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ORIGINAL PAPER

Using psychophysiological measures to evaluate the multisensory and emotional dynamics of the tea experience

Lekai Zhang[1] · Shouqian Sun[1] · Kejun Zhang[1] · Baixi Xing[1] · Wenjie Xu[1]

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Abstract
In recent years, the user experience has gradually become the main focus in the design of consumer products, rather than the products' features and functions. Therefore, designers should consider the user experience to be of paramount importance in the development of a successful product. In addition, user experience is not static, but rather it changes over the different stages of usage due to the variations in consumers' sensory modalities and emotional responses. Therefore, this study aims to use psychophysiological measures to explore how the interaction between the user and the product at each different stage influences sensory modalities and emotional responses to products. The experiment was conducted in five stages according to the different levels of interaction for two tea products. Subjective data about sensory modalities and emotions related to the products were collected. In addition, the research gathered objective data to examine the feasibility of relating physiological measures to subjective experiences. The results showed that the tea experience tends to be dynamic over the different stages of usage, demonstrating important variations in the different sensory modalities and emotional feedback. In addition, physiological signals such as galvanic skin response, have been shown to be of potential value for evaluation of the user's emotional reaction. Our findings could be important not only for a theoretical understanding of sensory and emotional feedback in a product experience but also as a measure of user experience using psychophysiological methods.

Keywords Multisensory · Emotion · Psychophysiological measures · Dynamic tea experience

Introduction

In recent years, people has shifted from product's function and durability to user experience. Unlike functional issues, user experience requirements are more tacit, latent and complex. In daily life, people interact with everyday products principally through five sensory modalities including vision, hearing, touch, smell, and taste. Research has highlighted that all the sensory modalities can affect consumer preferences, memories and choices [1, 2]. These modalities play a crucial role in creating experiences between users and products [3]. Therefore, it is required to understand the importance of the interaction between multiple senses [4, 5]. In addition, the interaction between users and products is divided into many different stages, including the purchase stage, the use stage, the post-use stage, and so on. Over these different interactive stages, user experience may fluctuate, because the role of our senses can vary and different emotions may be evoked. Therefore, the user experience with a consumer product is not static, but changes over time. It is only through real interaction with the product that a consumer can really get to know a product.

The experience and emotions evoked by the products discussed above are known as the perceived quality of a product. The other product quality is protective quality that refers to the customers' fundamental requirements for product efficiency and effectiveness [6]. However, consumers nowadays can no longer be convinced by a product's functions and durability, they focus closely on the perceived quality, which tries to provide positive experiences through the five human senses [7–9]. Therefore, Retailers must ensure that a product really captures the users' preferences and enhances their positive experience among many comparable alternatives [10]. Since these experiences play a significant role in consumer decision making, companies should ascertain more information that could be valuable in helping them to enhance the quality of products and improve their marketing

✉ Wenjie Xu
xuwj@zju.edu.cn

1 Zhejiang University, No. 38 Zheda Road, Hangzhou, Zhejiang, China

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strategies by assessing the dynamic experience between customers and products.

The traditional evaluation method of user experience applies the Kansei Engineering approach, which utilizes questionnaires to extract the subjective opinions or feelings of experts [11]. However, data collected in this manner is easily affected by viewers' circumstances, expectations, and requirements. Therefore, in order to identify the customers' original feelings or the users' emotions, some studies have focused on the user's perceptual response to a stimulus through physiological measurements [12, 13]. Therefore, the goal of this study is to explore how the interaction between the user and the product in the different usage stages influences the sensory modalities and emotional responses to products using psychophysiological measures. Subjective data about sensory modalities and emotions related to products were collected. In addition, this research gathered objective data to examine the feasibility of relating physiological measures to subjective experiences.

To explore how the type of interaction between the user and the product influences the perception of the product, an experiment was performed in five stages with various levels of interaction. Two different kinds of tea products were chosen as the experimental stimuli. We all know that tea drinking could provide dynamic feedback through the users' five sensory experiences over the different stages. In addition, tea is the second most widely consumed beverage worldwide after water [14]. Therefore, research on tea experiences can also be applied to other drinks or products. In this study, four research questions are addressed:

- Does the importance of different sensory modalities vary with the stages of usage for the different tea products?
- Do emotions vary with the stages of usage for the different tea products?
- Do physiological measures vary across the usage stages of different tea products?
- Do physiological measures correlate with the self-reported data of the user experience?

Related works

Multisensory feedback and experience

Human senses are fundamental in the reaction to a product, especially for food and beverages. There are two traditional methods to study the dynamics of sensory perception within the area of food and beverage research. They are time-intensity (TI) [15] and temporal dominance of sensations (TDS) [16]. However, both methods are used to evaluate the products in the eating and drinking stage, but the role of the sensory modality may fluctuate over the different stages of product usage. Schifferstein et al. highlighted the roles of the various senses and their interplay when people interacted with products and investigated how a dehydrated food product was experienced over different stages of product usage [17, 18]. Andersen et al. found that hedonic sensory and post-ingestive sensations can bring crucial information about consumers' satisfaction [19]. Fenko et al. studied the consumers' experience at four different usage stages and found that vision is the most important sensory modality in buying stage, after 1 month of usage, touch became more important than vision, and after 1 year, vision, touch and hearing became equally important [20].

Therefore, people's experience about products changes at different usage stages, it is important to explore their holistic impact on the experience of the product. However, to the best of our knowledge, the research to date has not investigated tea or other beverages using this method. Therefore, in this research, we used this approach to study the role of the sensory modalities across the different stages of the tea experience.

Emotion and experience

Previous studies suggest that emotions play an important role in the mental process of decision making. Therefore, customers' perceptions or preferences for a product can be evaluated by analyzing their emotions [21, 22]. There are two widely used and dominant models for the description of emotions: the discrete categories model and the dimensional model. For example, Ekman et al. proposed six basic discrete emotions [23], and Jordan described how products could evoke people's social, physiological, or psychological pleasure [22]. Furthermore, the relationship between categories and physiological signals is not clear [21]. Therefore, we chose the dimensional model, which puts forward a valence arousal scale to describe emotions [24]. In this model, emotions can be represented in a two-dimensional space: valence and arousal. In addition, some studies suggested that facial electromyography (EMG) and galvanic skin response (GSR) combined with this model were useful for understanding product perception [12]. Hence, this study adopted a dimensional model to measure the participants' emotions regarding tea products during different stages of usage.

Physiological signals and emotional reactions

In general, studies on user emotional reactions have mainly been based on self-reported data of the users' feelings and preferences [18, 25]. However, it has often been noted that this method requires a large number of participants and considerable time to analyze the subjective data [26]. In addition, the subjective method was not reliable for directly reflecting the user's psychological involvement and failed to explain the user's cognitive processing and emotional state. Therefore, in order to identify the user's original feelings or preferences, some studies have focused on a user's perceptual response to stimuli through physiological measurements [12, 13].

Physiological signals are known to be used for emotional assessment. Many researchers have utilized physiological signals to measure human emotions [27–29]. Picard et al. implemented physiological signals including electromyography of the jaw (EMG), galvanic skin response (GSR), respiration, and blood volume pulse (BVP) of a subject over multiple weeks and obtained 81% recognition accuracy on eight classes of emotion using feature-based recognition methods [30]. Koelstra et al. performed a single-trial classification of arousal, valence, and like/dislike ratings using features extracted from the EEG, peripheral physiological signals, and multimedia content analysis to evaluate music videos and obtained a better result than random classification [31].

In addition, physiological data can be captured in a continuous manner, which is consistent with the way people perceive emotions. For example, Andreassi found physiological signals, such as GSR, respiration rate, and BVP varied with experiences of frustration and emotionally toned stimuli [32]. However, actually, physiological measures of user experience were mainly used in HCI domains. For example, Ward and Marsden found that the value of GSR and HR decreased when participants answered questions by navigating through a well-designed website, while users navigating an ill-designed website were found to have decreases in GSR and HR because the users felt a high level of stress for most of the experience [33]. Moreover, Mandryk and Atkins put forward a fuzzy logic model for continuous emotions to evaluate video games using physiological data and proved that physiological methods were consistent with subjective user experience [34].

In contrast to subjective self-reported methods, the monitoring of physiological responses in real time is more useful for evaluating users' emotions when people are interacting with some objects. For example, such a method could avoid vehicular accidents using an emotion-detection system in real time, which could detect that a driver was drowsy or manufacturers could know a customer's emotional reaction about their product when people were interacting with it [35]. Schmitt et al. used self-reporting methods, eye tracking, and bio-signals to measure the emotional reactions to products as well as product components and found that eye tracking and bio-signals could be applied to indicate relevant product attributes and to measure the emotional responses of customers [21]. However, to the best of our knowledge, physiological measures have rarely been used in evaluating the user experience toward commercial products. Therefore, one goal of this study was to explore the value of physiological measures in evaluating the user experience of a real product.

Experiments

Participants

Forty-five healthy participants took part in this study. They were from China (mean age = 26.5 years, ranging from 20 to 35 years; 25 males and 20 females). The participants who did not have the habit of drinking tea and who had used two tea products before were excluded. In the experimental process, all the participants wore bio-sensors to measure their physiological signals for subsequent data analysis. All the participants were rewarded with 30 RMB.

Materials and Apparatus

The experimental materials are two tea products: one was P1, which is from the Netherlands; the other one was P2, which is from China (see Fig. 1). Through a preliminary experiment, we found that these two green products could evoke different kinds of emotions, so we choose them as the final experimental stimuli.

In order to examine the feasibility of relating physiological measures to subjective experiences, the experiments were conducted in two laboratory rooms with controlled illumination and temperature. One room was for the participants who performed in the experiments, another room was for the experimenter who recorded the physiological signals. The peripheral physiological signals including EMG, GSR, skin temperature, and respiration rate were recorded by ErgoLAB (see Fig. 2). Stimuli and instructions were presented on a 17-inch screen (1280 × 1024, 60 Hz). The electrode placements for acquisition of the peripheral physiological signals were: (a) electrodes attached on the left hand for capturing GSR and SKT signals; (b) electrodes attached over the

Fig. 1 Photo of the two kinds of tea products in this study. The left one is P1; the right one is P2. In order to protect their privacy, both brands' trademarks were blurred

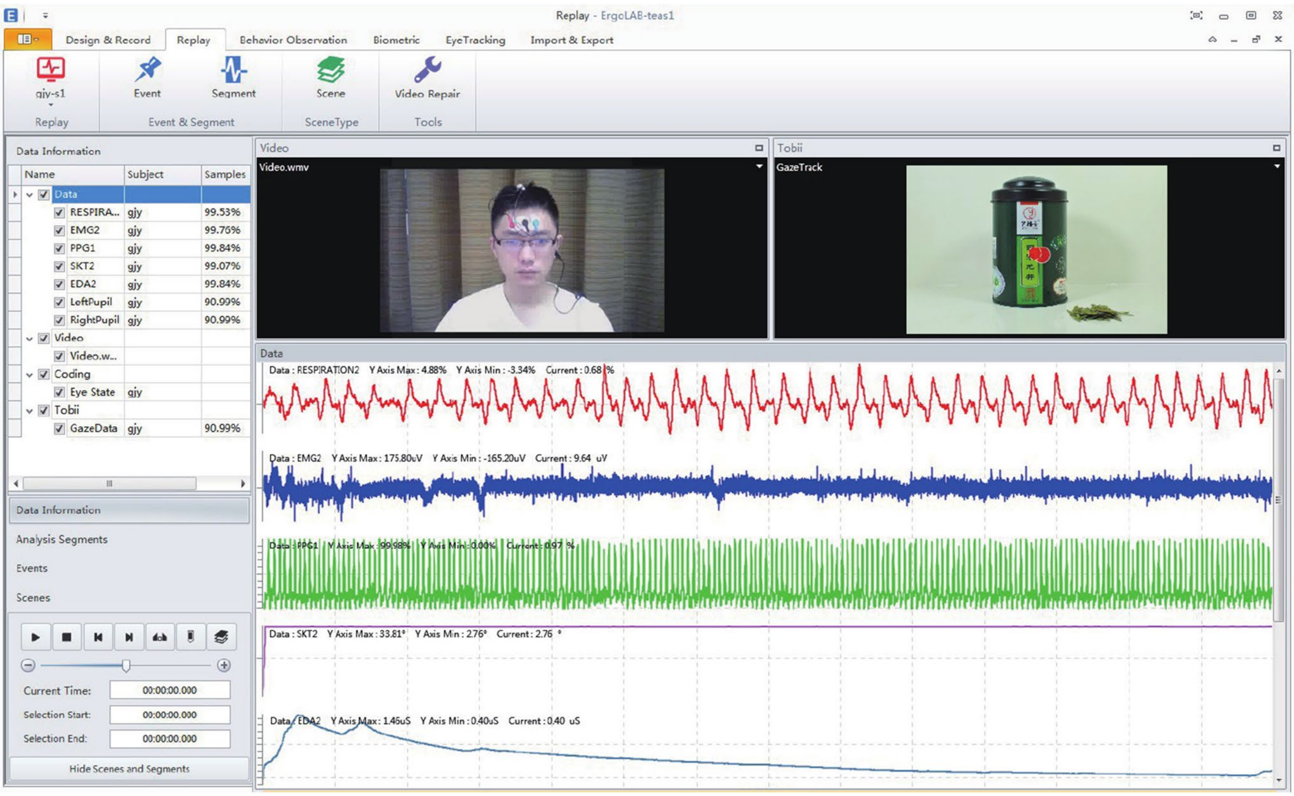

Fig. 2 Screenshot of the ErgoLAB interface

corrugator supercilii on the left side of the face for eliciting the EMG signal; (c) electrodes attached around the abdominal zone to measure respiration rate.

Procedure

Each participant was asked to read the instructions for the task flow and required procedure. Once the participants were clear on the experimental process, he/she was led to the laboratory room. After all the bio sensors were placed and their signals checked, the participants were trained to perform a practice trial to familiarize themselves with the system. Then the experimenter left the room and started to record the physiological signals when the participants began the experiment by pressing a key on the keyboard. To begin the experiment, a 2 min baseline for the signals was recorded, during which a picture of scenery was displayed on the screen for the participants, who were requested to be as relaxed as possible during this period.

Next, all the participants experienced two tea products over five stages: (1) View stage (imitates the experience of online shopping). Participants were asked to view a picture of tea product for 15 s in the center of the screen. (2) See and touch stage (imitates the experience of shopping in a store). Participants observed and touched the tea product for 15 s. (3) Open stage. At this stage, participants opened the package and took out the tea bags or tea leaves. Then they were asked to experience each of the products for 15 s. (4) Make stage. Participants put the tea bag or tea leaves into a teacup and made the tea with boiling water. Then they were asked to experience each of them for 15 s. (5) Sip stage. At this stage, participants sipped the tea for 15 s for each product. During each of the five stages, participants' peripheral physiological signals were recorded. After each of the five stages, they were asked to score their experience with the products using two questionnaires, respectively. During the experiment, both kinds of tea products were presented randomly. After each product, participants were asked to take a 2 min rest. The whole experiment took approximately 40 min.

The first questionnaire focused on five sensory modalities including vision, hearing, touch, smell, and taste. The participants indicated how important he/she found these five sensory modalities at each stage of the experience. The answers were on a five-point scale, which represented Not Important at All (1 point) to Very Important (5 points). After rating the five modalities of each tea product, the participants described why he/she felt some senses were more important than others at that stage.

The second questionnaire was a self-assessment manikin (SAM), which was a 9-point scale (see Fig. 3). For valence,

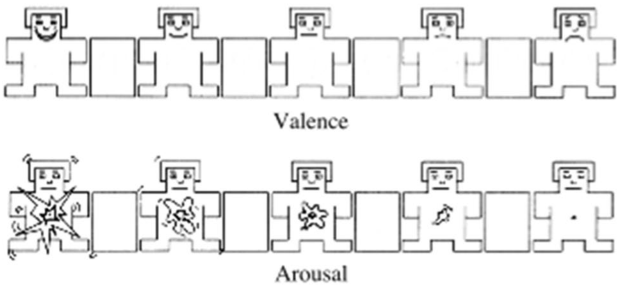

Fig. 3 Self-assessment manikin (SAM) for valence and arousal

1 represented Not Pleasant at All (1 point) to Very Pleasant (9 points), and for arousal, 1 represented Not Strong at All (1 point) to Very Strong (9 points). The participants were asked to read the instructions of the different scales used for self-assessment and rate the valence and arousal for each tea product over five stages, followed by a report of why he/she felt that way.

Data analyses

Three analyses were performed for different purposes:

Analysis 1 changes in ratings of importance of the sensory modalities for the five stages.

In order to evaluate the changes of sensory modalities during the five experimental stages, repeated measures ANOVAs were used. Post-hoc pairwise comparison of the significance of the differences between means was also tested with a Bonferroni adjustment.

Analysis 2 changes of emotion ratings for each product in five stages.

In order to evaluate the changes of emotions during the five experimental stages, repeated measures ANOVAs were also used. Post-hoc pairwise comparison of the significance of the differences between means was also tested with a Bonferroni adjustment.

Analysis 3 test the efficacy of the physiological measures in evaluating the tea product experience.

In order to evaluate the physiological signal changes during the five experimental stages, a repeated measures ANOVA was used. Post-hoc pairwise comparison of the significance of the differences between means was also tested with a Bonferroni adjustment. In addition, correlation analysis was used to analyze the relationships between physiological signals and subjective assessments of user experience.

Because physiological signals had very large individual differences, it was necessary to normalize the physiological data. Based on similar studies [34], physiological signals were normalized using the following formula for each participant. The same method was used to normalize the data from the EMG, skin temperature, and respiration.

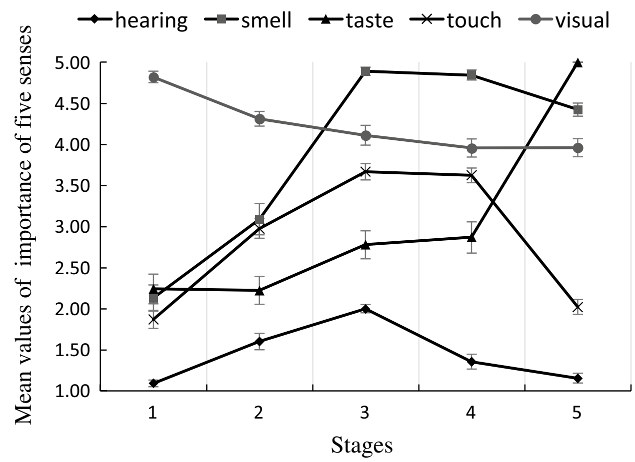

Fig. 4 Mean values for the importance of sensory modalities for the five stages of product usage. Error bars: Standard errors

$$\text{Normalized GSR'(i)} = \left(\text{GSR(i)} - \text{GSR}_{\min}\right) / \left(\text{GSR}_{\max} - \text{GSR}_{\min}\right) \times 100$$

All of the statistical analyses were performed using SPSS software (version 20).

Results

Analysis of sensory modalities

Repeated measures ANOVAs were used to analyze the ratings of the importance of sensory modalities with Stage, Sensory as within-participant factors. The results showed significant differences among different stages [F (3.41, 150.19) = 102.94, $p < 0.001$, $\eta_p^2 = 0.70$] and different sensory modalities [F (2.23, 98.27) = 182.48, $p < 0.01$, $\eta_p^2 = 0.81$], and contributed a significant two-way interaction Stage × Sensory [F (5.52, 242.80) = 91.21, $p < 0.01$, $\eta_p^2 = 0.68$]. To investigate these effects in more detail, we conducted a simple effect for each of the stage with sensory modalities and found that all the effects were all highly significant; multiple comparisons were then performed and are shown in Fig. 4.

In the first and second stage, vision was the most important sensory modality (all $p < 0.01$). In the third stage, vision and smell became equally important in this stage (all $p < 0.01$). In the fourth stage, smell dominated the product experience (all $p < 0.01$) and vision is more important than hearing, touch and taste (all $p < 0.01$). At the last stage, taste played a dominant role in the product experience (all $p < 0.01$) and smell is more important than hearing, touch and vision (all $p < 0.01$).

Analysis of emotions

Repeated measures ANOVAs were used to analyze the ratings of the valence and arousal, respectively with Stage, Product as within-participant factors. For arousal, the results showed significant differences among the different stages [F (4, 176) = 1084.05, p < 0.001, $\eta_p^2 = 0.96$] and different products [F (1, 44) = 19.37, p < 0.001, $\eta_p^2 = 0.31$], and contributed a significant two-way interaction Stage × Product [F (3.65, 160.83) = 8.94, p < 0.001, $\eta_p^2 = 0.17$]. To investigate these effects in more detail, we conducted a simple effect for each of the stages with the products and found in the first and second stage, the effect of different products was highly significant (all p < 0.05). Multiple comparisons were then performed and are shown in Fig. 5.

For valence, the results showed significant differences among the different stages [F (4, 176) = 388.45, p < 0.001, $\eta_p^2 = 0.89$] and different products [F (1, 44) = 691.99, p < 0.001, $\eta_p^2 = 0.94$], and contributed a significant two-way interaction Stage × Product [F (4, 176) = 243.29, p < 0.001, $\eta_p^2 = 0.85$]. To investigate these effects in more detail, we conducted a simple effect for each of the stages with the products and found in all five stages, the effect of different products was highly significant (all p < 0.05). Multiple comparisons were then performed and are shown in Fig. 6.

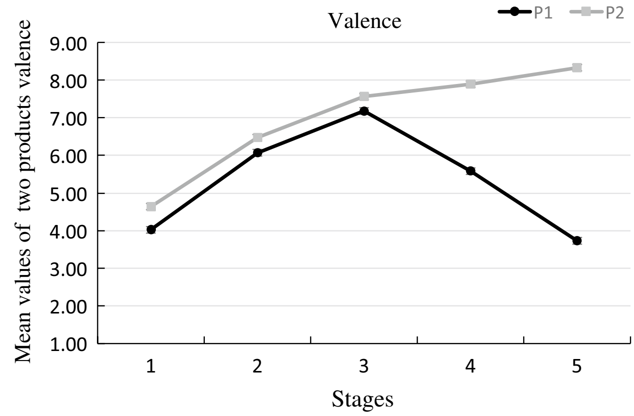

Fig. 6 Mean values for the valence of the two products for the five stages of product usage. *P1* is a tea product from the Netherlands; *P2* is a tea product from China

Analysis of physiological signals

During the experiment process, due to five participants' movements, some electrodes loosened and provided invalid results, thus only 40 participants (mean age = 25 years, ranging from 20 to 32 years; 20 males and 20 females) physiological data were analyzed. Analysis of physiological signals consisted of two parts. In order to answer the research questions, repeated measures ANOVA were used to evaluate the changes in physiological signals with Stage, Product, and normalized physiological data, respectively as within-participant factors. It yielded a significant main effect of Stage [F (1.94, 75.92) = 28.96, p < 0.01, $\eta_p^2 = 0.43$] with GSR signals. The other effects did not achieve statistical significance.

To further investigate the Stage effect, post-hoc pairwise comparison of the significance of the differences between means was also tested with a Bonferroni adjustment, which is shown in Fig. 7. It shows that in stage 2, participants had a higher mean value of normalized GSR signals than in stage 1 (p < 0.05). In addition, in stage 3, participants had the highest mean value of normalized GSR signals than in the other four stages (all p < 0.05).

The EMG, SKT, and Respiration rate data were also analyzed in the same way but no significant difference was found.

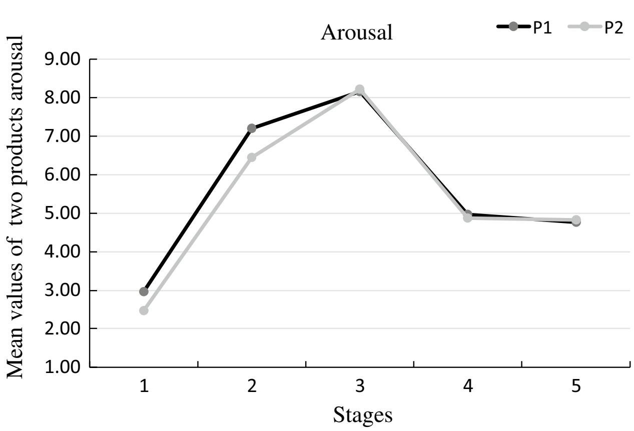

Fig. 5 Mean values for arousal for the five stages of product usage. *P1* is a tea product from the Netherlands; *P2* is a tea product from China. Error bars: Standard errors

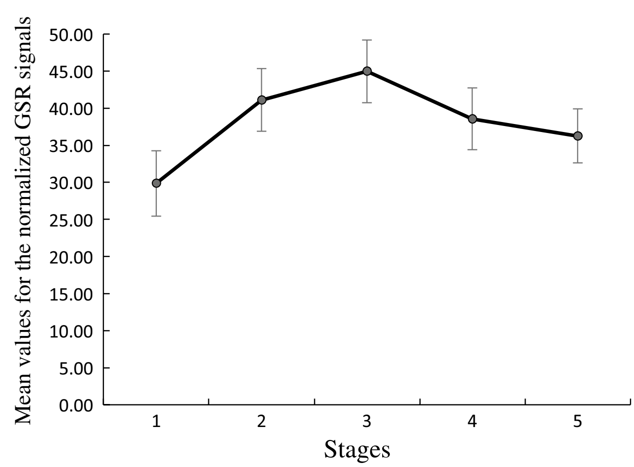

Fig. 7 Mean values for the normalized GSR signals for the five stages. Error bars: Standard errors

To investigate the relationships between the mean value of the normalized GSR and the subjective assessment of user experience in more detail, correlation analysis was used to analyze the mean value of normalized GSR with arousal and the valence, respectively. It showed that arousal was significantly correlated with GSR (Pearson's correlation = 0.35, $p < 0.01$); however, it showed no significant correlation between GSR and valence.

Discussion

The results discussed above answered the four research questions and showed that sensory modalities, emotions and physiological signals from tea experiences vary depending on the stages of product usage.

Discussion of sensory modalities

At the first two stages, vision was the most important modality during the experience of the products. This findings were also observed by Fenko et al. [20] who found that vision played the dominant role at the buying stage, because it is impossible for consumers to open the packages in retail environments and when online shopping. In addition, compared to stage 1, people could feel more information through smell and touch in stage 2, so smell and touch were the second most important modalities in stage 2.

In stage 3, people could open the package and identify the freshness of the tea by smell, and look at the shape and color of the tea through vision, so smell became as important as vision. Meanwhile, people could feel the quality of the product through touch the tea bags or tea leaves, which would influence their choices. Thus, touch was also important. In addition, they could listen to the sounds that were made when they opened the packages (P1's packages were made of paper, P2's package was made of metal), which explains why a bit of importance was attributed to hearing.

During the tea making stage, smell kept playing a dominant role, because participants could decide if this tea suited their taste through smell. Furthermore, vision was also important at this stage, because participants could see the state and the color of the tea leaves in water. In fifth stage, taste undoubtedly became vital. In addition, participants reported that a good smell could improve the taste, and tea bags or tea leaves could influence their taste experience, so smell and vision were also important.

In the first four stages, there is an interesting finding that although the participants had no actual reaction of the gustatory senses in these stages, they scored the importance of taste higher, because they reported that they could imagine the taste through the package based on their prior experiences. This result further supports the idea of Schifferstein et al. [18] that subjective data on sensory modality importance may reflect not only an actual sensory experience, but also people's imagination of what they might experience.

Discussion of emotions

The emotional reaction to a product was divided into two values: arousal and valence. Valence was represented as the participant's pleasance with a product. The results showed that in the first three stages, there were nearly no differences between the two products. From the fourth stage, the pleasance of P1 gradually declined. The reason for these changes can be found in the collected qualitative data. First, it shows that participants were displeased with the quality of the tea leaves used in P1, because the quality of the leaves in a closed bag was difficult to distinguish. Second, most of participants disliked its smell and taste in stages 4 and 5. However, participants were pleased with P2 from stage 1 to stage 5. The reasoning for this can be found after analyzing the collected qualitative data where we see that they knew the product and its quality, and additionally they had had good experiences with this domestic product before. It was concluded that a user's prior experience had a big influence on a user's purchasing decision. When a prior experience was satisfactory, users show a quicker and stronger feedback on levels of satisfaction for the second experience with the product; hence, they tend to make a faster buying decision.

With respect to arousal, there was no significant difference between the two products. Combined with the qualitative feedback, we could explain that in the first two stages, participants reported that a picture of the product (stage 1) provided less arousal feedback than the real product (stage 2), which could afford more details through the senses of touch and smell. In the third stage, both products were scored the highest, because participants could open the package and have a look inside which could afford more arousal feedback. From the fourth stage, the arousal of the two products went down, because although the P1's external package was new to the participants, when they opened the package, the inner package was as same as other tea bags which they saw regularly before. At the same time, participants were very familiar with P2's tea leaves; therefore, the value of arousal for the two products declined. In conclusion, participants feel emotional arousal when experiencing new products, therefore products should be refreshed every once in a while, to continue holding on to customer attention.

Discussion of physiological signals

Regarding physiological signals, there were two major findings. The first was that physiological signals such as GSR varied with the different tea products' usage stages. Second, significant correlations were found between GSR and subjective assessments of emotion, such as arousal.

These findings might be related to participants' expectations about products during the different stages. In the first three stages, all of the participants reported that they were curious about how they would experience the next stage; therefore, the mean normalized GSR signals increased gradually. However, when they made and drank the tea, they found P1's package was similar to other foreign packages, and the smell and taste of P1 was unpleasant, so they lost their expectations after stage 3. In addition, they were very familiar with the experience of making and drinking the tea like P2, so they did not have much expectations about P2 during stages 4 and 5. As a consequence, no statistically significant difference between the two products was evident. These results further support the idea of [21] where the valence was measured with facial electromyography and the emotional arousal was measured with the galvanic skin response (GSR), and more GSR implied higher emotional arousal.

Although we found a significant difference in GSR signals during different stages, no significant differences in EMG, SKT, and respiration rate data were found. The lack of statistical significance might be due to three reasons. First, physiological responses were not sensitive enough to distinguish different kinds of emotions with these two products. Second, the number of participants was not large enough to distinguish subtle EMG, SKT, and Respiration rate differences between the different stages. Finally, there were some methodological issues that contributed to irregular patterns of physiological signals. In particular, the act of performing the experiment throughout the different stages created greater physiological responses than the experimental manipulations themselves.

After addressing our methodological issues, the results answered our research questions such that physiological signals such as GSR, vary over the stages of usage for different products and can be used to some extent as an objective indicator to evaluate people's emotional reactions.

Conclusion

This study aimed to explore the dynamics of sensory modalities and emotional responses to tea products during the different stages of user product interaction. In addition, this research also carried out a preliminary study to examine the feasibility of relating physiological measures to subjective experience.

In future studies, the physiological response could be synchronized with brain wave signals and behavioral observation methods such as video records to explore the relationships between physiological states and users' subjective emotions, through which we can know what the problems are with a product and how users react to them. Furthermore, when testing with physiological signals, more participants are needed to ensure statistical validity because of the large individual differences in the data gathered.

In conclusion, this study shows some interesting findings that can be applied to optimize the design of tea products or consumer products in other categories. It has shown that the tea experience tends to be dynamic over the different stages of usage, demonstrating variations in the importance of different sensory modalities and emotional feedback. In addition, physiological signals such as GSR, were shown to be of potential value for evaluation of the user's emotional reaction. These findings could be used to test the user experience over product life-cycle to help develop a successful tea product. In addition, they are important not only for a theoretical understanding of sensory and emotional feedback on product experience, but also for the measure of user experience using psychophysiological methods.

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References

1. I. Katsaridou, Int. J. Market Res. **54**, 147–149 (2012)
2. A. Krishna, L. Cian, N.Z. Aydınoğlu, J. Retail. **93**, 43–54 (2017)
3. B. Hultén, Eur. Bus. Rev. **23**, 256–273 (2011)
4. A. Parsons, Int. J. Retail Distrib. Manage. **37**, 440–452 (2009)
5. P.W. Ballantine, A. Parsons, K. Comeskey, Int. J. Retail Distrib. Manage. **43**, 503–517 (2015)
6. B. Falk, B. Quattelbaum, R. Schmitt, *Product Quality from the Customers' Perspective–Systematic Elicitation and Deployment of Perceived Quality Information*. (Springer, Berlin, 2010) pp. 211–222
7. H.N.J. Schifferstein, P.M.A. Desmet, Des. J. **11**, 137–158 (2008)
8. M. Köhler, R. Schmitt, *Advances in Affective and Pleasurable Design*. (CRC Press, Boca Raton, 2012), pp. 503–512
9. L.H. Mielby, B.V. Andersen, S. Jensen et al., Food Res. Int. **82**, 14–21 (2016)
10. M. Bordegoni, U. Cugini, F. Ferrise, Emotional Eng. **2**, 219–242 (2013)
11. M. Nagamachi, A.S. Imada, Int. J. Ind. Ergon. **15**, 1–1 (1995)
12. J. Laparra-Hernandez, J.M. Belda-Lois, E. Medina, N. Campos, R. Poveda, Int. J. Ind. Ergon. **39**, 326–332 (2009)
13. G.G. Berntson, J.T. Cacioppo, K.S. Quigley, Psychophysiology **30**, 183–196 (1993)
14. A. Macfarlane, I. Macfarlane, *The Empire of Tea*. (The Overlook Press, New York, 2004)
15. M. Larson-Powers, R.M. Pangborn, J. Food Sci. **43**, 41–46 (1978)
16. J. Sudre, N. Pineau, C. Loret, N. Martin, Food Qual. Prefer. **24**, 179–189 (2012)
17. H.N.J. Schifferstein, C. Spence, Prod. Exp. **2008**, 133–161 (2008)
18. H.N.J. Schifferstein, A. Fenko, P.M.A. Desmet, D. Labbe, N. Martin, Food Qual. Prefer. **27**, 18–25 (2013)
19. B.V. Andersen, L.H. Mielby, I. Viemose et al., Food Qual. Prefer. **58**, 76–84 (2017)

20. A. Fenko, H.N.J. Schifferstein, P. Hekkert, Appl. Ergon. **41**, 34–40 (2010)
21. R. Schmitt, J.V. Durá, J. Diaz-Pineda, J. Sens. Sens. Syst. **3**, 315–324 (2014)
22. P.W. Jordan, *Designing Pleasurable Products: An Introduction to the New Human Factors*. (Taylor & Francis, Abingdon, 2000)
23. P. Ekman, W.V. Friesen, M. O'Sullivan, J. Pers. Soc. Psychol. **53**, 712–717 (1987)
24. J.A. Russell, J. Pers. Soc. Psychol. **39**, 1161–1178 (1980)
25. T. Lin, M. Omata, W. Hu, *Computer-Human Interaction Special Interest Group (CHISIG) of Australia, ACM*. (ACM, Brisbane, 2005) pp. 1–10
26. J. Annett, Ergonomics **45**, 966–987 (2002)
27. J. Kim, E. Andre, IEEE Trans. Pattern Anal. **30**, 2067–2083 (2009)
28. C.L. Lisetti, F. Nasoz, J. Eurasip, J. Adv. Signal Process. **2004**, 1672–1687 (2004)
29. G. Chanel, J.J.M. Kierkels, M. Soleymani, T. Pun, Int. J. Hum. Comput. Stud. **67**, 607–627 (2009)
30. R.W. Picard, E. Vyzas, J. Healey, IEEE Trans. Pattern Anal. **23**, 1175–1191 (2001)
31. S. Koelstra, C. Muhl, M. Soleymani, J.S. Lee, A. Yazdani et al., IEEE Trans. Affect. Comput. **3**, 18–31 (2012)
32. J.L. Andreassi, *Psychophysiology: Human Behavior and Physiological Response*. (4th edn). (Lawrence Erlbaum Associates Publishers, Mahwah, 2000)
33. R.D. Ward, P.H. Marsden, Int. J. Hum. Comput. Stud. **59**, 199–212 (2003)
34. R.L. Mandryk, M.S. Atkins, Int. J. Hum. Comput. Stud. **65**, 329–347 (2007)
35. J.N. Bailenson, E.D. Pontikakis, I.B. Mauss, Int. J. Hum. Comput. Stud. **66**, 303–317 (2008)