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RESEARCH ARTICLE

Stimuli Video Quantification Based on Valence-Arousal Elicitation in Children With Autism Spectrum Disorder (ASD)

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ABSTRACT Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by impaired social communication and repetitive behaviours. Understanding the emotional responses of children with ASD is crucial, especially for early interventions. Therefore, the study aims to validate appropriate stimuli in video forms that can elicit Autism Spectrum Disorder (ASD) children's emotions. The study involves 56 children, 28 of whom have ASD, from IDEAS Autism Center in Rawang, Malaysia, aged between five and nine years (M = 6.43, SD = 1.2), and 28 typically developed children (M = 5.65, SD = 2.2) from IIUM Educare, Gombak, Malaysia. The children were presented with 15 stimuli videos that were targeted to elicit five basic emotions, which are happy, sad, fear, anger, and calm. Expert blind coders validate the stimuli to mitigate potential sources of bias and errors in the experiment. The subjects' responses towards the stimuli videos were mapped onto the valence and arousal emotion model. The study observed that all stimuli were successfully classified into the respective emotion quadrants. The study also discovered that certain video stimuli produce higher intensity in emotion elicitation than others. Significant findings between ASD children's responses to the stimuli video are extensively discussed.

INDEX TERMS ASD children, autism, affective stimuli, emotion elicitation, emotion modeling, video validation, video coding.

ABBREVIATIONS

Term	Meaning.
ASD	Autism Spectrum Disorder.
ECG	Electrocardiograph.
IAPS	International Affective Picture System.
TD	Typical Developed.
DDST	Denver Developmental Screening Test.
SAND	Sensory and Neurocognitive Development.
VAS	Visual Analogue Scale.

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I. INTRODUCTION

The expression and regulation of emotions play a significant role especially in handling ASD children [1], [2]. Positive

emotions are needed to broaden thought-action patterns and build social, intellectual, and physical resources, meanwhile, negative emotions are essential for adaptation and survival [3]. The utilization of stimuli to induce emotional states is widely used in many kinds of research, especially psychological research. There are many stimuli used to induce emotion such as odors [4], [5], situational play [5], [6], cartoons [7], [8], [9], puppets [9], [10] or graphics like pictures [11], [12], [13], [14], [15]. All these stimuli can be used to invoke existing emotional memories. Other than pictures, videos also have been accepted in the field of emotion research and have been used for decades [16], [17], [18], [19], [20]. When compared to static picture stimuli, videos are dynamic and closer to real-life experience [21]. However, as picture stimuli is an internationally known method, i.e.: International Affective Picture System (IAPS), the normative ratings have been provided by researchers [22], but that is not the case with video clips.

Although there are proven advantages of using video stimuli, there are only a few research studies conducted on stimuli video quantification and normative ratings for ASD children subject. There is an effort to validate the video for the use as stimuli for adults with or without ASD [16], [23], [24], [25], however, to adopt these stimuli to ASD children, these stimuli are ineffective and less engaging [26]. Thus, there is a need to further investigate and validate suitable videos that can be used as effective stimuli for ASD children subject. In order to address the research gap pertaining to video stimuli for ASD children, this study developed a set of videos and evaluated its effectiveness in eliciting specific emotions in autistic children. By focusing specifically on ASD children, this study can provide insights into this population's emotional states and regulations that have not been previously explored. Additionally, the stimuli dataset used in this study is tailored to the needs of ASD children, which differs from previous studies that utilized stimuli that may not have been as engaging or effective for this population. The findings from this study have important implications for the development of more effective interventions and assessment tools for ASD children, making this study a significant contribution to the field.

In addition, validation and quantification of video stimuli in ASD children is crucial for standardization, as individual differences in sensitivity to specific stimuli can lead to variability in responses and behaviors [27], [28]. This variability can make it challenging to draw conclusive and generalizable findings, particularly in ASD research. By ensuring uniform exposure to video stimuli, researchers can achieve standardization, resulting in more reliable and accurate conclusions, a better understanding of the mechanisms underlying ASD, and the development of more effective interventions. Quantifying stimuli video in ASD can provide insight into the differences in perception and processing of visual and auditory information, inform the development of therapeutic interventions, and optimize the video content to achieve desired effects.

Gabel et al. [26] validated emotionally evocative film stimuli with 39 subjects that are children with an average age of 7.19 years. The stimuli consist of 20 videos that are provided with self-reported emotional responses to the videos. Apart from self-reported emotional responses, the facial expressions of the child are also recorded by trained coders. Two quantitative indices are used, which are the Self-Assessment Manikin and a set of standardized emotion face icons, as self-rating scales. The attentiveness of the children is also rated using a 4-point Likert scale as low attentiveness to the videos may affect the results. The emotions of interest in the study are positive affect, dysphoria, and fear. The videos' length varied from 1 minute 10 seconds to 4 minutes and 14 seconds.

Meanwhile Ruffman et al. [19] studied on the difference responses between toddlers (M = 2.53 years) and adults (M = 20 years) who watched four video types namely, the *Infant Crying, Infant Laughing, Infant Babbling*, and *Neutral Infant* accompanied by white noise. There were 20 videos used and equally divided between the four types of infant videos. The targeted emotions in the research were focused on happiness and sadness. The intensity of each emotion from the videos were also varied as the crying infant were very unhappy with near-continuous audible crying. The *Infant Laughing* video showed a very happy emotion with near-continuous laughing and the *Infant Babbling* video displayed neutral facial expressions and babbled near continuously. The last *Neutral Infant* video expressed neutral expressions and produced no audible sound. The length of each video was set at one minute with the close-up face of infant in all of them. Ruffman et al. [19] revealed that adults displayed higher degree of sadness towards infant crying than any other stimulus, meanwhile toddlers' response to crying and white noise were similar. In the case for the toddlers, the video of *Infant Laughing* managed to successfully elicit the emotion of happiness and laughing seemed contagious for toddlers when they are in group.

Egger et al. [29] developed a tool that could analyze emotion and attention for children aged between 12 and 72 months. The tool featured four different types of videos used to elicit the children's emotion, which were *Bubbles, Bunny, Mirror*, and *Toys & Songs* videos. The videos' length ranges from 20 to 35 seconds. Automatic coding and validation were used to validate three different emotions, which were positive, negative, and neutral emotions. In the research, the children were required to watch videos to elicit autism-related behaviors and they were analyzed from the aspects of emotions and behaviors.

Davis et al. [30] studied the emotion of sad and fear in 5 to 6 years old children (M = 5.818 years). The order of the videos watched by the children varied as sad-fear and fear-sad before being analyzed. In the study, there were three emotion regulation instructions set forth for the children. Both videos' order viewing and instruction were randomly assigned. The response from the children was coded by self-assessment reports and electrocardiograph (ECG) signals. The children viewed age-appropriate videos, for sad elicitation that was,

TABLE 1. Summary Of Recent Works Using Video Stimuli For Children Subjects From Year 2011-2022.

Authors	Numbers of stimuli	Auditory content	Emotional valence	Emotional intensity	Duration	Order and sequence	Personalized audience	Assessment
Gabel et al [26]	20	Yes	Positive affect Sadness/Anger Fear	4 levels	1 minute 10 seconds – 4 minutes 14 seconds	Not specified	Children (M = 7.19 years)	Self-assessment manikin
Ruffman et al [19]	20	Yes (70 dB)	Crying Laughing, Babbling Neutral with white noise	5 levels	1 minute	Random	Children (M = 2.53 years) Adults (M = 20 years)	5-point Likert scale
Egger [29]	4	Yes	Positive Negative Neutral	Not specified	20 – 35 seconds	Not specified	Autistic children. Age 1-6 years	Automatic behavioral coding of videos on emotions behaviors.
Davis et al [30]	2	Yes	Sad Fear	Mild level	Not specified	Yes sad-fear fear-sad	Children. (M = 5.818 years)	Physiological responses using RSA (Respiratory Sinus Arrhythmia)
Blau et al [7]	2	Not specified	Happy Sad	Not specified	5-7 minutes	Random	Children (M= 4.7 years)	Assessment on facial expressions and heart rates

The *Land Before Time* and *The Secret of NIMH* for fear elicitation. Both emotions targeted were mild sadness and mild fear elicitations.

On the other hand, Blau and Klein [7] used videos to elicit the emotion of happy and sad to 4-5 years old children (M= 4.7). The facial expressions and heart rates of the children were coded throughout the experiment. Interestingly, Blau et al. stated that the children responded differently from adults. It was found that positive emotions were used to generate an overall improvement in children's cognitive functioning. It was also found that the children improved their cognitive performance after eliciting positive emotions that occurred predominantly on tasks related to subject areas that they were familiar with. The videos used for the emotion elicitation were *Balu Meets Mogli* and *The Cat Flies Outside* for positive emotions. Both videos' length was around 6 minutes. For negative emotion elicitation, the *Pinocchio in the Cage* and *The Death of Mofasa* videos were used. Both videos' lengths ranged from 5 to 7 minutes.

Table 1 provides an overview of recent academic research studies that have employed video stimuli to elicit emotions. The scope of the reviewed works is specifically centered around the children population, exclusively focusing on research endeavors utilizing video stimuli.

For this paper, the study focuses on video stimuli that can induce arousal and valence effects on emotional states in ASD children. The response from the children is unique as they experience sensory overload throughout the experiment. The research design aims to study five basic emotions representing each quadrant of the valence-arousal model, namely happy (Quadrant 1), fear and anger (Quadrant 2), sad (Quadrant 3), and calm (Quadrant 4). The experiment is designed to evaluate two hypotheses on emotional responses, valence, and arousal:

H1: *ASD children subjects express the same emotion differently than the TD children. There exists ambiguity to interpret their emotions through facial expression alone. Thermal image from frontal facial view can be analyzed to identify emotion for ASD children.*

H2: *Video stimuli can be used to induce emotion with different level of intensity for ASD children*

II. METHODOLOGY

A. SUBJECTS

Subjects were recruited from the IDEAS Autism Center in Rawang and IIUM Educare Kindergarten, consisting of children with and without ASD. All subjects were recruited after obtaining the necessary approval from the IIUM Research Ethics Committee, and informed consent was obtained from the parents after providing them with a written description of the study.

The experiment was conducted in a classroom setting and all procedures were performed in a single session. Initially, a total of 80 subjects were recruited for the stimuli video validation study. However, seven subjects (2 with ASD and 5 without ASD) were excluded from the study due to medical reasons. Additionally, data from 17 subjects (10 with ASD and 7 without ASD) were not included in the final analysis as they did not complete all the stimuli videos. The reasons for exclusion included a lack of cooperation, excessive movement, and attention difficulties during the experiment.

The final sample comprised of 56 subjects, including two groups of age-matched individuals: those with ASD (N=28; age $\pm$ SD: 6.43 $\pm$ 1.2 years; range: 5-9 years) from amongst those who are diagnosed with moderate and high-functioning ASD and those without ASD, which constituted the Typical-Developed (TD) group (N=28; age $\pm$ SD: 5.65 $\pm$ 2.2 years;

TABLE 2. Description of the analyzed sample including various demographic information and descriptors, such as cognitive and language abilities.

	ASD (N=28)	TD – Control Group (N=28)
Age	6.43 years (SD: ± 1.2 years; Range: 5-9 years)	5.65 years (SD: ± 2.2 years; Range: 4-6 years)
Cognitive functioning	Moderate and High functioning	Not Applicable
Language abilities	Non-verbal / Low	Verbal
Gender (M:F)	23:5	13:15

TABLE 3. Details of the video stimuli.

Videos	Name	Target Emotion	Quadrant Number on Emotion Model	Time length (min)	Language	Type
1	*Pocoyo*			0:18	Non-verbal	Cartoon
2	*Larva*	Happy	Q1	1:13	Non-verbal	Cartoon
3	*Super wings*			1:15	English	Cartoon
4	*Didi*			0:23	Malay	Cartoon
5	*Upin Ipin Eid Moment*	Sad	Q3	1:05	Malay	Cartoon
6	*Abandoned Dog*			0:53	Non-verbal	Cartoon
7	*Flower*			0:21	Non-verbal	Nature
8	*SAND*	Calm	Q4	1:01	Non-verbal	Nature
9	*Pig*			0:36	Non-verbal	Cartoon
10	*Bank*			0:20	Non-verbal	Cartoon
11	*Siblings Fighting*	Angry	Q2	0:53	English	Real
12	*Kid*			0:35	English	Real
13	*Cockroach*			0:10	Non-verbal	Real
14	*Pigeon*	Fear	Q2	0:15	Non-verbal	Real
15	*Angry dog*			0:10	Non-verbal	Real

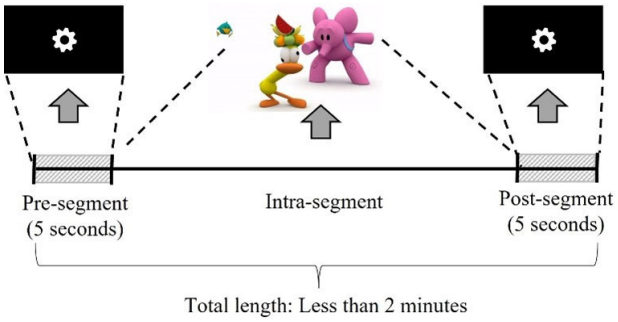

FIGURE 1. Segments in video stimuli.

range: 4-6 years). The subject profile is further described in Table 2.

Subjects with ASD were randomly selected from different classes at the Autism Center, and all had been diagnosed with ASD by a developmental pediatrician prior to inclusion in the study. An occupational therapist administered the Denver Developmental Screening Test (DDST) to assess developmental delays in areas such as motor skills, language, and social skills. Subjects were required to have the ability to interact and follow instructions in simple language, and although most had limited verbal language abilities, they were able to effectively communicate through nonverbal means.

B. STIMULI

There were 15 video stimuli selected for this study, representing positively and negatively valanced emotions, with neutral video (i.e., a white gear spinning in a black background) serving as a fixation point positioned at the pre-segment and post-segment of each video [31]. The video stimuli are used to investigate five basic emotions, with three videos per emotion. Each video was divided into three segments, as depicted in Figure 1, with the intra-segment designed to elicit targeted emotions.

It is important to note that all video stimuli utilized in the study underwent verification and approval by the psychiatrists and therapists involved in the research. The order of videos was arranged to avoid visual order effects that could arise between consecutive videos, based on two-dimensional valence-arousal spaces. The details of the video stimuli are listed in Table 3.

For the targeted happy emotion, the selected videos are *Pocoyo*, *Larva*, and *Superwings*. For *Pocoyo*, it is a dancing and smiling cartoon characters in a non-verbal setting. Meanwhile, the element of joy and repetitive actions revealing happiness are demonstrated in *Larva* video. Whereas, in the *Superwings* video, a fun and cheerful animated series of airplanes flying around as a rescuing team is portrayed.

For the elicitation of sadness, sad cartoon videos were utilized. These included videos from the *Upin Ipin* cartoon series who loses their loved one. *Didi* video is demonstrating

sadness resulting from separation from friends and the *Abandoned Dog* video depicts a dog left alone on the street.

To induce a state of calmness, a combination of nature and cartoon videos were used. A scene with beautiful flowers with calming audio is displayed in *Flower* video, meanwhile, a pink pig with animation and calming music is shown in the *Pig* video. As for the *Sensory and Neurocognitive Development (SAND) - Blue Water Sensory* video, the subjects were exposed to the calming sound from the water flowing.

To elicit the targeted anger emotion, three videos were utilized, which are *Siblings Fighting* depicting real kids engaged in a verbal dispute over toys, *Kid* featuring an angry child and a cartoon video titled *Bank* was included to provide variation and allow for comparison. The *Bank* video portrayed an angry man in a non-verbal setting at a bank.

Fear elicitation employed real videos with three different elements. *Cockroach* video shows abundant crawling cockroaches on a screen, while the *Pigeon* video depicts pigeons flying randomly, surrounding an object, and *Angry Dog* video shows a fiercely barking dog.

The length of the videos was kept under two minutes to accommodate the limited attention span of ASD children. The videos are sourced from feature-length films and open-source platforms. The subjects viewed the videos in their respective mother tongue languages, English and Malay. The stimuli encompassed real people, animals, cartoons, and pictures from the International Affective Picture System (IAPS) database. Each video's intensity levels were measured based on the valence and arousal they elicited.

C. EXPERIMENTAL PROCEDURE

The parental consent was obtained prior to the experiment day. Upon arrival, the subjects' demographic information was collected with the assistance of the teacher. Each subject is seated in a comfortable space in a 4-meter by 4-meter classroom. To optimize the viewing experience of the stimuli, the screen displaying the stimuli videos was positioned in the center to ensure a complete and unobstructed view for the subject. The videos are projected onto a computer screen. The complete experimental setup is shown in Figure 2, where the distance between the subject and the screen was positioned at 1 meter apart. The lighting level in the room is also dimmed to provide calm surroundings, focusing the subject's attention on the stimuli. The details of the experimental setup were discussed in previous study [32].

An introductory demonstration video was shown prior to the experiment to ensure the subject's readiness for the experiment which also entails the procedure. It is part of the procedure set in the pre-experiment stage as shown in Figure 3. After the introductory videos, the subjects were given a pre-questionnaire and were invited to ask questions about the procedure. During the presentation of the stimuli video, a neutral video featuring a white gear spinning on a black background was displayed. The subjects were prompted with questions and asked to respond during the activity to ensure their active engagement and comprehension.

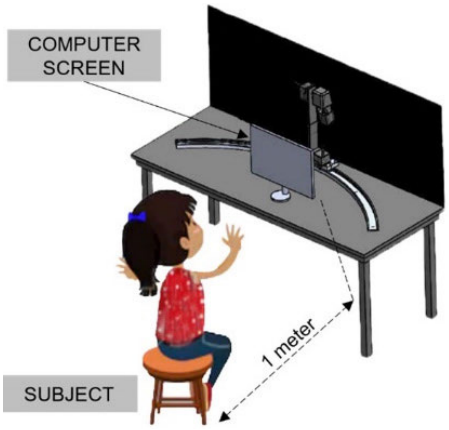

FIGURE 2. Experimental setup.

Once the pre-questionnaire is completed, the subject proceeds to view the stimuli videos, which are played sequentially until all 15 videos have been shown. Throughout this process, the expert blind coders are required to fill out intra-questionnaire using Visual Analogue Scale (VAS). VAS is an assessment instrument that utilizes graphical scales in the form of emoticon reactions to assess the subject's response to the stimuli. Following the completion of the video session, the subject is asked to fill out a post questionnaire set before receiving a reward. The combination of five emotions session lasts about 30 minutes, depending on the subject's alertness and engagement with the stimuli. The video includes pre-segment and post-segment intervals, providing the subjects with brief rests between stimulus presentations.

D. PRE-QUESTIONNAIRE

Pre-questionnaire consisted of demographic and emotion regulation questions. The demographic question collected information regarding the physical age, mental age, and gender of the subject. It is noteworthy to highlight that the mental age information was provided by the occupational therapist that administered Vineland Assessment Tool, to ensure accuracy in assessing the subject's cognitive development. Subsequently, in pre-questionnaire, five rating items were included to gather the background details specifically on how well the subject could respond to emotional stimuli. These items assessed the following aspects:

Q1. Is the subject capable of comprehending basic instructions provided by the caregiver/teacher?
Q2. Does the subject demonstrate the ability to express emotions without notable difficulties, as perceived by adults?
Q3. Can the subject adapt to activity or video transitions without extreme emotional reactions to sudden changes?

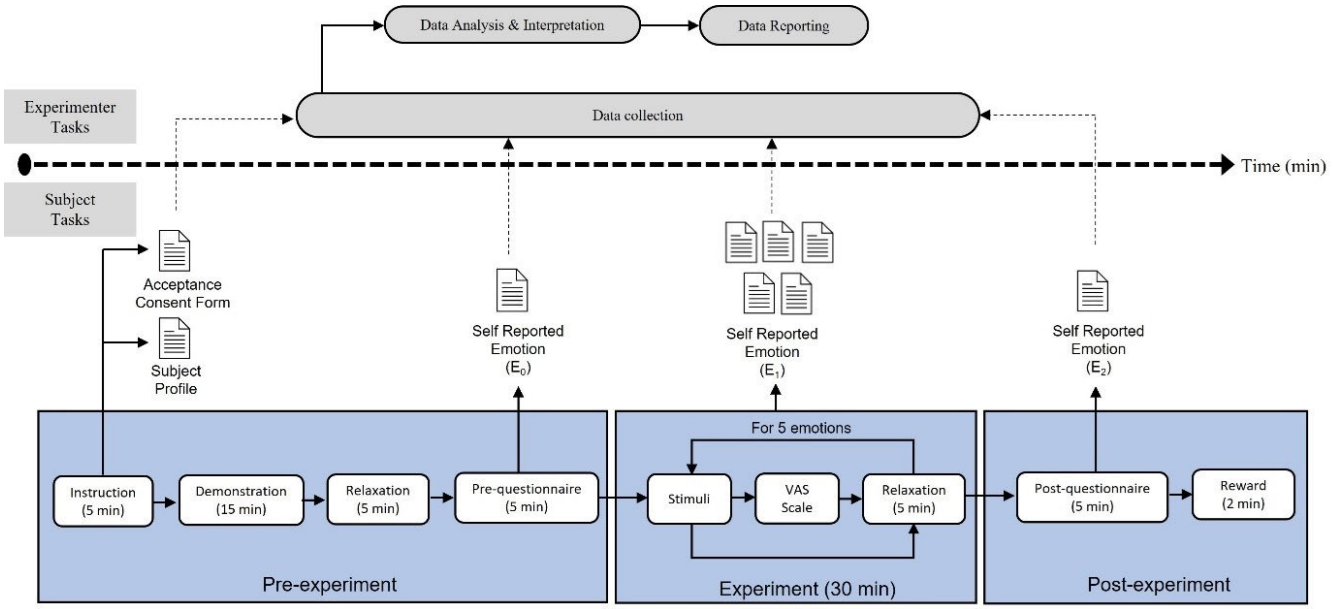

FIGURE 3. Experimental procedure.

Q4. Does the subject exhibit the ability to recover from distressing events?
Q5. Can the subject effectively communicate their emotions to nearby adults?

The 5-point scale was used in the questionnaire to record the responses, and the possible responses were *Strongly Disagree, Disagree, Neutral, Agree,* and *Strongly Agree*. To ensure optimal communication, the questions were presented in the Malay language, which aligns with the subjects' primary linguistic proficiency.

E. POST-QUESTIONNAIRE

The Post-Questionnaire consisted of five rating items that required responses from the expert blind coders on the subject's emotional responses to the stimuli. The items assessed the following aspects:

Q1. Does the subject consistently display appropriate emotional responses throughout the experiment?
Q2. Is the subject easily distracted by their surroundings?
Q3. Can the subject effectively adjust to activity or video transitions without experiencing extreme emotional reactions to sudden changes?
Q4. Does the subject exhibit sustained cooperation throughout the duration of the experiment?
Q5. Does the subject convey responses through body language, aside from facial expressions?

The five items described the subject's perception of environmental interruptions, their tolerance towards video transitions, and their overall level of cooperation and non-verbal communication throughout the experiment.

III. RESULTS

Based on the VAS assessment, the results are presented in graphical form in Figure 4. The graph illustrated emotional responses involved in each targeted emotion. For example, in targeted happy emotion, it is found that happy emotion is the most dominant emotion for all stimuli videos of *Pocoyo*, *Larva* and *Superwings* for both ASD and TD children. However, calm emotion also was evoked as the second highest response from the subjects with *Pocoyo* ($M_{ASD} = 7.0$; $M_{TD} = 5.0$), *Larva* ($M_{ASD} = 8.0$; $M_{TD} = 7.0$), and *Superwings* ($M_{ASD} = 8.5$; $M_{TD} = 5.0$). In the coders assessment report, several subjects were reported also showed the derivative emotion of calm state such as content, glad, relaxed, and pleased with these stimuli videos of happy. The derivative emotions in this context, can be defined as response that is derived from another emotion, or it is also can be referred as a mix of neighboring basic emotions [33]. Figure 4 (a) depicted varying levels of happiness reported across the three videos for both groups: *Pocoyo* ($M_{ASD} = 21.5$; $M_{TD} = 27.5$), *Larva* ($M_{ASD} = 26.0$; $M_{TD} = 22.5$), and *Superwings* ($M_{ASD} = 24.0$; $M_{TD} = 23.0$).

For targeted emotion of sad, the stimuli videos of *Didi*, *Upin Ipin Eid* and *Abandoned Dog* successfully evoked the emotion of sadness as sad was the dominant emotion as illustrated in Figure 4 (b). However, some of the subjects were reported to evoke the emotion happy for the cartoon stimuli video of *Didi* ($M_{ASD} = 7.5$; $M_{TD} = 2.5$), and *Upin Ipin Eid* ($M_{ASD} = 5.5$; $M_{TD} = 2.5$). In addition, the result indicated a significant difference in emotional responses between the ASD and TD subjects. In the ASD subjects, there were varying levels of sadness reported across the three videos: *Abandoned Dog* ($M_{ASD} = 27.0$), *Upin Ipin Eid* ($M_{ASD} =$

25.5), and *Didi* ($M_{ASD} = 23.0$). On the other hand, the TD subjects consistently reported having sad emotional response to all videos, with a mean sadness rating $M_{TD} = 28$ for each video.

For targeted emotion of calm, the stimuli videos of *Flower*, *SAND*, and *Pig* successfully evoked the emotion of calm as calm was the dominant emotion for both ASD and TD as illustrated in Figure 4 (c). The results indicated some of the subjects were reported to evoke the emotion happy for the cartoon stimuli video of *Pig* ($M_{ASD} = 5.5$; $M_{TD} = 2.5$), and nature video of *Flower* ($M_{ASD} = 6.5$; $M_{TD} = 1.5$). Several ASD subjects also reported eliciting emotional response of happiness with calming music of *SAND* stimuli video ($M_{ASD} = 3.5$). The result also indicated a significant difference in emotional responses between the ASD and TD subjects. In the ASD subjects, there were varying levels of calmness reported across the three videos: *Pig* ($M_{ASD} = 28.0$), *SAND* ($M_{ASD} = 27.0$), and *'Flower'* ($M_{ASD} = 25.5$). On the other hand, the TD subjects consistently reported having calm emotional response to all videos, with a mean calmness rating (M_{TD}) of 28 for each video.

For targeted emotion of anger, the stimuli videos of *Bank*, *Sibling Fighting*, and *Kid* successfully evoked the emotion of anger for both TD and ASD as anger was the dominant emotion as illustrated in Figure 4 (d), *Bank*($M_{ASD} = 26.0$; $M_{TD} = 26.5$), *Sibling Fighting*($M_{ASD} = 23.5$; $M_{TD} = 24.5$), and *Kid* ($M_{ASD} = 21.0$; $M_{TD} = 23.5$). The results also indicated that there several subjects remain calm and relaxed with this video stimuli in which the calmness emotional response is higher in TD groups with *Bank* ($M_{TD} = 6.5$), *'Sibling Fighting*($M_{TD} = 5.5$), and *Kid* ($M_{TD} = 6$) compared to ASD groups *Bank* ($M_{ASD} = 4.5$), *Sibling Fighting* ($M_{ASD} = 1.0$), and *Kid* ($M_{ASD} = 3$).

For targeted fear emotion, it is found that fear emotion is the most dominant emotion for all stimuli videos of *Cockroach* ($M_{ASD} = 22.0$; $M_{TD} = 24.5$), *Pigeon* ($M_{ASD} = 25.0$; $M_{TD} = 25.5$), and *Dog* ($M_{ASD} = 27.5$, $M_{TD} = 27.5$). Anger emotion also was evoked as the second highest response from the subjects with *Cockroach* ($M_{ASD} = 7.5$; $M_{TD} = 11.5$), *Pigeon* ($M_{ASD} = 7.0$; $M_{TD} = 11.0$), and *Dog*($M_{ASD} = 9.0$, $M_{TD} = 13.5$). In the coders assessment report, several subjects were reported also showed the derivative emotion of anger such as annoyed, tense, alarmed, and distressed with these stimuli videos of fear.

To examine the impact of the video stimuli on the valence and arousal levels, a repeated measure Analysis of Covariance (ANCOVA) test was conducted. This involved comparing the scores of the five tested emotions (happy, sad, calm, angry, and fear) across two elements of psychological reactance, namely the level of valence and arousal. The results indicated a significant effect on the number of videos in $F(2, 26) = 2318.75$, $p < 0.001$, partial $2 = 0.994$ for which the hypothesis 1 is accepted stating that subjects will experience different valence and arousal when elicited with video stimuli. Mauchly's Test of Sphericity indicated that the assumption of sphericity has been violated in this test where Arousal $\chi 2(2) = 273.83$, $p < 0.001$; Valence $\chi 2(2) = 367.33$, $p < 0.001$. The violations of sphericity were dealt with using the Greenhouse-Geisser correction to degrees of freedom.

The linear test of within subjects' contrasts also demonstrated a significant relation between the independent and dependent variables, for Valence: $F(1, 27) = 38.85$, $p < 0.001$, partial $2 = 0.59$; for Arousal: $F(1, 27) = 238.66$, $p < 0.001$, partial $2 = 0.89$. In order to test hypothesis 1 evaluating different valence and arousal on each video stimuli and hypothesis 2 stating that different video stimuli will induce different emotion intensities, therefore the response of the subject is plotted based on averaged value of arousal and valence values coded by the expert blind coders and the plot is illustrated in Figure 5. This plot is based on the -10 to $+10$ scale of arousal and valence. Negative emotions are plotted on 0 to -10 scale and positive emotions are plotted on 0 to $+10$ scale of the valence axis. Meanwhile, low arousal is plotted on -10 to 0 and high arousal is plotted on 0 to $+10$ scale.

The mean values from the expert blind coders' assessment were used to generate the plot in Figure 5 and the details was tabulated in Table 4. Based on the results, the first quadrant, Q1 illustrated the expression of happiness as the target emotion, characterized by high valence and arousal values for *Pocoyo* ($M_{VAL-ASD} = 6.08$, $M_{ARO-ASD} = 0.22$; $M_{VAL-TD} = 9.78$, $M_{ARO-TD} = 9.22$), *Larva*($M_{VAL-ASD} = 4.28$, $M_{ARO-ASD} = 4.36$; $M_{VAL-TD} = 5.14$, $M_{ARO-TD} = 4.18$) and *Superwings* ($M_{VAL-ASD} = 9.78$, $M_{ARO-ASD} = 1.28$; $M_{VAL-TD} = 3.39$, $M_{ARO-TD} = 7.64$). These valence and arousal values plotted in Q1 indicate that all stimuli videos successfully elicited the emotion of happiness. Additionally, a notable difference was observed between children with ASD and TD, where the ASD subjects showed lower valence and arousal values compared to TD subjects.

The second quadrant, Q2 represented the result of the target emotion of anger and fear. The videos successfully elicited anger, with all of them positioned on the right side of Q2; *Bank* ($M_{VAL-ASD} = -1.43$, $M_{ARO-ASD} = 3.89$; $M_{VAL-TD} = -2.44$, $M_{ARO-TD} = 7.54$), *Siblings fighting* ($M_{VAL-ASD} = -1.54$, $M_{ARO-ASD} = 3.39$; $M_{VAL-TD} = -2.54$, $M_{ARO-TD} = 4.26$), *Kid* ($M_{VAL-ASD} = -2.14$, $M_{ARO-ASD} = 1.82$; $M_{VAL-TD} = -4.43$, $M_{ARO-TD} = 4.29$). The results depicted there was a significant difference in the arousal levels of anger between children with ASD and TD subjects, where the ASD subjects showed lower arousal values compared to TD subjects.

For target emotion of fear, the videos successfully elicited fear, with all of them positioned on the left side of Q2; *Cockroach* video ($M_{VAL-ASD} = -9.07$, $M_{ARO-ASD} = 1.96$; $M_{VAL-TD} = -5.18$, $M_{ARO-TD} = 2.82$), *Pigeon* ($M_{VAL-ASD} = -9.79$, $M_{ARO-ASD} = 4.02$; $M_{VAL-TD} = -6.55$, $M_{ARO-TD} = 3.59$), and *Angry Dog* ($M_{VAL-ASD} = -8.83$, $M_{ARO-ASD} = 9.41$; $M_{VAL-TD} = -5.15$, $M_{ARO-TD} = 7.83$). Notably, a significant difference in valence levels of fear was observed between children with ASD and TD

FIGURE 4. The emotional response of each corresponding affective states.

subjects. Children with ASD exhibited a strong negative emotional response, with valence values approaching −10, indicating a pronounced aversion to fear-inducing stimuli.

For target emotion of sad, the videos successfully elicited sad, with all of them in Quadrant 3, Q3; *Didi* video ($M_{VAL-ASD} = -4.64$, $M_{ARO-ASD} = -3.50$; $M_{VAL-TD} = -4.16$, $M_{ARO-TD} = -2.19$), *Upin Ipin Eid* ($M_{VAL-ASD} = -5.22$, $M_{ARO-ASD} = -2.08$; $M_{VAL-TD} = -3.62$, $M_{ARO-TD} = -3.25$), and *Abandoned Dog* ($M_{VAL-ASD} = -7.72$, $M_{ARO-ASD} = -1.22$; $M_{VAL-TD} = -9.24$, $M_{ARO-TD} = -3.46$). The similar patterns of valence and arousal between ASD and TD subjects suggest that both groups emotionally

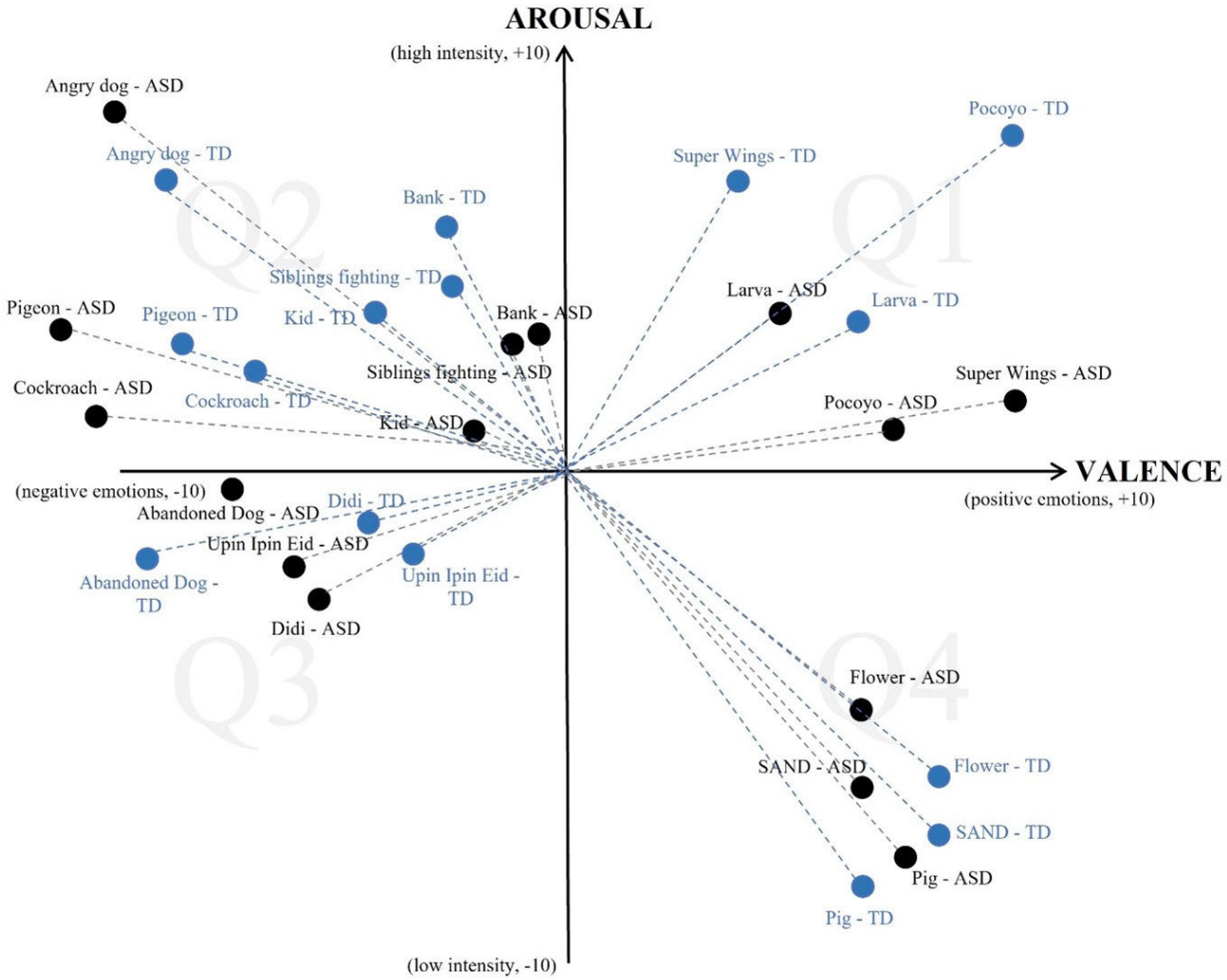

FIGURE 5. Plotting of valence-arousal model based on coders assessment.

engaged with the videos depicting sad stimuli. This finding showed the shared emotional response to sadness irrespective of neurodevelopmental differences.

The fourth quadrant, Q4 illustrates the result of target emotion calm. The videos successfully elicited calm, with all of them in Quadrant 4, Q4; *Flower* video ($M_{VAL-ASD} = 5.14$, $M_{ARO-ASD} = -5.50$; $M_{VAL-TD} = 7.72$, $M_{ARO-TD} = -6.42$), *SAND*($M_{VAL-ASD} = 5.00$, $M_{ARO-ASD} = -7.14$; $M_{VAL-TD} = 7.72$, $M_{ARO-TD} = -7.14$), and *Pig* ($M_{VAL-ASD} = 6.72$, $M_{ARO-ASD} = -9.42$; $M_{VAL-TD} = 5.14$, $M_{ARO-TD} = -9.64$). The similar patterns of valence and arousal between ASD and TD subjects suggested that both groups experienced and responded to the videos in a similar manner when it comes to feelings of calmness. This finding also indicated the potential universality of these videos in inducing a calming emotional state across different neurodevelopmental profiles.

It is noteworthy to mention that the results depicted that certain video stimuli produce higher intensity in emotion elicitation than others, as displayed in Figure 5. Plotting illustrated in Figure 5 also concluded that the videos; *Larva* (ASD-Happy), *Pocoyo*(TD-Happy), *'bandoned Dog* (TD-Sad and ASD-Sad), *Pig* (ASD-Calm and TD-Calm), *Bank* (TD-Anger and ASD-Anger), and *Angry Dog* (TD-Fear and ASD-Fear) have higher emotional intensity ratings as compared to other videos in the same target group.

IV. DISCUSSION

From the results presented in previous section, the objective of the study is fulfilled, in which the study aimed to validate the use of video stimuli in eliciting emotional responses in children with ASD. The results showed that the video stimuli were effective in eliciting emotional responses in this population, as indicated by significant changes in facial expressions and body language response.

TABLE 4. Mean of valence and arousal – coders assessments.

Quadrant	Target Emotion	Stimuli	ASD		TD – Control group	
			Valence	Arousal	Valence	Arousal
I	Happy	*Pocoyo*	6.08	0.22	9.78	9.22
		Larva	4.28	4.36	5.14	4.18
		Superwings	9.78	1.28	3.39	7.64
II	Anger	*Bank*	-1.43	3.89	-2.44	7.54
		Siblings Fighting	-1.54	3.39	-2.54	4.26
		Kid	-2.14	1.82	-4.43	4.29
	Fear	*Cockroach*	-9.07	1.96	-5.18	2.82
		Pigeon	-9.79	4.02	-6.55	3.59
		Angry dog	-8.83	9.41	-5.15	7.83
III	Sad	*Didi*	-4.64	-3.50	-4.16	-2.19
		Upin Ipin Eid Moment	-5.22	-2.08	-3.62	-3.25
		Abandoned Dog	-7.72	-1.22	-9.24	-3.46
IV	Calm	*Flower*	5.14	-5.50	7.72	-6.42
		SAND	5.00	-7.14	7.72	-7.14
		Pig	6.72	-9.42	5.14	-9.64

A. IMPLICATION OF THE FINDINGS

The implications of these findings are significant for both research and clinical practice. The use of video stimuli provides a standardized and objective method for eliciting emotional responses in children with ASD, which can help to reduce the potential for experimenter bias and increase the reliability of the results. This can be particularly important when studying emotion recognition deficits in ASD, which are often characterized by subtle or atypical emotional expressions.

In addition, the study was conducted in the subjects' classroom, which may contribute to accurately reflecting the emotional experiences of children with ASD in real-world situations. The self-report measures to assess emotional responses were also omitted and the expert blind coders were used to minimize the bias and social desirability effects.

B. ANALYSIS OF THE FINDINGS

It is noteworthy to highlight that during the study, it was observed that some of the subjects exhibited a happy emotional response while viewing the *Didi* sad stimuli video. This may be contributed by the popularity of *Didi* character in the Malaysian context, especially among children. It is important to note that the subjects of this study were children, and therefore, some of them might simply be delighted to see *Didi* on the screen.

In addition, in targeted emotion of happy and fear, it was observed that some of the subjects exhibited other significant emotions and its derivatives (mean rating of emotional response > 5). For instance, in target emotion of happy, besides the elicitation of happy emotion, calm emotional response and its derivative of content, glad, relaxed, and pleased were also evoked. While, in target emotion of fear, anger emotional response and its derivative of annoyed, tense, alarmed, and distressed.

From the results, it is also found that there is a significant difference in emotional response intensity associated with the video stimuli. Some video stimuli elicit the intended emotion in higher intensity compared to others video stimuli. For instance, *Larva* video elicits higher mean, and the same pattern can be seen in other quadrants, for example, *Angry Dog* video over other videos in Quadrant 2, *Abandoned Dog* in Quadrant 3, and *Pig* in Quadrant 4, as depicted in Figure 5.

The results also suggest that individuals with ASD exhibit a differential emotional response to video stimuli compared to TD children. The varying levels of emotions reported by ASD subjects across the stimuli videos indicate a potential variability in emotional processing within this group. In contrast, the consistent emotional response in TD group suggests a more homogeneous emotional processing pattern. These results contribute to the understanding of emotional processing differences between ASD and TD children.

The results of this study also provide insights into the emotional responses of individuals with ASD and TD children when exposed to anger-eliciting video stimuli. The presence of calmness as the second highest emotional response in targeted emotion anger stimuli video suggests that emotional regulation may differ among individuals within each group. The higher levels of calmness reported by TD children compared to ASD children indicate a potential difficulty in achieving a calm emotional state in response to anger-eliciting stimuli for the ASD group.

Furthermore, it was noted that most of the ASD subjects in the study displayed a positive response towards non-verbal animated stimuli, such as the *Larva* video. In addition, several female subjects expressed a liking for the calm stimuli video of *Pig*, which featured flowers and pink colors.

C. LIMITATION OF THE RESEARCH

There are several limitations associated with this study, which will be addressed in future work. First, the sample size was relatively small, which may limit the generalizability of the findings. Secondly, the emotional responses coded are limited to facial expressions and body language only as it is a part of the research that will utilize thermal images information to classify the emotion. Thirdly, the study limits the targeted emotions to five basic emotions only. Lastly, although the

video stimuli used in the study consists of different types of video stimuli (animated vs. real life), however, the ratio is imbalance and the aspect of the effectiveness of different types of video stimuli is not the focus of the study.

Future research should aim to address these limitations by conducting larger-scale studies using a combination of physiological measures and behavioral observations to assess emotional responses. In addition, it may be useful to explore the potential of video stimuli to elicit different types of emotions and to compare the effectiveness of emotional response with different types of video stimuli.

Overall, the present study provides preliminary evidence to support the use of video stimuli in emotion elicitation of children with ASD. Further research is needed to fully understand the potential benefits and limitations of this approach and to develop effective interventions for emotion recognition deficits in this population.

DATA AVAILABILITY STATEMENT

The stimuli data set is available at Github repository, *https://github.com/ariffrashidan/stimuli*.

The complete questionnaires which include pre-questionnaire (E_0), intra-questionnaire (E_1), and post-questionnaire (E_2) can be requested from the corresponding author.

CONFLICT OF INTEREST

The authors report no conflicts of interest.

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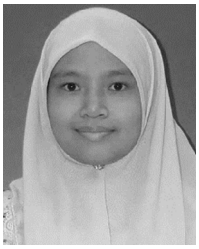

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