The Development of Perceptual-Attentional Processes of Children in the Recognition of Basic Emotional Facial Expressions: An Eye-Tracking Study

by

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Abstract

The current study investigated the role of facial areas in the recognition of six basic emotions (happiness, sadness, fear, anger, surprise and disgust) as well as the perceptual and attentional development of emotion recognition in school aged children. Participants viewed images of emotional facial expressions at various intensities and were asked to identify which emotion was being expressed while their eye movements were being tracked. Happiness was the easiest emotion to recognize, followed by anger then sadness for all children. The hardest emotions to recognize were surprise (5-year-olds) and fear (10-year-olds). Surprise was also the only emotion for which a difference between age groups occurred. All children spent more time looking at the eye/brow area for all emotions but anger. Only one relationship between recognition accuracy and time spent on different areas was found. The results of this study highlight the complexity of emotion recognition in developing children.

Keywords*:* emotion recognition, children, eye tracking, recognition thresholds, perceptual-attentional development

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Table of Contents

1. Introduction

The recognition of emotional facial expressions is a central feature to social interactions, allowing individuals to infer the emotional states of others and to plan their behaviours accordingly (Calvo & Nummenmaa, 2008; Ekman, 1999, 2003; Ekman & Cordaro, 2011; Ekman & Oster, 1979; Gao & Maurer, 2009). Facial expressions are the results of specific muscle activations of the face and these produced activations are the basis that allows for the recognition of emotions. According to some researchers, there are six emotions considered to be universal and produce the same muscle activations across all cultures thus allowing universal recognition; happiness, sadness, anger, fear, surprise, and disgust (Ekman & Friesen, 1971,1978; Izard, 1971).

1.1. Adult Emotional Facial Expression Recognition

Research on emotional facial expression recognition shows that adults recognize the six basic emotions at a higher level than is attributable to chance (Ekman, 2003; Ekman & Friesen, 1971, Izard, 1971). However, recognition rates vary as a function of the emotion. It is suggested that happiness is consistently the most accurately recognized emotion, followed by anger and surprise. Disgust, sadness, and fear have been reported as more difficult to recognize, particularly fear, which is the expression that is the least accurately recognized (Beaudry, Roy-Charland, Perron, Cormier & Tapp, 2014; Ekman & Friesen, 1971, 1986; Gosselin & Kirouac, 1995, Tracy & Robins, 2008).

Calvo, Avero, Fernandez-Martin, and Recio (2016), conducted a study to determine adult's recognition thresholds of the six basic emotions (happiness, sadness, anger, surprise, fear, and disgust). Each emotional facial expression was adjusted to create a total of seven intensities (20%,30%,40%,50%,60%,75%, and 100%). Participants randomly viewed all six-emotional facial expressions in the seven intensities a total of two times each. They were asked to identify which emotion from the six basic emotions was being expressed in each image. A non-parametric score was computed based on the signal detection theory from Macmillan and Creelman (2005). This score varied from 0-1 where .5 was considered chance level. The computed score takes into account the probability of hits (e.g. identifying a happy expression as happiness) as well as the probability of false alarms (e.g. identifying an angry expression as disgust). An emotion recognition threshold was established by identifying the lowest level of intensity at which the computed score was above chance level. Happiness had the lowest threshold being accurately identified at 20% intensity followed by sadness, anger, disgust, and surprise, all accurately identified at 40% intensity. Fear was the most difficult emotion to identify, with a recognition threshold of 50%. Recognition thresholds for happiness and fear are consistent with previous literature on recognition rates. Previous research has shown that happiness is the most accurately recognized emotion whereas fear is the least accurately recognized (Beaudry et al., 2014; Ekman & Friesen, 1971, 1986; Gosselin & Kirouac, 1995, Tracy & Robins, 2008). Calvo and colleagues (2016) found that happiness was recognized above chance level at lower intensities and fear required more intensity for recognition to occur. It was suggested that happiness may have a distinguishable feature, the mouth, allowing individuals to accurately discriminate and recognize it under minimal circumstances, thus explaining its low recognition threshold (Calvo et al., 2016).

Many researchers have evaluated the role of facial areas in the recognition of facial expressions (e.g. Calvo, Nummenmaa, & Avero, 2010; Jack, Blais, Scheepers, Schyns, & Caldara, 2009;

Martin, Slessor, Allen, Philips, & Darling, 2012; Smith, Cottrell, Gosselin, & Schyns, 2005). It is suggested that the accuracy of emotional facial recognition could be based on a single facial feature. For instance, the specific muscle activation or the ability of a feature to capture attention, such as the mouth during happiness as stated by Calvo et al. (2016), may be more distinctive in certain expressions thus allowing quicker and more accurate recognition (Calvo & Nummenmaa, 2008). Both the mouth and the eye/brow areas have been documented as comprising features to transmit emotional states (Ekman, Sorenson & Friesen, 1969). Moreover, when looking at faces, individuals typically look at the salient facial features which not only includes the eye/brow and mouth areas, but also the nose (Janik, Wellens, Goldbers & Dell'Osso, 1978). Various muscle activations are associated with these regions during emotional facial expressions (Ekman & Friesen, 1978). For example, fear is associated with the opening of the eyes, the elevation of the inner and outer areas of the eyebrows as well as eyebrow contractions. Moreover, even the activation of muscles other than eye/brow muscles can impact the appearance of this region. For instance, wrinkles on the nose, associated with disgust expressions, will give the appearance of lowering of the eyebrows. In addition, the raising of the cheeks can also give the appearance of eye shrinking and create wrinkles under and on the external corners of the eyes.

Sullivan, Ruffman & Hutton (2007), explored the role of the eyes/brows as well as the mouth in the recognition of the six basic emotions in both younger and older adults. Participants viewed 12 photographs of a facial region (e.g. eyes) and were asked to identify which emotion was being expressed in the photograph. However, since their main objective was to compare the individual role of these features during recognition, results regarding the importance of eye/brow and mouth areas in the recognition of each basic emotion when the full face is presented can not be analyzed. Nonetheless, results revealed that eyes/brows were effectively more important for the recognition of anger, fear, and sadness whereas the mouth was more important to recognize disgust. Both the eyes/brows and the mouth were important for the recognition of happiness and surprise (Sullivan et al., 2007).

Beaudry et al. (2014), examined the role of the eye/brow and mouth areas in the recognition of the six basic emotions when the full facial expression was being presented. They also investigated various intensities to reduce recognition rate ceiling effects for certain emotions. Participants randomly viewed all basic emotional facial expressions at each intensity level (20%, 30%, 50%, and 100%). Each image was presented one at a time and participants controlled the viewing time. They were asked to press the mouse button once they had deciphered the emotion being presented. Once a white screen appeared, they were asked to identify which emotion was being expressed in the image from a list of 10 emotions (happiness, fear, anger, sadness, disgust, surprise, contempt, guilt, shame, and interest). They also had the possibility of suggesting another emotion that was not on the list. Once an answer was recorded, a new facial expression was presented. Results revealed that the mouth attracted attention more quickly and participants spent more time looking at the mouth than the eyes/brows for happiness, whereas the eyes/brows attracted attention more quickly and were looked at significantly longer for the recognition of sadness. The latter is interesting, as the eye/brow muscle activations that occur with sadness are not a unique feature of this emotion as they are also seen in anger, fear, and surprise. Furthermore, results for other emotions are not as clear. For example, when identifying disgust expressions, participants took longer before looking at the mouth area compared to other emotions and they did not look at the mouth significantly longer compared to the eye/brow area. Also, consistent with previous literature on emotion recognition, happiness followed by surprise were the most accurately identified while disgust followed by fear were the least accurately recognized. Overall, results reveal that participants look at different areas before producing a response, even though they may spend more time on a feature or a certain feature may attract attention better, participants look at different areas (Beaudry et al., 2014).

1.2. Children Emotional Facial Expression Recognition

Although research on adult recognition is quite extensive, these results can not be applied to the recognition abilities of children. Research suggests that children acquire the ability to recognize emotions gradually throughout development (Batty & Taylor, 2006, Camras & Allison, 1985; De Sonneville et al., 2002; Gao & Maurer, 2009,2010; Gosselin, 2005: Herba, Landau, Russell, Ecker & Phillips, 2006; Roy-Charland, Perron, Young, Boulard & Chamberland, 2015; Vicari, Snitzer Reilly, Pasqualetti, Vizzoto & Caltagirone, 2000). It is suggested that infants have fully functional facial muscles that allow them to produce adult-like emotional facial expressions. How and when the activations of these muscles become associated with specific elicitors is still unknown. However, by the age of 5 years old, many of the specific muscle activations can be imitated (Ekman & Oster, 1979). Moreover, the acquisition of abilities to recognize emotional facial expressions does not emerge in one specific stage of life. In fact, there are anatomical and functional brain changes that occur throughout development until adulthood, which allows for the maturation of emotional facial recognition abilities (e.g. Prefrontal cortex, amygdala) (Thomas, De Bellis, Graham & LaBar, 2007). Thus, emotional facial expression recognition rates gathered from adult studies can not accurately depict children's recognition abilities. Recognition task studies have shown that younger children are significantly slower at identifying which expression illustrates a specific emotion when being presented with multiple facial expressions (Gosselin & Larocque, 2000; Tremblay, Kirouac, & Doré, 1987; Vicari et al., 2000) as well as when children must identify which emotion corresponds to a single facial expression (Gao & Maurer, 2009; Gosselin, Roberge, & Lavallée, 1995). More specific to the age groups of the current study, significant improvements between the ages of 5 and 10 can be observed on judgment tasks requiring children to select the emotional facial expression from a series of different expressions that corresponds with a given emotion (Gao & Maurer, 2009; Gosselin & Larocque, 2000; Markham & Adams, 1992; Tremblay et al., 1987).

Rodger, Vizioli, Ouyang, and Caldara (2015) mapped the development of facial expression recognition in individuals from 5 years of age to adulthood for the six basic emotions as well as for neutral emotional facial expressions. Participants viewed 252 grey-scaled images that had been blurred to create different intensities. They were asked to identify which emotion was being expressed in each image. Results revealed that overall recognition accuracy improved with age for all emotions but fear and happiness. All age groups were equally accurate at identifying happiness, and fear was equally more difficult to identify than any other emotion. Five-year-old's recognition of happiness and fear were both within adults' recognition range. Results also revealed that younger children had significantly more difficulty than older children at recognizing anger. They also confused anger more with neutral expressions, compared to older children who confused anger with disgust. Younger children also confused surprise more often with fear compared to older age groups. Moreover, results also revealed that recognition of disgust and anger expressions improves with age at a faster rate than sadness and surprise. They concluded that there are essentially two main stages of development where significant improvements can be observed; 5-12 years of age and from adolescence to adulthood (Rodger et al., 2015).

Gagnon, Gosselin, and Maassarani (2014) examined children's ability to recognize emotional facial expressions from a combination of traits in the upper face, in the center of the face, and in the bottom of the face, in order to investigate the role of certain areas in the recognition of fear, surprise, anger and disgust emotions. They presented a total of 33 images of full facial expressions as well as partial facial expressions (top face only, middle face only, or bottom face only) to 5-year-olds and 10-year-olds. All images were presented on a computer screen. In one condition, the expressions were properly identified and, in another condition, the expression had the wrong emotion label. Participants were asked to identify whether the label properly depicted the emotional facial expression. Given the multiple facial features present in each section of the areas, results are difficult to analyze in terms of the role of the specific areas that were used during recognition of the emotions. For example, the upper face contains not only the eye/brow area but also the nose and the bottom of the face area contains part of the nose, the cheeks, the mouth, and the chin. Nonetheless, results revealed that 5-year-old children can recognize fear, disgust, surprise, and anger but depending on the emotion the importance of the required area of the face varies. In fact, disgust is recognized from the middle of the face, while surprise is better recognized with the upper face area and, fear from the bottom of the face. Anger can also be recognized with the upper face area but this was only the case for girls. Additionally, 10-year-old children showed less difficulty recognizing anger with the bottom of the face. Overall, they concluded that children develop better abilities at recognizing surprise and anger but still have difficulty recognizing surprise from fear and anger from disgust.

Gao and Maurer (2010) investigated developmental changes with regards to the recognition of six basic emotions (happiness, surprise, anger, fear, disgust and sadness) at 20 different intensities ranging from 5% to 100% intensity all with 5% increments. There were four age groups within this study, 5-year-olds, 7-year-olds, 10-year-olds and adults between the ages of 18 and 22. The study was divided into two testing blocks, the first block consisted of showing participants pictures of happy, surprised, and fearful expressions at all intensity levels along with 4 neutral expressions, while the second block consisted of showing pictures of sad, disgusted, and angry expressions at all intensity levels along with 4 neutral expressions. In each block, participants were presented with four houses marked by a schematic face on the rooftop. They were asked to sort through the various pictures of emotional facial expressions and place them in the house which was marked by the schematic face best matching the facial expression of the picture. Results revealed, that by the age of 5, children are nearly as sensitive as adults when discriminating happy expressions, but make more misidentifications with surprise compared to adults. For sadness, surprise and disgust it is only between 7 and 10 years of age that children become as sensitive as adults. Both 5- and 7-year old's more often misidentified mi-range sad expressions as neutral or disgust (7-year old's only). Also, compared to adults, 5- and 7-year old's misidentified surprise more than adults, although all age groups made misidentifications. Disgust was misidentified as sadness more with 5-year-old children and as neutral for 7-year-old children. Both younger age groups also made more misidentifications compared to adults. For fear, 5-year-old children have a higher threshold than adults, but other children are as sensitive as adults. Finally, for anger, children between 5 and 10 years of age are more likely to misidentify it as neutral at lower intensities.

Ewing, Karmiloff-Smith, Farran, and Smith (2017) investigated emotion recognition processing strategies using the Bubbles reverse-correlation paradigm. In their study, younger children aged 6 to 9 years old, older children aged 10 to 13 years old, and adults 18-43 years of age viewed images of happiness, sadness, anger, and fear expressions. Each of these facial expressions were also decomposed into five spatial frequency bandwidths. The lower the spatial frequency, the less information is available (via fewer bubbles), the higher the spatial frequency the more information is available (via more bubbles). The task was composed of 8 blocks of 24 trials each, for a total of 192 trials. Participants were asked to identify the emotional expression of the face being presented by pressing the appropriate key on a labeled keyboard. Results revealed that adults perform significantly better than older children and older children performed in turn better than younger children. Moreover, happiness was the most accurately recognized emotion followed by fear, which was then followed by sadness and then by anger. Information use became increasingly more targeted throughout age groups. In fact, younger children and older children, but to a lesser extent, used a wider range of visual features to recognize emotional facial expressions compared to adults. The smiling mouth was used for the recognition of happiness by all age groups. For fear, results showed that the widening of the eyes and the opened mouth were dominant features for its recognition by all age groups. All age groups also used information from the downturned mouth for recognition of sadness, however, only older children and adults relied significantly on the eye region for recognition of this emotion. Finally, for anger, both younger and older children relied on the pinched eyes and furrowed brow and made no use of mouth information. Overall, younger children required more bubbles for fear and happiness compared to older children. Thus, recognition thresholds were similar for both younger and older children for anger and sadness, but lower for older children for both happiness and fear (Ewing et al., 2017).

In order to fully understand children's emotional facial recognition abilities, one must also be familiar with essential theoretical backgrounds that help explain the patterns and variances.

One assumption is the broad-to-differentiated hypothesis (Widen & Russell, 2003). According to this theory, emotions are understood gradually and change over the course of development. Children thus understand emotions in terms of valence (good or bad) and level of arousal rather than in terms of specific emotions. As children age and develop, they are gradually able to associate valence-based categories to specific emotions (Widen, 2013; Widen & Russell, 2008). Studies have shown that conceptually, children acquire happiness, sadness, and anger sooner than fear, surprise, and disgust (Widen & Russell, 2003;2008, Widen 2013). Moreover, errors do not tend to occur randomly, but rather systematically. In fact, children are more likely to mislabel a facial expression with a label from an emotion category of the same valence and similar level of arousal (e.g. angry instead of disgust or fear as surprised).

An alternative assumption is the perceptual-attentional limitations hypothesis (Roy-Charland et al., 2015). Each basic emotion is known to have its own combination of muscle activations (Ekman & Friesen, 1971,1978; Izard, 1971). While some features are more salient (e.g. mouth opening), others are more subtle (e.g. wrinkling of the skin). According to the perceptual-attentional limitations hypothesis, the greater the similarities between emotional facial expressions, more specifically between the muscle activations they produce, the more difficult they are to distinguish from one another and thus to recognize. Additionally, the more developed the perceptual abilities or visual system, the more easily an individual can discriminate subtle differences (Roy-Charland et al., 2015). The most common confusions are between fear and surprise, especially in children between the ages of 5 and 10 (Bullock and Russell, 1985) and between disgust and anger (Bullock & Russell 1985; Gosselin et al., 1995). In fact, fear and surprise share three muscle activations (raising of the inner brows and outer brows, raising of the upper eyelids) while disgust and anger share the lowering of the inner brows (Gagnon, Gosselin, Hudon-ven der Buhs, Larocque & Milliard 2010). It has been argued that these errors decrease significantly between the ages of 5 and 10, thus suggesting that older children have less difficulty distinguishing fear and surprise as well as disgust and anger (Gagnon et al., 2014). According to the above assumption, this is likely due to a maturation of the visual system as older children are better at noticing the more subtle differences between facial expressions with similar muscle activations.

1.3. The Current Study

The process by which an individual may recognize emotions throughout development is an important question, while there have been some studies that have attempted to better understand developmental patterns and variances, some questions still remain unanswered. The current study's goal was to examine the attentional-perceptual development of school-aged children emotional facial expression recognition and recognition thresholds while also determining the role of the eye/brow, mouth and nose areas during recognition of the six basic emotions (Happiness, sadness, fear, anger, surprise, and disgust). While Rodger et al. (2015) mapped the development of facial expression recognition in children through adulthood, the role of the specific areas of the face during recognition was not examined nor were recognition thresholds. Gagnon et al. (2014) examined, to some extent, the role of areas of the face during children's emotional facial expression recognition. However, as aforementioned, the way the face was divided into regions makes it difficult to determine what particular area was being used to recognize the facial expression. They also only examined the recognition of four basic emotions and did not observe recognition thresholds. Additionally, while Gao and Maurer (2010), did investigate children's thresholds for all six basic emotions, they determined thresholds by categorizing responses as either neutral or non-neutral and calculated if the non-neutral responses were correctly identified or misidentified, thus finding discrimination thresholds and not recognition thresholds. In other words, Gao and Maurer (2010), evaluated participants' ability to discriminate neutral expressions from emotional facial expressions, whereas this study seeked to determine at what intensity can children accurately recognize emotional facial expressions above chance level. Finally, Ewing et al. (2017) examined emotion recognition as well information processing efficiency in both younger (6-9 years old age) and older (10-13 years of age) children but only four basic emotions were used (sadness, happiness, anger and fear). The current study's goals were thus to determine the role of the eye/brow, mouth and nose area during emotional facial expression recognition of the six basic emotions while mapping the developmental changes in recognition abilities by comparing 5-year-olds to 10-year-olds recognition rates and thresholds.

Significant improvement between the ages of 5 and 10 have consistently been found in judgment tasks requiring participants to select the expression of a given emotion from an array of different expressions (Gao & Maurer 2009; Gosselin,1995; Gosselin & Larocque 2000; Tremblay et al., 1987). It has also been shown in recognition tasks (Gosselin et al. 1995; Vicari et al., 2000; Widen & Russell 2003). However, the improvement of each emotion is not expected to be uniform. Generally speaking, happiness and sadness are typically well recognized by the age of 5 (Gao & Maurer 2008; Gosselin 1995; Tremblay et al. 1987; Vicari et al. 2000), while fear and disgust recognition rates are quite low at that age, but improve significantly over the next five years (Gao & Maurer 2008; Gosselin & Larocque 2000; Vicari et al., 2000). Patterns for anger and surprise are more mixed, with some studies reporting high accuracy at 5 or 6 years of age, and others only moderate accuracy at that age but significant improvements in later years (Camras and Allison 1985; Gosselin 1995; Tremblay et al. 1987; Vicari et al. 2000).

Given the typical patterns within past research, we hypothesized that happiness would be the most accurately recognized emotion and that both 5-year-olds and 10-year-olds would have similar accuracy rates (Gao & Maurer, 2008, 2010; Gosselin 1995; Rodger et al., 2015; Tremblay et al. 1987; Vicari et al. 2000). Moreover, both age groups were expected to have a fairly low recognition threshold for this emotion, but given past research, it was possible that 5-year-old children would have a higher recognition threshold than 10- year-old children (Ewing et al., 2017). Sadness was also expected to be among the easiest to recognize even for the younger age group (Gao & Maurer 2008; Gosselin 1995; Tremblay et al. 1987; Vicari et al. 2000). However, it was expected that 10-year-old would perform better than 5-year-olds (Gao & Maurer, 2010). No difference between age groups was expected with regards to recognition thresholds for sadness (Ewing et al., 2017). Fear was expected to be the least accurately recognized emotion (Rodger et al.,2015). Additionally, 5-year-olds were expected to have a lower recognition rate compared to 10-year-olds (Gao & Maurer, 2008, 2010; Gosselin & Larocque 2000; Vicari et al., 2000). The same pattern was expected with regard to recognition thresholds (Ewing et al., 2017). Disgust was hypothesized to be among the most difficult to recognize and it was expected that 10-year-olds would perform better than 5-year-olds (Gao & Maurer, 2008, 2010; Gosselin & Larocque 2000; Vicari et al., 2000). To the best of our knowledge, no study has yet to investigate recognition thresholds for disgust in children thus thresholds were exploratory for that emotion. Patterns for accuracy of anger and surprise within literature are more mixed (e.g. Camras and Allison 1985; Gosselin 1995; Tremblay et al.,1987; Vicari et al. 2000), thus it was unclear whether we expected lower or higher recognition rates for both anger and surprise. For surprise, however, it was hypothesized that 10-year-olds would perform better than 5-year-olds, while similar recognition rates for both 5 and 10-year-old were expected for anger (Gao& Maurer, 2010). Recognition thresholds were expected to be similar between age groups for anger, and exploratory for surprise.

Finally, based on eye-tracking studies, we hypothesized that the mouth would be looked at longer for the recognition of happiness (Beaudry et al., 2014; Calvo et al. 2016; Sullivan et al., 2007) and no difference would be observed between younger and older children (Ewing et al., 2017). Expected results for fear were unclear as one study led us to hypothesize that the mouth would be looked at the most (Beaudry et al., 2014), while another indicated that both the mouth and the eyes/brows would be used for recognition (Ewing et al., 2017). Results for sadness in past research is also mixed as the eyes were shown to be important (Beaudry et al., 2014) but so did the mouth (Ewing et al., 2017). As such, expected results for this emotion was unclear. However, we did expect the eyes/brows to be used by older children (Ewing et al., 2017). Additionally, the eyes/brow were expected to be important for the recognition of anger (Ewing et al., 2017) as well as surprise (Gagnon et al., 2014) and the nose for disgust expressions (Gagnon et al., 2014).

2. Methods

2.1. Participants

Participants for this study were recruited from elementary schools within the Conseil Scolaire Catholique du Nouvel-Ontario. A total of 40 school-aged children participated in this research study. Twenty of these children were 5 years old while the other twenty children were 10 years old. Each age group was composed of 10 females and 10 males.

2.2. Stimuli

For this research study, Caucasian emotional facial expressions of the six basic emotions (happiness, sadness, fear, anger, disgust, and surprise) were obtained from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE) database (Matsumoto & Ekman, 1989).

There were 2 encoders (1 male, 1 female) for each emotion. These pictures were previously altered by Beaudry et al. (2014) with the Morpheus 7.0 program to generate four different levels of intensity (20%, 30%, 50%, and 100%) for each emotion. More particularly, the different intensities were created by morphing the emotional facial expressions with a neutral expression. The more pronounced the neutral expression in the morphed image, the less intense the emotional facial expression. A total of 48 stimuli were thus used in this study (See Figure 1 in Appendix A).

2.3. Apparatus

Eye movements were recorded using the Eyelink 1000 system (SR-Research Ltd, Mississauga, ON, Canada). This eye-tracking system has high accuracy (<0.5°) and a very high sampling rate (2000 Hz). This apparatus is composed of one camera and one infrared sensor. The camera was situated below a computer monitor which was precisely 70 centimeters in front of the participant. Head movements were controlled with the use of a chinrest. The current study tracked a single pupil, which, as default, was consistently the participants' right pupil. To standardize the eye movements, a nine-point calibration procedure with a maximum of one-degree deviation in visual angle was considered acceptable. Once a proper calibration was achieved, participants viewed the stimuli on a 21" ViewSonic monitor, while the experimenter could view participant gaze positions on a different monitor. These positions were presented with a gaze cursor of one degree in diameter allowing to verify the systems' accuracy.

2.4. Procedure

First, permission from the school board was obtained. Next permissions from individual school principals were also obtained. After permission was granted, informed consent forms were sent to the children's parents or caregivers which were distributed to them by the children's teacher. Upon the receival of the consent form, the child was asked to participate in the study. Only children whose parent or caregiver gave full informed consent and whom assented to participate could, in fact, participate. The children who participated in this study were tested in a single experimental session that lasted approximately 30 minutes. Each child was first read 6 short stories about a girl named Joannie (See Appendix B). The stories allowed to provide some context of what are emotions and provided children with an example of each emotion. Once the stories were read, the researcher informed the children that the stories would help them with the task that followed. Children were then asked to take a seat in front of a computer monitor where the researcher then calibrated and validated the Eyelink 1000 apparatus.

All images were randomly presented on the computer monitor situated in front of the participant. Participants were instructed that they would view emotional facial expressions and that the researcher would read aloud a list of 6 emotions from which to choose. This list was counterbalanced for each trial to eliminate potential biases. Once the child provided an answer, the researcher pressed a button to complete the trial, where a white screen with a cartoon of Caillou appeared. The researcher then made note of the child's answer. Once their response was recorded, a new image was presented.

3. Results

3.1. Recognition Accuracy

A 2 (age: 5 years, 10 years) x 6 (emotion: anger, disgust, fear, happiness, sadness, surprise) x 4 (intensity: 20%, 30%, 50%, 100%) mixed-design ANOVA was computed for emotional facial expression recognition accuracy. Results reveal a significant main effect for emotion, $F(5,190) = 31.05$, $p < 01$, $\eta^2_p = .45$, a significant main effect for intensity, $F(3,114) = 170.32$, $p < .01$, $\eta^2_p = .82$, and a significant main effect for age, $F(1,38)=12.88$, $p < .01$, $\eta^2_p = .25$. The interaction between emotion and age was also significant, $F(5,190)=4.29$, $p < .01$, $\eta^2_p = .10$, as was the interaction between emotion and intensity $F(15,570)=5.26$, $p < .01$, $\eta^2_p = .12$. However, the interaction between intensity and age was not significant $F(3,114)=.82$, $p = .49$, $\eta^2_p = .02$. The interaction between emotion, age and intensity was significant $F(15,570)=1.73$, $p < .05$, $\eta^2_p = .04$.

Because of the three-way interaction, simple main effects were computed separately for 5-year-olds accuracy of each emotion depending on the intensity as well as 5-year-olds accuracy for each intensity level depending on the emotion (See Table 1 in Appendix C for means and standard deviations; See Figure 2 in Appendix D for graph). The same analyses were also separately computed for 10-year-olds accuracy (See Table 2 in Appendix E for means and standard deviations; See Figure 3 in Appendix F for graph). Simple main effects tests were computed for the interaction using a Dunn's corrections ($p < .015$).

Analyses between age groups were also computed but, for sake of brevity, will not be presented explicitly here since there was only an interaction between age and intensity for surprise $F(3,114) = 3.01$, $p < .05$, $\eta^2_p = .07$. Simple main effect tests revealed that 10-year-olds were significantly more accurate than 5-year-olds at 50% intensity level $F(1,38) = 11.05$, $p < .025$, $\eta^2_p = .23$, and 100%, $F(1,38) = 20.19$, $p < .025$, $\eta^2_p = .35$, but not for 20% , $F(1,38) = 3.44$, $p = .07$, or 30 %, $F(1,38) = 1.79$, $p = .19$.

In regards to 5-year-olds accuracy, results revealed that recognition accuracy for anger, disgust, fear, and sadness respectively, depends on the intensity, $F(3,57) = 27.40$, $p < .015$, $\eta^2_p = .59$; $F(3,57)= 4.90$, $p < .015$, $\eta^2_p = .21$: $F(3,57)= 24.68$, $p < .015$, $\eta^2_p = .57$; $F(3,57) = 31.29$, $p < .015$, $\eta^2_p = .62$. However, recognition accuracy of happiness and surprise did not differ as a function of the intensity, $F(3,57)= 1.47$, $p = .23$, $\eta^2_p = .72$, $F(3,57)= 2.93$, $p = .04$, $\eta^2_p = .013$. Post hoc tests (LSD) revealed that 5-year-old children were better at recognizing anger when the intensity of the emotion was either 100%, 50% or 30% compared to when it was at 20% intensity. They were also better at recognizing anger with 100% intensity compared to 30% intensity. In regards to disgust, recognition accuracy was best with 100% or 50% intensity compared to 20%. Fear was better recognized when intensity was 100% or 50% compared to 20% and better with 100% compared to 30%. In regards to sadness, it was better recognized with 100%, 50% or 30% compared to 20%, better recognized with 100% and 50% compared to 30% and even better recognized with 100% compared to 50%. Moreover, 5-year-olds accuracy of emotional facial expressions of 20%, 30%, 50% and 100% intensity respectively, depends on the emotion, $F(5,95) = 19.09$, $p < .015$, $\eta^2_p = .50$; $F(5,95)= 9.97$, $p < .015$, $\eta^2_p = .34$: $F(5,95)= 6.11$, $p < .015$, $\eta^2_p = .24$; $F(5,95) = 11.49$, $p < .015$, $\eta^2_p = .38$. Post hoc tests (LSD) revealed that 5-year-old children were better at recognizing happiness with 20% intensity compared to all other emotions, and better at recognizing happiness at 30% intensity compared to all emotions but anger. Moreover, they were worst at recognizing surprise and fear compared to anger when intensity levels were at 30%. In regards to 50% intensity, they were better at recognizing happiness compared to disgust and fear, but fear was more accurately recognized compared to disgust. They were also less accurate when recognizing surprise compared to anger, happiness and sadness. Finally, in regards to 100% intensity, disgust and surprise were the worst accurately recognized emotions.

In regards to 10-year-olds accuracy, results revealed that recognition accuracy for anger, disgust, fear, happiness, sadness and surprised respectively, depends on the intensity, $F(3,57)= 20.42$, $p < .015$, $\eta^2_p = .52$; $F(3,57)= 10.01$, $p < .015$, $\eta^2_p = .35$: $F(3,57)= 17.83$, $p < .015$, $\eta^2_p = .48$; $F(3,57)= 6.14$, $p < .015$ $\eta^2_p = .24$, $F(3,57)= 22.37$, $p < .015$, $\eta^2_p = .54$, $F(3,57)= 13.98$, $p < .015$, $\eta^2_p = .42$. Post hoc tests (LSD) indicate that 10-year-old children were better at recognizing anger with 50% or 100% intensity compared to both 30% and 20%, better at recognizing disgust with 100% intensity compared to all other intensities, better at recognizing fear with 100% or 50% intensity compared to 30% and 20%, worst at recognizing happiness with 20% intensity compared to 100% intensity, better at recognizing sadness with 100% intensity compared to 50%, 30% and 20% intensity, and better at 50% intensity than 20% for sadness as well and finally were better at recognizing surprise with 100% or 50% intensity compared to 20% and 30%. Results also revealed that 10-year-olds accuracy with emotional facial expressions of 20%, 30%, 50% and 100% intensity respectively, depends on the emotion, $F(3.79,72.06)= 14.07$, $p < .015$, $\eta^2_p = .43$; $F(5,95)= 11.56$, $p < .015$, $\eta^2_p = .38$: $F(5,95)= 7.25$, $p < .015$, $\eta^2_p = .28$; $F(3.02,57.44)= 7.26$, $p < .015$, $\eta^2_p = .28$. Post hoc tests (LSD) revealed that 10-year-old children were better at recognizing happiness than all other emotions and worst at recognizing fear than all other emotions when intensity was 20%. They were also recognizing happiness with more accuracy when intensity was at 30% compared to all other emotions and better at recognizing anger at 30% intensity compared to disgust, fear and surprise. In regards to 50% intensity, they were better at recognizing anger compared to disgust and fear, and more accurate with recognition of happiness compared to disgust, fear, sadness and surprise. Finally, 10-year-old children were worst at recognizing fear compared to anger, happiness and surprise and worst at recognizing disgust compared to happiness when intensity was 100%.

3.2. Trial Dwell Time

A 2 (age: 5 years, 10 years) x 6 (emotion: anger, disgust, fear, happiness, sadness, surprise) x 4 (intensity: 20%, 30%, 50%, 100%) mixed-design ANOVA was computed for trial dwell time. Results revealed a significant main effect for emotion, $F(3.78,143.77)= 6.46$, $p < .01$, $\eta^2_p= .15$, a significant main effect for intensity, $F(3,114)= 18.00$, $p < .01$, $\eta^2_p = .32$, and a significant main effect for age, $F(1,38)=10.94$, $p < .01$, $\eta^2_p = .22$. The interaction between emotion and intensity was significant, $F(7.56,287.23)=2.20$, $p < .01$, $\eta^2_p = .06$. However, the interaction between intensity and age was not significant $F(3,114)=.36$, $p = .79$, $\eta^2_p = .01$, nor were the interactions between emotion and age as well as between emotion, intensity and age respectively ($F(3.78,143.77)=.74$, $p = .56$, $\eta^2_p = .02$; $F(7.56,287.23)=.74$, $p = .65$, $\eta^2_p = .02$).

Simple main effects tests were computed for the interaction using a Dunn's corrections ($p < .015$) (See Table 3 in Appendix G for means and standard deviations; See Figure 4 in Appendix H for graph).

Results revealed that trial dwell time on emotional facial expressions at 30% intensity differs as a function of the emotion $F(3.93,153.14)= 7.15$, $p < .015$, $\eta^2_p = .16$, but trial dwell time did not significantly differ from one emotion to another when intensities were, 20%, 50% or 100% respectively $F(3.54,138.05)= 1.63$, $p = .18$, $\eta^2_p = .40$; $F(2.43,94.79)= 3.95$, $p = .016$, $\eta^2_p = .09$; $F(5,195)= 1.44$, $p = .21$, $\eta^2_p = .04$. Post hoc tests (LSD) revealed that when emotional facial expression intensity was 30%, children spent significantly less time looking at anger and happiness compared to surprise expressions, and significant spent less time looking at disgust expressions compared to fear, sadness and surprise. Results further revealed that trial dwell time for anger, fear, sadness and surprise, respectively, depends on the intensity of the emotion $F(1.68,65.38)= 6.44$, $p < .015$, $\eta^2_p = .14$; $F(3,117)= 4.48$, $p < .015$, $\eta^2_p = .10$: $F(2.04,79.52)= 4.45$, $p < .015$, $\eta^2_p = .10$; $F(3,117)= 4.01$, $p < .015$, $\eta^2_p = .09$. However, trial dwell time did not significantly differ as a function of the intensity for disgust and happiness respectively $F(2.28,88.86)= 3.65$, $p =.03$, $\eta^2_p = .09$; $F(2.37,92.36)= 2.65$, $p=.07$, $\eta^2_p = .06$. Post hoc tests (LSD) revealed that children looked at anger and fear expressions longer when they were at 20% intensity compared to 50% and 100%, when sadness expressions were at 100% intensity, children spent significantly less time looking at it than any other intensities and when surprise was at 100% intensity, they spent significantly less time looking at it compared to 20% and 30% intensity.

3.3. Eye Tracking Data

A 2 (age: 5 years, 10 years) x 6 (emotion: anger, disgust, fear, happiness, sadness, surprise) x 4 (intensity: 20%, 30%, 50%, 100%) x 3 (interest area: eyes/brows, mouth, nose) mixed-design ANOVA was computed for proportion of time spent looking at each interest area as a function of the total time spent looking at the stimuli. Results revealed a significant main effect for emotion, $F(3.37,127.92)= 3.90$, $p < .01$, $\eta^2_p= .09$, a significant main effect for intensity, $F(3,114)= 16.58$, $p < .01$, $\eta^2_p = .30$, a significant main effect for interest area, $F(1.48,56.05)= .84.82$, $p < .01$, $\eta^2_p = .69$ but not main effect of age $F(1,38)=.60$, $p = .46$, $\eta^2_p = .02$. The interaction between emotion and age, emotion and interest area and intensity and interest area respectively, were also significant $F(3.37,127.92)= 2.60$, $p < .05$, $\eta^2_p= .06$; $F(10,380)= 11.55$, $p < .015$, $\eta^2_p= .23$; $F(6,228)= 9.06$, $p < .015$, $\eta^2_p= .19$. However, the interactions between intensity and age, interest area and age as well as emotion and intensity respectively, were not significant $F(3,114)=1.32$, $p = .27$, $\eta^2_p = .03$; $F(1.48,56.05)=.34$, $p = .65$, $\eta^2_p = .01$; $F(15,570)=1.25$, $p = .23$, $\eta^2_p = .03$. The triple interaction between intensity, interest area and age as well as between emotion, intensity and interest area were found to be significant $F(6,228)= 2.67$, $p < .05$, $\eta^2_p= .07$; $F(30,1140)= 3.42$, $p < .01$, $\eta^2_p= .08$. However, the interactions between emotion, intensity and age, between emotion, interest area and age, and between emotion, intensity, interest area and age were not significant $F(15,570)=1.21$, $p = .26$, $\eta^2_p = .03$; $F(10,380)=1.38$, $p = .19$, $\eta^2_p = .04$; $F(30,1140)=.68$, $p = .91$, $\eta^2_p = .02$.

For the interaction between interest area, age and intensity, simple main effects were computed for both age groups using a Dunn's correction ($p < .021$) (See Table 4 in Appendix I for means and standard deviations as a function of intensity and age; See Figure 5 in Appendix J for graph). At 20%, 30%, 50% and 100% intensity, respectively, 5 year-old children spent proportionally different amount of times on the interest areas, $F(2,38)= 40.99$, $p < .021$, $\eta^2_p= .68$; $F(1.31,24.92)= 38.71$, $p < .021$, $\eta^2_p= .67$; $F(1.31, 24.99)= 53.03$, $p < .021$, $\eta^2_p= .74$; $F(1.32, 25.06)= 55.94$, $p < .021$, $\eta^2_p= .75$. Post Hoc tests (LSD) revealed that for all intensities, the proportion of time spent looking at the eyes/brows was greater compared to the mouth and the nose. Moreover, results revealed that 5 year-old children spent significantly different proportions of time on the eyes/brows as a function of the intensity $F(3,57)= 21.40$, $p < .021$, $\eta^2_p= .53$. However, the proportion of time on the mouth or the nose for did not differ as a function of the intensity, $F(3,57)= 2.17$, $p = .10$, $\eta^2_p = .10$, $F(3,57)= 1.24$, $p = .30$, $\eta^2_p = .06$. Post Hoc tests (LSD) revealed that the 5-year-old children spent proportionally less time on the eyes/brows when stimuli intensities were 20% or 30% compared to 50% and 100%.

Moreover, for 20%, 30%, 50% and 100%, respectively, 10 year-old children spent proportionally different amount of time looking at the different interest areas, $F(2,38)= 43.15$, $p < .021$, $\eta^2_p= .69$; $F(2,38)= 23.37$, $p < .021$, $\eta^2_p= .55$; $F(1.55, 29.52)= 30.34$, $p < .021$, $\eta^2_p= .62$; $F(2, 38)= 39.47$, $p < .021$, $\eta^2_p= .68$. Post Hoc tests (LSD) revealed that for all intensities, the proportion of time spent looking at the eyes/brows was greater than the proportion of time spent looking at the mouth and nose. Results further revealed that 10 year-old children spent significantly different proportions of time on the eyes/brows as a function of the intensity $F(3,57)= 8.28$, $p < .021$, $\eta^2_p= .30$. However, the proportion of time on the mouth or the nose did not differ as a function of the intensity, $F(3,57)= 1.12$, $p = .35$, $\eta^2_p = .06$, $F(3,57)= 1.62$, $p = .20$, $\eta^2_p = .08$. Post Hoc tests (LSD) revealed that the 10-year-old children spent proportionally more time on the eyes/brows when stimuli intensities were 20% compared to 30%, but significantly less time when intensities were 30% compared to 50% and 100%.

Given the triple interaction between emotion, intensity, and interest area, simple main effects were also computed for each emotion using a Dunn's corrections (p< .021) (See Table 5 in Appendix K for means and standard deviations as a function of interest area and intensity; See Figure 6 in Appendix L for graph).

In regards to disgust emotional facial expressions, results revealed that depending on the intensity, children spent different proportions of time on the eyes/brows and the mouth $F(2.51,97.92)= 8.24$, $p < .021$, $\eta^2_p= .17$; $F(3,117)= 6.39$, $p < .021$, $\eta^2_p= .14$ but not on the nose, $F(2.56,99.87)= 2.28$, $p = .09$, $\eta^2_p= .06$. Post hoc tests (LSD) revealed that children spent proportionally more time looking at the eyes/brows when intensity was 20% compared to 30%, 100% compared to 20% and 30% and 50% compared to 30%. They also spent significantly more time looking at the mouth when intensity of the disgust emotional facial expressions was 20%

and 30% compared to 50% and 100%. Results further revealed that children spent different proportions of time looking at the interest areas of the disgust expressions of 20%, 30%, 50% and 100% intensity respectively, (F(1.64,63.92)= 54.48, $p < .021$, η^2_p= .58; F(2,78)= 24.57, $p < .021$, η^2_p= .39; F(1.40,54.63)= 44.41, $p < .021$, η^2_p= .53; F(1.48,57.57)= 56.11, $p < .021$, η^2_p= .59. Post hoc tests (LSD) revealed that for all intensities, the proportion of time spent looking at the eye/brow area was greater than the proportion of time spent looking at the mouth and nose.

In regards to fear emotional facial expressions, results revealed that that depending on the intensity, children spent different proportions of time on the eyes/brows, F(3, 117)= 7.18, $p < .021$, η^2_p= .16. but not on the mouth or the nose respectively, F(3,117)= 2.09, p = .11, η^2_p = .05, F(3,117)= 1.14, p = .34, η^2_p = .03. Post hoc tests (LSD) revealed that children spent proportionally more time looking at the eyes/brows when intensity was 100% compared to 30% and 50%. Results further revealed that children spent different proportions of time looking at the different interest areas for fear expressions of 20%, 30%, 50% and 100% intensity respectively, F(1.74,68,02)= 76.40, $p < .021$, η^2_p= .66; F(1.73,67.34)= 43.48, $p < .021$, η^2_p= .53; F(1.71,66.51)= 56.66, $p < .021$, η^2_p= .59; F(1.58,61.49)= 88.37, $p < .021$, η^2_p= .69. Post hoc tests (LSD) revealed that for all intensities, the proportion of time spent was greater for the eyes/brows compared to the mouth and nose. Results also revealed that the time spent looking at the mouth for fear expressions of 30%, 50% and 100% intensity was significantly greater compared to the time spent looking at the nose.

In regards to happiness emotional facial expressions, results that depending on the intensity, children spent different proportions of time on the mouth and nose, F(3, 117)= 3.79, $p < .021$, η^2_p= .09; F(2.46, 95.86)= 5.70, $p < .021$, η^2_p= .13. but no on the eyes/brows, F(2.41,94.06)= .68, p =.54, η^2_p = .02. Post hoc tests (LSD) revealed that children spent proportionally more time looking at the mouth, when intensity level of the happiness was 50% compared to 100%, and spent more time looking at the nose when intensity levels of the happy expression was 100% compared to 30% and 50%. Results further revealed that children spent different proportions of time at the interest areas for expressions of 20%, 30%, 50% and 100% intensity respectively, ($F(2,78)= 32.58$, $p < .021$, $\eta^2_p= .46$; $F(2,78)= 36.61$, $p < .021$, $\eta^2_p= .48$; $F(1.61,62.66)= 46.42$, $p < .021$, $\eta^2_p= .54$; $F(2,78)= 32.49$, $p < .021$, $\eta^2_p= .45$. Post hoc tests (LSD) revealed that for all intensities, the proportion of time spent looking at the eyes/brows was greater compared to the time spent looking at the mouth and nose. Results also revealed that the time spent looking at the mouth with happiness expressions of 20%, 30% and 50% intensity was significantly greater compared to the time spent looking at the nose.

In regards to sad emotional facial expressions, results revealed that depending on the intensity, children spent different proportions of time on the eyes/brows $F(3, 117)= 7.17$, $p < .021$, $\eta^2_p=$ .16. but not on the mouth and nose, $F(3,117)= 2.41$, $p = .07$, $\eta^2_p = .06$; $F(2.59,100.84)= 1.03$, $p =$ .38, $\eta^2_p = .03$;. Post hoc tests (LSD) revealed that children spent proportionally more time looking at the eyes/brows, when intensity level of the sadness emotion was 100% compared to 20% and 30%. Results further revealed that children spent different proportions of time looking the different interest areas of sadness expressions at 20%, 30%, 50% and 100% intensity respectively $F(1.55,60.42)= 50.23$, $p < .021$, $\eta^2_p= .56$; $F(1.31,50.97)= 37.68$, $p < .021$, $\eta^2_p= .49$; $F(1.41,54.85)=52.14$, $p < .021$, $\eta^2_p= .57$; $F(1.55,60.29)= 78.34$, $p < .021$, $\eta^2_p= .69$. Post hoc tests (LSD) revealed that for all intensities, the proportion of time spent looking at eyes/brows was significantly greater than the time spent looking at the mouth and nose.

In regards to surprise emotional facial expressions, results revealed that depending on the intensity, children spent different proportions of time on the eyes/brows and mouth d $F(3, 117)=$

5.00, $p < .021$, η^2_p= .11; F(3, 117)= 10.002, $p < .021$, η^2_p= .20 but time spent on the nose did not differ as a function of the intensity of the stimuli, F(3,117)= 1.95, p =.13, η^2_p = .05. Post hoc tests (LSD) revealed that children spent proportionally more time looking at the eyes/brows, when intensity level of the sadness emotion was 20% compared to 30% and they spent more time looking at the mouth when intensity levels were 30%, 50% or 100% compared to 20%. Results further revealed that children spent different proportions of time looking at the different interest areas of surprise expressions at 20%, 30%, 50% and 100% intensity respectively, F(2,78)= 65.48, $p < .021$, η^2_p= .63; F(2,78)= 21.49, $p < .021$, η^2_p= .36; F(2,78)= 46,68, $p < .021$, η^2_p= .55; F(1.72,67.12)= 44.39, $p < .021$, η^2_p= .53. Post hoc tests (LSD) revealed that for all intensities, the proportion of time spent looking at the eyes/brows was greater than the time spent looking at the mouth and nose. Results also revealed that for 30%, 50% and 100% intensity, the mouth was attended to more compared to the nose.

Correlations were also computed for each age group, using accuracy scores for the six basic emotions (anger, disgust, fear, happiness, sadness, surprise) and time spent on each facial area (eye/brow, mouth and nose). For sake of brevity, these will not be presented explicitly here since only one significant correlation was found. In fact, results revealed that the more time 10-year-old children spent on the mouth for fear expressions, the less accurate they were at recognizing that emotion, r = -.67, p < .05 (all other rs < .43, p = .06).

4. Discussion

The current study had three main objectives. First, it evaluated accuracy rates of school-aged children (5 and 10-year-olds) in the recognition of emotional facial expressions of six basic emotions (happiness, sadness, fear, anger, surprise, and disgust). It also looked at determining recognition thresholds for each basic emotion. Finally, it also looked at determining the perceptual attentional processing by examining the role of the eye/brow, mouth, and nose areas during recognition. While Rodger et al. (2015), did map the development of facial expression recognition in children through adulthood, the role of the specific areas of the face during recognition was not examined, nor were recognition thresholds observed. Also, while Gagnon et al. (2014), examined the role of areas of the face during children's emotional facial expression recognition, it is difficult to determine the specific facial region used during recognition as they divided the facial areas as upper, middle, and lower regions. For example, the upper face contains not only the eye/brow area but also the nose and the bottom of the face area contains part of the nose, the cheeks, the mouth, and the chin. In addition, while Gao and Maurer (2010), did examine children's as well as adult's thresholds, they observed discrimination thresholds rather than recognition thresholds and did not observe the roles of facial areas during recognition. Finally, while Ewing et al. (2017) examined emotion recognition as well information processing efficiency in both younger (6-9 years old age) and older (10-13 years of age) children, they only focused on four basic emotions (sadness, happiness, anger, and fear). Thus, none of the previously mentioned studies observed recognition abilities and thresholds as well as the role of key facial features during recognition of the six basic emotional facial expressions in children all within a single study.

4.1. Recognition Accuracy and Eye Tracking Data

In the current study, when observing 5-year-olds accuracy rates, happiness was the most accurately recognized emotion followed by anger for all intensities except at 100%. At 100% intensity, sadness was actually the most accurately recognized emotion followed by happiness. Moreover, in all instances, surprise was the least accurately recognized emotion. When observing 10-year-old accuracy rates, happiness was the most accurately recognized emotion followed by anger for all intensities except at 100%. At 100% intensity, happiness was still the most accurately recognized emotion, but it was rather followed by sadness. In all instances, fear was the least accurately recognized emotion. Only one significant difference occurred between age groups; 10-year-old children were significantly more accurate than 5-year-olds at recognizing surprise, at 100% and 50% intensity.

When looking at eye-tracking data, results revealed that overall both age groups spent a similar amount of time looking at the different emotional facial expressions. Moreover, both 5 and 10-year-old children spent more time looking at the eye/brow area compared to looking at the mouth and nose no matter the intensity and for all emotions, except for anger where no significant differences were observed. For fear, happiness, and surprise expressions, all children (5- and 10-year-olds) also looked at the mouth more than the nose at most intensity levels. The mouth was also looked at longer than the nose at lower intensities compared to higher intensity levels for disgust expressions. Additionally, the nose was looked at longer at 100% intensity compared to 30 and 50% for happy expressions. In order to better illustrate these results, they are discussed as a function of each separate emotion.

4.1.1. Happiness

Previous literature on children recognition abilities shows that happiness can be recognized quite well by the age of 5 (Camras & Allison, 1985; Gao & Maurer, 2008; Gosselin et al., 1995; Tremblay et al., 1987; Vicari et al., 2000; Widen & Russell, 2008). Research has also shown that its recognition is adultlike as early as 5 years old, suggesting that recognition abilities for this emotion are fully developed at that age (Durand, Seigneuric, Robichon & Baudouin, 2007; Gao

& Maurer, 2010). The current study's results for 5-year-old children mostly align with previous literature as it was the most accurately recognized emotion, except at 100% intensity. Nonetheless, it was still among the easiest emotion to recognize being the second most accurately recognized emotion at 100% intensity. As for 10-year-old children, happiness was always the most recognized emotion for all intensity levels, aligning with previous research. There was no significant difference between age groups. With regards to eye tracking, both 5 and 10-year-old children looked at the eye/brow area longer than the mouth or the nose when looking at happiness expressions. However, they also spent more time on the mouth compared to the nose at all intensity levels but 100%. Our study also revealed no relationship between recognition accuracy of happiness and the time spent on the different facial areas. Consequently, when all information is available in the face, children's perceptual-attentional processing of the face is not linked to their recognition of happiness. Since this result was similar for most emotions and for both groups of children, they will be discussed below in relation to the perceptual-attentional limitations hypothesis (Roy-Charland et al., 2015).

4.1.2. Anger

Past research has shown mixed patterns in regards to the recognition of anger. While some studies have reported high recognition even as early as 5 years of age, other studies have found only moderate recognition rates with improvements in the later years (Camras & Allison, 1985; Tremblay et al., 1987; Vicari et al., 2000; Widen & Russell 2003, 2008, 2010, 2013). In the current study, for both 5- and 10-year-old, anger was among the easiest emotion to recognize. However, at 100% intensity, it was the 3rd lowest score, but this was only the case for 5-year-old children. Despite being among the lower scores, it was only slightly less (only 8% separating the four-best recognized at 100%) and not significantly less accurately recognized than other emotions. There was no significant difference between age groups. Thus, our results align with studies that have previously reported high recognition rates. Eye-tracking results revealed that neither 5-year-olds nor 10-year-olds looked at any area significantly longer when looking at anger expressions. Additionally, correlation results revealed no relationship between recognition accuracy and the time spent on the different facial areas, thus children's perceptual-attentional processing of the face is not linked to their recognition of anger.

4.1.3. Sadness

Sadness has also been shown to be recognized quite well by the age of 5 (Camras & Allison, 1985; Gao & Maurer, 2008; Gosselin et al., 1995; Kirouac et al., 1985; Tremblay et al., 1987; Vicari et al., 2000; Widen & Russell, 2008). In fact, it is often reported as being the second easiest emotion to recognize, with variations depending on the intensity of the expression (e.g. Camras & Allison, 1985; De Sonneville et al. 2002; Gao & Maurer 2009,2010). However, research has shown that rates are typically lower for 5 years old compared to older children (Gao & Maurer, 2010; Montirosso, Peverelli, Frigerio, Crespi & Borgatti, 2010) while other studies have shown that children can recognize intense sad expressions as accurately as adults by the age of 5 (Durand et al., 2007; Vicari et al., 2000). Results from the current study found no significant difference between age groups, and that for both 5 and 10-year-old children, while not the second most accurately recognized, sadness was among the most accurately recognized emotions except at 20% intensity. For the most part, these results align with previous studies, as sadness is mainly among the most accurately recognized emotion. Eye-tracking data further revealed that children, both 5 and 10 years of age, spent more time looking at the eyes and brow area compared to that of the mouth and nose. However, no correlation between accuracy and facial area attended was observed. Our study also revealed no relationship between recognition accuracy of sadness and the time spent on the different facial areas. Thus, again, when all information is available in the face, children's perceptual-attentional processing of the face is not linked to their recognition of this emotion.

4.1.4. Disgust

Recognition of disgust has been shown to be typically quite low at the age of 5 (Gao & Maurer, 2008; 2010; Gosselin et al., 1995; Gosselin & Larocque, 2000; Kirouac et al., 1985; Stifter et Fox, 1987; Tremblay et al., 1987; Vicari et al., 2000). Additionally, while it is fairly well recognized by the age of 7 or 8, it continues to improve past the age of 10 (Durand et al., 2007; Gosselin et al., 1995). Results from the current study showed no significant difference between age groups, and that for both 5 and 10-year-old children, recognition for this emotion is quite low, not being accurately recognized above chance levels except at 100% intensity for 10-year-old children. However, even though the level of recognition is above chance level at peak intensity for this age group, it still remains the second hardest emotion to recognize. Our results align with past research showing that disgust is not an easy emotion to recognize and that while improvements are seen by the age of 10, it still remains difficult to recognize compared to other emotions. In regards to eye-tracking data, results showed that both 5 and 10-year-old children spent more time looking at the eye/brow area compared to the mouth area. However, they spent more time on the mouth area at lower intensities compared to higher intensity levels. Once again, no relationship between accuracy and facial area attended was observed so, children's perceptual-attentional processing of the face is not linked to their recognition of disgust.

4.1.5. Fear and surprise

Literature has shown that recognition of fear is typically quite low at the age of 5 (Gao & Maurer, 2008; 2010; Gosselin et al., 1995; Gosselin & Larocque, 2000; Kirouac & Doré 1987; Kirouac, Doré & Gosselin, 1985; Stifter et Fox, 1987; Tremblay et al., 1987; Vicari et al., 2000) and reaches adult-like abilities by 10 years of age (Durand et al., 2007). As for surprise, literature has been mixed, with some studies showing high recognition rates even at the age of 5 years and others only moderate recognition (Camras & Allison, 1985; Tremblay et al., 1987; Vicari et al., 2000). The current study results revealed that surprise was the hardest emotion for 5-year-old children to recognize at all intensity levels and fear was, in most instances, among the hardest emotion to recognize. Interestingly, at 100% intensity, fear was actually moderately recognized and not among the hardest. However, it was not recognized significantly better than any of the other emotions. For 10-year-old children surprise was among the hardest emotions to recognize at lower intensity levels and moderately recognized at 50% and 100% intensity while fear was always the hardest emotion to recognize. While no significant difference was observed between age groups for recognition of fear, results revealed that 10-year-olds were significantly better at recognizing surprise at higher intensities compared to 5-year-olds. Eye-tracking data revealed that for both fear and surprise, 5 and 10-year-old children spent more time looking at the eye/brow area compared to that of the mouth and nose. Our results also showed that the mouth was looked at longer than the nose at most intensity levels. Furthermore, results showed that attending to different facial areas had no impact on the recognition accuracy of surprise but that the less time spent looking at the mouth when processing fear expressiond, the better the recognition. However, this is only true for 10-year-old children; no difference was observed with 5-year-old children.

In summary, the above results illustrate that emotion recognition gradually develops throughout childhood and that between the ages of 5 and 10, variations in accuracy levels as well as perceptual-attentional processing can be observed. In fact, happiness, anger as well as sadness were among the easiest emotions to recognize, while surprise, fear, and disgust were the most difficult for both 5 and 10-year-old children. However, differences did occur as a function of the intensities as well as between age groups, highlighting the developmental aspect of emotion recognition. For instance, while sadness was among the easiest to recognize, it was not when information was less available (lower intensity) for both age groups. Moreover, 10-year-old children was the only age group able to accurately recognize disgust above chance level, but only at peak intensity. Finally, while fear and surprise were both the hardest to recognize, surprise was particularly harder for 5-year-old children, whereas 10-year-old children's results revealed a similar pattern to those of adults, with fear being the hardest emotion to recognize. Similarly, eye tracking results revealed that both 5 years old and 10-year-old children looked at the eye/brow area longer than the mouth and the nose, for all emotions except anger, where no difference was observed. In all instances, but fear, no relationship was found between the time spent on different facial areas and recognition accuracy. The only significant relationship found was that for 10-year-old children only, the more time they spent looking at the mouth area, the less accurate they were at recognizing fear. Thus, for all emotions, except fear, the full face is important for accurate recognition to occur. For fear expressions results show a relationship between children's perceptual-attentional processing of the face and recognition.

A potential explanation that can be proposed for the developmental differences is the perceptual-attentional limitations hypothesis (Roy-Charland et al., 2015). As previously mentioned, each emotion has its own combination of muscle activations (Ekman & Friesen, 1971,1978; Izard, 1971). This theory proposes that emotion recognition may be impacted by the visual similarities between facial expressions and by the development of the visual system of the decoder. The more similar the expressions, the more difficult it is to visually perceive and detect differences between them. Thus, when facial expressions share muscle activations, they are more easily confused between one another which may lead to inaccurate recognition. Also, the more developed the perceptual abilities, the more easily an individual can discriminate subtle differences. The most common confusions reported have been between fear and surprise, especially in children between the ages of 5 and 10 (Bullock and Russell, 1985) and between disgust and anger (Bullock & Russell 1985; Gosselin et al., 1995). According to the perceptual-attentional limitations hypothesis, the less attention given to the relevant cues (muscle activations) the more negatively recognition is impacted. In the current study, surprise was found the be the most difficult emotion to recognize for 5-year-old children while fear was the most difficult to recognize for 10-year-old children. According to the above hypothesis, one might suggest that these emotions were the hardest to recognize given their visual similarities. In fact, one may argue, that when recognizing these emotions, children gave less attention to the relevant cues, thus leading to inaccurate recognitions. However, eye-tracking data revealed only one significant correlation between facial area attended and accuracy. Specifically, the less time spent on the mouth area, the more accurate their recognition of fear, and this was only true for 10-year-old children. Visual system development differences between 5-year-olds and 10-year-olds, as also proposed by the perceptual-attentional limitations hypothesis, may better explain recognition differences. However, it can only help to explain recognition of surprise as our results revealed that surprise was the only emotion for which a significant difference in accuracy was observed between age groups. Particularly, 10-year-old children were more accurate at recognizing surprise compared to 5-year-old children at 100% and 50% intensity. Thus, the current study's results reveal that children's recognition accuracy of emotional facial expressions can only be partially explained by the attentional perceptual limitations hypothesis.

An alternative explanation for these variations is the broad-to-differentiated hypothesis (Widen & Russell, 2003). This hypothesis postulates that children understand emotions and emotional facial expressions gradually and over the course of development. In fact, younger children understand emotions in terms of valence (pleasure and displeasure) as well as in terms of level of arousal rather than discrete categories (e.g. fear, disgust) (Widen, 2013). As children acquire more knowledge on emotions, their initially broad emotion categories narrow down to more specific concepts and they begin to add more categories to their repertoire (Widen & Russell, 2003; Widen, 2013). More specifically, younger children have a limited set of categories including happiness, sadness, and anger, and only acquire categories for fear, surprise, and disgust with age. Also, even when these categories are acquired, children use fear, surprise, and disgust less often to label emotions as they are still relatively less accessible (Widen & Russell, 2003). The current study's result mostly aligns with this hypothesis, as happiness, sadness, and anger were the easiest emotions to recognize, while disgust, surprise, and fear were the hardest. Given that surprise was the hardest emotion to recognize for 5-year-old children and not for 10-year-old children, it could suggest that surprise is conceptually more difficult to recognize compared to fear. Adult studies have shown that fear is the hardest emotion to recognize and recognition of that emotion, even in adulthood, is quite low (Beaudry et al., 2014; Ekman & Friesen, 1971, 1986; Gosselin & Kirouac, 1995, Tracy & Robins, 2008). Our results reveal that somewhere between 5 and 10 years old, children conceptually acquire a better knowledge of surprise and that by 10 years of age, recognition abilities align more consistently with those of adults. However, again this hypothesis may not be fully satisfactory. In fact, while generally speaking our results align with this hypothesis, a few inconsistencies occurred. For instance, at peak intensity, for 5-year-old children, fear was actually among the easiest emotions to recognize, yet conceptually fear is not yet acquired at that age. Moreover, for 10-year-old children, at 50% intensity, sadness was among the hardest emotions to recognize, while surprise was among the easiest, yet at a lower intensity level (30%), this was not the case. While recognition levels for sadness and surprise at 50% intensity was not significantly different, it still suggests that intensity level and conceptualization of emotions are not necessarily the only explanation for developmental differences in recognition accuracy of emotions among school aged children.

4.2. Recognition Thresholds

In real life, emotions are rarely expressed at 100%, so understanding recognition of emotional facial expressions at different intensities is an important question. In the current study, 5-year-olds recognized happiness above chance level at 20 % intensity, anger was accurately recognized at 30% intensity, sadness at 50%, and fear at 100%. Interestingly, disgust and surprise seem to be the hardest emotions for 5-year-olds to recognize since, even at 100% intensity, children struggled to accurately recognize this emotion and were not better than chance level. For 10-year-old children, happiness was accurately recognized above chance level at 20% intensity, anger at 30% intensity, sadness and surprise at 50%, and fear, as well as disgust, can be recognized above chance levels at 100% intensity.

While Gao and Maurer (2010) did examine discrimination thresholds, recognition and discrimination thresholds are inherently different. In fact, in Gao and Maurer's study discrimination thresholds were obtained by categorizing participants' responses as neutral or non-neutral whereas in the current study, recognition thresholds were established by determined at which intensity level children can accurately recognize the emotion above chance level. To the best of our knowledge, only one other study investigated children's recognition thresholds which is a study by Ewing et al. (2017). In their study, they adapted the Bubbles reverse-correlation paradigm by adding noise to the facial expression and presented variations of information at different spatial frequency bandwidths to their participants; adults, and two groups of children (6-9-year-olds and 10-13-year-olds). In order to better illustrate the current study's results, the thresholds of each emotion will be discussed individually. Comparisons of the two studies mentioned above will also be provided throughout the discussion.

4.2.1. Happiness

Our study reveals that children both 5 and 10 years of age can accurately recognize happiness above chance level at 20% intensity. This indicates that both 5- and 10-year-olds recognition threshold of happiness is somewhere between 0 and 20%. In Gao and Maurer's (2010) study, they found a mean discrimination threshold of 25% for both age groups. In their study, they presented participants with pictures of happiness, surprise, and fearful expressions along with neutral expressions, while our study consisted of a recognition task where only one facial expression was shown at a time. Our study reveals that children, even as young as 5 years old, can accurately recognize subtle happy expressions when this emotion is presented alone. Gao and Maurer's (2010) study, shows that when happiness is presented alongside other emotions and neutral expressions, children have more difficulty. Nonetheless, the discrimination threshold still remains low. Thus, while both thresholds differ, our study aligns with that of Gao and

Maurer (2010) as both studies show that children require little information for both accurate discrimination and recognition to occur. In Ewing et al.'s (2017) study, they found that children aged 6-9 required more information than children aged 10-13 in order to recognize happiness. Moreover, compared to anger, fear, and sadness, it required significantly less information. Our study also aligns with that of Ewing et al. (2017) as compared to other emotions, children were able to recognize happiness with less information compared to other emotions.

4.2.2. Anger

The current study found that both 5- and 10-year-olds have a recognition threshold somewhere between 20 and 30% for anger given that they can both accurately recognize it above chance level at 30% intensity. Thus, anger is recognized quite well by all children even at lower intensity levels. Gao and Maurer's study found that both 5 and 10-year-old children can discriminate anger around 26% intensity. While both thresholds differ, our study aligns with that of Gao and Maurer (2010) as both studies show that children require little information for both accurate discrimination and recognition to occur. In Ewing et al.'s (2017) study, they found that all participants required more information to identify anger compared to other emotions. However, no difference was found between the younger (6-9-year-olds) and the older children (10-13-year-olds). Our results thus differ from that of Ewing et al. (2017), as their study shows anger was not among the easiest to recognize. This indicates that when presented alone, children are able to recognize anger fairly well, however, when presented alongside other emotions, as well as a neutral expression, they have more difficulty.

4.2.3. Sadness

Both 5- and 10-years old children in the current study, were able to accurately recognize sadness above chance level at 50% intensity and thus have a recognition threshold somewhere between 20% and 50%. Gao and Maurer (2010) found that 5-year-old children could discriminate sadness around 40% whereas 10-year-old children only required 35%. They suggested that young children have more difficulty identifying more subtle expressions of sadness and are more likely to misidentify it. Our study reveals a different pattern as both age groups were unable to accurately recognize sadness above chance level at intensity levels below 50%. However, our study did not measure abilities with intensities between 30% and 50% so, it possible that children could have been able to accurately recognize this emotion at a lower intensity than 50% but higher than 30%, have it been tested. Age differences may have also been observed. Another possibility is that while children can discriminate that the expression is not neutral at 40% intensity and 35% intensity (5 and 10-year-olds respectively), they may only be able to accurately recognize sadness at 50% intensity. This potential explanation aligns with Ewing et al.'s (2017) study, as they did not find any significant difference with regards to information required for sadness to be recognized by either of their two children age groups.

4.2.4. Disgust

Results from the current study with regards to disgust reveal that 5-year-olds are unable to accurately recognize this emotion above chance level even at peak intensity, whereas 10-year-old children are able to recognize it above chance level at 100% intensity. Their recognition threshold is thus somewhere between 50% and 100%. Gao and Maurer's (2010) study, found that 5 and 10-year-old children can discriminate disgust from a neutral expression as early as 27% intensity. Based on our results and those of Gao and Maurer (2010), while children are able to discriminate disgust from a neutral expression when only 27% of the emotion is expressed, our study reveals that accurate recognition of this emotion is still quite difficult, especially for 5-year-old children.

4.2.5. Fear and surprise

Both 5 and 10-year-old children in the current study were able to accurately recognize fear above chance level at peak intensity, while for surprise, only 10-year-old children were able to recognize it accurately above chance level at 50% intensity. This indicates that 5-year-old children have a recognition threshold for fear somewhere between 50% and 100% but are not able to accurately recognize surprise above chance level even at 100% intensity. As for 10-year-old children, they have a recognition threshold that sits somewhere between 50% and 100% for fear, and somewhere between 30% and 50% for surprise. Gao and Maurer (2010) found discrimination thresholds for fear to be 30% for 5-year-olds and 26% for 10-year-olds, while for surprise, thresholds were 35% and 25% for 5 and 10-year-olds respectively. These results are interesting, as they suggest that surprise is actually harder than fear for 5-year-olds to discriminate. This aligns with our study, as we found that surprise was also more difficult to recognize compared to fear, but only for 5-year-old children. Additionally, while Gao and Maurer (2010) found that 5-year-old children can discriminate surprise from neutral expressions at 35% intensity, our study shows that they are unable to accurately recognize it above chance level even at 100% intensity. A similar pattern occurred for fear for both 5 and 10-year-old children. In fact, while they can discriminate that an emotion is present at an intensity as low as 30% and 26% (5- and 10-year-olds respectively), our study shows that they can only accurately recognize it above chance level somewhere between 50% and 100% intensity. These results also align with Ewing et al.'s (2017) study as they found no difference with regards to information required to recognize fear expressions between their two children age groups.

In summary, our results reveal some similarities and differences in recognition thresholds found in Ewing et al.'s (2017) as well as results found in Gao and Maurer (2010). In the current study, happiness, followed by anger required the least information for accurate recognition to occur for both 5 and 10-year-old children whereas disgust was among the emotions requiring the most information. For 5-year-old children, surprise was also among the emotions requiring the most information, whereas for 10-year-old children it was fear. Sadness however, required moderate information for accurate recognition to occur for both age groups. In Ewing et al. (2017) study, they also found that happiness was the emotion that required the least information for accurate recognition to occur, however, fear nor surprise required the most information, but rather anger. Additionally, in all instances, except for happiness and anger, discrimination thresholds as found by Gao and Maurer (2010), were lower than recognition thresholds found within this current study. In other words, children may be able to draw out the visual cues necessary to discriminate an emotional facial expression from a neutral expression, but being able to recognize and associate it with a specific emotion appears to be more difficult.

Again, two alternate explanations may be proposed; conceptual and perceptual. On one hand, the broad to differentiated hypothesis proposed by Widen and Russell (2003) and on the other hand, perceptual.

On a conceptual level, children acquire the categories of happiness, sadness, and anger earlier and only acquire categories for fear, surprise, and disgust with age and development (Widen & Russell, 2003). Recognition thresholds for most emotions found within this study, maintain a similar pattern. In fact, happiness and anger were among the easier emotions to recognize for both age groups, thus requiring less intensity for accurate recognition to occur, while disgust, was among the hardest, requiring more intensity for accurate recognition to occur, again for both age groups. However, differences occurred with regards to surprise, fear, and sadness. For 5-year-old children, sadness was also among the easiest emotion to recognize and fear as well as surprise among the hardest, which also follows the expected pattern with regards to information required. For 10-year-old children, fear was the hardest emotion to recognize, requiring more information and thus also following the expected conceptual pattern. However, surprise and sadness for 10-year-old children neither followed or went against the expected pattern as both required moderate information for accurate recognition to occur.

On a perceptual level, differences may be associated with the development of the visual system. In fact, the various brain structures involved in the visual system have been shown to develop throughout childhood (Bezrukikh & Terebova, 2009). As children age and develop, their visual processing becomes more precise and sensitive and the easier children can distinguish subtle differences. In other words, the more their visual system is matured, the better their perceptual abilities, and the less information required for them to be able to accurately recognize an emotion. In the current study, both 5 and 10-year-old children had similar recognition thresholds for happiness, anger, sadness, and fear. However, their thresholds differed for surprise and disgust. While 10-year-olds were able to recognize these emotions above chance level at 50% intensity (surprise) or 100% intensity (disgust), 5-year-old children were unable to accurately recognize these emotions even at peak intensity. This difference may very well be associated with developmental differences in their perceptual abilities. Somewhere between the ages of 5 and 10, children's visual system matures to a point where they can perceptually distinguish that disgust and surprise are the emotions being expressed. However, it is also possible that younger children have the perceptual abilities to distinguish subtle visual cues, but rather struggle to associate with a conceptual category, thus impeding their recognition threshold. A combination of both conceptual and perceptual hypotheses better explains the current study's results.

5. Conclusion

The current study's goals were to map the development of emotional facial expression recognition and thresholds of the six basic emotions by comparing results of 5-year-olds to those of 10-year-olds all while tracking their eye movements to determine the role of the eye/brow, mouth, and nose area during recognition.

Past studies reveal a general consensus that children recognize happiness, sadness and anger quite well, while fear, surprise, and disgust take a bit more time for accurate recognition to occur (Camras & Allison, 1985; Kirouac et al., 1985; Gosselin et al., 1995; Boyatzis, Chazan & Ting,1993). Results from the current study are mostly consistent with previous literature given that happiness was the easiest emotion to recognize and had the lowest recognition threshold, followed by anger then sadness, for both 5 and 10-year-old children. Similarly, the hardest emotions to recognize were surprise for 5-year-old children and fear for 10-year-olds. For both age groups, disgust was the second hardest emotion to recognize. However, our results also suggest emotion recognition in children is much more complex.

In fact, while 10-year-old children were able to accurately recognize fear and disgust above chance level at peak intensity, despite being the most difficult emotions for them to recognize, 5-year-old children were unable to recognize surprise and disgust above chance level even at peak intensity. Additionally, 10-year-olds were found to be significantly more accurate at recognizing surprise compared to 5-year-old children. This was true at higher intensity levels. These interesting patterns highlight the developmental aspect of emotion recognition.

According to the perceptual-attentional limitations hypothesis (Roy-Charland et al., 2015), emotion recognition may be impacted by the visual similarities between facial expressions and by the development of the visual system of the decoder. The greater the similarities between emotional facial expressions, more specifically between the muscle activations they produce, the more difficult they are to distinguish from one another and thus to recognize. Also, the more developed the perceptual abilities, the more easily an individual can discriminate subtle differences (Roy-Charland et al., 2015). However, our study revealed no relationship between the time spent on a facial area and accuracy rates except for fear where the more time spent on the mouth, the less accurate the recognition. This was also only true for 10-year-old children. Consequently, in most instances, when all information is available in the face, children's perceptual-attentional processing of the face is not linked to their recognition of emotions. Additionally, the immaturity of the visual system can also only explain results partially, as results for recognition accuracy of surprise was the only emotion for which a significant difference was observed between age groups. Thus, the attentional perceptual limitations hypothesis is not sufficient to explain the results from the current study.

A second assumption proposed was the broad-to-differentiated hypothesis (Widen & Russell, 2003), which postulates that children understand emotions and emotional facial expressions gradually and over the course of development. As children acquire more knowledge on emotions, their initially broad emotion categories narrow down to more specific concepts and they begin to add more categories to their repertoire (Widen & Russell, 2003; Widen, 2013). That being said, children acquire the categories of happiness, sadness, and anger earlier and only acquire categories for fear, surprise, and disgust with age and development. Given that surprise was the hardest emotion to recognize for 5-year-old children and not for 10-year-olds, it could suggest that surprise is conceptually more difficult for younger children compared to fear. Thus, our results reveal that somewhere between 5 and 10 years old, children conceptually acquire a better knowledge of surprise and that by 10 years of age, recognition abilities align more consistently with those of adults. However, again this hypothesis is not fully satisfactory. For instance, at peak intensity, for 5-year-old children, fear was actually among the easiest emotions to recognize, yet conceptually fear is not yet acquired at that age. These results not only highlight the complexity of emotion recognition in developing children, but also suggests that theoretical background that can be used to explain adult recognition abilities, is not sufficient to explain the variances observed in children's recognition abilities. Our study rather reveals that other factors play a role in recognition patterns. For instance, children development in a more general sense does not occur at the same rate for all children. In fact, some children reach developmental milestones such as walking or talking at an earlier age than others. In that same manner, individual differences may be influencing variances observed within this study. Past literature has also shown that factors such as social environment and exposure can also influence recognition abilities. In fact, social environment provides a place for training and learning about the emotional world (Ferretti & Papaleo, 2018). As every child's exposure differs, variances within the current study may also be the result of various social environments and differences in learning of the emotional world.

While the current study offers insight the development of school-aged children emotional facial expression recognition and recognition thresholds as well as the importance, or lack of importance of facial areas during recognition, this study is not without its limitations. For instance, while children were asked to identify which emotion was being expressed from the six basic emotions (happiness, sadness, anger, disgust, surprise, and fear), they were never explicitly told that they may suggest another emotion not present within the list provided. While they were also never told they weren't allowed to suggest another emotion, not having explicitly advised them they may, may have led to some sentiment of forced choice within participants.

Additionally, further research should also seek to explore a broader range of intensity levels in order to better decipher exact recognition thresholds. In fact, the current study only looked at four different intensities (20%,30%,50% and 100%). When obtaining a recognition threshold somewhere between 20% and 30%, the gap is much smaller than between 50% and 100%. When an emotion can be accurately recognized above chance level at 100% intensity, for example with fear in this study, it leaves a very wide gap for which many questions can arise. For example, are children able to recognize it above chance level at an intensity between 50% and 100%? Perhaps at 75% intensity? Would this only be true for older children or both age groups? Thus, future studies should seek to examine recognition thresholds using intensities with more consistent increments such as 5% increments as was done in Gao and Maurer's (2010) study.

Another possible methodological limitation resides in the task prior to the emotion recognition task. As a way to provide children with context of what are emotions, six stories were read to the children. Each story provided children with an example of each basic emotion relevant to this study. While children were asked to identify the emotion being felt by the character for each story and when unable to do so they were provided with the correct answer, it may have been more beneficial to use a more relatable task. For instance, in Gagnon et al.'s (2014) study, they asked participants to recall a personal memory in which they have felt a given emotion. Asking children to provide a personal story may be a better method then stories about a fictional character. Moreover, providing children with synonyms to the different emotions, for instance allowing them to use the word “gross” instead of disgust should also be considered to avoid the possibility that children, especially younger children, may have wrongfully chosen another emotion label due to lack of comprehension of the labels provided.

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Appendices

Appendix A

Figure 1: Examples of emotional stimuli (*From left to right:* 20%, 30%, 50%, 100% intensity).

Appendix B

Stories read to children

Joie : Hier c'était la fête de Joannie. Tous ses amis sont venus pour fêter sa fête et lui ont tous donner des cadeaux. Comment penses-tu Joannie se sent?

Colère : Joannie attend en ligne. Un garçon coupe devant elle et prend sa place dans la ligne. Il n'a même pas demandé. Joannie le pousse hors de la ligne et le chicane. Comment penses-tu Joannie se sent?

Peur : Joannie marchait sur le trottoir. Un gros chien commence à courir envers elle en grondant. Joannie crie et s'enfui aussi vite qu'elle peut. Comment penses-tu Joannie se sent?

Surprise : Joannie est arrivé à la maison et remarque que les cheveux de sa mère sont roses. Ceci n'était jamais arrivé auparavant. Joannie ne peut pas arrêter de regarder. Elle essaie de comprendre pourquoi les cheveux de sa mère sont rose. Comment penses-tu Joannie se sent?

Dégoût : Joannie a pris une bouchée d'une pomme, mais la pomme était pourrie à l'intérieur. Le goût de la pomme était horrible et Joannie a crashé sa bouché de pomme par terre. Elle ne voulait pas le manger. Comment penses-tu Joannie se sent?

Tristesse : Joannie a hâte à sa fête. Elle pense que sa grand-mère lui donnerait une balle multicolore pour sa fête. Elle a toujours voulu une balle multicolore. Mais, quand Joannie ouvre le cadeau, elle trouve des bas et non une balle. Comment penses-tu Joannie se sent?

Appendix C

Table 1

Means and Standard Deviations of Facial Recognition Accuracy for 5-year-old Children as a Function of the Intensity

	Level of Intensity			
Emotion	20%	30%	50%	100%
Anger	.20 (.25)	.55 (.39)	.70 (.34)	.85 (.24)
Disgust	.18 (.24)	.33 (.37)	.43 (.44)	.48 (.47)
Fear	.18 (.29)	.23 (.30)	.45 (.36)	.88 (.28)
Happiness	.78 (.30)	.80 (.30)	.85 (.29)	.90 (.27)
Sadness	.18 (.29)	.38 (.28)	.63 (.36)	.93 (.24)
Surprise	.08 (.18)	.18 (.29)	.30 (.38)	.33 (.44)

Appendix D

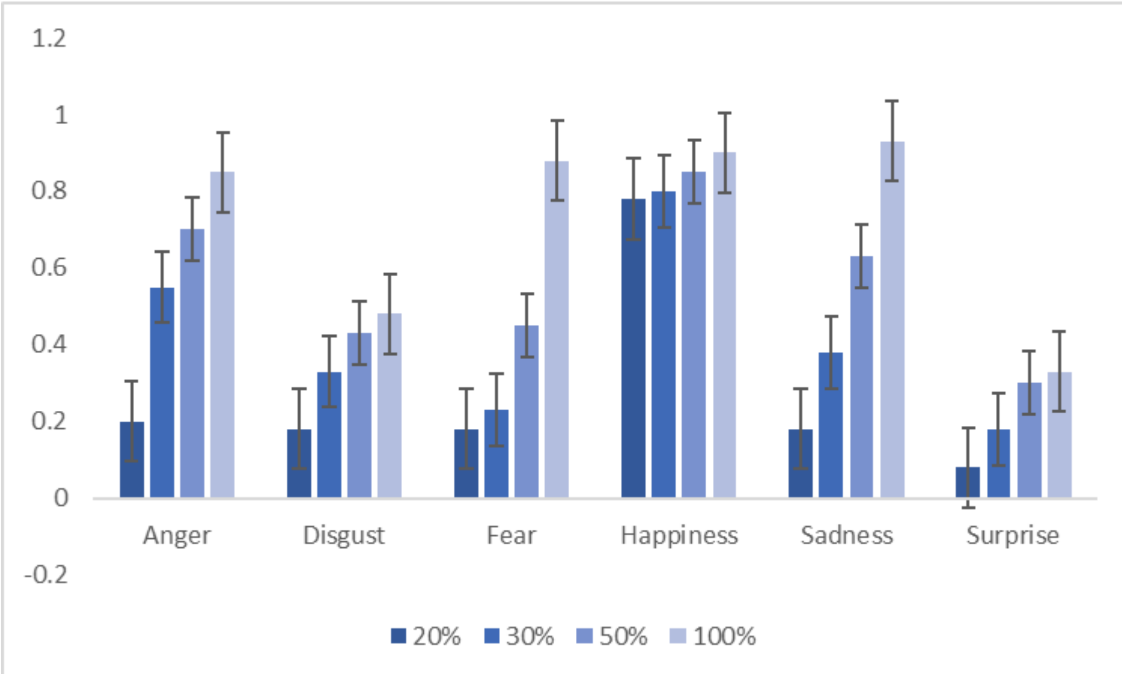


Figure 2. Five-year olds accuracy rates for each emotion as a function of the intensity

Appendix E

Table 2

Means and Standard Deviations of Facial Recognition Accuracy for 10-year-old Children as a Function of Intensity

	Level of Intensity			
Emotion	20%	30%	50%	100%
Anger	.43 (.29)	.63 (.22)	.88 (.22)	.93 (.18)
Disgust	.33 (.34)	.33 (.34)	.45 (.43)	.73 (.34)
Fear	.00 (.00)	.18 (.34)	.40 (.42)	.58 (.37)
Happiness	.78 (.26)	.88 (.22)	.93 (.18)	1.00 (.00)
Sadness	.23 (.34)	.43 (.41)	.65 (.37)	.95 (.15)
Surprise	.25 (.38)	.33 (.41)	.68 (.34)	.85 (.29)

Appendix F

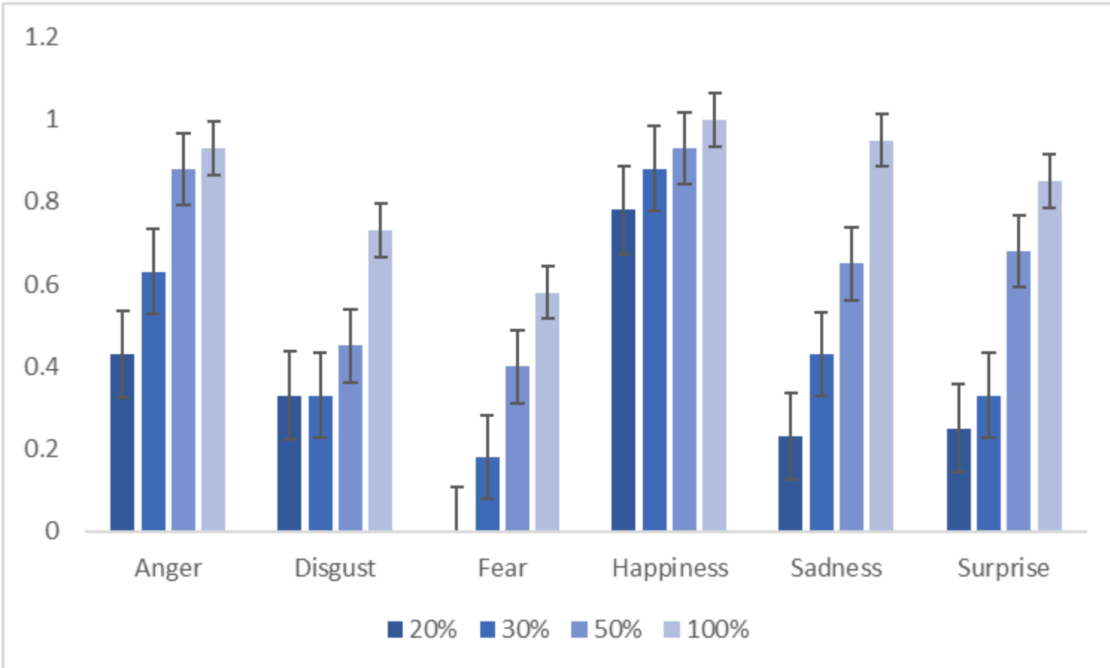


Figure 3. Ten-year olds accuracy rates for each emotion as a function of the intensity

Appendix G

Table 3

Means and Standard Deviations of Trial Dwell Time on Facial Expressions for all Children as a Function of Intensity

	Level of Intensity			
Emotion	20%	30%	50%	100%
Anger	6045.56 (6053.60)	4030.08 (2348.78)	3279.69 (2067.62)	3446.30 (2831.21)
Disgust	4450.80 (2908.20)	3079.36 (1425.21)	3125.78 (2234.02)	3631.53 (2777.98)
Fear	4981.15 (3045.33)	4576.53 (3603.90)	3509.94 (2148.10)	3191.71 (2314.31)
Happiness	4142.26 (2711.98)	3445.20 (3113.56)	2870.98 (2366.62)	3053.88 (2750.52)
Sadness	5229.21 (3437.84)	5023.51 (3997.22)	5516.95 (6500.53)	2561.93 (1184.82)
Surprise	5947.15 (4915.54)	6665.46 (4516.04)	5526.05 (5938.54)	3708.61 (2390.42)

Appendix H

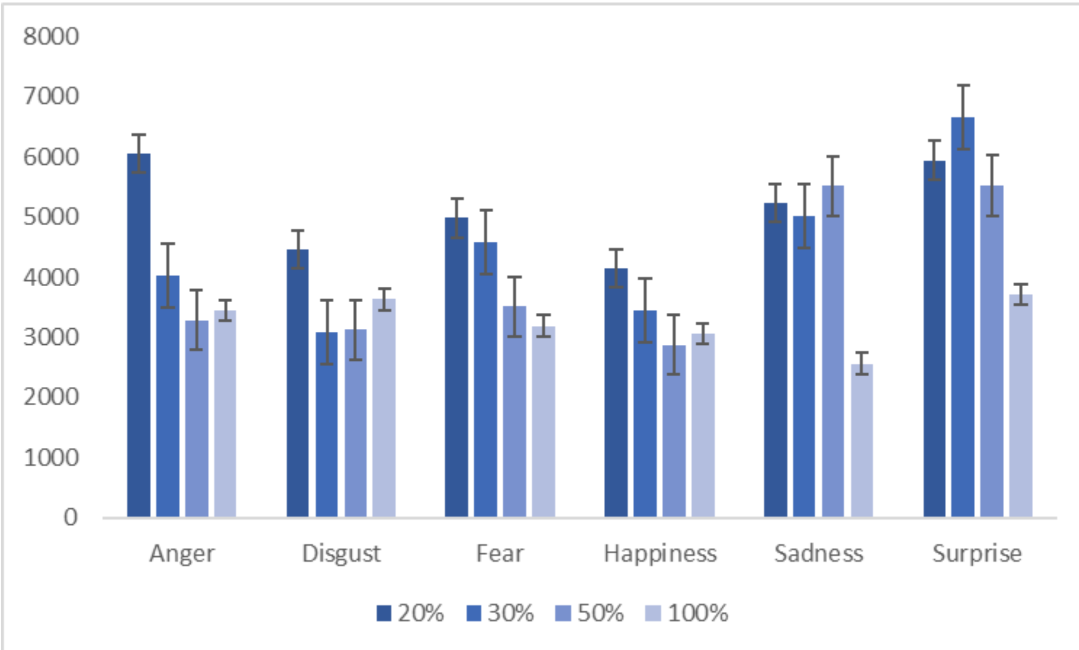


Figure 4. Time spent on each emotional facial expression as a function of intensity for all children

Appendix I

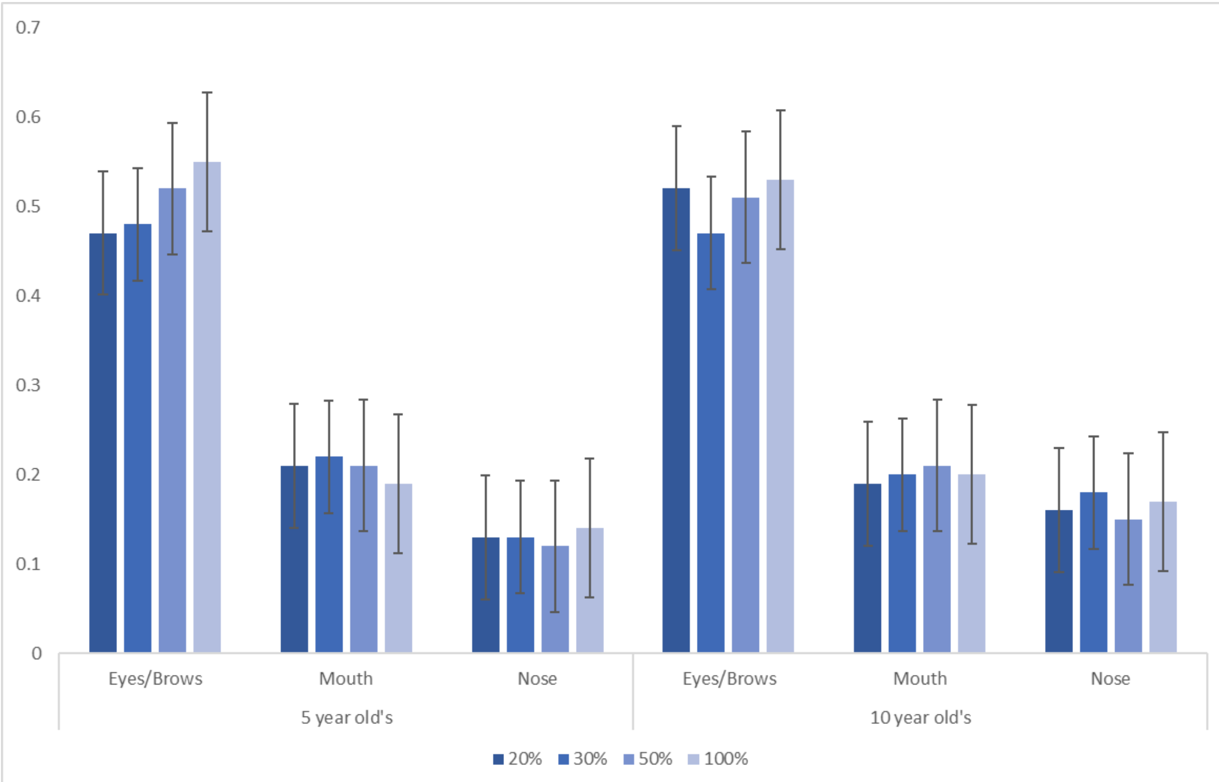
Table 4

Means and Standard Deviations of Proportions of Time Spent on Eyes/Brows, Mouth and Nose Areas as a Function of Intensity and age

	Level of Intensity			
Variable	20%	30%	50%	100%
Eyes/brows				
5-year-olds	.47 (.12)	.48 (.14)	.52 (.14)	.55 (.15)
10-year-olds	.52 (.16)	.47 (.17)	.51 (.18)	.53 (.17)
Mouth				
5-year-olds	.21 (.11)	.22 (.11)	.21 (.11)	.19 (.10)
10-year-olds	.19 (.10)	.20 (.11)	.21 (.11)	.20 (.09)
Nose				
5-year-olds	.13 (.07)	.13 (.06)	.12 (.06)	.14 (.07)
10-year-olds	.16 (.08)	.18 (.10)	.15 (.09)	.17 (.09)

Appendix J

Figure 5. Proportion of time spent on facial areas as a function of the intensity and age



Appendix K

Table 5

Means and Standard Deviations of Proportions of Time Spent on Emotional Facial Expressions for all Children as a Function of Interest Area and Intensity

	Level of Intensity			
Variable	20%	30%	50%	100%
Anger				
Eyes/brows	.50(.18)	.56 (.19)	.58 (.21)	.56 (.21)
Mouth	.17 (.10)	.15 (.13)	.18 (.14)	.17 (.13)
Nose	.13 (.12)	.15 (.12)	.12 (.08)	.13 (.11)
Disgust				
Eyes/brows	.50 (.17)	.45 (.19)	.54 (.22)	.56 (.21)
Mouth	.21 (.13)	.20 (.13)	.15 (.10)	.15 (.11)
Nose	.16 (.10)	.21 (.13)	.21 (.16)	.20 (.13)
Fear				
Eyes/brows	.52 (.17)	.46 (.17)	.52 (.19)	.57 (.17)
Mouth	.18 (.12)	.21 (.15)	.23 (.14)	.20 (.15)
Nose	.13 (.09)	.13 (.10)	.11 (.11)	.11 (.09)
Happiness				
Eyes/brows	.46 (.17)	.47 (.18)	.48 (.18)	.49 (.20)
Mouth	.27 (.16)	.26 (.16)	.28 (.14)	.21 (.12)
Nose	.14 (.11)	.13 (.11)	.12 (.11)	.19 (.15)
Sadness				
Eyes/brows	.48 (.18)	.48 (.21)	.52 (.21)	.59 (.20)
Mouth	.21 (.13)	.18 (.11)	.18 (.14)	.16 (.11)
Nose	.15 (.08)	.17 (.12)	.14 (.09)	.16 (.11)
Surprise				
Eyes/brows	.51 (.16)	.42 (.19)	.47 (.18)	.49 (.18)
Mouth	.17 (.13)	.26 (.14)	.25 (.14)	.26 (.15)
Nose	.17 (.12)	.15 (.15)	.12 (.11)	.13 (.11)

Appendix L

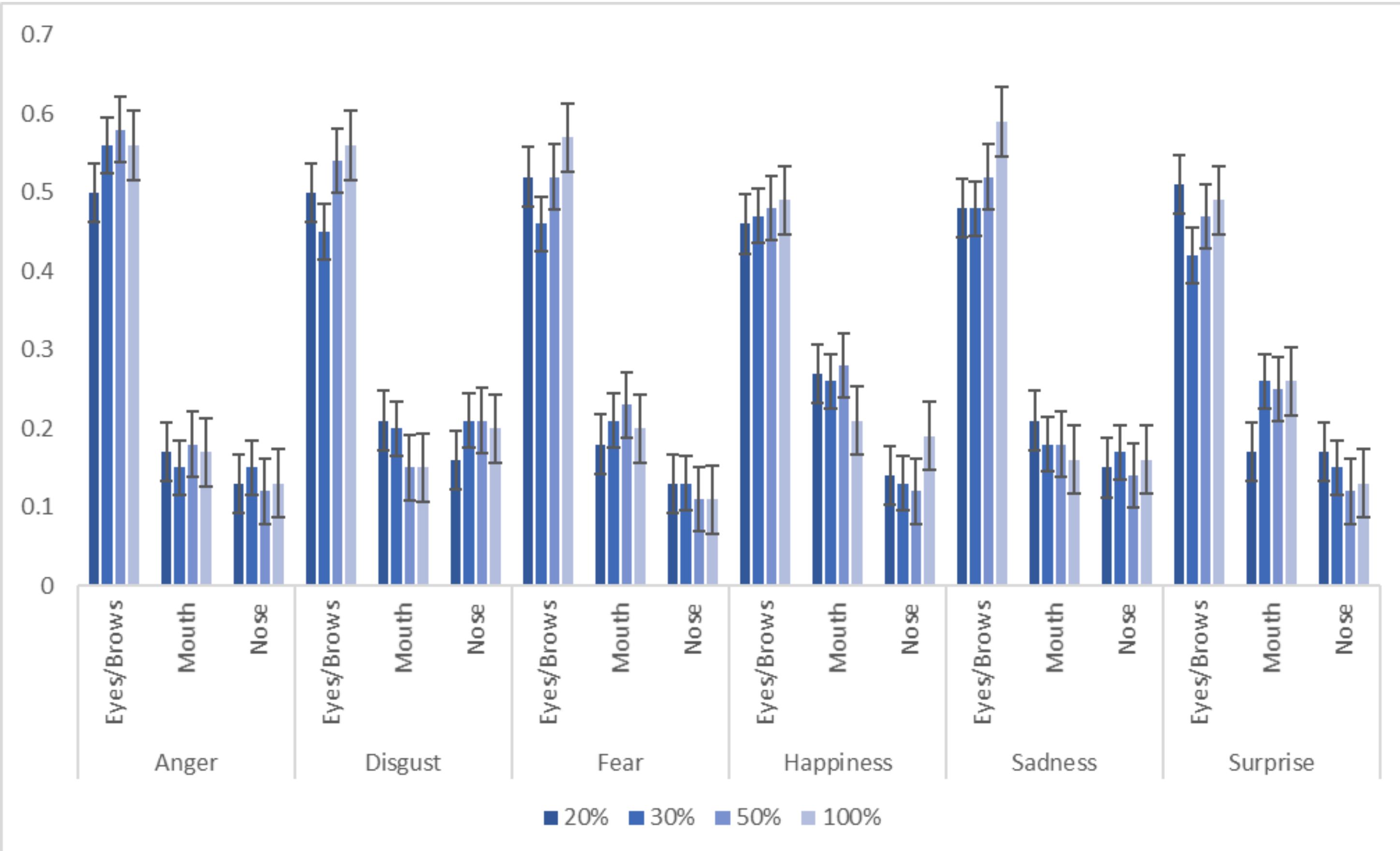


Figure 6. Proportion of time spent on facial areas as a function of the intensity and emotion for all children