The Foreign Language Effect and the Gambler' s Fallacy:
Evidence from Neurophysiology

Márcia Costa

UMinho | 2022

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outubro de 2022

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Dissertação de Mestrado
Mestrado Integrado em
Psicologia

Trabalho efetuado sob a orientação do(a)
Professor Doutor Pedro Moreira
Professora Doutora Ana Paula Soares

outubro de 2022

Agradecimentos

Ao meu orientador, Professor Doutor Pedro, agradeço as inúmeras aprendizagens, a disponibilidade e o sentido de humor. À Professora Doutora Ana Paula, a partilha de conhecimento e ajuda valiosa. Obrigada por acreditarem no meu potencial.

Agradeço aos meus pais, por estarem sempre por perto, por acreditarem sempre em mim e me apoiarem de todas as formas possíveis. Ao meu querido irmão, Pedro, pelo carinho e preocupação. À minha família, pelas mensagens de apoio constantes e pela motivação.

Aos meus amigos, um eterno obrigada por compreenderem a minha ausência em determinados momentos ao longo deste percurso e por me apoiarem incondicionalmente.

STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

Braga, 17 de Outubro de 2022

Márcia Filipa Rodrigues Costa

(Márcia Filipa Rodrigues Costa)

O Efeito da Língua Estrangeira e a Falácia do Jogador: Evidência da Neurofisiologia

Resumo

Estudos recentes mostraram que, quando usam uma segunda língua (L2), pessoas bilíngues tendem a ser menos enviesadas, um efeito experimental designado por Efeito de Língua Estrangeira (*Foreign Language Effect*, FLE). Alguns destes estudos investigaram o FLE em contexto de tomada de decisão de risco, onde a Falácia da Mão Quente (*Hot Hand Fallacy*, HHF) e a Falácia do Jogador (*Gambler's Fallacy*, GF) surgem frequentemente, sugerindo que apenas a primeira é influenciada por este efeito. Neste trabalho, procurámos clarificar os resultados obtidos por estes estudos, empregando uma tarefa que envolve um jogo de cartas, manipulando valência (positiva vs. negativa) e língua (Português vs. Inglês). Medidas comportamentais e psicofisiológicas de 41 participantes foram recolhidas. Os resultados mostram uma proporção semelhante de GF em ambas as línguas. A valência do feedback revelou-se significativa para a amplitude de SCR (maior amplitude para feedback negativo), mas nenhum efeito significativo de língua emergiu. As implicações destes resultados são discutidas.

Palavras-Chave: Efeito de Língua Estrangeira, Bilinguismo, Tomada de Decisão, Falácia do Jogador, Psicofisiologia

The Foreign Language Effect and the Gambler's Fallacy: Evidence from Neurophysiology

Abstract

Recent studies have shown that using a second language makes individuals less prone to bias, an experimental effect known as the Foreign Language Effect (FLE). Some of these studies have tested the FLE in risky decision-making context, where the Hot Hand Fallacy (HHF) and the Gambler's Fallacy (GF) often emerge, suggesting that only the first is affected by this effect. Here, we aimed to further clarify the results obtained by these studies, using a card gambling task, manipulating valence (positive vs. negative) and language of feedback (Portuguese vs. English). Behavioural and psychophysiological measures of 41 Portuguese-English bilinguals were collected. Results revealed a similar proportion of GF in both language contexts. We found a significant effect of valence for SCR amplitude (higher amplitude for negative feedback), but no significant effect of language emerged. The implications of these results are discussed.

Keywords: Foreign Language Effect, Bilingualism, Decision-Making, Gambler's Fallacy, Psychophysiology

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Background

More than half of the world's population is bilingual (Bialystok et al., 2012; Grosjean, 2010). Typically, a second language is mostly used in jobs related to politics, finances, education, and others where daily decisions are crucial and affect other people's lives in important ways. Although we tend to think that the tongue in which those judgments and decisions are made is an irrelevant factor, that is not what previous studies have found (e.g., Alempaki et al., 2020; Geipel et al., 2015; Hadjichristidis et al., 2015; Woumans et al., 2020; Yang et al., 2022). For example, some studies revealed that bilinguals' perception of dishonesty and crime is diminished in a second language compared to a native language (Alempaki et al., 2020; Woumans et al., 2020).

Interestingly, other studies suggest that, when using their second (L2) rather than their first language (L1), people tend to be less biased, an effect that has been referred to as the Foreign Language Effect (FLE). This was first observed by Keysar et al. (2012), who found that participants tended to be less affected by the framing effect and by loss aversion. Subsequent studies have shown an FLE on discounting and ambiguity aversion (Costa et al., 2014), risk aversion (e.g., Hadjichristidis et al., 2015; Keysar et al., 2012), hot hand fallacy (Gao et al., 2015), bias blind spot (Niszczota et al., 2021), causality bias (Díaz-Lago & Matute, 2019), the endowment effect (Karatas, 2020), judgment bias (Zhang, et al., 2022), among others. Nonetheless, this effect has mostly been studied in moral dilemmas, such as the trolley dilemma, showing consistent findings that when responding in their L2, people make fewer deontological decisions (e.g., Hayakawa et al., 2017).

To account for the FLE, several hypotheses and mechanisms have been proposed, such as the emotion-reducing hypothesis (Keysar et al., 2012), the positivity bias (Zheng et al., 2020), the cognitive load (Costa et al., 2014; Miozzo et al., 2020), the cognitive disfluency (Costa et al., 2014), and the mental imagery reduction (Hayakawa & Keysar, 2018). Although the debate is still open, the first two are the ones most discussed in scientific literature once they seem to gather more empirical support. These hypotheses share the prediction that the FLE is restricted to emotionally rooted biases, that is, the FLE is absent in purely cognitive tasks (i.e., tasks that do not involve affective processing; Białek et al., 2019; Costa et al., 2014; Vives et al., 2018). However, according to the emotion-reducing account, decision biases are less pronounced when presented in one's L2 compared to one's L1, regardless of the emotional valence elicited by the context. On the other hand, according to the positivity bias hypothesis, this reduction in emotional response in L2 is restricted to negative emotions, whereas positive emotions receive an enhanced emotional response (e.g., Zheng et al., 2020; He et al., 2021). In fact, previous studies with bilinguals clearly demonstrate that the emotional reactivity to valenced stimuli is diminished in an L2 compared to L1, especially for negative stimuli such as childhood reprimands, swear words and taboo words, as evidenced by subjective reports of perceived emotional intensity (Dewaele, 2004a, 2004b; Puntoni et al., 2009), psychophysiological activation (i.e., skin conductance responses and pupil dilation; Harris et al., 2003; Iacozza et al., 2017) and, even, event-related potentials (ERPs; Jończyk et al., 2016; see Pavlenko, 2012, for a review). It is believed that this occurs because an L2 is usually learned at school, in a friendly context, where positive emotions might often be experienced but not negative emotions, leading to a positivity bias (e.g., Zheng et al., 2020).

Besides the context of L2 acquisition, other factors may influence the emotional resonance elicited by emotional stimuli such as the age of acquisition (AoA; e.g., Caldwell-Harris et al., 2014), L2 proficiency (Stankovic et al., 2022), language dominance (Harris, 2006), immersion (Degner, 2012), language use (Caldwell-Harris et al., 2014; Degner, 2012; Del Maschio et al., 2022), L1-L2 similarity (e.g., Circi et al., 2021) and language cultural environment (e.g., promoting vs inhibiting emotional expression; Dylman & Champoux-Larsson, 2020). As Dylman and Champoux-Larsson (2020) explain, most of these factors are related to the context in which the L2 is used to communicate with others, increasing the exposure of the speaker to situations in which the language use co-occurs with the emotional arousal, and, thus, contributing to a higher emotional resonance (Caldwell-Harris et al., 2014). Recent neuroimaging studies investigating bilinguals suggested that proficiency have also shown that the L2 usage or dominance, and AoA interact to shape both the functional and structural organization of the bilingual mind (e.g., Fedeli et al., 2021; Gullifer et al., 2018; Sulpizio et al., 2020), possibly unveiling new perspectives and insights about how a L2 influences brain and functioning.

As Costa and colleagues (2014) put forward, assessing the mechanisms and factors behind the FLE requires exploring its generalizability to different biases and fallacies settings. One context in which it is particularly relevant to explore the FLE is in situations of risky decision-making, where the Gambler's Fallacy (GF) and the Hot Hand Fallacy (HHF) often emerge. GF refers to a misconception that a certain random event is less likely to happen after a series of the same event (i.e., negative recency), while the HHF refers to the misconception that a random event is more likely to happen after a series of the same event (i.e., positive recency; Ayton & Fischer, 2004). For instance, in games such as the roulette, the GF is defined as the strategy to keep betting on the same color after a streak of losses (Xue, et al., 2012b; but for an example of GF in real life context see Liu, 2021). In fact, some studies found an FLE for the

HHF (Gao et al., 2015), but not for the GF (Zheng et al., 2020), suggesting that only the first is affected by the effect.

Gao and colleagues (2015) found an HHF pattern that was diminished in the L2 context (i.e., fewer gambles and slower responses), compared to L1 context, thus observing an FLE. The authors used ERPs and found that, specifically, positive feedback was driving these differences. They analyzed the feedback-related negativity (FRN) and the P300, known to be modulated by feedback, and found that FRN was significantly amplified for L1 words compared to L2 words, and that, the larger the P300 amplitude elicited by feedback in L2 compared to L1, the greater the difference in the proportion of risky decisions between the two language contexts, resulting in a more pronounced FLE.

Interestingly, using the exact same task (i.e., equal-odds bets with the same values), Zheng and colleagues (2020) found an opposite pattern of behavior (GF-like behavior), and no FLE was observed. However, the authors found that participants with higher activations in the right amygdala and bilateral ventromedial prefrontal cortex (areas known to be involved in affective decision-making) tended to use less GF-like strategies in L2 compared to L1. Also, although there was no language effect on GF-like behavior, positive feedback provided in L2, compared to L1, led to higher activation in bilateral caudate and bilateral amygdala and to higher activation of the reward brain networks. Most importantly, these results are opposite to what Gao et al. (2015) found, neurophysiologically as well as behaviorally. Furthermore, while Gao et al. (2015)'s work is congruent with the emotion-reducing account, the findings of Zheng et al. (2020)'s study seem to be more in line with the positivity bias account.

In a recent *f*MRI study, Hu et al. (2022) used the same task employed by Gao et al. (2015), and, similarly, found an L2 modulation consisting of a reduced tendency to gamble after positive feedback. However, unlike Gao et al. (2015), this decrease in gambles following winning happened regardless of language context, which indicates the absence of the HHF, that is characterized by an increase instead, and was found in L1 context in the previous study. Besides, no FLE was observed. At the neural level, an interplay between the right lingual gyrus (RLG), left fusiform gyrus (LFG), and right inferior frontal gyrus (RIFG) was found, consisting of LFG' attenuated responses to positive feedback in L2 compared to L1, that led to a reduction in gambling. Hence, the use of an L2 seems to attenuate emotional reaction to positive feedback, diminishing subsequent risk-taking behavior, whereas negative feedback elicits detachment from negative emotion, preventing an effect on subsequent decision-making. These results appear to support the emotion-reducing account.

Another *f*MRI study, by He et al. (2021), used an identical version of the gambling task initially employed by Gao et al. (2015). The findings demonstrated a greater activation of the hippocampus for positive feedbacks than neutral feedbacks in L2, which led to the authors' belief that this was the cause for the tendency to gamble more after positive feedbacks in L2 compared to L1. Nonetheless, evidence also showed a mediation of loss aversion by the dorsolateral prefrontal cortex (dlPFC), exclusive of L2 context. This area also showed strong functional connectivity with the visual cortex, suggesting a possible protective mechanism that allows avoidance of negative emotion processing in L2. Hence, the authors concluded that FL influenced decision-making by both avoiding processing of negative emotions and enhancing emotional response to positive stimuli - a pattern consistent with the positivity bias hypothesis and its protective mechanism version. For studies using ERPs and fMRI investigating FLE out of risky decision-making context, see Liu et al. (2022) and Liu et al. (2020).

These findings are interesting because they show that the presentation of a single word as feedback of a game, in either the participants' L1 or L2, can elicit an FLE. Moreover, the differences highlighted between L1 and L2 regarded only valenced feedback, which seems to emphasize the hypothesis that FLE is present only in emotionally rooted biases, although results do not always point to the same account (i.e., emotion-reducing or positivity bias account). Furthermore, these results illustrate a modulation of the FLE at the neural level, on different brain regions and neural pathways. In fact, although neuroimaging and psychophysiological measures could give new insights about the mechanisms underlying the FLE, to our knowledge, only the studies mentioned above have used them. Moreover, results are not fully consistent, revealing, for example, either an enhancement of emotional reactivity to positive stimuli in L2 or a decrease, when compared to L1.

In this thesis we aimed to contribute to the FLE literature, specifically regarding the context of risky decision-making, where the GF often emerges. We intend to further clarify the results obtained in previous studies with respect to the influence of FLE on GF. To that purpose we have resorted to a gambling task, in which instructions and feedback are presented in L1 as well as in L2. We intend to assess the influence of language (L1 vs L2) on participants' gambling behavior (i.e., proportion of GF and reaction times).

Furthermore, we will use psychophysiological measures (i.e., electrodermal activity, EDA, and heart rate, HR), to study the FLE on decision-making, what, to the best of our knowledge, was never done before. We will record EDA measures while participants receive feedback, as a measure of their emotional reactivity, since EDA measures, namely skin-conductance responses (SCR), are modulated by novel, emotionally arousing, or personally significant stimuli and by anticipation of significant stimuli (Siegel et al., 2018). EDA studies may be relevant since they offer a different perspective on the interaction between emotionality and language, when compared to self-reported emotional responses, since the two are sometimes inequivalent (Caldwell-Harris & Ayçiçeği-Dinn, 2009; Harris et al., 2003). On the other hand, heart rate (HR) has been shown to be a valid measure of autonomic nervous system for inferring emotional reactivity (Siegel et al., 2018). Hence, we recorded HR as an additional measure of emotional reactivity to feedback in the different language contexts, using both EDA and HR.

Since the two explanations that seem to gather more empirical evidence are the emotion-reducing and positivity bias account, we will test both concurrent hypotheses, using the psychophysiological measures described earlier. Considering the nature of the GF we will manipulate the streak length of the outcome, expecting that for longer compared to shorter streaks of the same outcome, GF will be higher. Importantly, we predict that this difference in GF will be moderated by language of feedback (Portuguese vs English). Additionally, we predict differences in RT, such that, where we expect higher GF we predict shorter RT, as well as a moderation of language on the relationship between RT and streak length.

Methods

Participants

Forty-one Portuguese-English bilingual students (all females; *Mage*=21.683, *SD*=3.971) were recruited from the School of Psychology. This sample size was assumed to be sufficient, considering the 16 and 32 participants' samples used by Gao et al.'s (2015) and Zheng et al.'s (2020) works, respectively. Verbal and written information about the study was provided and participants who intended to participate gave online consent, just before the beginning of the experimental task. All participants had to be right-handed and with normal or corrected-to-normal vision, no language disabilities, and no reported history of neurological or psychiatric disorders. Also, only Portuguese dominant bilinguals with intermediate English proficiency and no history of living in an English-speaking country were admitted. To assess these and other important variables participants responded to a short version of the Language History Questionnaire, Lexical Test for Advanced Learners of English (LexTALE) and Cambridge General English Test (CGET). Participants were rewarded for their participation with academic credits. The study was approved by the Social and Human Sciences Ethics Committee of the University of Minho (CEICSH 120/2021).

Instruments

Second Language Characterization Questionnaires and Tests

To guarantee that participants met the required linguistic criteria, we applied the following questionnaires and tests. The aim of these three instruments is to better assess participants' L2 proficiency, since a poor characterization of bilingual participants may be a common pitfall of previous studies.

The short version of the Language History Questionnaire (LHQS), developed using Qualtrics, is a short version of the Language History Questionnaire (Li, Sepanski & Zhao, 2006), consisting of 31 questions. The questionnaire assesses participants' sociodemographic data, handedness, history of L2 acquisition and use, self-reported measures of proficiency (i.e., reading, writing, speaking, listening), and results of previous L2 proficiency evaluation tests.

Lexical Test for Advanced Learners of English (LexTALE) is a test of vocabulary knowledge for medium to highly proficient speakers of English as an L2, specially intended for studying bilingual participants in an experimental setting. It consists of 60 trials of a simple un-speeded visual lexical decision task (www.lextale.com). The result is a percentage of the correct trials. This test also gives a fair indication of general English proficiency (Lemhöfer & Broersma, 2012). Several authors (e.g., Stankovic et al., 2022; Miozzo et al., 2020) advocate the importance of using objective and valid measures to assess L2 proficiency and knowledge, such as LexTALE, so as to investigate bilingualism in a continuum.

Cambridge General English Test (CGET) is an online English level of proficiency diagnosis test consisting of 25 multiple choice questions, in which the final score corresponds to the number of correct answers. For each question, the best option must be chosen to complete the sentence or conversation. Hence, this test evaluates participants' comprehension and implicitly assesses vocabulary and grammar knowledge. The percentage of correct answers indicates the level of proficiency. This test is of free access and is available online at: https://www.cambridgeenglish.org/test-your-english/general-english/

Impulsive Behavior Scale (UPPS)

Since gambling behavior (i.e., more or less GF) may be influenced by participants' impulsivity, we applied the Impulsive Behavior Scale (Lynam et al, 2009) as a global measure of participants' impulsive behavior. UPPS is a 59-item self-report scale (Lynam et al, 2009) that assesses impulsivity as a multi-dimensional construct, comprising negative urgency (NU; i.e., the tendency to act rashly under extreme negative emotions), lack of premeditation (PM; i.e., the tendency to act without thinking), lack of perseverance (PS; i.e., inability to remain focused on a task), sensation seeking (SS; i.e., tendency to seek out novel and thrilling experiences), and positive urgency (PU; i.e., tendency to act rashly under extreme positive emotions; Whiteside & Lynam, 2001).

Psychophysiological Measures

Skin Conductance Responses (SCRs) is a measure of the electrodermal system that records the momentary increase in electrical conductance of the skin due to additional sweat in the eccrine ducts, reported as numbers of responses over a period of time. We used James One portable sensors that are connected to the computer via Bluetooth (see Moreira et al., 2019 for a quality comparison with Biopac MP36). Participants' baseline signal was registered for one minute, while they were instructed to remain calm and looking at a fixation cross at the center of the screen.

Heart Rate (HR) is a measure of the cardiovascular system that consists of the number of beats per unit of time, usually one minute. HR was also recorded using JamesOne sensors, which record the blood volume pulse waveform.

SCRs and HR were collected simultaneously to behavioral data, throughout the experiment.

The Gambler's Fallacy Task

The experimental task was built using PsychoPy's software (v.2021.2.3). We applied a gambling task consisting of a card guessing game (adapted from Xue, et al., 2012b). In this task, participants are asked to decide what they think the computer's choice of cards is (either red or black card). Each trial starts with the simultaneous presentation of these two cards, on the left and right sides of the screen. First, the computer (C1) chooses one card in 1000 ms. Then, the participant (P2) guesses which card was chosen by the computer by pressing the corresponding button within 2000 ms. In our study, besides the choices of both the computer and the participant, verbal feedback in either English or Portuguese (depending on the block) was also displayed during 6000 ms to allow for a EDA measure, similar to what Agren et al. (2018) did.

The total of points detained was shown at the end of the entire game. A correct decision rewarded the player with 1 point, while an incorrect decision or an absent response resulted in a loss of the same amount. It was stated in the instructions that the computer chooses the cards randomly (i.e., the probability of choosing each card was 50%) and that it was a game of chance.

A win followed by a change of response represents a use of the GF. Similarly, a loss followed by a maintenance of the response demonstrates the use of the GF. The participant expects that, as the streak (i.e., same card selected by the computer over a period of time) gets longer, there is a correction of the probabilities. This means that, in a win situation, the other option becomes the winning one, and that, in a loss situation, the current choice has an increasing probability of becoming the winner. This win-shift-lose-stay strategy consists in deviating from the computer's last choice. The opposite strategy is the win-stay-lose-shift (WSLS), used in the remaining trials (Xue et al., 2012).

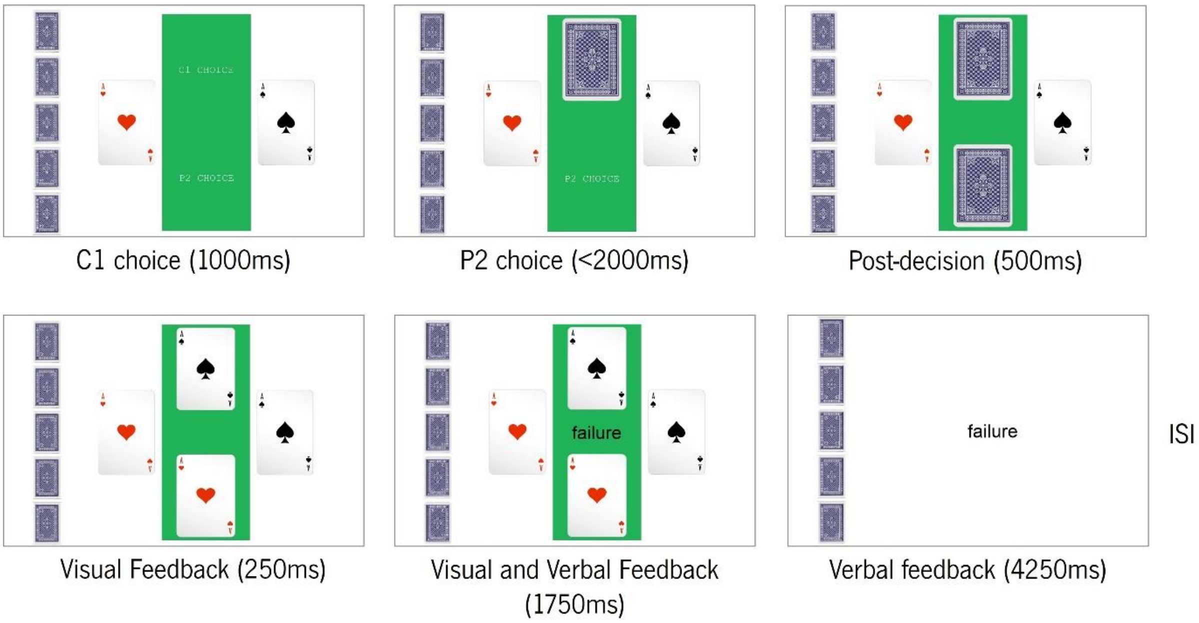
To guarantee that the probability that a streak will continue or break is always 50%, the computer's choices followed a sequence generated by a Bernoulli process ensuring: (1) equal number of black and red cards, (2) switch of card choice on half of the trials, and (3) streak length in an exponential distribution (Xue et al., 2012). The minimum streak length was, obviously, of one, and the maximum of six. This process is important because the optimal strategy for individuals in this type of game would be to choose the red or black card randomly.

To verify if the task was understood, participants completed five practice trials. To guarantee the same language activation induced by the presentation of the practice trials, 5 practice trials were also displayed before the beginning of the second block.

The procedure consisted of two 126-trial blocks, one with instructions and feedback in Portuguese and the other one in English. Block order was counterbalanced across participants. To minimize possible participants' exhaustion, the blocks were separated by a pause. Similar to what Xue et al. (2012) did, the computer's last five choices were displayed on the left side of the screen to reduce the working memory load. An example of a task trial can be seen in figure 1.

Figure 1

Example of an Experimental Task Trial



Note. The total amount of verbal feedback was 6000ms. Inter stimulus intervale (ISI, mean = 700ms) was varied to reduce expectancy effects. A fixation cross placed at the center of the screen was displayed during this time.

Stimuli

Positive feedback words were shown for wins and negative feedback words were shown for losses (Table 1). For each feedback valence condition, three English words and three Portuguese words were used. These words were non-cognate words (words only similar in meaning) once cognates words (words that are similar in form and meaning; Kroll & Groot, 2009), such as the Portuguese word “excelente”, would strongly activate the homonymous word in English (“excellent”; see Costa et al., 2005). Furthermore, these words were balanced for various linguistic measures known to affect processing, such as lexical frequency and length, and affective variables, such as arousal and valence, so that these parameters were equivalent between and within languages both for the positive and negative valenced words. The English words were selected from the BRM database (Warriner et al., 2013). Portuguese words were selected from ANEW-PT database and a previous pilot study (N=206 females, M=22.70 years, SD=1.53), aiming to increase the number of words in ANEW-PT database (Soares et al., 2012). Lexical frequency values (i.e., Lg10WF) were retrieved from SUBTLEX-US (Brysbaert & New, 2009) and SUBTLEX-PT (Soares et al., 2015).

Table 1

Feedback Words Used in the Gambling Task

Language	Words	Arousal Mean	Arousal SD	Valence Mean	Valence SD	N letters	Frequency
Portuguese	Bestial	6.10	2.1	7.50	1.2	7	3
	Deslumbrante	4.60	2.5	7.10	1.3	12	2.45
	Espantoso	6.40	2.0	7.20	1.4	9	3.16
	Errado	5.5	2.0	3.2	1.4	6.0	4.19
	Engano	5.10	1.83	3.33	1.49	6	3.32
	Fracasso	6.4	2.34	1.7	0.99	8	2.93
English	Amazing	6.29	2.58	8	1.05	7	3.62
	Awesome	5.85	3.41	8.5	0.76	7	3.20
	Beautiful	5.41	2.92	7.43	1.83	9	4.15
	Mistake	4.78	2.95	3.07	0.58	7	3.72
	Wrong	5.43	2.34	3.5	1.22	5	4.43
	Failure	4.79	2.25	1.89	1.18	7	3.01

Procedure

After the researcher explained the task, participants gave written informed consent. Excessive sweating was cleaned from participants' hands to enhance signal quality. Then, two electrodes with solid gel were then placed on the participants' left-hand palm (to record EDA) and another one to the index finger of same hand (to record HR). Participants could now start the experimental task by reading the instructions.

Following the completion of the experimental task, the researcher presented the questionnaires, explaining what was demanded and addressing any doubts. Participants first evaluated all feedback words regarding their arousal and valence, using the self-assessment manikin scale (Bradley & Lang, 1994). They also reported the subjective frequency of those words (i.e., perceived frequency of contact with each word) using a scale from 1 (never) to 7 (several times per day). Participants whose evaluation significantly deviated from the values retrieved from the words' database were excluded from further analysis. This was meant to serve as a manipulation check procedure. Since no major differences were found between participants ratings of the feedback words and the metrics from the databases, no data was excluded.

Participants then responded to the LHQ, LexTALE, CGET, and, finally, UPPS. The questionnaires assessing the language characteristics were presented after the experimental task to prevent any possible effect on data originating from this previous exposure to English content.

Data Analysis

L2 Characterization Questionnaires and Tests and UPPS-P Data Analysis

Descriptive data for the LexTale, CGET and self-reported proficiency (i.e., average score of the 4 self-reported measures already mentioned) was calculated, as well as for the 5 dimensions of UPPS-P. Unidimensional reliability for each of the dimensions was computed.

Behavioral Data Analysis

All data from PsychoPy was firstly pre-analyzed in Excel, where we calculated the proportion of GF and the average response times, for each streak length and language. Using Jasp software (0.16.2), we calculated the descriptive statistics (e.g., mean, SD) of the same variables. Afterwards, we partially replicated the analysis of the authors that originally built the Gambler's Fallacy Task (Xue et al., 2012). We computed a lagged logistic regression to examine the influence of streak length (1 to 6), outcome feedback (gain vs. loss), and the interaction of these two factors on the participant's subsequent strategy (GF or WSLS). For each participant two models were computed, one for each language block. Our main interest here was the overall accuracy of these models, which indicates how predictable is the subject's behavior once we know the introduced variables. Using t-test paired samples, we compared the accuracy of the two language blocks (Portuguese vs. English) for each participant. Like Xue et al. (2012), we divided the streak length into two categories: short (1 to 3) and long (4 to 6). The reasoning for this resides in the expectation that, as mentioned earlier, for longer streak lengths, the probability of using GF strategy is higher. Thus, we conducted repeated measures ANOVA using streak length (short vs. long) and language (Portuguese vs. English) as within-subjects factors to compare the differences in the proportion of GF as well as in RT, and, thus, verify if language moderates the relationship between streak length and GF, as well as with RT. We also computed Pearsons's correlation coefficients (or the equivalent non-parametric Spearman's correlations when the normality assumption was not met) to examine possible correlations between the proportion of GF, RTs, accuracy of the two logistic regression models, and the results of each questionnaire.

Psychophysiological Data Analysis

Using EDA recorded data files and PsychoPy's output file, we compared the onset times for feedback presentation, since studying participants reactivity to this event is our main interest using these measures. Thus, for each participant, a file of events, containing baseline and feedback onset times, feedback duration (6000ms) and conditions (language and valence) was built. Afterwards, we analysed participants data individually. The data from each subject was analyzed with NeuroKit2, a Python toolbox for neurophysiological data processing, such as ElectroDermal Activity (EDA). NeuroKit2 allows users to manage data, extract events and epochs from signals, process signal, among other operations (Makowski et al., 2021). After cleaning the data, EDA was divided into its tonic (slow changes in EDA signal) and phasic (rapid and marked changes in EDA signal) components (Posada-Quintero & Chon, 2020). SCR amplitude was also computed. We extracted the events and epochs (i.e., the interval from 1s after feedback onset to 1s after its offset). Finally, means for SCR amplitude, EDA Tonic (adjusted to participants baseline response) and EDA Phasic were calculated for each condition.

Unfortunately, due to technical errors, we lost a high proportion of our HR data, which made impossible its valid analysis. We also lost some of our EDA data, resulting in a total of 25 participants.

Results

L2 Characterization Questionnaires and Tests and UPPS-P Results

The descriptive statistics for UPPS-P and L2 proficiency assessment tests are presented on table 2.

The internal consistency obtained for UPPS-P achieved adequate levels for all the dimensions, ranging from 0.863 to 0.962. For self-reported proficiency questions, the internal consistency was of 0.937, also indicating an adequate level.

Table 2

Descriptive statistics, normality checks, and internal consistency for L2 proficiency questionnaires and tests and UPPS-P dimensions

	Mean	SD	Shapiro-Wilk	P-value of Shapiro-Wilk	Internal Consistency (Cronbach's alpha)
AoA English Speaking	7.9	2.426	0.923	.01*	–
AoA English Reading	8.275	2.025	0.907	.003**	–
AoA English Writing	8.45	2.195	0.907	.003**	–
Estimated number of years learning English	11.6	2.753	0.977	0.576	–

Percentage of time per day using Portuguese	79.644	14.393	0.902	.002**	–
Percentage of time per day using English	20.356	14.393	0.902	.002**	–
Self-Reported English Reading Proficiency	5.675	1.309	0.791	< .001**	–
Self-Reported English Writing Proficiency	4.8	1.572	0.927	.012*	–
Self-Reported English Speaking Proficiency	5.15	1.369	0.895	.001**	–
Self-Reported English Listening Proficiency	5.675	1.269	0.859	< .001**	–
Self-Reported Proficiency	5.325	1.276	0.923	.010*	0.937
Estimated capacity to learn new languages	4.756	1.179	0.866	< .001**	–
LexTale	70.235	12.284	0.976	.535	–
CGET	17.951	4.806	0.928	.013*	–
UPPS-PU	33.878	3.422	0.97	.343	0.962
UPPS-SS	30.756	3.787	0.987	.92	0.863
UPPS-NU	27.78	3.328	0.96	.158	0.91
UPPS-PM	19.073	6.976	0.922	.008**	0.938
UPPS-PS	21.707	4.445	0.953	.092	0.925

Behavioral Results

Table 3 shows descriptive statistics for the main measures for both Portuguese (PT) and English (EN), and the corresponding results of normality assumption checks. More detailed descriptive data can be consulted in appendix A.

Table 3

Descriptive statistics for the main measures

	Mean	SD	Shapiro-Wilk	P-value of Shapiro-Wilk
GF (all)	0.471	0.111	0.932	0.017
GF (Portuguese)	0.477	0.131	0.978	0.604
GF (English)	0.464	0.126	0.933	0.018
GF (short streak)	0.433	0.098	0.872	< .001
GF (long streak)	0.509	0.160	0.975	0.493
GF (Portuguese, short streak)	0.439	0.103	0.923	0.009
GF (Portuguese, long streak)	0.515	0.208	0.965	0.232
GF (English, short streak)	0.426	0.121	0.926	0.011
GF (English, long streak)	0.502	0.183	0.988	0.937
RT (all)	0.539	0.096	0.976	0.524
RT (Portuguese)	0.534	0.105	0.985	0.841
RT (English)	0.544	0.117	0.954	0.097
RT (short streak)	0.544	0.103	0.968	0.286
RT (long streak)	0.534	0.100	0.962	0.179
RT (Portuguese, short streak)	0.542	0.114	0.981	0.699
RT (Portuguese, long streak)	0.525	0.123	0.977	0.562
RT (English, short streak)	0.546	0.117	0.954	0.097
RT (English, long streak)	0.542	0.128	0.953	0.092
Accuracy LR[a] Portuguese	65.589	8.729	0.915	0.005
Accuracy LR[a] English[b]	65.558	7.575	0.958	0.145

a) Logistic Regression. b) This measure presents missing data for one participant.

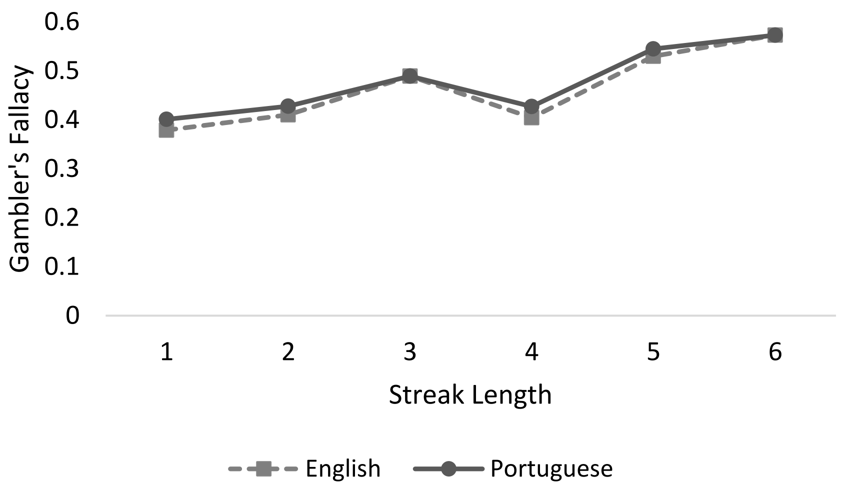
Consistent with our expectations and previous findings (e.g., Xue et al., 2012; 2018), there was a significant effect of streak length on GF [$F(1,40)$ =10.934, p= .002, η^2= .099], such that longer streak lengths have higher GF (M=0.509,SD=0.160) than shorter streak lengths (M=0.433 SD=0.098), indicating that participants were more likely to deviate from the computer's choice after long streaks (Figures 2 and 3). However, no statistically significant effects were found for language [$F(1,40)$ = 0.393, p= .534, η^2=.003], suggesting that language of feedback did not influence the strategy used for gambling.

Finally, no significant effect was found for the interaction between language and streak length on the GF [F(1,40)= 5.158e^{-4}, p= .982, η^2 =3.175e^{-6}; Figure 2]. For RT no significant effects of streak length [F(1,40)=0.984, p=.327, η^2=.005], language [F(1,40)=0.345, p=.560, η^2=.005], nor the interaction of both factors [F(1,40)=0.419, p=.521., η^2=.002] were found.

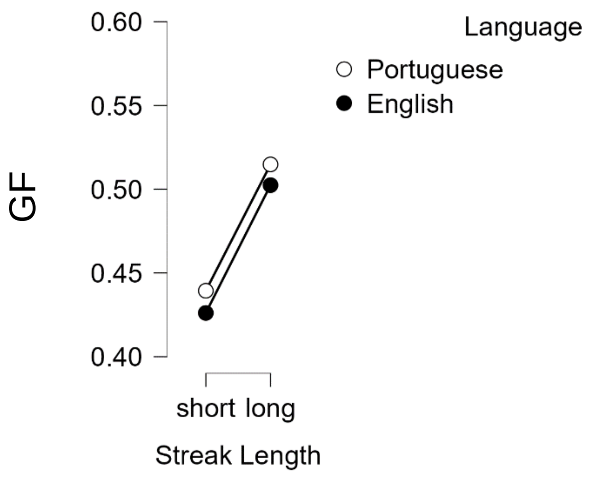
Figure 2

Differences in GF for the different streak lengths and for each language condition

a)



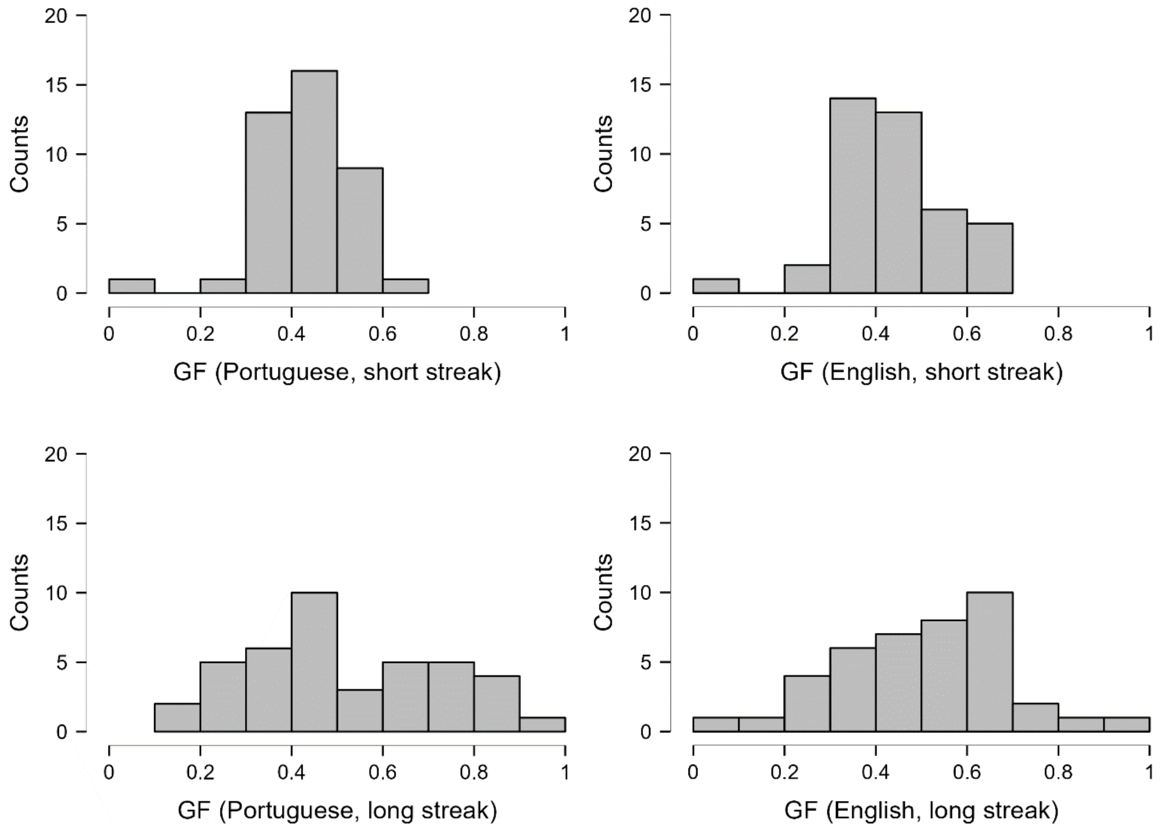
b)



Note. a) shows the differences in proportion of GF for all streak lengths, and b) the differences for short streak length (<4) vs. long streaks lengths (≥4). It is clear that, for short streaks, WSLS strategy is preferred, whereas for long streaks, a shift to GF occurs, a result also obtained by Xue et al. (2018).

Figure 3

Histogram of individual differences in the use of the GF strategy for short (<4) and long streaks (≥4) for each language condition



The accuracy of the logistic regression models for Portuguese (M=65.589, SD=8.729) and English (M=65.558, SD=7.575) conditions revealed no statistically significant differences [t(39)= 0.551, p= .585, d =0.087], indicating that streak length, outcome feedback and their interaction allowed a similar accuracy in the prediction of the participant's next strategy (deviate vs follow computer's last choice) in both Portuguese and English contexts. These accuracy values are similar to the 63.9 value obtained by Xue et al. (2018), who used an identical model. A significant positive correlation emerged between RT for Portuguese and UPPS-PS dimension (r=0.311, p=.048). There's also a significant negative correlation between RT in English condition and Lextale performance (s=-0.388, p=.012) and, also, with the Self-reported proficiency (s=-0.314, p=.048). RT in Portuguese for short streak also presents a significant correlation with UPPS-PS (r=0.314, p=.046). The accuracy of the individual logistic regression models for English was also significantly associated with the UPPS–SS [r=-0.342, p=.031; all correlations are presented in appendix B].

Psychophysiological Results

Descriptive statistics are displayed in Table 4. Considering the SCR Amplitude, the evidence revealed a significant effect of valence of feedback [$F(1,24)=5.517$, $p=.027$, $\eta^2=0.011$], such that negative feedback elicited higher SCR amplitudes (M=0.061, SD=0.057) compared to positive feedback (M=0.044, SD=0.44). However, no significant effect of language [$F(1,24)=0.216$, $p=.646$, $\eta^2=0.008$] or of interaction [$F(1,24)=0.716$, $p=.406$, $\eta^2=0.002$] emerged (Figure 4). For the tonic component of the signal, no significant effects of either valence [$F(1,22)=0.874$, $p=.360$, $\eta^2=2.124e^{-4}$], language [$F(1,22)=0.895$, $p=.354$, $\eta^2=.039^{4}$] and of interaction [$F(1,22)=9.101e^{-5}$, $p=.992$, $\eta^2=1.305e^{-8}$] were found. Similarly, phasic component revealed no significant effects of valence[$F(1,22)=0.098$, $p=.757$, $\eta^2=0.002$], language [$F(1,22)=0.567$, $p=.460$, $\eta^2=0.007$] or of interaction [$F(1,22)=0.008$, $p=.930$, $\eta^2=1.113e^{-4}$].

Table 4

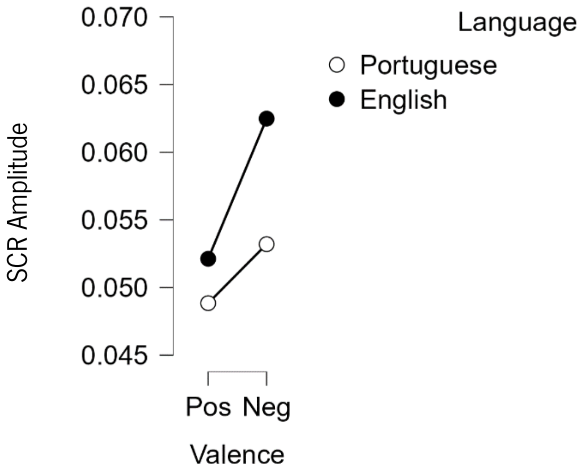
Descriptive statistics for psychophysiological measures.

	Mean	SD
SCR_Amp_PT_Pos	0.049	0.045
SCR_Amp_PT_Neg	0.053	0.053
SCR_Amp_EN_Pos	0.052	0.059
SCR_Amp_EN_Neg	0.062	0.074
Tonic_PT_Pos	-0.515	2.481
Tonic_PT_Neg	-0.489	2.433
Tonic_EN_Pos	-0.418	2.886
Tonic_EN_Neg	-0.375	2.848

	Mean	SD
Phasic_PT_Neg	3.167e-4	0.007
Phasic_EN_Pos	0.001	0.005
Phasic_EN_Neg	0.002	0.008

Figure 4

SCR Amplitude for positive and negative valence, for each language context



Discussion

The present study aimed at investigating the FLE in the context of risky decision-making, specifically regarding the use of GF strategy. We used a gambling task with feedback in either Portuguese (L1) or English (L2) to assess the influence of language on participants' gambling behavior (i.e., proportion of GF and RT). Furthermore, we used EDA to obtain a different perspective on the interaction of FLE and emotional reactivity, what no previous study has done before. Besides, we intended to test two similar but concurrent hypotheses: emotion-reducing and positivity bias hypothesis.

The results obtained show a significant effect of streak length, which indicates that the manipulation of the task had the intended effect on the proportion of GF (i.e., more GF for longer than shorter streak length). However, contrary to our predictions, this difference in GF was not moderated by language of feedback, with similar results for both Portuguese and English conditions. For RT, neither of variables revealed a significant effect. Besides, the accuracy of the individual logistic regression models for both languages were identical, revealing that streak length, outcome feedback and their interaction allowed an equally good prediction of participants' subsequent strategy for both Portuguese and English contexts. Thus, to what concerns behavioural data, we conclude that no significant FLE was found.

Regarding EDA, there was only one significant effect which concerned the SCR Amplitude and valence of feedback, such that negative feedback elicited higher SCR amplitudes compared to positive feedback. This result is consistent with previous literature showing that negative stimuli elicit greater autonomic arousal than positive stimuli (e.g., Harris et al., 2003). Besides, since the task involved losses in a game and participants are susceptible to loss aversion (i.e., the perceived pain of losing is more powerful than the pleasure of gaining), this result makes even more sense. Since no significant effect of language emerged, we conclude that no FLE was found at the psychophysiological level, although the mean scores show that SCR amplitudes tend to be higher in English compared to Portuguese. Hence, we conclude that, although some minor hypotheses were verified, we could not verify our main hypothesis regarding the L2 influence on participants GF-like behavior, both behaviorally and neurophysiologically.

The absence of FLE on GF is consistent with previous results already mentioned (e.g., Zheng et al., 2020) that found GF in a task with equal-odds bets with the same values that was similar in L1 and L2 contexts. Other studies involving this task also failed to find a FLE (e.g., Hu et al., 2022). Thus, as previously mentioned in our introduction, it is possible that GF is not influenced by language of feedback, even tough the similar HHF is (Gao et al., 2015). In fact, unlike most of the decision biases, GF was found to be positively correlated with stronger cognitive control ability, reflected by higher working memory and conflict resolution capacities, but negatively correlated with their affective decision-making capacities, as measured by the Iowa Gambling Task (Xue et al., 2012a). Moreover, Tijms (2022) suggests that GF is not the result of a biased decision, but instead results from the intuitive understanding of mathematical probability, which leads us to erroneously apply the law of large numbers to small numbers, because it requires compensating for runs of the same outcome (see also Tversky & Kahneman, 1971). Considering the cognitive nature of the GF and the growing evidence indicating that FLE is present exclusively in emotionally rooted biases, the absence of FLE is a consistent result. Together, these aspects may justify the fact that GF was not affected by FLE.

Regarding the two theoretical explanations (emotion-reducing and positivity bias account), even though there was only a significant effect of valence, English context appears to induce higher SCR amplitudes, a pattern that seems partially in line with the positivity bias account. Nevertheless, results should be interpreted carefully given the lack of statistically significant findings. Furthermore, it is also possible that FLE is the result of multiple factors, depending on the linguistic profile of each bilingual and its history of L2 acquisition. Furthermore, although emotion-reducing and positivity explanations are the ones that gather more empirical evidence, it is still possible that FLE results from a combination of reduced emotionality, cognitive enhancement, and cognitive overload (Kirova & Camacho, 2021).

One limitation of our study resides in the fact that we analysed only Portuguese-English bilinguals and no English-Portuguese bilinguals or other pairs of languages, which does not allow us to eliminate the possibility that the results found are exclusive of these population and do not generalize to all bilinguals. Besides, it is also possible that the total amount duration of out experimental task (approximately 40 minutes) resulted in participants' exhaustion.

Further investigation is needed to build solid and congruent evidence on the FLE boundaries. This will also allow a better comprehension of the factors responsible for this effect. Future studies should make efforts to conduct studies with appropriate samples to attempt to disentangle the effects of variables such as L2 age of acquisition, proficiency, usage, immersion, and acculturation, even though some of these may be partially overlapping (e.g., self-reported proficiency may indicate less L2 use and, in turn, weaker emotional experience; Luk & Bialystok, 2013). Investigation should also include different types of bilinguals, since it is mostly conducted with sequential bilinguals who acquired L2 in school context, a population that is distinct from early bilinguals, who have comparable emotional resonances in both languages (e.g., Harris et al., 2003; Harris et al., 2006). A thorough assessment with valid instruments is also crucial to better comprehend bilinguals' characteristics, analysing variables in a continuum. Furthermore, we believe that FLE literature would benefit from crossing data from bilingual, decision-making, and emotionality research. For example, McFarlane and Cipolletti Perez (2020) acknowledge that emotionality is a highly complex concept and one that is hard to measure in the absence of a predictive and generalizable theory of emotion.

The present study adds evidence to the FLE literature, as well as for understanding emotional reactivity through a more rigorous and objective measure, like EDA.

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Appendix A

Table A1

Proportion of trials using the GF strategy following different streak lengths in each language

		Streak Length					
		1	2	3	4	5	6
Portuguese	Mean	0.401	0.428	0.489	0.427	0.545	0.573
	Standard Deviation	0.103	0.126	0.192	0.205	0.310	0.363
English	Mean	0.379	0.410	0.489	0.404	0.530	0.573
	Standard Deviation	0.114	0.149	0.183	0.218	0.280	0.363

Table A2

Mean Reaction Times in milliseconds following different streak lengths in each language condition

		Streak Length					
		1	2	3	4	5	6
Portuguese	Mean	0.552	0.544	0.532	0.544	0.523	0.509
	Standard Deviation	0.120	0.141	0.113	0.119	0.191	0.220
English	Mean	0.546	0.547	0.545	0.565	0.576	0.485
	Standard Deviation	0.124	0.124	0.127	0.183	0.182	0.200

Appendix B

	UPPS-P					LexTale	CGET	Self-Reported Proficiency
	PU	SS	NU	PM	PS			
GF (All)	0.026	0.006	-0.023	-0.084	-0.110	0.116	0.207	0.161
	(p=.874)[b]	(p=.971)[b]	(p=.886)[b]	(p=.600)[b]	(p=.494)[b]	(p=.469)[b]	(p=.195)[b]	(p=.319)[b]
GF (Portuguese)	-0.108	-0.082	0.049	0.005	-0.175	—	0.290	0.099
	(p=.503)	(p=.611)	(p=.761)	(p=.978)	(p=.272)		(p.=066)	(p=.543)
GF (English)	0.177	0.034	-0.093	-0.123	0.056	0.079	0.136	0.147
	(p=.268)[b]	(p=.831)[b]	(p=.563)[b]	(p=.445)[b]	(p=.727)[b]	(p=.625)[b]	(p=.397)[b]	(p=.366)[b]
GF (short streak)	0.031	0.146	-0.306	-0.280	-0.139	-0.052	0.012	0.014
	(p=.847)[b]	(p=.364)[b]	(p=.052)*[b]	(p=.076)[b]	(p=.387)[b]	(p=.746)[b]	(p=.941)[b]	(p=.933)[b]
GF (long streak)	0.062	-0.023	0.120	0.020	-0.045	0.206	0.317	0.196
	(p=.702)	(p=.888)	(p=.453)	(p=.899)[b]	(p=.780)	(p=.197)	(p=.044)*[b]	(p=.226)
GF (Portuguese, short streak)	-0.074	0.173	-0.194	-0.232	-0.293	0.130	0.117	-9.417e-4
	(p=.644)[b]	(p=.279)[b]	(p=.225)[b]	(p=.145)[b]	(p=.063)[b]	(p=.419)[b]	(p=.465)[b]	(p=.995)[b]
GF (Portuguese, long streak)	-0.114	-0.112	0.071	0.153	-0.126	0.090	0.214	0.104
	(p=.478)	(p=.485)	(p=.658)	(p=.339)	(p=.434)	(p=.578)	(p=.178)	(p=.524)
GF (English, short streak)	0.133	0.150	-0.297	-0.321	-0.031	-0.145	-0.051	0.075
	(p=.405)[b]	(p=.348)[b]	(p=.060)[b]	(p=.041)*[b]	(p=.848)[b]	(p=.366)[b]	(p=.753)[b]	(p=.645)[b]
GF (English, long streak)	0.238	0.088	0.130	-0.110	0.064	0.259	0.357	0.226
	(p=.134)	(p=.584)	(p=.417)	(p=.495)	(p=.689)	(p=.102)	(p=.022)*[b]	(p=.160)
RT (All)	-0.134	-0.161	0.074	0.277	0.305	-0.348	-0.167	-0.250
	(p=.402)	(p=.315)	(p=.644)	(p=.079)[b]	(p=.053)*	(p=.026)*	(p=.296)	(p=.120)[b]
RT (Portuguese)	0.023	-0.145	0.127	0.230	0.311	-0.226	-0.077	-0.171
	(p=.887)	(p=.364)	(p=.427)	(p=.148)[b]	(p=.048)*	(p=.156)	(p=.634)	(p=.290)[b]
RT (English)	-0.241	-0.134	0.008	0.167	0.222	-0.388	-0.164	-0.314
	(p=.128)	(p=.402)	(p=.959)	(p=.295)	(p=.163)	(p=.012)*[b]	(p=.306)	(p=.048)*[b]
RT (short streak)	-0.144	-0.181	0.120	0.179	0.284	-0.369	-0.118	-0.223
	(p=.369)	(p=.257)	(p=.456)	(p=.262)	(p=.071)	(p=.018)*	(p=.464)	(p=.166)[b]
RT (long streak)	-0.110	-0.122	0.019	0.164	0.292	-0.269	-0.200	-0.289
	(p=0.495)	(p=.446)	(p=.904)	(p=.304)	(p=.064)	(p=.089)[b]	(p=.210)	(p=.070)[b]
RT (Portuguese, short streak)	-0.098	-0.181	0.198	0.296	0.314	-0.305	-0.085	-0.054
	(p=.540)	(p=.258)	(p=.214)	(p=.060)[b]	(p=.046)*	(p=.053)*	(p=.595)[b]	(p=.739)[b]
RT (Portuguese, long streak)	0.131	-0.080	0.033	0.057	0.238	-0.102	-0.031	-0.245
	(p=.415)	(p=.619)	(p=.837)	(p=.724)	(p=.133)	(p=.526)	(p=.845)[b]	(p=.128)

	UPPS-P					LexTale	CGET	Self-Reported Proficiency
	PU	SS	NU	PM	PS			
RT (English, short streak)	-0.158 (p=.324)	-0.143 (p=.371)	0.018 (p=.911)	0.113 (p=.480)	0.196 (p=.220)	-0.359 (p=.021)*[b]	-0.060 (p=.710)	-0.329 (p=.038)*[b]
RT (English, long streak)	-0.297 (p=.060)	-0.114 (p=.477)	-0.002 (p=.992)	0.202 (p=.205)	0.227 (p=.154)	-0.345 (p=.027)*[b]	-0.242 (p=.128)[b]	-0.307 (p=.054)*[b]
Accuracy LR[a] Portuguese	-0.051 (p=.751)[b]	0.052 (p=.745)[b]	-0.026 (p=.869)[b]	-0.179 (p=.262)[b]	0.047 (p=.769)[b]	-0.221 (p=.165)[b]	-0.220 (p=.167)[b]	-0.006 (p=.972)[b]
Accuracy LR[a] English	0.043 (p=.793)	-0.342 (p=.031)*	0.143 (p=.377)	0.131 (p=.422)	0.120 (p=.461)	-0.068 (p=.676)	0.002 (p=.989)	-0.075 (p=.649)

a) Logistic Regression. b) Spearman's coefficient.

Universidade do Minho

Conselho de Ética

Comissão de Ética para a Investigação em Ciências Sociais e Humanas

Identificação do documento: CEICSH 120/2021

Relatores: Emanuel Pedro Viana Barbas Albuquerque e Marlene Alexandra Veloso Matos

Título do projeto: *The Foreign Language Effect and the Gambler's Fallacy: Evidence from Neurophysiology*

Equipa de Investigação: Pedro Miguel Silva Moreira, Centro de Investigação em Psicologia (CIPsi), Escola de Psicologia, Universidade do Minho; Ana Paula Carvalho Soares, Centro de Investigação em Psicologia (CIPsi), Escola de Psicologia, Universidade do Minho; Márcia Costa, Mestrado Integrado em Psicologia, Escola de Psicologia, Universidade do Minho

PARECER

A Comissão de Ética para a Investigação em Ciências Sociais e Humanas (CEICSH) analisou o processo relativo ao projeto de investigação acima identificado, intitulado *The Foreign Language Effect and the Gambler's Fallacy: Evidence from Neurophysiology.*

Os documentos apresentados revelam que o projeto obedece aos requisitos exigidos para as boas práticas na investigação com humanos, em conformidade com as normas nacionais e internacionais que regulam a investigação em Ciências Sociais e Humanas.

Face ao exposto, a Comissão de Ética para a Investigação em Ciências Sociais e Humanas (CEICSH) nada tem a opor à realização do projeto nos termos apresentados no Formulário de Identificação e Caracterização do Projeto, que se anexa, emitindo o seu parecer favorável, que foi aprovado por unanimidade pelos seus membros.

Braga, 11 de janeiro de 2022.

O Presidente da CEICSH

(Acílio Estanqueiro Rocha)

Anexo: Formulário de identificação e caracterização do projeto

Comissão de Ética para a Investigação em Ciências Sociais e Humanas (CEICSH)

Universidade do Minho

Formulário de identificação e caracterização do projeto

Identificação do projeto

Título do projeto	The Foreign Language Effect and the Gambler's Fallacy: Evidence from Neurophysiology		
Data prevista de início	**November, 2021**	**Data prevista fim**	**July, 2021**

Investigador principal e filiação	Pedro Miguel Silva Moreira - Research Centre on Psychology (CIPsi), School of Psychology, University of Minho
Orientador(es) e filiação	Pedro Miguel Silva Moreira - Research Centre on Psychology (CIPsi), School of Psychology, University of Minho; Ana Paula Soares - Research Centre on Psychology (CIPsi), School of Psychology, University of Minho;

Nota: No caso de projetos de mestrado ou doutoramento deve ser indicado o estudante como investigador principal e o nome do mestrado ou doutoramento

Instituição proponente	Research Centre on Psychology (CIPsi), School of Psychology, University of Minho
Instituição(ões) onde se realiza a investigação	Research Centre on Psychology (CIPsi), School of Psychology, University of Minho

Entidades financiadoras	Not applicable

Questões relativas ao envolvimento de investigadores exteriores		
Estão envolvidos no projeto, colegas de outra (s) Escola(s)/Instituição(ões)?	S	N
Se sim, este pedido de parecer cobre o seu envolvimento?	S	N

Qualificação dos investigadores

Doctor Pedro Miguel Silva Moreira possesses qualifications and knowledge in the field of decision-making and also in the domain of neurophysiological measures and its data analysis. Doctor Pedro is currently a researcher at Neuropsychophysiology Laboratory, at the Center of Investigation in Psychology (CIPsi), University of Minho.

Doctor Ana Paula Carvalho Soares is Assistant Professor at the Basic Psychology Department of University of Minho and and a senior investigator at Center of Investigation in Psychology (CIPsi, https://www.psi.uminho.pt/pt/investigacao/Paginas/Centro_de_Investigacao_em_Psi cologia_(CIPsi).aspx) of School of Psychology, University of Minho. Doctor Ana Paula is also the coordinator of Psycholinguistics Research Group (PRG) of the same university (see http://escola.psi.uminho.pt/unidades/psicolinguistica/).

Márcia Costa currently a student of the Integrated Master's Degree in Psychology at the University of Minho, has already successfully completed the first year of the Master and the three previous years of the degree. During this period, the researcher had the opportunity to acquire relevant knowledge about research in the field of Psychology and knowledge specifically focused on psychological neuroscience and on the development of this area.

Caracterização do projeto e questões de carácter ético relativas à sua execução

Introdução justificativa do projeto e sumário dos seus objetivos

When using their foreign (L2) rather than their native language (L1), people tend to be less biased, an effect that has been referred to as the *Foreign Language Effect* (FLE). Since the findings of Keysar et al. (2012), several studies have tested the FLE in different bias contexts and with distinct L1-L2 combinations (e.g., Costa et al., 2014). Two of such biases are the Hot Hand Fallacy (HHF) and the Gambler's Fallacy (GF), that often emerge in situations of risky decision making. Indeed, the results of previous studies assessing the FLE in these biases seem to suggest that only the HHF is subject to the effect (Gao et al., 2015, Zheng et al., 2020). In this study, we aim to further clarify the results obtained by these studies, using a card guessing task, manipulating the valence (positive vs negative) and language of feedback (Portuguese vs English). Behavioral and psychophysiological measures of thirty Portuguese-English bilinguals will be collected. Variables regarding history of language use and acquisition will be assessed and only participants with intermediate L2 proficiency will be admitted.

Two distinct theoretical hypotheses will be put to test: the emotion reduction account and the positive bias account. According to the emotion reduction account, decision biases that involve an emotional reaction are less pronounced when presented in one's L2 rather than one's L1. On the other hand, according to the positive bias hypothesis, in L2 the reduction in emotional response is restricted to negative emotions. These two hypotheses are, essentially, distinct in predictions regarding the emotional reactivity to negative emotions, assumed to be decreased in L2 compared to L1 context. Thus, it is expected that, according to the emotion reduction account, lower amplitudes of SCRs and lower HR are found for both positive and negative feedback in L2 compared to L1. In line with the positive bias hypothesis, it is predicted that lower amplitudes of SCRs and lower HR are found for L2 compared to L1, particularly for negative feedback.

Hence, considering that GF is predicted by an attenuation in emotional reactivity, as mentioned before, according to the emotion reduction accounting, it is hypothesized that GF will be increased in L2 compared to L1 context, independently of feedback valence. However, according to the positive bias accounting, it is expected that GF will be increased in reaction to feedback in L2 compared to L1, particularly in the context of negative feedback.

Furthermore, it is hypothesized that reaction times will be inversely proportional to emotional reactivity (i.e., where we predict a greater emotional reactivity, we also expect shorter reaction times, and vice-versa).

Participantes

Thirty Portuguese-English bilingual students will be recruited from the School of Psychology. Thirty is assumed to be a sufficient sample size in line with Gao et al.'s (2015) and Zheng et al.'s (2020) works. All participants will have to be right-handed and with normal or corrected-to-normal vision, no language disabilities, and no reported history of neurological or psychiatric disorders to be admitted. Also, only Portuguese dominant bilinguals with intermediate English proficiency and no history of living abroad will participate in the study. To assess these and other important variables participants will respond to a questionnaire developed in *Qualtrics*, Lexical Test for Advanced Learners of English and Cambridge General English Test, all online.

Recrutamento e triagem

Participants will be recruited from School of Psychology of the University. After signing in for participation, participants will be given information about the study. If they wish to participate they will have to provide an online consent.

Compensação e custos

Participants will be rewarded for their participation with academic credits. Besides, the three participants that have the better results (largest amount of points) will also receive movie tickets.

Procedimento

After register for participation, participants will read and give online informed consent. Then, they will respond to a short version of the Language History Questionnaire (Li, Sepanski & Zhao, 2006) developed using *Qualtrics*, followed by Cambridge General English Test (https://www.cambridgeenglish.org/test-your-english/general-english/), and, lastly, LexTALE (http://www.lextale.com/takethetest.html; Lemhöfer & Broersma, 2012). The aim of these measures is to better assess participants L2 proficiency, since a poor characterization of bilingual participants may be a common pitfall of previous studies.

Once in the soundproof chamber of the laboratory, the electrodes and transducer will be attached to participants' left hand and index finger, while they read the task instructions. Importantly, to motivate the participants and induce perception of real losses, participants will be told, truthfully, that the better 3 players will receive movie tickets after all data is collected. At this stage, participants will also be told that the outcome of the game is random. This is important because the optimal strategy for individuals in this type of game would be to choose the red or black card randomly.

Subsequently, to verify if the task is understood and every device is working correctly, participants will complete 10 practice trials.

We will apply a gambling task consisting of a card guessing game (adapted from Xue, et al., 2012). In this task, participants are asked to decide what they think the computer's choice of cards is (either red or black card). Each trial starts with the simultaneous presentation of these two cards, on the left and right sides of the screen (cards' positions are counterbalanced across participants). First, the computer chooses one card in 1000 ms. Then, participant decides which card he thinks was chosen by the computer by pressing the corresponding button within 2000 ms (buttons are counterbalanced across participants). In our study, besides the choices of both the computer and the participant, verbal feedback in either English or Portuguese (depending on the block) will also be displayed during 6000 ms to allow for a SCR measure. The outcome of the guess will consist of positive feedback words (for wins) or negative feedback words (for losses), and the points earned/lost, as well as the total of points detained by participants. A correct decision will reward the player with 1 point, while an incorrect decision will result in a loss of the same amount. For each feedback valence condition, 10 English words and 10 Portuguese words will be used. Importantly, these words will be controlled for various linguistic measures, such as lexical frequency, extension, semantics, and affective variables, such as arousal. To do that, words will be selected from the English and Portuguese versions of the database ANEW (Soares et al., 2012).

The whole procedure will consist of two 64-trial blocks, one block with instructions and feedback in Portuguese and the other one in English. Block order will be counterbalanced across participants. To minimize possible participants' exhaustion, the experiment will take place in two sessions. This study will consist of 2x2 within-subject design, with language (L1, L2) and feedback valence (positive, negative) being the factors manipulated.

Benefícios, Riscos e Desconforto

No risks are anticipated. Stress due to reactivity to loss in the task might be experienced. Every participant will be compensated with academic credits.

Confidencialidade

Data collected during the study will be kept anonymous and confidential. Electronical data will be encrypted. Only a limited number of people (members of the investigation team) will have access to data, being subject to confidentiality duty.

Conflito de interesses

No conflict of interests to report.

Consentimento Informado

A investigação envolve apenas voluntários saudáveis?	<u>S</u>	N
A investigação envolve grupos vulneráveis: crianças, menores, idosos ou outras pessoas com incapacidade temporária ou permanente?	S	<u>N</u>
O pedido de parecer inclui a declaração de consentimento informado, livre e esclarecido?	<u>S</u>	N

Aqui tem de escolher o formato de consentimento informado

[x] Consentimento informado, livre e esclarecido para participação em investigação - de acordo com a Declaração de Helsínquia e a Convenção de Oviedo
[ ] Consentimento informado não assinado - E.g. formulário para questionários preenchidos online. Deverá adicionar a informação incluída e o modo de os participantes concordarem em participar
[ ] Consentimento informado alterado - Um formulário de consentimento informado que omite informação requerida. E.g., se não indica o objetivo do estudo para evitar o viés na resposta dos participantes. Deve explicar o racional no procedimento e os processos de *debriefing*
[ ] Isenção de consentimento – quando não é obtido consentimento informado – esta opção pode ser apropriada para utilização de dados já disponíveis. Justifique

Anexe o formulário de consentimento informado e outro material informativo relevante quando adequado, ou justifique a isenção de consentimento

Assinatura do Investigador Responsável

………………………………………………………………………………………

Documentação a anexar

i. Cópia dos questionários ou formulários de recolha de dados a utilizar, quando aplicável;
ii. Modelo de consentimento informado, de acordo com as declarações, diretivas e regulamentos internacionais, europeus e nacionais, se aplicável, devidamente ajustado linguística e culturalmente às populações a que é dirigido;

iii. Declaração do(s) responsável(eis) pelo projeto, explicitando que os dados obtidos são confidenciais e usados apenas no âmbito do estudo em questão;
iv. Modelo de declaração de compromisso para outros investigadores ou colaboradores na investigação, se aplicável, destinada a documentar o seu envolvimento nas garantias de confidencialidade dadas pelo(s) responsável(eis) do projeto no âmbito do processo apresentado;
v. Informação a que se refere o número 3 do artigo 4.º das normas orientadoras da CEICSH, sobre o enquadramento, apoio e viabilidade do projeto, facultada pelo responsável da unidade/subunidade orgânica e/ou serviço onde se vai desenvolver o projeto e/ou onde serão recolhidos os dados;
vi. Declaração do(s) orientador(es) científico(s) do estudo, se aplicável, de acordo com o estabelecido no número 4 do artigo 4.º das normas orientadoras da CEICSH;
vii. Cópia de notificações a autoridades nacionais (e.g., Direção-Geral da Educação, no caso dos inquéritos em ambiente escolar) europeias ou internacionais competentes, se aplicável, juntamente com o parecer/autorização das mesmas, se emitido;
viii. Curriculum vitae resumido do(s) responsável(eis) pelo projeto e dos restantes membros da equipa de investigação.

Deverá ser seguido o Regulamento Geral de Proteção de Dados (RGPD), com entrada em vigor em 25 de Maio de 2018, - REGULAMENTO (UE) 2016/679 DO PARLAMENTO EUROPEU E DO CONSELHO, de 27 de abril de 2016, relativo à proteção das pessoas singulares no que diz respeito ao tratamento de dados pessoais e à livre circulação desses dados, que revoga a Diretiva 95/46/CE (Regulamento Geral sobre a Proteção de Dados).