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Original Article

Multi-layered and Multidimensional Structure of Evaluative, Affective, and Psychophysical Impressions While Viewing Hug Scenes

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Abstract: Psychophysical and affective experiences while watching audiovisual content can be antecedents to determine the overall evaluation of viewing experiences. However, the layered relationships among these experiences have been hardly discussed. We investigated these experiences and their semantic structure while watching hug scenes. We selected 38 adjectives describing hugs and classified them into three layers: psychophysical, affective, and overall evaluation. Participants scored each of the 24 videos containing hugging scenes using these adjectives. The structure among the three layers was computed: the four psychophysical factors affected the four affective factors, which in turn affected the two overall evaluation factors, i.e., joyful and reassuring. The model was confirmed to have statistical validity by structural equation modeling and semantic validity by experiments using dummy links. The results will lead to the determination of measures to enhance affective experiences when viewing videos, and the formulation of criteria for measuring and evaluating affective experiences.

Keywords: Affective experience, Emotion, Psychophysical factor, Structural equation modeling

1. Introduction

Cognitive and affective judgments or experiences are involved in a variety of daily activities, such as viewing videos, reading, traveling, shopping, and playing sports (e.g., Schindler et al., 2017). Overall satisfaction with activities is based on an ensemble of such experiences (Bao et al., 2019; Bartl et al., 2013; Guest et al., 2011; Hashim et al., 2017; Hosany & Gilbert, 2010; Hosany & Witham, 2010; Kawabata & Niwa, 1989; Kidoma et al., 2017; Kumar et al., 2001; Mano & Oliver, 1993; Matsumura et al., 2020; Nagano et al., 2018; Okamoto et al., 2016; Okamoto et al., 2021; Tu et al., 2018). For example, satisfaction with cruising can be synthesized by feelings of entertainment and aesthetics in travel settings (Hosany & Witham, 2010). Product consumption satisfaction was analyzed from the viewpoint of the buyer's emotions and product utility (e.g., Mano & Oliver, 1993). Understanding how overall evaluation, such as satisfaction with activities, can be broken down into affective and low-level cognitive (i.e., psychophysical) factors would lead to guidelines for designing affectively appealing activities for service providers. Furthermore, this will lead to the establishment of a measure for overall evaluation. Considering the generality and access to stimuli, we analyzed the structure of hedonic, affective, and psychophysical evaluations of short videos of hug scenes.

Some previous studies have decomposed satisfaction felt from activities and stimuli into multiple affective components (Bao et al., 2019; Bartl et al., 2013; Hosany & Gilbert, 2010; Kumar et al., 2001; Mano & Oliver, 1993; Matsumura et al., 2020; Schindler et al., 2017; Tu et al., 2018). These studies have not aimed to provide guidelines for creating commercial services that evoke satisfaction. Other studies have estimated affective experiences from the psychophysical features of activities (Hosany & Witham, 2010; Okamoto et al., 2016; Pizzi et al., 2015; Thomson et al., 2010). These studies did not aim to provide an understanding of the factors constituting overall satisfaction. In other words, expressing the overall

satisfaction, affective factors, and psychophysical aspects linked in a model has not been pursued by many earlier studies. Several researchers have established such models (Guest et al., 2011; Kawabata & Niwa, 1989; Kidoma et al., 2017; Okamoto et al., 2021); however, they did not target affectively evocative stimuli, such as hug scenes with lengths of several seconds, which were used in this study.

In this study, we collected subjective scores for overall satisfaction, affective, and psychophysical attributes from participants who viewed the hug scenes. We aimed to determine the structures between the attributes of these three categories, as shown in Figure 1, which leads to a guideline for designing affectively appealing audiovisual content and helps understand the construct of overall satisfaction with them. This study is an extended version of the authors' earlier work (Ogura et al., 2023) where fewer types of subjective evaluation items were collected than in this study and the statistical and semantic validities of the model were not examined.

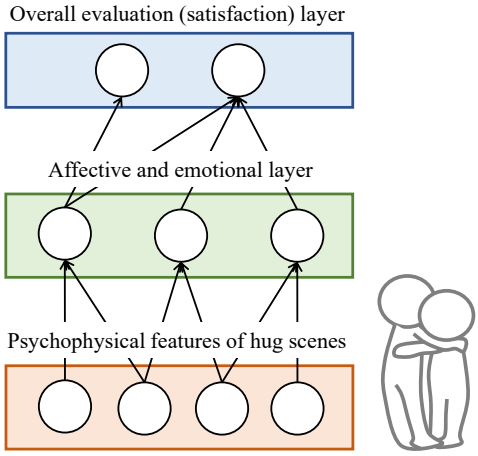

Figure 1: Three-layered semantic structure of affective experience, i.e., viewing hug scenes. Each layer is composed of multiple independent factors, i.e., white circles in the figure.

Further, a novel methodology to semantically validate multi-layered models is introduced in this study. Such models are usually statistically validated by, for example, structural equation modeling method. However, the semantic validation of the models is also important and this process has largely been performed by referring to literature and experts' knowledge (Chen et al., 2009; Fujisaki et al., 2015; Guest et al., 2011; Kawabata & Niwa, 1989; Kidoma et al., 2017; Okamoto et al., 2021). This study employs a user experiment to quantitatively examine the semantic validity of multi-layered models. This experiment-based semantic validation approach can be a general method for multi-layered models.

As aforementioned, this study has two important aspects. The first is to establish and implement a method to compute a multi-layered model comprising overall satisfaction, affective, and psychophysical factors, which helps understand and design affectively evocative contents. The second is to develop an experimental method for semantically validating such models. We demonstrate these two features by adopting hug scenes as an example of affective stimuli.

2. Methods

2.1 Participants

Twelve university students (five females, mean age: 24.6 years) participated in Task 1, and 11 of them participated in Task 2 after providing written informed consent. Task 2 was conducted on different days after Task 1. Participants were unaware of the objectives of the study.

2.2 Video stimuli: Hug scenes

Twenty-four videos were selected by the authors and colleagues from a research group. All the videos were posted on video-sharing websites. The lengths of the videos ranged from 4 s to 23 s. The videos were limited to hugging scenes between two people or a human and an animal. Videos with similar content were not included redundantly. Videos featuring one or more of the four emotions (pleasant, unpleasant, activation, and deactivation) that form the basis of the

circumplex model of emotion (Russell, 1980) were included. We included as many different types of videos as possible in terms of the age, sex, and race of the characters. The movies include, for example, hug scenes of a mother and daughter after a long separation; those between friends after arguing or separation; lovers; animals and owners; hugs to comfort each other in sorrow; and hugs to greet close friends or non-close acquaintances.

2.3 Adjective attributes used to evaluate hug-scenes

Using search engines on websites, we selected 58 words related to hugging that could describe the attributes of hugging. These include evaluative and affective words as well as those explaining the appearance of people and hugging motions in the videos. Onomatopoeic words were excluded. Subsequently, from the 58 words, we selected those used to describe the hug scenes using the check-all-that-apply method. In this method, participants watched 24 hug scenes and answered yes/no to whether each word described those scenes. Finally, the 38 words that received more than two-thirds of the participants' votes were adopted in a later experiment.

The adopted 38 attributes were as follows: reassuring, satisfying, joyful, attractive, relaxing, comforting, gentle, physically warm, stressful, loving, arousing, full-hearted, sweet, sympathetic, exciting, enjoyable, possessive, sad, reliable, awkward, passionate, respectable, intimate, cheering, close contact, protective, physically strong, dynamic, forcible, violent, tight, sudden, embracive, soft, mannish, feminine, happy faces, and sad faces. Descriptions of the attributes presented to the participants are listed in Table 1.

Table 1: Attribute words and description used in the experiment.

Attribute word	Description	Attribute word	Description
Reassuring	I feel peaceful, calm, and free from anxiety.	Physically strong	People strongly embrace each other.
Relaxing	The hug scene relieves and unwinds my tension.	Dynamic	The hugging motion is not still and dynamic.
Comforting	I feel comfortable in watching the scene.	Forcible	It appears that one hugs the other without his/her consent.
Gentle	The scene feels warm and compassion.		
Physically warm	People hugging in the video feels the other person's body temperature.	Violent	The hugging motion is not kind.
		Tight	The people are tightly hugging.
Satisfying	I feel satisfied and happy.	Sudden	One person suddenly gives a hug to the other.
Joyful	I feel joy.	Embracive	One puts his/her arms around the other.
Stressful	I feel stressed by watching the hug scene.	Soft	The hugging motion is soft.
Loving	I feel that people in the video love each other.	Reliable	I feel that people trust each other.
Closely contacted	People in the video are hugging in close contact.	Awkward	I feel the hug scene is unnatural.
Arousing	I feel aroused.	Mannish	I feel the hug is manly.
Full-hearted	The hug fills my heart with feelings.	Feminine	I feel the hug is womanly.
Sweet	I feel enchanted.	Passionate	I feel strong feelings of love or friendship.
Sympathetic	I feel people in the video share their feelings.	Respectable	I feel that people respect each other.
Exciting	I am excited by the hug.	Intimate	I feel the intimacy of people in the video.
Enjoyable	The hug is enjoyable and fun.	Attractive	The hug scene is attractive.
Protective	One of the people hugging appears to protect the other.	Cheerful	The hug scene is cheerful.
Possessive	One of the people hugging appears to monopolize the other.	Happy faces	The people hugging are smiling and look happy.
Sad	The hug scene is heart-wrenching.	Sad faces	The people hugging look sad.

2.4 Task 1: Assessment of hug-scenes to build a layered structure

2.4.1 Procedure

Individual participants watched 24 videos containing hugging scenes played on a computer screen, in random order. After viewing each video, they rated it on a nine-grade visual scale for each of the 38 attributes. As shown in Figure 2, two extremities of the scale were labeled "very" and "little," whereas the center was "neutral."

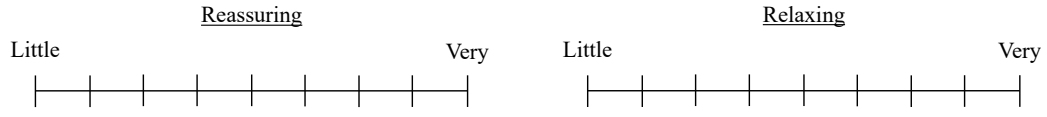

Figure 2: Nine-graded visual scale of attribute words.

After evaluating the 24 videos, the participants assigned all the adjective attributes to one of the three layers in a forced-choice task. These three layers are psychophysical, affective, and evaluative. A description of each layer

provided to the participants is as follows: The psychophysical category is the physical aspect of hugging, which can be determined by observing the images. The affective layer is an attribute judged based on past experiences and feelings, in addition to information from the psychophysical layer. The overall evaluation layer relates to the comprehensive quality or preference of the hug based on these two layers. These layers were determined based on previous studies (Guest et al., 2011; Okamoto et al., 2021).

2.4.2 Data analysis

The layer to which the 38 adjectives belonged was determined by the participants' votes. The results of the 9-grade scaling were normalized within individuals for each attribute. A principal component analysis (PCA) was applied to the adjectives for each layer. Principal components with eigenvalues greater than one were employed according to the Kaiser-Guttman criterion. Promax rotation was applied to the coefficient matrix to facilitate the interpretation of the principal components.

The structures of the lower (psychophysical), middle (affective), and upper (overall) principal components are investigated. Multiple regression analysis was applied to the upper and middle layers and the middle and lower layers using the principal components of the upper layer (category) as the objective variable and the principal components of the lower layer (category) as the explanatory variables to determine the potential connections between the layers of the principal components. Only regression coefficients with significant effects ($p<0.05$) were adopted to construct a hypothetical layered model for structural equation modeling. Subsequently, links determined to be significant ($p<0.05$) by structural equation modeling were adopted in the final model. For the structural equation modeling, *lavaan* (version 0.6) for *R* was used. The sample size was 288 (12 participants × 24 replications), which is in the range of typical sizes for structural equation modeling (Hoshino et al., 2005).

2.5 Task 2: Semantic validation of layered structure

2.5.1 Procedure

The participants viewed the layered model established as a result of Task 1, which showed a directed graph with nodes and arrows as the principal components and the influence between them, respectively, along with the coefficients representing the strength of the influence. These coefficients were computed using structural equation modeling. The participants were then asked, "Do you agree with the influence from one node to another?" for each arrow in the layered model. Participants answered yes or no in a forced-choice manner.

As shown in Figure 3, the directed graph presented to participants randomly included dummy connections that differed from the model obtained in Task 1. The dummy arrows have inverted signs for the coefficients of the arrows obtained in Task 1. Dummy arrows were randomly generated for each participant and each participant was presented with two dummy arrows. The participants were suggested the existence of the dummy arrows. Without such dummies, the participants could be led to believe that all connections were valid, causing them to experience an implicit pressure to respond affirmatively in all cases. Okada et al. (2019) used a similar method to examine the semantic validity of the causal models. They presented an authentic model and a few modified models, of which arrows were randomly deleted and added, and participants determined the model that they could agree. Their method could investigate whether the authentic model would be entirely endorsed or not. In contrast, the method in this study can examine the semantic validity of each arrow in the model. Furthermore, the introduction of dummy connections provided the basis for hypothesis tests for the proportions of "yes" or "no" responses to all the connections as described in Section 2.5.2.

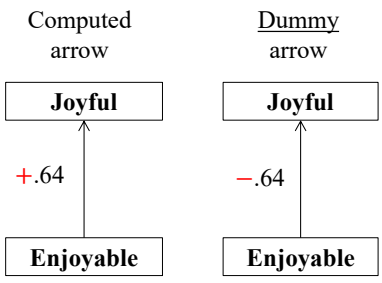

Figure 3: Dummy arrow presented to participants in Task 2.
The sign of the dummy arrow's coefficient was inverted.

2.5.2 Data analysis

For each directional link of the layered structure, the proportion of respondents who agreed with the meaning of the link was compared to the proportion of respondents who agreed with the dummy links, supposing that the former should be greater than the latter if the computed links were semantically valid. The rate of the latter proportion was 0.41 (9/22). To compare the proportions, a hypothesis test (z-test) for two-sample proportions was used.

3. Results

Table 2 shows the results of the categorization of the 38 attributes. Four adjectives were classified in the overall evaluation layer, 19 in the affective and psychological layers, and 15 in the psychophysical layer.

Table 2: Categorization of adjective.

Layers	Description	Adjectives
Evaluative and preferential	The overall evaluation layer relates to the overall quality or preference of the hug based on the other two layers.	reassuring, satisfying, joyful, attractive
Affective and psychological	Layer of attributes judged based on one's past experiences and feelings, in addition to the psychophysical layer.	relaxing, comforting, gentle, stressful, loving, arousing, full-hearted, sweet, sympathetic, exciting, enjoyable, possessive, sad, reliable, awkward, passionate, respectable, intimate, cheering
Psychophysical	Layer of the physical aspects of hugging, which can be judged by looking at the images.	closely contacted, protective, physically strong, dynamic, forcible, violent, tight, sudden, embracive, soft, physically warm, mannish, feminine, happy faces, sad faces

Table 3 lists the coefficients of the principal component analysis computed for each layer. This table lists the four major attributes and the coefficients for each component. The overall evaluation, affective/psychological, and psychophysical layers comprised two, four, and four principal components, respectively.

Table 3: Coefficients of principal components after promax rotation.

Principal component	Overall evaluation		Affective and psychological		Psychophysical	
1	Joyful	0.69	Possessive	0.50	Physically strong	0.53
	Satisfying	0.69	Sweet	0.50	Tight	0.46
	Attractive	0.48	Loving	0.30	Closely contacted	0.40
	Reassuring	−0.08	Comforting	0.30	Dynamic	0.39
2	Reassuring	0.96	Enjoyable	0.51	Feminine	0.61
	Joyful	−0.21	Exciting	0.49	Sad faces	0.46
	Attractive	0.15	Sad	−0.38	Mannish	−0.41
	Satisfying	0.12	Cheering	0.36	Happy faces	−0.41
3	–		Relaxing	0.61	Protective	0.60
			Kind	0.37	Embracive	0.54
			Comforting	0.35	Soft	0.34
			Stressful	−0.29	Closely contacted	0.32
4	–		Awkward	−0.47	Forcible	0.65
			Respectable	0.44	Sudden	0.52
			Sweet	−0.38	Violent	0.43
			Reliable	0.34	Protective	0.24

The three-layered model computed is shown in Figure 4. The variables represented by the squares are the principal components, and their names and main attributes are shown in the squares. Values next to the arrows indicate the intensity of influence. We adopted only significant coefficients ($p<0.05$). R^2 is the coefficient of determination that indicates how well a principal component can be explained by the linear sum of the principal components in the lower layer.

The overall evaluation layer consists of two principal components: joyful and reassuring. The affective/psychological layer consisted of four principal components: sweet, enjoyable, relaxing, and reliable. The psychophysical layer comprises four principal components: physically strong, feminine, protective, and forcible. The results of the structural equation modeling showed that the goodness of fit of the model was GFI=0.99 (which is preferred to be greater than 0.90–0.95 (McDonald & Ho, 2002)), the relative goodness of fit with the consideration of the degrees of freedom was CFI=0.98 (which is preferred to be greater than 0.90 (McDonald & Ho, 2002)), and the significant probability for χ^2 was $p=0.16$ (which is preferred to be greater than 0.05 (McDonald & Ho, 2002)). Based on these indices, the model shown in Figure 4 was considered statistically valid.

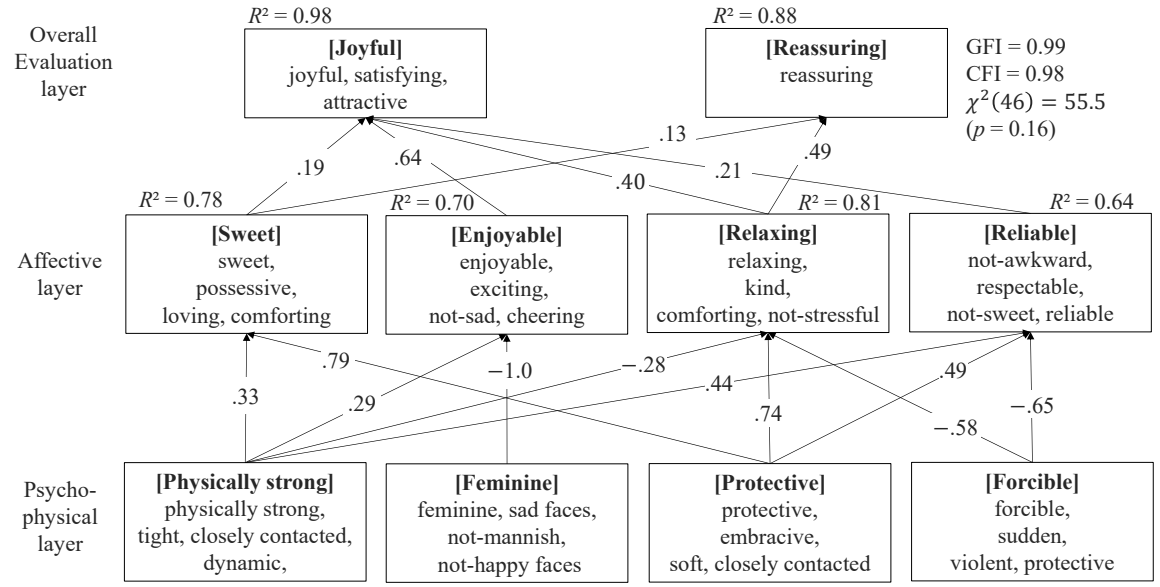

Figure 4: Three-layered structure of impressions toward hug scenes. The values nearby the arrows are the coefficients to determine the magnitudes of influences from the lower layer.

The results of the semantic validation experiment using dummy links are shown in Figure 5. Fourteen of the 16 links exhibited *p*-values less than 0.05, indicating that they were semantically agreed upon by the participants. The two links exhibited *p*-values between 0.05 and 0.10. Most links were semantically endorsed. No link had an agreement proportion below 0.41, which favors the dummy links.

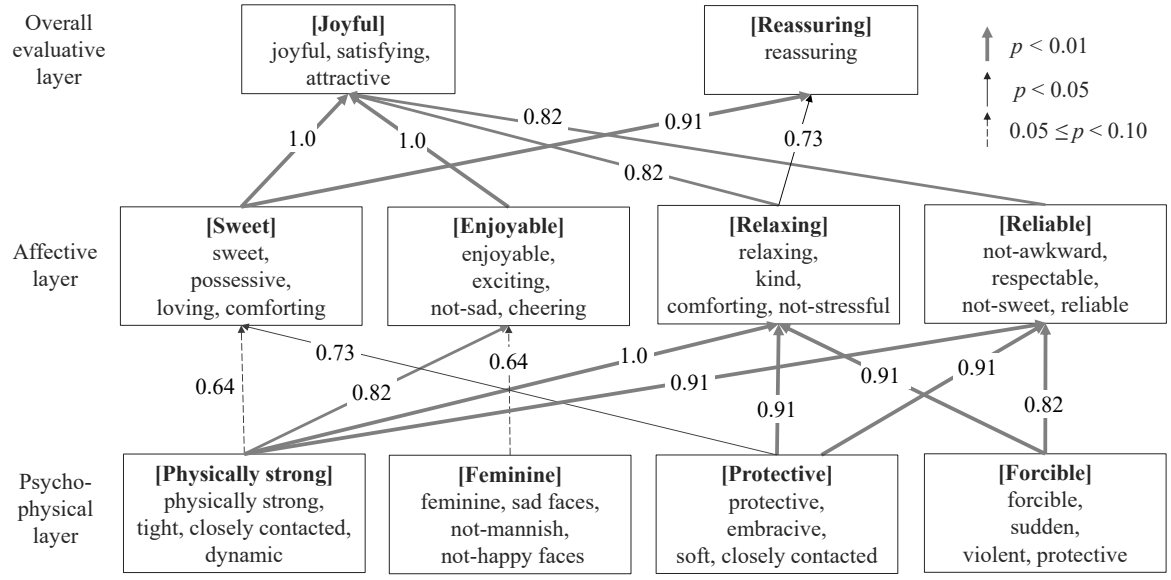

Figure 5: Proportions of semantic agreement for each link in the layered model. Numbers nearby the links are the proportions. Rigid and bold arrows are significantly greater than 0.41 that is the proportion of agreement toward dummy links.

4. Discussion

Regarding the multi-layered model in Figure 4, goodness-of-fit indices above the standard criterion supported the statistical validity of the model. For the individual variables in the upper and middle layers, the R^2 value for the reliable component was the smallest and $R^2 = 0.64$, indicating that the correlation coefficient between the observed and estimated values for this principal component variable was $R = 0.80$. Generally, this value indicates a strong correlation (Akoglu, 2018). Hence, the model is validated in terms of overall and local goodness-of-fit values.

In contrast, in Task 2, the semantic validity of the model was supported. Most of the 16 directive links among the components were semantically approved. Furthermore, all linkages were approved by the majority of participants. Nonetheless, strong approval was not given for a few linkages in Task 2. The least approved relationships were the linkage between feminine and enjoyable and between physically strong and sweet. As shown in Figure 4, regarding the feminine-enjoyable linkage, its coefficient was negative, and more feminine (not-mannish, sad face, not-happy face) scenes felt less enjoyable. In general, being mannish or feminine in hug scenes may not determine the feeling of enjoyment; hence, the link between feminine and enjoyable was not agreed upon by some participants. In the set of hug scenes used in this study, a large proportion of the videos judged as feminine might have caused sadness. Similarly, regarding the relationship between physically strong and sweet, no general influence exists, and it is reasonable that some participants did not approve of the linkage between these two attributes. In our video set, these two attributes may have been correlated by coincidence. Furthermore, another potential reason that the semantics of these linkages were not agreed upon by a large portion was the difference in the conditions between Task 1, in which the model was computed based on specific videos, and Task 2, in which the model was semantically tested based on the common sense of participants. In Task 2, general impressions of hugging were judged without viewing videos on a day different from that of Task 1. Such discrepancies in the conditions between the two tasks may have led to a few less-approved connections in the established model.

Although directly comparing our model and the literature is difficult, a partial comparison is possible. We consider the connections between the top and middle layers represent emotional experiences well while viewing hug scenes. The top layer of the structure, shown in Figure 4, includes the joyful and reassuring components. The joyful component is largely composed of enjoyable and relaxing components, and may capture the positive valence caused by viewing the videos. The reassuring component mainly comprises the relaxing component and may express a less arousing status (Russell, 1980). These results suggest that the overall emotional value of hug scenes is judged along with emotional valence and arousal in Russell's circumplex emotional model. Thus far, models similar to those computed in the present study for affectively evocative movies have not been reported; however, such concordance with Russell's model suggests its validity. Furthermore, as shown in Figure 5, all connections between the top and middle layers were semantically supported by the participants. It may be meaningful to compare our results with those of studies based on experiences other than hug scenes. We found similarities between the results of this study and those of Hosany and Gilbert (2010). They reported that the emotional factors in travel experiences were joy, love, and surprise. Joy directly corresponded to the joyful component in our study. Love corresponds to the sweet component (possessive, loving, and comforting) in the middle layer of our model. Our evaluative attributes in Table 1 did not include those related to surprise, and Hosany and Gilbert did not include feelings of reassurance or relief; hence, some differences in the results exist between the two studies. Nonetheless, these differences mainly originate from variations in the attribute words used in the two studies, and it must be noted that the disagreement is not substantial.

This study has some limitations. First, the three-layered linear model is the simplest form of a multilayered structure, although it exhibits statistical and semantic validity. To further refine the model, we may employ other methods (Kidoma et al., 2017; Okamoto et al., 2020) to produce flexible layered models in which the number of layers can vary according to the complexity of the problem. Second, the model established in this study may fit people with cultural backgrounds similar to those of the participants. For those with different backgrounds, the model should be recreated using data collected from them. This is also true for audiovisual content. Currently, we must prepare for multilayered models specified for each type of audiovisual content.

5. Conclusion

To date, the layered structure of the overall evaluative, affective, and psychophysical impressions of short video scenes has not been investigated. Such structures help to understand how overall satisfaction with video-viewing experiences is decomposed into affective and psychophysical antecedents. We exemplified hug scenes to establish a 2-4-4-factor model in which the overall evaluation comprised two factors: joyful and reassuring. Structural equation modeling statistically validated the model. Furthermore, the semantic validation of individual relationships in the model was largely agreed upon by the participants. The established model was specifically designed for hug scenes. However, the method employed in this study is potentially applicable to other types of emotionally appealing videos.

Ethics Statement

This study was approved by the Institutional Review Board of Hino Campus, Tokyo Metropolitan University (H22-014).

Author Contributions

YO: conceptualization, stimulus preparation, experiment, statistical analysis, and writing of the manuscript. SO: conceptualization, statistical analysis, manuscript editing, and supervision. YK: experiment, stimulus preparation, and manuscript review. All authors contributed to and approved the submitted manuscript.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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