Animated Scale: Adaption of the Motivational Scale for User Testing with Children

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ABSTRACT

Addressing the challenge of accurately assessing motivational levels in young children through traditional questionnaires, such as the Intrinsic Motivation Inventory (IMI) and the Player Experience of Need Satisfaction (PENS) questionnaire, this study introduces a novel approach by transforming bipolar questions into unipolar ones and employing animated scales using Memoji available on the iOS system. The paper details the design process, application, and evaluation of these animated scales through pilot studies involving 62 children aged 7-14, highlighting the potential of this approach in enhancing children's comprehension and engagement with questionnaires.

CCS CONCEPTS

• **Human-centered computing → User studies**.

KEYWORDS

Testing with Children; Intrinsic Motivation Scale; Player Experience of Need Satisfaction Scale

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1 INTRODUCTION

We have witnessed the recent growth in applications designed for young children, which underscores the importance of accurately assessing and fostering their motivation. Traditional tools like the Intrinsic Motivation Inventory (IMI) [17] and the Player Experience of Need Satisfaction (PENS) [2][16] questionnaire are pivotal in these assessments. However, their standard bipolar 7-point Likert scale format poses comprehension challenges for children, especially those aged 7-8 years [6][5]. The bipolar nature of these scales, combined with the language used in negatively worded statements, may lead to misunderstanding. Additionally, children are more likely to give extreme responses which raises questions about the granularity of these tools in capturing the nuanced emotional states of young children [6]. Consequently, we looked for ways to improve the granularity of the responses in collecting self-report data for young children.

In this paper, we introduced a novel approach to transform bipolar questions into unipolar ones to eliminate the confusion surrounding double negatives; and the design of an animated scales using Memoji available on iOS system, which is used to express facial expressions [18]. As children could be fascinated by using these animated Memojis to express their feelings [20], we planned to explore how to facilitate children to understand and accurately respond to the motivational questionnaires. We described the design process of the animated scales. The application of these scales in two pilot studies with 62 children aged 7-14 provided us with data, showcasing the possibilities of our approach in enhancing children's comprehension and engagement with the questionnaires.

This paper contributes to the field of HCI by presenting a novel method to refine motivational questionnaires for young children. Our approach not only aids in the accurate collection of data but also enhances the respondent's experience. The promising results pave the way for future research, where the scope of animated scales can be expanded to encompass diverse survey formats and demographic groups.

2 RELATED WORK

The Smileyometer scale is a widely recognized tool for gauging children's emotions and opinions, offering a child-friendly alternative to the traditional Likert scale for collecting quantitative data [25][27]. Research has shown its efficacy in enabling children to differentiate ratings across various conditions [10][13][15]. However, its reliability is predominantly noted among children aged 10-12 years, as younger demographics tend to favor the highest ratings, resulting in limited data variability [24][14][15][27]. Attempts to refine the Smileyometer, such as incorporating variations of smiling faces or enhancing graphical elements to appeal to younger users, have been made [9]. Yet, these modifications have only demonstrated reliability for children aged 9-11 years [4].

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In seeking alternatives, the Fun Semantic Differential Scale merges photographs with semantic differential scales tailored for young children. This scale employs specific photographic expressions (e.g., "happy," "sad") to capture emotional responses. However, its specificity limits its application in broader contexts, such as our study [27].

The exploration of emojis as tools for emotional profiling presents a promising avenue. Studies have employed emoji scales to assess various emotional states in children [19]. They successfully utilized a collection of 33 emojis to gauge children's emotional responses to food tasting among children aged 11-13. Another innovative approach [20] involved an animated emoji scale, specifically designed to assess dental anxiety in children aged 4-14, highlighting its novelty and child-friendly attributes. Similarly, an emoji-based pictorial facial scale [22] was applied to measure emotional responses in children aged 8-11 years, utilizing a 7-level scale and verbal stimuli names. This approach addresses the potential of emoji scales in capturing nuanced emotional states. Furthermore, research integrating emojis and drawings within survey methodologies has been conducted [8], notably in assessing children's attitudes towards mathematics among 8-9.

In a recent study, the Memoji Pain Scale [18] was introduced as a novel tool for assessing pain in children. Validated through testing with 250 children aged 5-9, the scale's effectiveness was corroborated by a Pearson correlation test. This tool, scoring pain on a scale of 0-10, demonstrates the potential of child-centric scales like the Memoji Pain Scale as alternative methods for assessing pain and other nuanced emotional states in young children.

While the related work has laid a foundational understanding of children's self-reported answers through various scales, our research advances this domain by introducing an interactive approach that offers a more engaging and comprehensive tool for assessing their motivational states.

Figure 1: Recording with two actors.

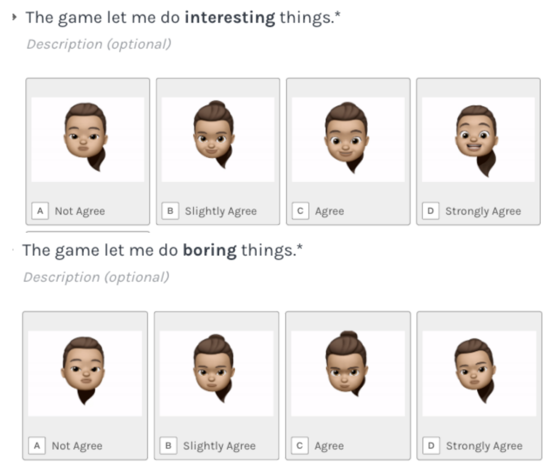

Figure 2: Recording with two actors.

3 DESIGN OF THE ANIMATED SCALE

To enhance the granularity of responses and augment the construct validity of our measurement tool, we transitioned from a bipolar to a unipolar scale. This modification effectively expanded each psychological need statement into a dichotomous set, comprising three affirmative and three negating propositions (e.g.,"The game enabled engaging activities" juxtaposed with"The game induced monotonous activities"). The sequence of these inquiries was randomized within the questionnaire to mitigate potential bias.

The PENS scale was developed based on SDT for assessing the game experience, including scales for competence to assess the perceived efficacy playing the game, autonomy to assess the sense of self-determined behaviors, and relatedness to assess the sense of social connections from PENS. We also measured the game enjoyment of children with 2 items adapted from IMI [17][16]. The PENS and IMI statements are originally rated on a bipolar 7-point Likert scale where 1 represents "strongly disagree" and 7 represents "strongly agree".

We changed the scale from a bipolar scale to a unipolar one, effectively turning the three statements of each psychological need into six statements, three positive and three negative ones (e.g., "The game let me do interesting things" and "The game let me do boring things"). These questions were randomized in the questionnaire. Furthermore, to aid children to select more nuanced answers, we developed an animated scale using the animated cartoon characters Memoji available from iOS, which are more colorful and visually expressive than characters used in previous research.The scale's uniqueness is further accentuated by the dynamic facial expressions and gestures, choreographed based on the performances of two actors. See Figure 1. These expressions and movements correlate with the intensity of the responses – for instance, a pronounced smile coupled with vigorous nodding signifies strong agreement with a positive statement, whereas a subdued sad expression with minimal nodding indicates slight agreement with a negative statement. Figure 1 exemplifies this dynamic representation.

The facial expressions were associated with the intensity of the movements (e.g., "strongly agree" with a positive statement: big smile and strong nodding; "slightly agree" with a negative statement: a weak sad face and slight nodding). See Figure 2. The animated scales include different characters with different genders, races, and appearances since children may tend to choose the character that matched their gender [26]. See Figure 3. Children could select one character and then use the same character during the entire questionnaire. A preliminary study was conducted to assess the efficacy of the animated scales [6].

Figure 3: Recording with two actors.

4 APPLICATION OF THE ANIMATED SCALE

We incorporated selected sections from the Player Experience of Need Satisfaction (PENS) questionnaire alongside the Intrinsic Motivation Inventory (IMI) to investigate children's cognitive engagement during gameplay with fantasy in a previous study. The enjoyment section of IMI, the Autonomy and presence section of PENS were selected to identify motivation and experience aspects of players. It is noticeable that the PENS questionnaire can be used for commercial purposes. For non-commercial use, confidentiality is required, thus the specific items of the questionnaire cannot be disclosed in publications. All dimensions of the Fantasy State Scale (FSS) were applied to understand participants' identification, imagination, analogy, and satisfaction aspects of fantasy states.

We test the animated emoji scale with two games: "MathMythosAR2" and "FancyBookAR, each with a Fantasy and a Real-life version." Each game type's Fantasy and Real-life versions were tested within subjects, meaning the same participants played both versions. On the other hand, the comparison between "MathMythosAR2" and "FancyBookAR" was done between subjects, indicating different participants were used for each game type. Both games were developed using Unity 3D and the Vuforia package and were built on Android phones. With the concept of integrating interactive 3D elements into storybooks, Mathmythos AR2 embeds tasks related to math calculations, while FancyBook AR combines the knowledge of sentence construction in language learning.

Overall, 62 participants are involved in the experiment. Participants are children aged from 7-14. About 32 participants self-identified as male while 30 participants self-identified as female. Participants are invited to play one version of the game, then fill in the animated emoji scales, and subsequently repeat this process for the other version. The sequence of within-subject gameplay is randomized in a counterbalanced manner. Data collection is conducted in collaboration with a local after-school center in Qingdao China, where every student participating can receive stationery as a reward in addition to gaining knowledge. Contents were achieved from their parents. This research is approved by the Ethics Review Board at the Eindhoven University of Technology in advance.

4.1 Reliability Test

In this study, the utilization of the animated emoji scale aimed to enhance children participants' comprehension of a four-point scale including " disagree, slightly agree, agree, completely agree." The reliability analysis indicates that, overall, the animated emoji scale exhibits acceptable reliability, as reflected by a Cronbach's Alpha value exceeding 0.7 across all divisions. Notably, the Identification and Satisfaction divisions of the Fantasy State Scale demonstrate particularly robust reliability, falling within the ranges of good to excellent. The animated emoji scale appears to play a role in facilitating their comprehension of the items and report of the experiences using the scale. See Table 1 in APPENDICES.

4.2 Validity Test

We employ two confirmatory factor analysis (CFA) to assess the validity of animated emoji scales applied to SDT, FSS. With the SDT scale, only the Autonomy and Presence dimensions are subjected to testing due to the requirement of the study. With FSS, we collect data from all dimensions. It is noticeable that SDT requires authorization for use, this article will not disclose the content of items in the SDT scale while interpreting the data.

The fit indices (Table 2 in APPENDICES) including the Chi-square to degrees of freedom ratio (CMIN/DF), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI) were evaluated to determine the model's adequacy.

4.2.1 Validation for FSS. As fit indices presented in Table 3, CMIN/DF is preferred to be between 1 and 3 for an acceptable fit. With a value of 2.767, the FSS model comfortably nests within this acceptable region, indicating a reasonable fit from this perspective. However, the value exceeds the ideal threshold with a figure of 0.120 of RMSEA suggesting that the model's alignment with the empirical data might be less than optimal. Besides, the TLI and CFI value shows an acceptable fitting level of the model.

The fit indices indicate that the model demonstrates general acceptability in terms of CMIN/DF, TLI, and CFI, yet the elevated RMSEA suggests there may be room for improvement. This discrepancy points to a possible need for model refinement. It is important to consider that the FSS was not originally tailored for a child audience, which could lead to challenges in how children comprehend and interact with the constructs it aims to measure. This understanding issue may be further compounded when using an animated emoji scale, which, while engaging, might not effectively capture the nuances of the FSS constructs for younger participants. Further research and thoughtful adaptation of the scale may be required to ensure that it resonates with and is appropriate for children, thereby improving the model's applicability and the validity of the results.

The weight (Table 3 in APPENDICES) of most items suggests a good relationship with their dimensions, except for the imagination. The Imagination construct require further investigation, specifically for item 2 (The story of this game includes an ideal entity that does not exist in real life) and item 3 (I can control the events in the game which I can only imagine in my real life)'s low weight. It suggests that they are not as strongly related to the Imagination construct as the others for this construct.

AVE (Average Variance Extracted) measures the level of variance captured by the construct in relation to the variance due to measurement error [3]. The AVE value above 0.5 are generally considered good. The Identification, Analogy, and Satisfaction constructs show strong factor loadings, good AVE values, except for Imagination. CR (Composite Reliability) is an indicator of the reliability of the dimension. CR values above 0.7 are typically considered acceptable, suggesting that the items have relatively high internal consistency [12]. In our case, all dimensions are above the acceptable level.

4.2.2 Validation for SDT. In this study, we examine the SDT scale by focusing specifically on the Autonomy and Presence dimensions. The model fit indices for validating the animated emoji scale for SDT's dimensions of Autonomy and Presence are presented in Table 3. CMIN/DF is preferred to be between 1 and 3 for an acceptable fit. The obtained value of 1.715 falls within this range, suggesting the model is reasonably consistent with the data. Our model achieves an RMSEA of 0.076, denoting a reasonable fit and implying that the model approximates the data well. The model's TLI of 0.918 is above this threshold, which supports the model's fit. With a CFI of 0.944, the model demonstrates an excellent fit to the observed data. Overall, when applied to the Autonomy and Presence dimensions of the SDT, the scale exhibits a fit that is reasonably acceptable within the context of the SEM framework. See Table 4 in APPENDICES.

The standardized regression weight for each item is shown in the estimate column. The weight of most items suggests a good relationship with their dimensions, except for Presence 4R which reveals a notably low estimate associated with Presence dimension. Presence 4R is a reversed question. Previous research has highlighted challenges faced by children when confronted with reversed questions within a scale [7]. In this case, the animated emoji scale doesn't help children's accurately interpreting and expressing their attitude toward reversed questions in the presence dimension of the SDT scale.

AVE measures the amount of variance that a set of items captures in a construct. If the construct is multidimensional and not all dimensions are included, the items measured may not fully capture the construct's variance, leading to a lower AVE [3]. In our case, the AVE value is around 0.5. Because we only collect data from Autonomy and Presence dimensions of SDT, the low AVE value could be attributed to the exclusion of other dimensions in SDT. The CR for Autonomy is 0.72 and for Presence is 0.89, which is at an acceptable level.

5 DISCUSSION AND CONCLUSION

In this work, we introduce and validate an animated emoji scale designed to facilitate the collection of self-reported data from children, utilizing a case where we employ this scale to assess children's engagement and mental states of fantasy during gameplay. This innovative tool aims to bridge the gap between complex conceptual understanding and the expressive capabilities of young participants.

The reliability of the animated emoji scale exhibited acceptable levels across all dimensions, with Cronbach's Alpha values indicating consistency in responses. The result indicates that the animated scale effectively aided children in understanding and reporting their experiences.

The validity of the scale, as assessed through confirmatory factor analysis (CFA), presented a more complex picture. Presence 4 as the reversed item in SDT shows a low estimate associated with the Presence dimension. It is suggested that the animated emoji scale, e.g. nodding and head shake with disagreed expression might not adequately support children's understanding and expression when dealing with reversed questions in the SDT context. It points to a potential area for refinement in the design of the animated scale to enhance its efficacy in capturing nuanced responses to reversed question formats. Previous work also suggests that providing a pre-instruction and a pre-test before administering the questionnaires would help improve children's understanding of questions that require cognitive effort [1]. While the dimensions of Autonomy and Presence within the SDT shows generally acceptable model fit and reliability, models of FSS have issues with fitting and reliability. One possible reason for the low fit is that children's attention and engagement can significantly diminish during tasks that they perceive as monotonous [11], impacting the accuracy and reliability of their responses, especially with abstract questions in FSS. Specifically, items related to more abstract concepts of imagination state of fantasy in FSS may not resonate as strongly with the children. A potential discrepancy between the scale's content and the participants' interpretive abilities exists especially on items that describe imaginary content that doesn't exist in real-life. Certain phenomena could also be attributed to the developmental characteristics of children. Young children when exhibit an understanding of the boundary between reality and fantasy, sometimes perceive elements from games as part of their real-life experiences [23]. This developmental stage can result in ambiguities in how children interpret items describing imaginary content, as their distinction between fantasy and real-life is not always clear-cut [21]. These factors should be considered in refining the scale to ensure it aligns with the interpretive abilities of the target age group.

The above observation highlights that while the animated emoji scale is an innovative tool that can aid children's interpretation of scales, its application is not a one-size-fits-all solution for the challenges inherent in children's understanding and response to questionnaire items. The successful deployment of the animated emoji scale demands a detailed consideration of the children's cognitive developmental stages and a deep understanding of how they comprehend the questions presented. Additionally, even with engaging tools and clear comprehension, the challenge of sustaining children's attention throughout an extensive questionnaire must not be overlooked.

To bolster the effectiveness of the animated emoji scale in future applications, it is advisable to simplify the questions, steer clear of ambiguous concepts, and potentially integrate explanatory narratives along with playful interactions. These strategies can help in enhancing children's understanding, maintaining their engagement, and ensuring the collection of accurate and meaningful data. A future could be to harness the principles of gamification and leverage AI, such as a narrative-driven structure for contextual explanations, and a conversational interface with real-time feedback to create a more immersive and interactive questionnaire experience for children.

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A TABLES

A.1 Table 1

Table 1: Reliability Analysis

Questionnaires	Divs.	Cronbach's α	Items
Self–Determination Theory	Autonomy	0.713	3
	Presence	0.739	9
Intrinsic Motivation Inventory	Enjoyment	0.743	5
Fantasy State Scale	Identification	0.873	5
	Satisfaction	0.903	3
	Analogy	0.781	3
	Imagination	0.728	5

A.2 Table 2

Table 2: Model fit indices for validity of FSS and SDT with Dimensions of Autonomy and Presences

Index	Standard	Result (FSS)	Result (SDT)
CMIN/DF	1–3, an acceptable fit	2.767	1.715
RMSEA	RMSEA < .05, a close fit	0.120	0.076
	RMSEA < .08, a reasonable fit		
TLI	> 0.9 a good fit	0.815	0.918
	> 0.8 an acceptable fit		
CFI	> 0.9 a good fit	0.867	0.944
	> 0.8 an acceptable fit		

A.3 Table 3

Table 3: Standardized Regression Weight of FSS

Items	Path	Dimensions	Estimate	AVE	CR
Identification1	⟵	Identification	0.776	0.58	0.87
Identification2	⟵	Identification	0.647		
Identification3	⟵	Identification	0.82		
Identification4	⟵	Identification	0.834		
Identification5	⟵	Identification	0.732		
Imagination1	⟵	Imagination	0.661	0.3722	0.7228
Imagination2	⟵	Imagination	0.319		
Imagination3	⟵	Imagination	0.319		
Imagination4	⟵	Imagination	0.797		
Imagination5	⟵	Imagination	0.765		
Analogy1	⟵	Analogy	0.758	0.5498	0.7855
Analogy2	⟵	Analogy	0.724		
Analogy3	⟵	Analogy	0.742		
Satisfaction1	⟵	Satisfaction	0.67	0.7675	0.9061

A.4 Table 4

Table 4: Standardized Regression Weight of SDT with Dimensions of Autonomy and Presences

Items	Path	Dimensions	Estimate	AVE	CR
Autonomy1	⟵		0.598		
Autonomy2	⟵	Autonomy	0.627	0.46	0.72
Autonomy3	⟵		0.797		
Presence1	⟵		0.769		
Presence2	⟵		0.86		
Presence3	⟵		0.772		
Presence4	⟵		0.036		
Presence5	⟵	Presence	0.584	0.50	0.89
Presence6	⟵		0.714		
Presence7	⟵		0.733		
Presence8	⟵		0.743		
Presence9	⟵		0.775		