgkinson, G. P., Sadler-Smith, E., Burke, L. A., Claxton, G., & Sparrow, P. R. (2009). Intuition in organizations: Implications for strategic management. *Long Range Planning*, *42*(3), 277–297. https://doi.org/10.1016/j.lrp.2009.05.003

Huang, D., Chen, S., Wang, S., Shi, J., Ye, H., Luo, J., & Zheng, H. (2017). Activation of the DLPFC reveals an asymmetric effect in risky decision making: Evidence from a tDCS study. *Frontiers in Psychology*, *8*, 38. https://doi.org/10.3389/fpsyg.2017.00038

Iannello, P., & Antonietti, A. (2008). Reciprocity in financial decision making: Intuitive and analytical mind-reading strategies. *International Review of Economics*, *55*(1-2), 167–184. https://doi.org/10.1007/s12232-007-0031-4

Iannello, P., Colombo, B., & Antonietti, A. (2014). Non-invasive brain stimulation techniques in the study of intuition. In M. Sinclair (Ed.), *Handbook of research methods on intuition* (pp. 130–143). Edward Elgar Publishing.

Julmi, C. (2019). When rational decision-making becomes irrational: A critical assessment and re-conceptualization of intuition effectiveness. *Business Research*, *12*(1), 291–314. https://doi.org/10.1007/s40685-019-0096-4

Kahneman, D. (2011). *Thinking, fast and slow*. Macmillan.

Koelsch, S. (2014). Brain correlates of music-evoked emotions. *Nature Reviews Neuroscience*, *15*(3), 170–180. https://doi.org/10.1038/nrn3666

Koelsch, S. (2018). Investigating the neural encoding of emotion with music. *Neuron*, *98*(6), 1075–1079. https://doi.org/10.1016/j.neuron.2018.04.029

Koenigs, M., & Tranel, D. (2007). Irrational economic decision-making after ventromedial prefrontal damage: Evidence from the ultimatum game. *Journal of Neuroscience*, *27*(4), 951–956. https://doi.org/10.1523/JNEUROSCI.4606-06.2007

Konečni, V. J., Wanic, R. A., & Brown, A. (2007). Emotional and aesthetic antecedents and consequences of music-induced thrills. *The American Journal of Psychology*, *120*(4), 619–643. https://doi.org/10.2307/20445428

Lawrence, A. J., Luty, J., Bogdan, N. A., Sahakian, B. J., & Clark, L. (2009). Problem gamblers share deficits in impulsive decision-making with alcohol-dependent individuals. *Addiction*, *104*(6), 1006–1015. https://doi.org/10.1111/j.1360-0443.2009.02533.x

Lerner, J. S., Small, D. A., & Loewenstein, G. (2004). Heart strings and purse strings: Carryover effects of emotions on economic decisions. *Psychological Science*, *15*(5), 337–341. https://doi.org/10.1111/j.0956-7976.2004.00679.x

Martínez-Pérez, V., Castillo, A., Sánchez-Pérez, N., Vivas, A. B., Campoy, G., & Fuentes, L. J. (2019). Time course of the inhibitory tagging effect in ongoing emotional processing. A HD-tDCS study. *Neuropsychologia*, *135*, 107242. https://doi.org/10.1016/j.neuropsychologia.2019.107242

Nelissen, R. M., Leliveld, M. C., van Dijk, E., & Zeelenberg, M. (2011). Fear and guilt in proposers: Using emotions to explain offers in ultimatum bargaining. *European Journal of Social Psychology*, *41*(1), 78–85. https://doi.org/10.1002/ejsp.735

O'Reilly, R. C. (2010). The what and how of prefrontal cortical organization. *Trends in Neurosciences*, *33*(8), 355–361. https://doi.org/10.1016/j.tins.2010.05.002

Patros, C. H., Alderson, R. M., Kasper, L. J., Tarle, S. J., Lea, S. E., & Hudec, K. L. (2016). Choice-impulsivity in children and adolescents with attention-deficit/hyperactivity disorder (ADHD): A meta-analytic review. *Clinical Psychology Review*, *43*, 162–174. https://doi.org/10.1016/j.cpr.2015.11.001

Prete, G., Tommasi, V., & Tommasi, L. (2019). Right news, good news! The valence hypothesis and hemispheric asymmetries in auditory imagery. *Language, Cognition and Neuroscience*, *35*(4), 1–11. https://doi.org/10.1080/23273798.2019.1659990

Qiao-Tasserit, E., Garcia Quesada, M., Antico, L., Bavelier, D., Vuilleumier, P., & Pichon, S. (2017). Transient emotional events and individual affective traits affect emotion recognition in a perceptual decision-making task. *PloS one*, *12*(2), e0171375. https://doi.org/10.1371/journal.pone.0171375

Riepl, K., Mussel, P., Osinsky, R., & Hewig, J. (2016). Influences of state and trait affect on behavior, feedback-related negativity, and P3b in the ultimatum game. *PloS one*, *11*(1). https://doi.org/10.1371/journal.pone.0146358

Rolls, E. T. (2019). The cingulate cortex and limbic systems for emotion, action, and memory. *Brain Structure and Function*, *224*(9), 1–18. https://doi.org/10.1007/s00429-019-01945-2

Sadler-Smith, E., Hodgkinson, G. P., & Sinclair, M. (2008). A matter of feeling? The role of intuition in entrepreneurial decision-making and behavior. In W. J. Zerbe, C. E. J. Hartel, & N. M. Ashkanasy (Eds.), *Emotions, ethics and decision-making* (pp. 35–55). Emerald Group Publishing Limited.

Schulreich, S., Heussen, Y. G., Gerhardt, H., Mohr, P. N., Binkofski, F. C., Koelsch, S., & Heekeren, H. R. (2014). Music-evoked incidental happiness modulates probability weighting during risky lottery choices. *Frontiers in Psychology*, *4*, 981. https://doi.org/10.3389/fpsyg.2013.00981

Schwarz, N., & Clore, G. L. (1983). Mood, misattribution, and judgments of well-being: Informative and directive functions of affective states. *Journal of Personality and Social Psychology*, *45*(3), 513. https://doi.org/10.1037/0022-3514.45.3.513

Sinclair, M., & Ashkanasy, N. M. (2005). Intuition: Myth or a decision-making tool? *Management Learning*, *36*(3), 353–370. https://doi.org/10.1177/1350507605055351

Sinclair, M., Ashkanasy, N. M., Chattopadhyay, P., & Boyle, M. V. (2002). Determinants of intuitive decision-making in management: The moderating role of affect. *Managing Emotions in the Workplace*, 143–163. https://doi.org/10.4324/9781315290812-19

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, *119*(1), 3. https://doi.org/10.1037/0033-2909.119.1.3

Smith, E. R., & DeCoster, J. (2000). Dual-process models in social and cognitive psychology: Conceptual integration and links to underlying memory systems. *Personality and Social Psychology Review*, *4*(2), 108–131. https://doi.org/10.1207/S15327957PSPR0402_01

Soyata, A. Z., Aksu, S., Woods, A. J., İşçen, P., Saçar, K. T., & Karamürsel, S. (2019). Effect of transcranial direct current stimulation on decision making and cognitive flexibility in gambling disorder. *European Archives of Psychiatry and Clinical Neuroscience*, *269*(3), 275–284. https://doi.org/10.1007/s00406-018-0948-5

Stanovich, K. E. (2004). Balance in psychological research: The dual process perspective. *Behavioral and Brain Sciences*, *27*(3), 357–358. https://doi.org/10.1017/S0140525X0453008X

Tay, R. Y. L., & Ng, B. C. (2019). Effects of affective priming through music on the use of emotion words. *PloS one*, *14*(4), e0214482. https://doi.org/10.1371/journal.pone.0222965

Treffers, T., Klarner, P., & Huy, Q. N. (2020). Emotions, time, and strategy: The effects of happiness and sadness on strategic decision-making under time constraints. *Long Range Planning*, *53*(5), 101954. https://doi.org/10.1016/j.lrp.2019.101954

Van Kleef, G. A. (2009). How emotions regulate social life: The emotions as social information (EASI) model. *Current Directions in Psychological Science*, *18*(3), 184–188. https://doi.org/10.1111/j.1467-8721.2009.01633.x

Van't Wout, M., Kahn, R. S., Sanfey, A. G., & Aleman, A. (2006). Affective state and decision-making in the ultimatum game. *Experimental Brain Research*, *169*(4), 564–568. https://doi.org/10.1007/s00221-006-0346-5

Wang, Y., Highhouse, S., Lake, C. J., Petersen, N. L., & Rada, T. B. (2017). Meta-analytic investigations of the relation between intuition and analysis. *Journal of Behavioral Decision Making*, *30*(1), 15–25. https://doi.org/10.1002/bdm.1903

Wray, J. M. (2020). The weight of emotions on decision-making: A comparative analysis. *Inquiries Journal*, *12*((09|9)).

Yamagishi, T., Horita, Y., Mifune, N., Hashimoto, H., Li, Y., Shinada, M., … Simunovic, D. (2012). Rejection of unfair offers in the ultimatum game is no evidence of strong reciprocity. *Proceedings of the National Academy of Sciences*, *109*(50), 20364–20368. https://doi.org/10.1073/pnas.1212126109