Original Article

The effect of discount messages on impulse buying and self-control: investigating arousal through brain's emotion signals

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Abstract

Background: This study investigated the impact of discount messages and individual self-control on arousal and Impulse buying behavior during purchasing processes.

Methods: A laboratory experiment was conducted using a 2×3 between-subjects factorial design with 99 participants (mean age = 24.5, SD = 3.2; 52% female), randomly assigned to six experimental groups. The independent variables were self-control and discount message type (product-based discount, percentage discount, or no discount). Participants completed a simulated online shopping task while EEG data were recorded from 19 channels (10-20 system), focusing on frontal beta-to-alpha power ratios as a neural marker of arousal. Impulse buying was measured via post-experiment purchase intentions and actual checkout behavior. Data were analyzed using mediation analysis (PROCESS Model 4) with bootstrapping (5,000 samples).

Results: The findings indicate that arousal did not significantly mediate the relationship between self-control and impulse buying. However, arousal significantly mediated the effect of product discount on impulse buying but not percentage discount. Furthermore, product discounts had a direct positive effect on impulse buying, while percentage discounts did not significantly influence impulse buying. These results highlight that discount type plays a crucial role in triggering arousal-driven impulse buying behavior. EEG analysis revealed that heightened arousal levels (beta-to-alpha ratios in frontal regions) corresponded with increased impulse Buying, reinforcing the role of arousal as a driver of emotional decision-making.

Conclusion: These insights emphasize the need for marketing strategies that balance emotional engagement and consumer self-regulation. Businesses should consider differentiating discount types and promotional techniques to sustain consumer interest while mitigating post-purchase regret.

Keywords: Arousal; Electroencephalography; Percentage Discount; Product Discount; Self-Control.

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Introduction

Impulse buying is a widely recognized consumer behavior that has attracted significant attention in marketing and psychological research. It is typically characterized as an unplanned purchase driven by emotional and psychological factors rather than rational decision-making (1-4). From a theoretical perspective, impulse buying reflects a conflict between two systems: the impulsive system (driven by emotional arousal) and the reflective system (governed by self-control), as posited by Dual-System Theory. This emotional behavior is often influenced by external stimuli such as discount messages, store environments, and promotional strategies, which reduce decision-making barriers and increase consumer arousal (5).

Research has shown that discount messages play a pivotal role in impulse buying. When consumers encounter attractive discounts, they are more likely to make unnecessary and unplanned purchases (6). According to the PAD (Pleasure-Arousal-Dominance) model, arousal mediates the effect of environmental stimuli (e.g., discounts) on behavior. For example, product-based discounts (e.g., "Buy One, Get One Free") may evoke stronger arousal than percentage discounts (e.g., "50% off"), as they directly amplify perceived hedonic benefits (7). Specifically, discount messages, with their urgent and appealing nature, stimulate emotional responses that encourage quicker purchasing decisions (8).

In the context of online shopping, arousal and pleasure are key factors influencing impulse buying behaviors. Various external factors such as time pressure, quantity pressure, economic benefits, social influence, visual stimuli, and sound stimuli contribute to heightened arousal levels, which can prompt immediate purchases (9). However, individual differences also play a crucial role in impulse buying. Consumers with high levels of self-control are generally more resistant to environmental stimuli and tend to make purchasing decisions based on logical priorities rather than emotional impulses (10-11). This aligns with the Dual-System Theory, where self-control deficits weaken the reflective system's ability to inhibit impulsive urges.

Given the interplay between discount messages, self-control, and arousal, this study aims to examine whether arousal mediates the relationship between discount messages, self-control, and impulse buying behavior. Specifically, it seeks to explore how external environmental stimuli (e.g., discount messages) and intrinsic individual characteristics (e.g., self-control) influence impulse buying behavior through the mediating effect of arousal. By clarifying these relationships, this study contributes to a deeper understanding of consumer psychology and decision-making processes.

The findings of this research have practical implications for marketers and businesses seeking to understand and regulate impulse buying behaviors. A deeper understanding of the dynamic interaction between psychological constructs (e.g., self-control), emotional states (e.g., arousal), and consumer behaviors (e.g., impulse buying) can help businesses develop more effective marketing strategies. By leveraging this knowledge, companies can refine their promotional approaches to enhance consumer engagement while mitigating the negative consequences associated with impulse buying.

Methods

Research Setting and Study Population

The experiment was conducted at the University of Tehran's Business Research Laboratory. Participants in this study were university students who voluntarily took part in the experiment.

Data Collection Method

In this study, electroencephalography (EEG) was used to ensure accurate neural data collection. The experiment employed a

2 (self-control: depleted vs. control) × 3 (discount type: no discount, percentage discount, product discount) between-subjects design, with 99 participants randomly assigned to six experimental groups (see Table 1 for group allocation). Each group contained 16–17 participants to ensure balanced cell sizes.

Participant Allocation Details:

- Groups with Stroop test (Self-control Depletion):
  - Group 2 (No Discount): 16 participants
  - Group 4 (Percentage Discount): 17 participants
  - Group 6 (Product Discount): 17 participants
- Groups without Stroop test (Control):
  - Group 1 (No Discount): 16 participants
  - Group 3 (Percentage Discount): 16 participants
  - Group 5 (Product Discount): 17 participants

Table 1. Experimental Groups and Sample Sizes

Self-Control Manipulation	Discount Type	Group	Sample Size
With Stroop test	No Discount	2	16
With Stroop test	Percentage Discount	4	17
With Stroop test	Product Discount	6	17
Without Stroop test	No Discount	1	16
Without Stroop test	Percentage Discount	3	16
Without Stroop test	Product Discount	5	17

This experiment consisted of six groups, and participants were randomly assigned to one of these experimental groups. Self-control manipulation was performed in two groups. In one group, an activity was introduced to reduce self-control among participants. In this group, at the beginning of the experiment and before the shopping task, participants took part in the Stroop test. The Stroop task is a standard method used to deplete self-control in laboratory settings (12). Prior research indicates that this activity reduces self-control due to the cognitive effort involved (13). In the control group, no preliminary activity was conducted.

After the self-control manipulation, participants entered the online shopping process. At the beginning of the process, a scenario was introduced to induce impulse buying tendencies in participants. In this scenario, participants were asked to imagine that they entered a store with a predefined shopping list but encountered products that were not on their list. Each product was displayed on the computer screen for 10 seconds, and the participant had to indicate whether they wanted to purchase it or not. Participants could select either "Buy" or "Do Not Buy." If they did not respond within 10 seconds, the system automatically moved to the next image. The time for each image was limited to 10 seconds so that the time constraint could enhance impulse buying behavior (14-15).

Experiment Description and Participant Allocation

At the beginning of the experiment, participants were simple randomly assigned to one of the six experimental groups. Table 1 presents the research's experimental groups. Participants in Groups 2, 4, and 6 were part of the manipulated groups, whereas participants in Groups 1, 3, and 5 underwent inhibitory control training.

Participant Randomization Protocol

To ensure unbiased group allocation, we implemented a computer-generated block randomization procedure:

1. Stratification:
   - Participants were stratified by gender (male/female) to ensure balanced distribution.
2. Randomization:
   - A randomization sequence was generated using a validated algorithm (based on random number tables) with a 1:1 allocation ratio for self-control (Stroop/no

Stroop) and equal distribution across discount types.

- Assignments were concealed in sealed, opaque envelopes opened after baseline EEG setup.

3. Blinding & Verification:

- Researchers were blinded to group assignments during data collection.
- Post-hoc chi-square tests confirmed no significant demographic differences across groups (*p* > 0.05).

Since the products used in the study were supermarket items that are purchased by individuals from various social classes and age groups, the target population was considered to include all individuals aged 18 to 49 years. To encourage participation in the study, an advertisement for the experiment was posted on online platforms and university-related channels, allowing interested individuals to contact the researcher and schedule a suitable time to participate in the experiment. Participants then visited the laboratory for data collection. Therefore, the sampling method was random sampling. The experiment was conducted at the Business Research Laboratory of the Faculty of Management at the University of Tehran.

Statistical Analysis

During the experiment, participants' Arousal were assessed through EEG data analysis. EEG signals in the alpha frequency range (8–12 Hz) and beta frequency range (13-30 Hz) were collected from frontal channels (AF3, AF4, F3, F4), as illustrated in Figure 1. Data processing was conducted using the Emotiv cloud-based analyzer, and Arousal variations were measured throughout the shopping process (16).

The research employs a laboratory experiment with a factorial design, incorporating two independent variables. The first independent variable is self-control (two levels: low self-control and control group), and the second independent variable is the type of discount message (three levels: "Buy One, Get One Free," "50% Discount," and "No Discount"). Impulse buying is the dependent variable.

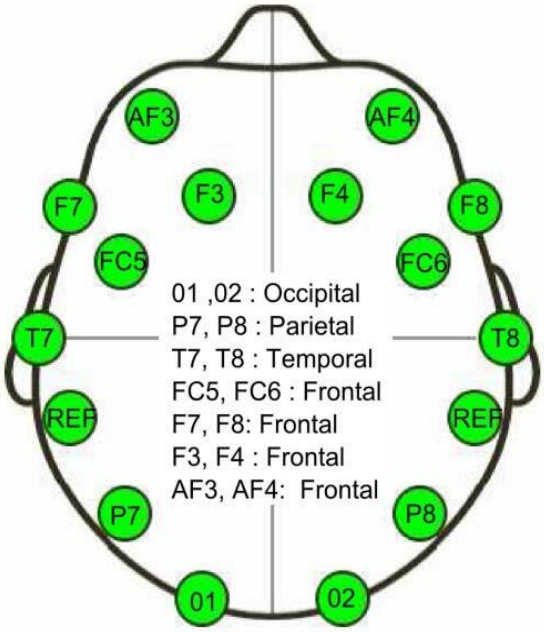

Figure 1. Emotiv Epoc+ device channel locations

In the final stage of the experiment, participants answered demographic questions. Then, they were directed to another location and, in collaboration with the experimenter, received an amount of 2،000,000 Rials.

Statistical analysis and results

Participants and descriptive statistics

In this study, a total of 99 participants took part. This experiment was conducted at the Business Research Laboratory of the Faculty of Management at the University of Tehran. Data collection took place between May 20 and July 28, 2024.

According to Table 2, the gender composition included 45.45% female and 54.55% male. The mean age of the participants was 24 years (SD = 4.6).

The educational level of the participants was as follows: 12% Ph.D., 25% master's degree, and 63% bachelor's degree. The academic background primarily consisted

of individuals holding a bachelor's degree (62.63%), followed by master's students (25.25%), and Ph.D. candidates (12.12%).

Table 2. Participants and descriptive statistics

Sex	No.	Age	Education		
			BA[a]	MS[b]	PhD[c]
Female	45	18-33	27	11	7
Male	54	18-49	35	14	5
Total	99	18-49	62	25	12

a: Bachelor's degree, b: Master's degree, PhD: Doctor of Philosophy

EEG Data Analysis and Arousal Measurement

Initially, the raw EEG signal data were filtered to isolate the desired frequency range, specifically the alpha band (8–12 Hz). This filtering process separates alpha activity from other brain wave patterns, such as beta and theta waves (17).

For precise EEG data analysis, the collected signals from EmotivPRO software were imported into Prism (version 10), where normalization was performed using the statistical functions of this software. Normalization was essential to reduce the impact of outliers, adjust for individual differences, compensate for baseline brain activity variations, and enhance data comparability.

The patients' EEG data was transformed into a coordinate in Thayer's arousal emotion plane (18). The EEG data processing was inspired by Ramirez (16) where it is shown that the computed arousal values indeed contain meaningful information about the user's emotional state. Artifact detection/elimination was performed by visual inspection of the signal. EEG data was normalized to avoid inter-participant variability. Using the EEG signal of a participant, his/her arousal level was computed as the ratio of the beta (12–30 Hz) and alpha (8–12 Hz) brainwaves (see Equation 1). EEG data was recorded in 4 locations on the prefrontal cortex: AF3, AF4, F3, and F4 (see Figure 1). Beta (b) waves have been associated with alert or excited states of mind, while alpha (a) waves are associated with relaxed or brain inactivation states of mind. Thus, the ß/α ratio may be considered as an indicator of the arousal state of a person. More precisely, the instantaneous arousal level of a participant was computed as specified by Equation 1 below:

$$\text{Arousal} = (ßF3+ßF4+ßAF3+ßAF4)/(αF3+αF3+αAF3+αAF4) \quad (1)$$

Results

To analyse the relationships between impulse buying and the study's key variables, a correlation analysis was conducted. Table 3 presents the results of the Pearson correlation test, displaying the relationships between self-control, arousal, percentage discount, and product discount with impulse buying. The results indicate a negative and significant correlation between self-control and impulse buying (r=-0.454, p=0.022), suggesting that higher self-control is associated with lower impulse buying behavior. Similarly, arousal exhibits a negative and significant correlation with impulse buying (r=-0.320, p=0.001), implying that higher arousal levels reduce impulse buying tendencies. Regarding discount types, the correlation between percentage discount and impulse buying was not significant (r=0.047, p=0.648), indicating that percentage-based discounts do not directly influence impulse buying in this study. Likewise, the correlation between product discount and impulse buying was also not significant (r=0.153, p=0.129), suggesting that the presence of a product-based discount alone does not strongly drive impulse buying behavior. In terms of descriptive statistics, the mean value of impulse buying was 0.084, with a minimum value of -0.878 and a maximum of 1.178. The standard deviation of impulse buying was 0.451, indicating a moderate level of variability in participants' impulse buying tendencies. These findings suggest that individual factors such as self-control and arousal play a more significant role in impulse buying than external discount messages, reinforcing the importance of psychological

and emotional mechanisms in consumer decision-making.

Multivariate Regression Analysis

The mediation test is presented in Table 4. The self-control variable has a negative and significant effect on impulse buying (Effect=-1.726, p=0.000, CI [-2.498, -0.953]), indicating that an increase in self-control substantially reduces impulse buying. This result support hypothesis H1a.

Table 3. Correlation among study variables

Variable	Impulse buying
Self-control	-0.454* (0.022)
Arousal	0.320* (0.001)
Percentage Discount	0.047 (0.648)
Product Discount	0.153 (0.129)
mean	0.084
Minimum	-0.878
Maximum	1.178
Standard Deviation	0.451

*. Correlation is significant at the 0.05 level (2-tailed).

The percentage discount variable has a positive but non-significant effect on impulse buying (Effect=0.854, p=0.066, CI [-0.060, 1.768]), meaning that percentage discounts do not significantly influence impulse buying. As a result, this finding does not support Hypothesis H1b. However, the product discount variable has a positive and significant effect on impulse buying (Effect=1.090, p=0.021, CI [0.164, 2.017]), indicating that product discounts increase impulse buying. This result supports Hypothesis H1b.

The arousal variable has a positive and significant effect on impulse buying (Effect=2.452, p=0.007, CI [0.657, 4.247]), demonstrating that higher arousal leads to increased impulse buying. This finding support hypothesis H2.

This model explains 54.8% of the variance in impulse buying (R^2=0.548) and is significant overall (F=10.104, p<0.001), demonstrating a strong explanatory power for the predictors used.

Regarding the mediation test, although arousal has a significant direct effect on impulse buying, its indirect effect in mediating the relationship between self-control and impulse buying is statistically significant (Effect=-0.248, SE=0.130, CI [-0.528, -0.024]), as the confidence interval does not include zero. Therefore, arousal significantly mediates the effect of self-control on impulse buying, supporting Hypothesis H2 for self-control.

For the effect of discount messages, the indirect effect of percentage discount through arousal is not significant (Effect=-0.177, SE=0.166, CI [-0.562, 0.088]), as the confidence interval includes zero. Similarly, the indirect effect of product discount through arousal is also not significant (Effect=-0.030, SE=0.135, CI [-0.377, 0.157]). These results indicate that arousal does not significantly mediate the effect of percentage or product discounts on impulse buying.

Thus, Hypothesis H2 is partially supported, as arousal mediates the effect of self-control on impulse buying but not the effect of discount messages.

Discussion

The results of this study indicate that self-control and arousal significantly influence impulse buying behavior. Higher self-control is associated with lower impulse buying, while increased arousal leads to higher impulse buying. The study also reveals that percentage-based discounts do not have a significant effect on impulse buying, whereas product discounts do. Additionally, arousal mediates the relationship between self-control and impulse buying, reinforcing the role of psychological factors in consumer decision-making. However, arousal does not mediate the effect of discount messages on impulse buying. These findings highlight the complex interplay between individual self-regulation, emotional arousal, and external marketing stimuli in shaping impulse buying behaviors.

Table 4. Regression Analysis of Arousal and Discount Messages on Self-Control

Regress on arousal					
Row		B	SE B	Sig	LLCI 95%	ULCI 95%
Constant		0.906	0.042	0.000	0.822	0.990
Self-Control		-0.101	0.042	0.020*	-0.186	-0.161
Percentage Discount		-0.072	0.051	0.166	-0.174	0.030
Product Discount		-0.012	0.053	0.814	-0.117	0.092
R^2	0.272					
F statistic	2.541					
p value	0.060					
Regression on Impulse buying						
Constant		3.381	0.900	0.000	1.593	5.169
Self-Control		-1.726	0.388	0.000***	-2.498	-0.953
Arousal		2.452	0.904	0.007*	0.657	4.247
Percentage Discount		0.854	0.460	0.066	-0.060	1.768
Product Discount		1.090	0.466	0.021*	0.164	2.017
R^2	0.548					
F statistic	10.104					
p value	0.060					
Indirect effect(s)						
		Effect	Boost SE	Boost LLCI	Boost ULCI	
Product Discount on Impulse buying		-0.030	0.135	-0.377	0.157	
Percentage Discount on Impulse Buying		-0.177	0.166	-0.562	0.088	
Self-control on impulse buying		-0.248	0.130	-0.528	-0.024	

*$p < 0.05$; ***$p < 0.001$

Among these findings, the strongest effect was observed in the relationship between self-control and impulse buying, where higher self-control significantly reduced impulse buying. This aligns with prior research indicating that self-control acts as a cognitive barrier against spontaneous purchasing behaviors (19). Furthermore, the results confirm that heightened physiological arousal increases impulse buying, supporting the Stimulus-Organism-Response (S-O-R) framework, which suggests that external stimuli (e.g., discount messages) trigger emotional reactions (e.g., arousal), leading to impulse buying behavior (20). These findings are consistent with prior studies (21), which have also highlighted the role of emotional responses in purchasing decisions. However, while previous research suggests that both percentage-based and product discounts significantly impact impulse buying (22, 23), the current study only found a significant effect for product discounts.

The observed discrepancy regarding the influence of discount types on impulse buying may be attributed to differences in consumer perception. Some studies have suggested that percentage discounts are more effective when applied to high-priced products, whereas product discounts are more influential in lower-cost purchases (24). The sample characteristics in this study may have played a role in these findings, as consumer responses to discount strategies often vary across cultural and socioeconomic contexts. Additionally, the lack of a significant effect for percentage discounts could be due to the specific product categories used in the study, as different industries may experience varying impacts of discounting strategies. Future research should explore these factors in greater depth to better understand the nuances of discount effectiveness.

This study has several strengths. It provides empirical evidence for the psychological mechanisms underlying impulse buying, particularly emphasizing the mediating role of arousal. Additionally, the use of multivariate analysis strengthens the reliability of the findings by controlling for

multiple factors simultaneously. However, some limitations should be acknowledged. The controlled experimental setting may not fully replicate real-world shopping experiences, where environmental and sensory stimuli, such as music, store layout, and social influences, also play a role in impulse buying. Furthermore, cultural and demographic differences in consumer behavior were not extensively examined, which may limit the generalizability of the results (25).

From a public health perspective, understanding impulse buying behaviors can contribute to more informed consumer protection policies. Excessive impulse buying, often driven by aggressive marketing tactics, has been linked to financial stress and compulsive purchasing disorders, which can negatively affect mental health and overall well-being. By identifying self-control and arousal as key psychological factors, this study highlights potential intervention strategies, such as financial literacy programs and behavioral training, to help consumers make more rational purchasing decisions (26).

Future studies should investigate the long-term effects of arousal-driven impulse buying, particularly in digital shopping environments where personalized promotions and AI-driven recommendations further complicate consumer decision-making. Additionally, exploring alternative strategies for regulating arousal, such as mindfulness-based interventions or cognitive control techniques, could provide valuable insights for both consumers and policymakers.

Overall, this study enhances our understanding of the psychological mechanisms behind impulse buying, reinforcing the importance of self-control and emotional regulation in consumer decision-making. These insights can guide the development of more ethical and effective marketing strategies that balance business interests with consumer well-being.

Conclusion

This study provides valuable insights into the psychological mechanisms driving impulse buying behavior, highlighting the significant roles of self-control, arousal and discount messages. The findings demonstrate that higher self-control reduces impulse buying, while increased arousal enhances them. Additionally, product discounts, rather than percentage-based discounts, significantly influence impulse buying. Arousal was found to mediate the relationship between self-control and impulse buying, further emphasizing the interplay between emotional and cognitive factors in consumer decision-making.

These results contribute to the existing literature by confirming the role of arousal as a critical psychological factor in impulse buying behaviors. They also underscore the importance of considering individual differences in self-control when designing marketing strategies. From a practical perspective, businesses can use these insights to develop more effective and ethical marketing approaches that account for consumer well-being, while policymakers can leverage them to design interventions that promote responsible spending habits.

Given the limitations of this study, including the controlled experimental setting and the potential influence of cultural and demographic factors, future research should explore impulse buying behavior in more diverse and real-world contexts. Additionally, investigating long-term consumer responses to arousal-driven purchasing and the impact of digital marketing techniques on impulse buying could provide further valuable contributions.

Ultimately, understanding the dynamics of self-control, arousal, and marketing stimuli in impulse buying can help consumers make more informed purchasing decisions, guide marketers in creating responsible

advertising strategies, and contribute to broader efforts in consumer protection and financial well-being.

Authors' contribution

Sina Taghizadeh and Rosa Hendijani developed the study concept and design. Hashem Aghazadeh and Mohsen Nazari acquired the data. Sina Taghizadeh and Rosa Hendijani analyzed and interpreted the data, and wrote the first draft of the manuscript. All authors contributed to the intellectual content, manuscript editing and read and approved the final manuscript.

Informed consent

Questionnaires were filled with the participants' satisfaction and written consent was obtained from the participants in this study.

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Conflict of interest

The authors declare that they have no conflict of interests.

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