Emotional responses in online social interactions: the mediating role of flow

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Received 2 February 2022
Revised 23 June 2022
5 August 2022
Accepted 5 August 2022

Abstract

Purpose – Drawing on the three flow-channel model and the stimulus–organism–response model, this research aims to understand how the influence of interactivity on purchase intention is mediated by the state of flow.

Design/methodology/approach – This research entails a neurophysiological experiment combined with a survey-based study. This study analyzes, first, participants' heart rate variability through the parasympathetic and sympathetic indexes during five different activities, and, second, the mediating effect of flow through a structural equation model.

Findings – This study contributes to research on the role of flow in interactive marketing. The findings reveal that flow state is associated with less stressful activities, such as navigating highly interactive websites and playing online games. This research confirms the mediating effect of flow between interactivity and purchase intention.

Originality/value – This paper contributes to interactive marketing and flow theory by combining traditional methods with a peripheral physiological technique that draws on neuroscience. In addition, it confirms the positive but indirect effect of interactivity on purchase intention in online contexts.

Keywords Flow, SOR, Interactivity, Heart rate variability, Neuromarketing, Social commerce

Paper type Research paper

1. Introduction

In social commerce contexts, users not only buy products but also interact and socialize with others and with companies (Zhang and Benyoucef, 2016; Lin *et al.*, 2017; Turban *et al.*, 2018; Wu *et al.*, 2022). In this vein, interactions in social commerce are believed to have a crucial effect on the customer experience (Manthiou *et al.*, 2020).

In recent years, interactive marketing researchers have aimed to understand how to generate an effective customer experience (Bleier *et al.*, 2019; Hoyer *et al.*, 2020; Lemon and Verhoef, 2016). The crucial point lies in understanding individuals' internal process from interaction to enacting a certain behavior – that is, how the emotions generated by interactivity influence the customer's behavior. In this vein, the question also arises as to how firms should take advantage of interactivity in order to improve customers' purchase intention.

Flow theory (Csikszentmihalyi, 1975) has been used in social commerce context to explain the effect of interactivity in the social commerce experience (e.g. Gao and Bai, 2014; Zhang *et al.*, 2014), to explain how positive experiences achieved by users turn into purchase

This work was supported by the Government of Aragón and the European Social Fund (GENERES Group-54), the Ministry of Science and Innovation of the Government of Spain (PID2020-118425RB-I00) and HIF-Hosei University.

Asia Pacific Journal of Marketing and Logistics

1355-5855
DOI 10.1108/APJML-02-2022-0091

intentions (Zhang *et al.*, 2014; Cuevas *et al.*, 2021) and is particularly interesting during social interactions, where users can reach a state of flow when they are absorbed in and concentrating on the interaction, enjoying the moment and even being unaware of time passing (Herrando *et al.*, 2018). In response to reaching this state of optimal experience, users often show higher purchase intention and loyalty (Cuevas *et al.*, 2021; Hausman and Siekpe, 2009; Herrando *et al.*, 2019; Hyun *et al.*, 2022; Richard and Chebat, 2016).

This connection between flow and purchase intention indicates the relevance of the stimulus–organism–response (SOR) model (Mehrabian and Russell, 1974), because it provides a theoretical framework by which to understand the impact of certain stimuli on flow, and their consequences. Previous studies have demonstrated that various social commerce stimuli – whether hedonic, utilitarian, cognitive or affective – can have a positive effect on the organism (in the form of flow), resulting in a positive response (eWOM, purchase intention, or purchase) (Liu *et al.*, 2016; Herrando *et al.*, 2018, 2019).

With the rise of social commerce, social stimuli started to be considered in research based on the socio-interactive characteristics of this new environment (Chang, 2013; Lin *et al.*, 2017; Liu *et al.*, 2016; Zhang *et al.*, 2014). Studies carried out from both flow and SOR approaches have included the interactivity variable, since there is consensus that interactivity is a stimulus; however, there is some controversy regarding the relationships between interactivity, flow, and purchase intention. Whereas in some cases interactivity has been seen as a direct antecedent of flow (Arghashi and Yuksel, 2022; Zhang *et al.*, 2014; Wu and Chang, 2005), in other cases it has been viewed as an antecedent to purchase intention without being linked to the state of flow (Cuevas *et al.*, 2021; Liu *et al.*, 2020).

Therefore, agreement is lacking as to whether the role of interactivity has a direct effect on flow or on purchase intention. In this study we consider interactivity as an antecedent of flow state that is, we view the interactivity of social commerce websites as positively influencing the emotions experienced by the individual, which increases purchase intention. Thus, the contribution of this work lies in its examination of the mediating effect of flow between interactivity and purchase intention.

The objective of this study is thus to analyze, using a SOR approach, the effect of interactivity on individuals' flow state in social commerce, considering how various daily activities with different levels of interactivity influence individuals' emotions, and how the optimal state (flow) mediates the relationship between interactivity and purchase intention. To this end, our study combines a neuroscience study, in which we compare users' physiological responses to different levels of interactivity by monitoring their heart rate variability (HRV), with an online survey to test the mediating role of flow between interactivity and purchase intention. This combination of techniques enables triangulation of the data and thus presentation of more robust and valid conclusions, while avoiding biases that have been strongly criticized by recent studies (Verhulst *et al.*, 2019).

2. Theoretical framework, proposals and hypothesis

2.1 SOR and flow theory

The SOR framework in e-commerce posits that certain environmental stimuli affect users' states, resulting in positive behavioral responses (Eroglu *et al.*, 2001, 2003). These stimuli can be utilitarian or hedonic. In the first case, some studies have considered usability (Casaló *et al.*, 2008; Lee and Koubek, 2010), quality content and quality systems (Cuevas *et al.*, 2021) and the aesthetics of the website (Nia and Shokouhyar, 2020). Hedonic stimuli refer to the "*experiential affect associated with the object*" in terms of how pleasant and agreeable these feelings are (Batra and Ahtola, 1991, p. 161). These kinds of stimuli, which include interactivity, socialization, and enjoyable atmosphere on the website, allow customers to enjoy an optimal experience (Mahnke *et al.*, 2015; Herrando *et al.*, 2019).

Drawing on the SOR framework (Mehrabian and Russell, 1974), flow, as an organism, is considered to be influenced by various stimuli and to always yield a positive response thereto (Zhang *et al.*, 2014; Herrando *et al.*, 2018, 2019). The state of flow has been described as a rewarding experience in which people are so absorbed in the activity they are performing, and concentrating so hard on it, that they are not conscious of themselves or of time passing, enjoy every single minute of the experience, and afterward seek to replicate the sensation (Csikszentmihalyi, 1975). Flow theory has been used in social commerce research, wherein flow state is considered as the organism to understand user experience and behavior (Gao and Bai, 2014; Zhang *et al.*, 2014; Liu *et al.*, 2016; Herrando *et al.*, 2018). Upon reaching the state of flow, the individual responds with a higher use intention, return intention, or purchase or repurchase intention, among other responses (Zhang *et al.*, 2014; Gao and Bai, 2014; Liu *et al.*, 2016; Herrando *et al.*, 2018, 2019; Cuevas *et al.*, 2021).

2.2 Neuroscience studies on flow

Marketing scholars have questioned the use of traditional research methods alone, and have begun to embrace combinations of neuroscience and traditional marketing techniques (Casado-Aranda *et al.*, 2017, 2022; Harris *et al.*, 2018; Verhulst *et al.*, 2019). Recent experiment-based flow research has utilized neuroscience in order to study the physiological and neuronal reaction of experiencing flow *in situ*. For this purpose, various biosensors and technologies can be used, such as electroencephalograms (Berta *et al.*, 2013; Wang and Hsu, 2014), functional magnetic resonance (Huskey *et al.*, 2018), galvanic skin response sensors (Nacke *et al.*, 2011), and electrocardiograms (Harmat *et al.*, 2015; Tozman *et al.*, 2015; De Manzano *et al.*, 2010).

Neuroscience research on flow has focused on understanding the flow-channel model (Csikszentmihalyi, 1975) by analyzing various activities of daily life that may lead to boredom, flow, or anxiety (Harmat *et al.*, 2015; Tozman *et al.*, 2015; Peifer *et al.*, 2014; Keller *et al.*, 2011; De Manzano *et al.*, 2010). Neurophysiological techniques, such as HRV, have been widely used to understand people's reactions and behavior in response to diverse stimuli. The HRV literature has focused on a wide variety of fields. For instance, with respect to pleasurable activities such as yoga, HRV has been used to analyze the effect of yoga for reducing depressive symptoms and perceived stress (Chu *et al.*, 2017). With regard to stressful activities related to Internet gaming disorder, HRV has been used to study individuals' control while playing online games (Lee *et al.*, 2018). Therefore, it is expected that participants' HRV reacts differently depending on the activity they are performing; thus, in the present study the different states of mind will be taken into consideration when interpreting the results.

Neurophysiological studies of flow have indicated that HRV helps researchers to compare differences among states of mind by analyzing the parameters of LF (low frequency of the sympathetic activity) and HF (high frequency of the parasympathetic activity). In general, higher levels of flow have been associated with decreased HRV (De Manzano *et al.*, 2010). According to Harmat *et al.* (2015), flow is associated with a nonreciprocal coactivation of the sympathetic and parasympathetic system; this suggests that flow is associated with relaxation and positive affect. Tozman *et al.* (2015) determined that flow is related to a decrease in LF activity compared to anxiety, while higher levels of flow are associated with moderate HF parasympathetic activity. Therefore, flow should be higher during moderate, and lower during high or low, physiological arousal, as also stated by Peifer *et al.* (2014). Hence, anxiety is characterized as a stressful activity that is related to high physiological arousal and to an increased sympathetic nervous system; boredom is considered a relaxed activity that is associated with low physiological arousal; and flow is expected to be located between boredom and anxiety, thereby serving as a state of moderate activation of the sympathetic nervous system (Peifer *et al.*, 2014).

Additionally, Csikszentmihalyi's (1975) theoretical framework suggests that in everyday life activities a flow state can be reached as a balance of the individual's skills with challenges faced (Novak *et al.*, 2000). Under this assumption, if the skills surpass the challenges the individual may become bored; if the challenges surpass their skills, the individual can become anxious; but if there is a positive balance between skills and challenges, the individual can reach a state of flow.

Drawing on the flow-channel model (Csikszentmihalyi, 1975) and the work of Tozman *et al.* (2015), this research proposes that everyday life activities with different levels of interactivity trigger three different states of mind (boredom, flow, and anxiety) that will show different HRV parameters, summarized as follows research proposals:

RP1. LF is higher when the individual is in a state of boredom.

RP2. LF is moderate when the individual is in a state of flow.

RP3. LF is lower when the individual is in a state of anxiety.

And related to flow state:

RP4. A higher level of interactivity leads to a higher perception of the state of flow, higher return intention, and higher social word-of-mouth (sWOM) intention.

With the purpose of exploring individuals' emotional states (boredom, anxiety, and flow), in the first step of this study a neuroscience study is conducted.

2.3 Interactivity

In social commerce contexts, the possibility to conduct social interactions via websites gives users a perception of interactivity (Chen and Shen, 2015; Wang and Herrando, 2019). In this vein, the possibility of users sharing their experiences through reviews, ratings, recommendations, and so on, will increase the perceived interactivity. Hence, interactivity can be manipulated through two-way communication system features, such as chat rooms, comment forms, frequently asked question pages, bulletin boards, reviews, and so on, which uses synchronicity to ensure timely responses and offer users a certain level of control (Song and Zinkhan, 2008; Chen and Shen, 2015).

In the SOR model in social commerce, perceived interactivity is considered a technological feature that acts as an environmental stimulus (Zhang *et al.*, 2014). Traditionally, interactivity has been considered an antecedent of flow (Novak *et al.*, 2000; Huang, 2003); in fact, higher levels of interactivity are associated with a higher likelihood of undergoing a flow experience (Baabdullah *et al.*, 2022; Cuevas *et al.*, 2021; Herrando *et al.*, 2019), such that interactivity has become a predictor of flow (Van Noort *et al.*, 2012).

Purchase intention (Moon *et al.*, 2018; Herrando *et al.*, 2019) has been considered the positive response within the SOR model. Findings have suggested that flow experience is directly and positively associated with purchase intention (Mortazavi *et al.*, 2014; Herrando *et al.*, 2019; Cuevas *et al.*, 2021).

Based on the above argumentation, we purpose the following hypothesis:

H1. Flow acts as mediator between interactivity and purchase intention.

3. Materials and methods

3.1 Neuroscience study, participants, and procedures

Data were collected in Tokyo. The first part of our study aims to verify that different levels of interactivity lead to different emotional states in the user. In order to corroborate that flow is a consequence of interactivity, we analyze the mean differences between three online daily

activities: (1) playing a video game (pleasure activity that causes flow), (2) translating an English text into the mother tongue (stressful activity that causes anxiety), and (3) doing nothing (tedious activity that causes boredom), and two different social commerce websites that entail (4) high interactions and (5) low interactions. In terms of return intention, sWOM intention, and the components of flow.

The activity of browsing on websites (high/low interactions) was distributed in the morning (10 a.m.) and in the afternoon (4 p.m.) to avoid tiredness. A counterbalancing technique was used to deal with order effects. Users had 20 min to navigate each website and select a restaurant based on the information presented. The low-interaction website comprises an online platform that is completely flat (with no hyperlinks) and with a low chance of user interaction, since it allows users to read reviews and post, but does not include a live forum. It offers reviews about restaurants in Tokyo.

The high-interaction website is Tabelog (www.tabelog.com), a well-known review-based and high-interaction website for searching for restaurants. Tabelog includes a large volume of restaurants, and provides reviews with consumer comments and pictures, as well as information on the number of reviews, ratings in the form of stars and numerically from 1 to 5 (scoring not only the general experience, but also dishes, service, atmosphere, cost performance, and drinks), whether the reviews have been validated, restaurant rankings, the possibility to share on social networks, and so on. The different level of interactivity was checked by asking participants whether they perceived the website they had navigated to provide chances for interaction with the item "I perceived the website to be highly interactive" (Wu, 2005).

Between the two browsing sessions, participants completed the other three tasks: (1) playing a video game, (2) translating an English text, and (3) doing nothing (randomly ordered). These tasks also lasted 20 min, and took place at 1 p.m., 2 p.m., and 3 p.m., respectively, with 40 min of rest in between to avoid fatigue bias. That is, participants were at their university all day, and each participant completed the experiment in one day by coming to the laboratory five times, once for each of the five tasks. For the video game task, the participants themselves chose what game they wanted to play (all participants were keen gamers). For the translation task, participants were asked to translate an English text; all selected participants self-identified as having a low basic level of English. In doing nothing, the participants were requested to simply sit on a chair and stay quiet. Ten participants, with ages ranging between 20 and 22 years, took part in the experiment. Although the total of 10 subjects is lower than is common in marketing research, in neuroscience research, the use of a small sample size is common and accepted (Boksem and Smidts, 2015; Verhulst *et al.*, 2019). Likewise, neuroscience studies commonly have within-subjects designs, so the sample is not considered too small (see Boksem and Smidts, 2015; Casado-Aranda *et al.*, 2018; Cascio *et al.*, 2015; Lin *et al.*, 2017; Plassmann *et al.*, 2015; Zhang *et al.*, 2021).

Participants had to complete a short questionnaire after every activity (five times in total). Although in the literature the concept of flow has been used in different contexts, there is no consensus on which variables measure flow state (Ghani and Deshpande, 1994; Hoffman and Novak, 1996), even in social commerce contexts (Wu and Chang, 2005; Lee and Chen, 2010; Wang and Hsu, 2014). Considering the features of social commerce, interactions take place on the basis of pleasant experiences, which absorb users – causing temporal distortion – and require their concentration. These three components of the state of flow (concentration, enjoyment, and temporal distortion), have been successfully utilized in social commerce contexts (Herrando *et al.*, 2018, 2019).

Moreover, in the questionnaire administered after navigating the high- and low-interaction websites only, participants were asked about their intention to return to the website and their intention to spread sWOM.

3.2 Survey study, sample and data collection

In the second part of this study we collected data via an online survey. The total number of responses was 194 (44% female, 56% male), with ages ranging from 18 to 34 years, representing generations Y (1981–1990) and Z (1991–2000) – meaning people who grew up with technology and are savvy users thereof (Herrando *et al.*, 2019). All respondents were social commerce consumers. At the beginning of the questionnaire, participants were given an explanation about the concept of social commerce and then, they were asked about the most recently online purchase they had made using a social commerce platform. Those respondents who answered positively, continued with the survey.

Before starting data collection, the survey instrument was checked by various experts to ensure that all items and text were understandable, and to assess face and content validity.

Interactivity was measured with three items using the scale of Song and Zinkhan (2008). Flow was based on the work of Herrando *et al.* (2018) was measured as a second-order reflective construct consisting of three subdimensions -concentration, enjoyment, and temporal distortion- from the scales of Jackson and Marsh (1996), Koufaris (2002), Agarwal and Karahanna (2000), and Novak *et al.* (2000). Purchase intention was measured using Hausman and Siekpe (2009) scales and Kim and Park (2013). All survey variables were measured on a 7-point Likert scale, with the lowest score being 1 (strongly disagree), and the highest 7 (strongly agree).

4. Results

4.1 Neuroscience study

4.1.1 Descriptive analysis. Following previous neurophysiological studies of flow that have analyzed the flow-channel model under the same task with a different skill–challenge balance (Tozman *et al.*, 2015; Peifer *et al.*, 2014; De Manzano *et al.*, 2010), the first part of our study proposes three different tasks (playing video games, translating, and doing nothing) that are directly associated with boredom, flow, and anxiety, respectively. Next, it compares flow experience during navigation of high- versus low-interaction websites.

The data collected through the face-to-face questionnaire following the five tasks allow us to compare participants' perceptions of having experienced flow indirectly, through enjoyment, concentration, and temporal dissociation. Based on studies by Herrando *et al.* (2018, 2019), it is expected that tasks that are more closely related to pleasant activities will show higher means on these flow components. As can be seen in Table 1, pleasant activities related to flow (both kinds of navigation and playing a video game) have higher means, while stressful activities (translating a text) and boring activities (doing nothing) report lower means. This indicates that lower levels of flow are associated with emotional states where individuals are bored or anxious. When comparing high-interaction versus low-interaction websites, it is also worth highlighting the higher values of enjoyment, concentration and

Table 1. Means and standard deviations

	Translating		Videogames		Do nothing		Low interactivity		High-interactivity	
Items	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Enjoyment	1.916	*1.019*	5.833	*2.015*	1.083	*0.235*	3.933	*1.646*	5.400	*0.966*
Concentration	3.500	*1.763*	5.875	*0.941*	2.583	*2.136*	3.333	*1.440*	4.400	*1.184*
Temporal distortion	2.062	*0.971*	4.708	*1.687*	1.729	*1.265*	2.466	*0.804*	3.100	*1.045*
Return Intention							2.250	*1.086*	4.700	*1.475*
sWOM Intention							2.466	*1.239*	4.400	*1,447*

Note(s): SD = Standard Deviation

temporal distortion derived from the interactive website, and, most importantly, the effect of interactivity on the intention to return and to spread sWOM. Therefore, these findings suggest us that the higher the level of interactivity the higher the level of flow and the stronger the intention to return to the website and to spread sWOM.

Likewise, as can be seen in Figure 1, and as stated by Peifer *et al.* (2014) and Tozman *et al.* (2015), the patterns of activities are all distributed in the same way, showing a greater incidence of flow when playing video games and navigating high-interaction websites. Comparing the three pleasurable tasks (playing video games, navigating a high-interaction and a low-interaction website), a visual inspection clearly shows different degrees of flow, from higher to lower intensity (see Figure 1).

4.1.2 Heart rate variability analyses. Electrocardiogram recordings were created for the 10 subjects in the five different activities: (1) navigating the high-interaction website, (2) navigating the low-interaction website, (3) playing a video game, (4) translating an English text, and (5) doing nothing. This led to a total sample of 50 records. Data were digitized at a sampling rate of 200 Hz. R wave occurrence times TR_n and their intervals $\tau_n (= TR_{n+1} - TR_n$ were measured offline. The instantaneous heart rate at the mid-point of the R wave occurrence times t_n is defined as the reciprocal of intervals τ_n. Here,

$$t_n = \frac{TR_{n+1} + TR_n}{2}$$

The unevenly spaced sequence of the instantaneous heart rate $(t_n, 1/\tau_n)$ was then obtained, and a spline-interpolated function of the sequence resampled at 4 (Hz) and utilized for the subsequent spectral analysis. The power spectra were estimated for resampled instantaneous heart rate signals, and frequency band powers LF (0.04–0.15 Hz) and HF (0.15–0.4 Hz) were estimated. HF and LF/HF are known to be indices of parasympathetic and sympathetic activity (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

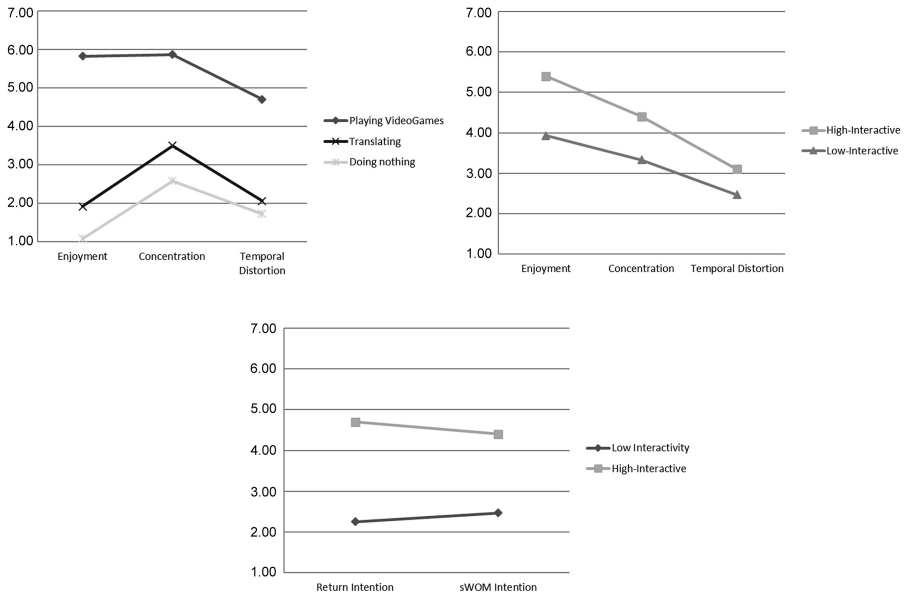

Figure 1.
Total means in the five tasks

Figure 2 shows the heart rate changes when a subject is either translating text written in an unfamiliar foreign language or playing a video game. Both HF and LF indices showed significantly lower values in the video game task compared to the translation task (HF : $3.1 \times 10^{-4} bps^2/Hz$ vs. $6.7 \times 10^{-4} bps^2/Hz$; LF : $3.1 \times 10^{-4} bps^2/Hz$ vs. $5.3 \times 10^{-4} bps^2/Hz$). This indicates that the total autonomic control was less intense for the video game task. A visual inspection of the heart rate changes in Figure 2 verifies this fact, as smaller fluctuations can be seen in the video game task. However, it should be noted that sporadic increases in heart rate could be observed in the translation task. If playing a video game causes a flow-like state, it could be characterized by basic steady and less variable cardiac activity, with sporadic short bursts of sympathetic activity. The task in which participants did nothing was used as a control in order to test the individual cardiac rate. Figure 3 shows two examples of power spectra for comparison between viewing the high-interaction versus low-interaction website for 20 min.

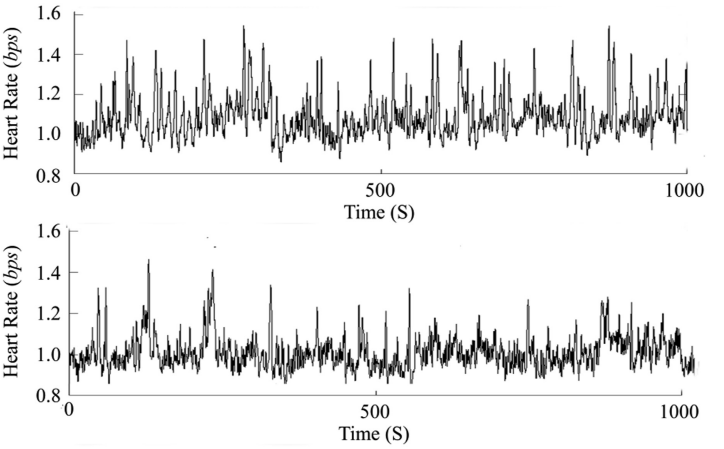

Figure 2.
Heart rate fluctuations during the two different tasks

Note(s): Figure above represents HRV in translating a text written in a foreign language (anxiety). Figure below represents HRV in playing a videogame (flow)

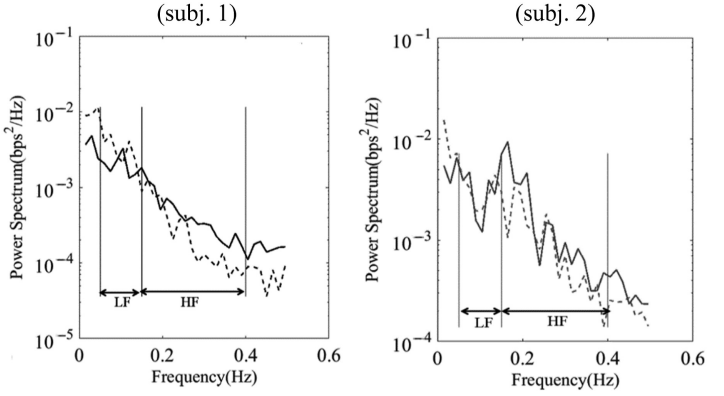

Figure 3.
Power spectra comparison between browsing of high-interaction versus low-interaction websites

Note(s): Solid line: Interactive, Dotted line: low-interactive

In Figure 3, we can compare for only two subjects the power spectra obtained for high-interaction web browsing (solid lines) and low-interaction web browsing (dotted lines). It is clear that these two subjects show prominent differences in HF and LF indices. Estimated indices for the 10 subjects are summarized in Table 2. It should be noted that LF/HF tends to be smaller for low-interaction website browsing, suggesting that this task is less stressful than high-interaction browsing. Our findings align with suggestions by Harmat *et al.* (2015) that the higher respiratory depth during high flow is indicative of a more relaxed state, possibly reflecting increased parasympathetic activity.

To sum up, it is interesting to note that only in high-interaction website navigation do both HF (the HRV index showing parasympathetic activities) and LF/HF (the index showing sympathetic activities) show high values. Thus, it can be said that, overall, in autonomic activities both sympathetic and parasympathetic activities entail a significant flow state. Nevertheless, the statistical significance is weak for the HF and LF/HF analyses in this study.

4.2 Survey study

Flow was considered a second order reflective factor. Herrando *et al.* (2018) test flow dimensionality, structure and measurements, consisting of the variables concentration, enjoyment and temporal distortion. The authors confirm flow dimensionality, using the rival models technique to compare unidimensionality versus multidimensionality. That is, after determining the three-dimensional structure of flow, they analyze the convergence of concentration, enjoyment, and temporal distortion toward a single factor, flow. Moreover, Herrando *et al.* (2018) test a flow reflective second-order model, that was later one confirm in further studies (Herrando *et al.*, 2019).

In computer mediated environments, the multidimensionality of the flow concept was analyzed and it was examined whether flow should be measured in a formative or a reflective model, showing better fit for the reflective version (Siekpe, 2005). Furthermore, some authors have found cognitive absorption – derived from the state of flow – to be reflective, since covariance is expected among the indicators that measure it (Agarwal and Karahanna, 2000; Reychav and Wu, 2015). Likewise, when measuring psychological constructs that show an attitude or behavior, it is better to use reflective indicators because they are the origin of the observed variable and their effects are reflected in this variable.

4.2.1 Measurement model analysis. To ensure the validity and reliability of the measurement scale, construct validity was analyzed using partial least squares (PLS) with the statistical software Smart PLS 3 (Ringle *et al.*, 2015). Construct validity determines whether there are high correlations between measures of the same construct – i.e., convergent validity – and low correlations between measures of constructs that are expected to differ – i.e., discriminant validity (Straub, 1989; Campbell and Fiske, 1959).

Based on Fornell and Larcker (1981), to assess convergent validity the reliability of each item was examined and deemed to show internal consistency when the Cronbach's alpha (CA) values were higher than 0.70 (Nunnally and Bernstein, 1994; Nunnally, 1978). The composite reliability (CR) of each construct was also considered, with values greater than 0.60 deemed acceptable (Bagozzi and Yi, 1988; Fornell and Larcker, 1981), along with the average variance extracted (AVE), which had to exceed the value of 0.50 (Fornell and Larcker, 1981) and advisable be greater than 0.70 (Hair *et al.*, 2014). See Table 3.

Table 2. Changes in heart rate variability indices

	HF ($\times 10^{-4} bps^2/Hz$)	LF ($\times 10^{-4} bps^2/Hz$)	LF/HF
High-Interactive	3.98 ± 1.67	6.02 ± 2.98	1.55 ± 0.59
Low-Interactive	4.46 ± 3.41	7.21 ± 2.68	2.10 ± 1.15

The discriminant validity was tested to confirm that the constructs differed from each other. To do so, first, the cross-loadings (Hair *et al.*, 1999) were analyzed. Second, a symmetric matrix was used to corroborate that the AVE on the diagonal was larger than its corresponding squared correlation coefficients in its rows and columns (Fornell and Larcker, 1981; Hair *et al.*, 1999). Finally, the HT/MT (Heterotrait/Monotrait) ratio between correlations (Henseler *et al.*, 2015) was determined; this showed discriminant validity when the correlations between the construct items were higher than the correlations that measured other constructs. See Table 4.

4.2.2 Structural model analysis. The validity of the model was assessed by analyzing the structural path coefficients and the percentage of variance explained. To test the mediating effect of flow between interactivity and purchase intention, we estimated the model with and without the mediating effect of flow and then tested the significance of the mediation. Bootstrapping was performed with 5,000 subsamples to test the statistical significance. The empirical results of the model without mediating effect (shown in Table 5) confirm that the relationships in the model are supported.

Within the SOR model, flow has been considered the organism that mediates between the stimulus and the response (Herrando *et al.*, 2019; Rodríguez-Torrico *et al.*, 2021). As suggested, a new causal model was analyzed to test mediating effects (Real *et al.*, 2014). We analyzed the significance of the indirect effects using bootstrapping method with 5,000 subsamples in PLS (Baron and Kenny, 1986; Preacher and Hayes, 2008).

The overall effect of flow on purchase intention can be expressed as the sum of the direct and indirect effects (Taylor *et al.*, 2008). We tested the overall, direct, and indirect effects, the variance accounted for (VAF), and the confidence interval for flow as the mediator variable. When the confidence interval does not contain zero, the indirect effect is significantly different from zero with a 95% confidence level (Williams and MacKinnon, 2008).

As can be seen in Table 6, the path does not contain the value zero; thus, the indirect effect for this relationship is statistically significant. From Table 6 we can calculate the direct

Table 3. Reliability and convergent validity of the measurement model

Variable	Rho_A	Cronbach alpha (CA)	Composite reliability (CR)	Average variance extracted (AVE)
Interactivity	0.759	0.746	0.851	0.655
Flow	0.919	0.907	0.922	0.504
Purchase Intention	0.908	0.901	0.938	0.834

Table 4. Discriminant validity

Variable	Interactivity	Flow	Purchase intention
Interactivity	*0.809*	0.327	0.215
Flow	0.254	*0.710*	0.619
Purchase Intention	0.204	0.587	*0.913*

Note(s): Diagonal values are AVE squared roots. Below the diagonal: correlations among factors. Above the diagonal: the HT/MT ratio

Table 5. Structural model without the mediating effect of flow

Hypotheses tested	beta (β') p-value	R^2 adjusted
Interactivity → Purchase intention	0.130 (0.01)	36.00%
Flow→ Purchase intention	0.577 (0.01)	

($\beta = 0.058$) and indirect ($\beta = 0.254 * 0.573 = 0.1455$) effects. The overall effect of interactivity on purchase intention can be expressed as the sum of both ($\beta = 0.2035$). Subsequently, the variance accounted for (VAF = 71.49%) and the confidence interval (0.097–0.414) were calculated. The confidence interval does not contain zero, so the indirect effect is significantly different from zero with a 95% confidence level (Williams and MacKinnon, 2008). When the VAF is greater than 20%, partial mediation is said to occur; when it is greater than 80%, full mediation is indicated (Hair *et al.*, 2016). Therefore, in our study flow is considered to yield a partially, almost fully, mediating effect.

Figure 4 shows a summary of the models and results.

5. Conclusions

Grounded in the SOR model and flow theory, the aim of this study was to analyze flow as a mediator between interactivity and purchase intention in a social commerce context. To provide robust and valid results, first the study explored how physiological reactions vary when individuals experience different emotional states during different activities with different levels of interactivity. Second, this study empirically tested the significance of flow as a mediating factor.

Following the recommendations of several authors (Harris *et al.*, 2018; Verhulst *et al.*, 2019), a neurophysiological technique was combined with quantitative traditional methods to improve robustness. The findings from the neurophysiological technique allow us to draw three main conclusions. First, the descriptive analyses clearly indicate the presence of flow when individuals experience activities related to pleasurable states of mind, such as playing a video game or navigating a social commerce website; whereas individuals do not reach flow during stressful or anxious activities, such as translating, or boring activities, such as doing nothing. It must be highlighted that the more enjoyable the activity, the higher the flow; thus, flow is directly related to enjoyment. Second, the HRV analyses corroborate this finding. That is, HRV increases with stressful or anxiety-inducing activities, while it reduces, indicating greater relaxation, during pleasurable activities related to flow. Third, focusing on website

Hypotheses tested	beta (β) p-value	R^2 adjusted
Interactivity → Flow	0.254 (0.01)	
Interactivity → Purchase intention	0.058 (0.01)	41.70%
Flow→ Purchase intention	0.573 (0.01)	
VAF (variance accounted for) = 71.49%		
Confidence interval: 0.097–0.414		

Table 6.
Structural model with the mediating effect of flow

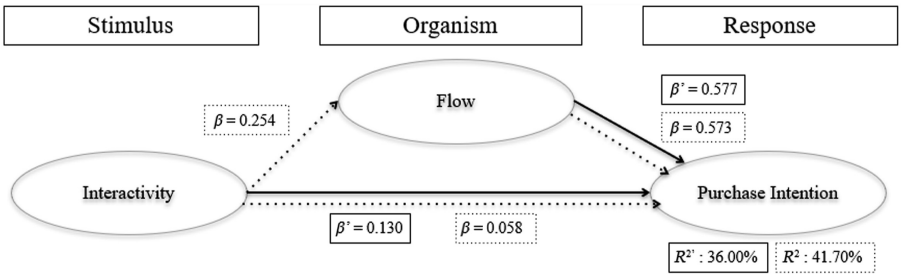

Figure 4.
Structural model

Note(s): Dot-arrows correspond to the structural model with the mediating effect of flow

navigation, this exploratory research allows us to conclude that individuals who navigated the high-interaction social commerce website showed smaller LF/HF values compared to those who navigated the low-interaction website; this means that they saw the high-interaction website as less stressful and were more likely to experience flow when using it. In response to proposition 4, it can be said that interactivity in social commerce websites contributes to reaching the state of flow, or optimal experience.

The findings from the second part of the study, first, verify the applicability of the SOR model to social commerce contexts: the stimulus (interactivity) produces a psychological effect on the organism (flow), which has a response (an increase in purchase intention); and second, support the hypothesis regarding the mediating effect of flow between interactivity and purchase intention. Consequently, interactivity has mainly a positive and indirect effect through flow. The study can thus help marketers to understand, via a simple model, the importance of enhancing interactivity on their websites, but in a specific way that also increases the feeling of flow, since this is the key to increasing purchase intention.

In sum, activities from daily life that require greater interactivity drive people to experience more pleasurable psychophysiological states, such as flow. Thus, commercial activities that are directly linked to interactivity, such as social commerce, will more readily stimulate individuals to reach a state of flow, which will result in higher purchase intention.

6. Theoretical and managerial implications

6.1 Theoretical implications

The stimulus–organism–response (SOR) model explains how different environmental factors can be stimuli (S) that influence people's emotional state (O) and finally produce a response (R) (Mehrabian and Russell, 1974). The findings from the neurophysiological experiment confirm that different levels of interactivity (S) trigger different emotional states in the user (O).

Moreover, the study confirms a first model where interactivity (S) and flow (O) are antecedents of purchase intention (R). Further, a second model confirms that flow (O) plays a mediator role between the stimulus and the response. The mediating model presents better results and confirms the mediating role of flow between interactivity and behavioral intention. All this leads us to corroborate flow theory in the context of social commerce websites.

Our findings have several theoretical implications. First, methodologically, combining neuroscience with survey techniques opens new horizons in electronic commerce research. This enables triangulation of the data and thus presentation of more robust and valid conclusions, while avoiding biases that have been criticized by recent studies. To date, research in electronic commerce has been fundamentally carried out through qualitative and quantitative techniques. Drawing on a neuroscience approach, this research enables academics and practitioners to understand the state of flow using a combination of techniques. The results from the heart rate analysis show that the index of sympathetic activity (LF/HF) tends to be smaller for high-interaction websites, where it is easier to experience flow, versus low-interaction websites. These findings encourage academics to continue flow research based on physiological techniques.

Second, our findings advance interactivity research by providing empirical evidence of how flow theory and the SOR model apply to the social commerce context. The interest in flow theory for electronic markets stems from the fact that those who report having reached this state of optimal experience tend to indicate greater intentions to purchase, repurchase, and return to the website (Kamis *et al.*, 2010). We highlight the importance of mediate effect of flow between interactivity and purchase intentions, which theoretically clarifies the positive but indirect role of interactivity in online purchase processes. In short, the main implication is that there is an intermediate step between web design (S) and behavior (R), flow (O). Flow is defined by temporal distortion, concentration and enjoyment so that the more the web design

is oriented to stimulate these three states, the higher the flow reached by the individual, and the higher the purchase intention.

On the other hand, social commerce aims to involve customers in the online purchasing process, optimizing their social experience by allowing them to generate and share information (Lin *et al.*, 2017; Turban *et al.*, 2018). Furthermore, social commerce features enable users to access other users' opinions, as well as to derive pleasure, to concentrate, and to lose track of time when browsing websites and/or interacting with other users (Zhang *et al.*, 2014; Herrando *et al.*, 2018). Our findings directly highlight enjoyment as an essential part of flow. The work demonstrates that joyful and interactive environments, such as those pertaining to online games, produce a psychological effect on the individual that is very close to the optimal state. This indicates a need to change the landscape of interactive marketing by including gamification in marketing programs.

6.2 Managerial implications

This paper also has implications at the managerial level. Specifically, the opportunities offered by interactivity can serve to support sales social commerce platforms. Our findings indicate that online businesses can foster optimal experience and interactivity through the use of gamification; that is, by adding video games as part of their social commerce website experience. Some gamification studies have shown how flow can be generated by using interactive games during the experience, resulting in positive learning outcomes in the field of education (Hamari and Koivisto, 2014; Hamari *et al.*, 2016). Therefore, managers are advised to test how the use of games in social commerce enhances levels of flow, though without disregarding its impact on users' intentions to spread WOM and to return to the website.

Social commerce drives companies to facilitate user participation and social interactions, since the success of these websites depends on these relationships (Chen and Shen, 2015). One way in which to achieve these social relationships is to optimize tools and website design in order to make surfing easier and to enable users to reach a state of flow while keeping them engaged with the website (Kamis *et al.*, 2010). Nevertheless, while gamification tools can be considered useful, such games should not be so easy that they drive users to boredom, or so tedious that they cause anxiety. Following the line of Tozman *et al.* (2015), flow lies between these two states.

Flow state enhances loyalty and intention to spread positive WOM (O'Cass and Carlson, 2010; Herrando *et al.*, 2018). Therefore, understanding how to generate flow in social commerce will help companies to improve the online customer experience. Hence, marketers should design their websites to offer stimuli that trigger flow states to drive positive responses.

The findings also suggest that companies should incorporate social interactivity tools in their websites in order to generate the high-interaction environment typical of social commerce. Although companies cannot work directly on users flow state, they can design websites that stimulate this experience. The results of the two studies in this paper show that, when users are occupied with an activity that requires greater personal involvement, such as video game playing, the indicators of flow (temporal distortion, concentration and enjoyment) are much higher than those experienced in activities that do not require personal involvement. Furthermore, it is shown that the effect of interactivity on purchase intention is considerably enhanced when emotions mediate between interactivity and behavior.

The findings will help companies to bridge the gap with respect to managing social commerce websites, since a rewarding optimal experience such as achieving a state of flow can boost intention to return to the website, as well as enhancing purchase intention and intention to spread positive WOM. We need to continue research on the combination of website interactive elements which increase individual engagement and make users to experience flow.

This work is not exempt from limitations. In the neuromarketing study conducted in this research, some participants showed remarkable differences in their HRV depending on the task. This could have been due to the small size of the sample. Although neuromarketing studies accept the use of small samples, future lines of research should focus on increasing the sample size of this exploratory experiment in order to come to more robust conclusions.

Future research should also concentrate on identifying online interactive activities that increase users' feelings of enjoyment, temporal distortion, and concentration without giving rise to anxiety and comparing the effect of interactivity for different types of products depending on whether they are hedonic or utilitarian. To that end, experimental designs should be conducted in which different activities and products are tested. Additional future research should be directed toward testing the mediating role of flow on other variables, such as satisfaction or sWOM intention.

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