THE CONFUSION OF FEAR/SURPRISE AND DISGUST/ANGER IN CHILDREN: NEW EVIDENCE FROM EYE MOVEMENT TECHNOLOGY

by

Cheryl Young

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Arts (MA) in Psychology

School of Graduate Studies
Laurentian University
Sudbury, Ontario, Canada

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

THESIS DEFENCE COMMITTEE/COMITÉ DE SOUTENANCE DE THÈSE

Laurentian Université/Université Laurentienne
School of Graduate Studies/École des études supérieures

Title of Thesis Titre de la thèse	THE CONFUSION OF FEAR/SURPRISE AND DISGUST/ANGER IN CHILDREN: NEW EVIDENCE FROM EYE MOVEMENT TECHNOLOGY		
Name of Candidate Nom du candidat	Young, Cheryl		
Degree Diplôme	Master of Arts		
Department/Program Département/Programme	Psychology	Date of Defence Date de la soutenance	April 11, 2014

APPROVED/APPROUVÉ

Thesis Examiners/Examinateurs de thèse:

Dr. Annie Roy-Charland
(Co-supervisor/Co-directrice de thèse)

Dr. Mélanie Perron
(Co-supervisor/Co-directrice de thèse)

Dr. Cynthia Whissell
(Committee member/Membre du comité)

Dr. Linda A. Camras
(External Examiner/Examinatrice externe)

Approved for the School of Graduate Studies
Approuvé pour l'École des études supérieures
Dr. David Lesbarrères
M. David Lesbarrères
Director, School of Graduate Studies
Directeur, École des études supérieures

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Abstract

Research shows that children often confuse facial expressions of fear with surprise and disgust with anger. According to the perceptual-attentional limitations hypothesis, facial expressions are confused because they share *action units* (Camras, 1980; Wiggers, 1982). Experiment 1 tested this hypothesis for the confusion between fear and surprise and Experiment 2 for the confusion between disgust and anger. Eye movements were monitored in both experiments. In experiment 1, the results showed that children were more accurate when two distinctive *action* units were presented than when the brow lowerer was the only distinctive *action unit* differentiating between fear and surprise. Furthermore, the results showed that participants spent more time fixating on the mouth than the eyebrows. They made more saccades when the only distinctive cue was in the eyebrows. In experiment 2, participants identified the emotion as anger when the mouth was open, and disgust when the mouth was closed, spending more time on the mouth when the mouth was open. These findings suggest that facial expressions are confused, not only because of the amount of visual similarities they share, but also because children do not allocate their attention to facial regions equally; they tend to focus on the mouth.

Keywords: Perceptual-attentional limitations hypothesis; Age Differences; Disgust; Fear; Eye Movements

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Acknowledgements

This thesis would not have been possible without the help of my thesis advisors, Dr. Annie Roy-Charland and Dr Melanie Perron. I would like to extend my sincerest thanks to them both for their continual support and guidance throughout this process. Thank you both for your endless patience and enthusiasm about research. I would also like to thank Dr. Cynthia Whissell for your help and contributions to my Master's thesis. I would like to extend my thanks to the members of the Cognitive Health Research Lab, and especially Jessica Boulard, for their help with this project and for making my Master's degree an amazing experience. Finally, I would like to thank my friends and loved ones for their support and encouragement throughout my education.

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Table of Contents

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

List of Tables

Name ***Page***

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

List of Figures

Name ***Page***

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

List of Appendices

Name ***Page***

The Confusion of Fear/Surprise and Anger/Disgust in Children: Evidence from Eye Movement Technology

Since antiquity, philosophers, and later psychologists, have been interested in understanding emotion (Solomon, 2008). Despite the extensive amount of research that has been generated, there is no accepted definition of emotion (Sander & Scherer, 2009; Bear, Connors, & Paradiso, 2001; Rolls, 2007; Solomon, 2008; Izard, 2010). However, most researchers tend to agree that emotional experiences involve several components (Ekman, 1992; Izard, 2009; Tooby & Cosmides, 2008). Commonly accepted components of emotion include the subjective feeling of the emotion, the physiological response (i.e. changes in autonomic activity), behavioural manifestations (i.e. facial expressions, voice qualities, hand movements), action tendencies, and cognitive appraisals of events in the environment (Sander & Scherer, 2009). Izard (2010) interviewed prominent researchers in the area of emotion in regard to their definition of emotion. Even among emotion researchers, there was a significant amount of variability in how emotion was defined. However, there were some components that were identified as being important by many researchers, such common neural systems, emotion response systems, the subjective feeling of the emotion, expressive behaviours (i.e. facial expressions, tone of voice, etc.), specific appraisals that precede the emotion, and a higher-level cognitive interpretation of the emotion (Izard, 2010). In line with this multicomponnential view of emotion, Sander and Scherer (2009) defined emotion as a set of episodic variations that occur in response to significant events and situations, involving several parts of the organism.

Many researchers have argued for the existence of a set of basic emotions (Ekman, 1992, 1999; Izard, 2009). These theorists suggest that there are a series of discrete emotions, which are fundamentally different from one another and are adaptive along psycho-evolutionary terms

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

(Ekman, 1992, 1999; Izard, 2009; Izard, 2011). Ekman (1992a, 1999) defines basic emotions as those which have universally recognized facial expressions and have evolved over the course of human history because they provide adaptive advantages in dealing with fundamental life tasks. Izard (2011) focuses more on the interaction between emotion and cognition, however he, still agrees that some emotions may be considered basic in that they are not accompanied by higher-level cognition and occur in response to stimuli that are evolutionarily important. Ekman (1999) proposed a list of sixteen basic emotions. In a review article, Matsumoto and colleagues (2008) have argued that only anger, disgust, fear, happiness, sadness, and surprise meet all of the criteria to be considered as basic emotions. There are, of course, other emotional states (i.e. anxiety, jealousy, etc.). However, these emotional states are not considered to be basic because they involve complex cognition. In addition, the basic emotions, unlike other emotional states, have evolutionary value in the sense that they are rapid responses to the environment that promote survival. The functions of more cognitively complex emotions do not have such a clear evolutionary purpose (Izard, 2009).

Facial Expressions of Emotion

This study will focus on one component of emotion: facial expressions. Ekman (1992a, 1999) proposed that each of the basic emotions is associated with a distinctive set of facial expressions. Researchers have found both support and criticisms of this claim. The first line of research supporting the validity of the facial expressions of the basic emotions has come from studies of spontaneously expressed emotion. In a recent review, Matsumoto and colleagues (2008) noted that there are at least twenty-five published studies demonstrating that spontaneous facial expressions of emotion match the proposed facial expressions of emotion. Thirdly, research from cross-cultural studies has revealed that these facial expressions are similarly understood in the Western, non-Western, and isolated cultures (Ekman & Friesen, 1971; Ekman et al., 1987). A meta-analysis of 162 studies of facial expression recognition reported that facial expressions were accurately recognized at a level significantly higher than chance across cultures (Elfenbein & Nalini, 2002). Fourthly, research has also suggested that the presence of these facial expressions corresponds with self-reports of subjective emotion (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2012). Finally, several studies have pointed to the conclusion that these facial expressions are recognized relatively early in development (Camras & Allison, 1985; Widen & Russell, 2003; Gosselin, 2005).

Other research has suggested that, to some degree, facial expressions may be recognized automatically. The first set of findings supporting this conclusion comes from research on responses to subliminally presented facial expressions of emotions (Dimberg, Thunberg, & Elmehed, 2000; Winkelman, Berridge, & Wilbarger, 2005; Whalen et al. 1998; Tracy & Robins, 2008). For example, Winkelman, Berridge, and Wilbarger (2005) found that participants' behaviour could be affected by the valence of a subliminally presented facial expression. This finding suggests that, not only did participants perceive the subliminally-presented facial expression, but they were able to extract positive and negative meaning from the facial expression, without cognitive awareness. The second set of research comes from studies indicating that facial expressions can be accurately recognized very rapidly, within as little as six hundred milliseconds (Tracy & Robins, 2008; Sweeny, Suzuki, Grabowecky, & Paller, 2013). Furthermore, research suggests that facial expressions can be accurately recognized when participants' attention is divided with another task (Tracy & Robins, 2008).

That being said, several contemporary researchers have questioned the link between specific facial expressions and emotions. Nelson and Russell (2013) have argued that many cross-cultural studies have over-estimated the amount of agreement between cultures in regard to the emotion conveyed by facial expressions. In combining the results of numerous cross-cultural studies, they found that cultural and language-based factors did influence facial expression recognition. Furthermore, these researchers argued that methodological factors, such as the use of posed facial expressions, forced-choice tasks, and within-subject designs have exaggerated the amount of agreement between cultures. Furthermore, a review article by Reisenzein, Studtmann, and Horstmann (2013) argued that the facial expressions predicted by Ekman and Friesen (1978) do not often occur, either in partial or complete form, in laboratory studies that have induced emotions. Finally, another review article by Fernandez-Dols and Crivelli (2013) suggested that there is a low correlation between the predicted facial expressions and emotions in naturalistic studies.

In light of this research, it would appear that facial expressions are highly complex social behaviour, that have multiple causes and meanings (Fernandez-Dols & Crivelli, 2013). More research needs to be done, examining the links between emotion and facial expressions. That being said, there is still a large body of research, summarized above, providing support for the link between the facial expressions predicted by Ekman and Friesen (1978) and the basic emotions. In addition, facial expression recognition remains an interesting and useful research area. The ability to correctly recognize facial expressions has been linked with empathy (Besel & Yuille, 2010; Carr & Lutjemeier, 2005), social skills (Besel & Yuille, 2010), and prosocial behaviour (Marsh, Kozak, & Ambady, 2007).

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

In line with research linking facial expression recognition to positive outcomes, Ekman (1992a; 1999) has argued that facial expressions are universally recognized with relatively high accuracy because, in evolutionary terms, the ability to produce and recognize facial expressions is an evolved behaviour that provides humans and primates with an adaptive advantage. More specifically, the production and recognition of facial expressions facilitates interpersonal interactions. Other researchers have shared this psychoevolutionary explanation of facial expressions. Erickson and Schulkin (2003) noted that facial expressions are a means of communicating important information about the environment. Other researchers have pointed to the importance of facial expressions in communicating emotional information and understanding emotions in others (Campos, Frankel, & Camras, 2004).

The purpose of this thesis will be to explore the tendency of children to confuse certain facial expressions. Two studies were conducted in order to test the ability of the perceptual-attentional limitations hypothesis to explain the confusion between fear and surprise and between disgust and anger by children. Firstly, this paper will discuss research on facial expression recognition in adults. Secondly, this paper will address the development of the ability to recognize facial expressions throughout childhood and the types of errors children tend to make in facial expression recognition tasks. After outlining the typical errors that are observed, this paper will provide an outline of the hypotheses that have been generated to explain these errors.

Facial Expression Recognition in Adults

Research has shown that adults have high levels of accuracy in recognizing facial expressions of emotion (Kohler et al., 2004; Wiggers, 1982; Tracy & Robbins, 2008; Gosselin & Kirouac, 1995; Calvo & Lundqvist, 2008; Ekman & Friesen, 1986; Matsumoto & Sung Hwang, 2011; Palermo & Coltheart, 2004). However, accuracy has been found to differ across emotions.

More specifically, several studies have demonstrated that the facial expressions of fear and disgust are recognized less accurately than those of the other basic emotions (Kohler et al., 2004; Wiggers, 1982; Gosselin & Kirouac, 1995; Calvo & Lundqvist, 2008; Ekman & Friesen, 1986; Matsumoto & Sung Hwang, 2011; Palermo & Coltheart, 2004; Widen & Russell, 2010b). For example, in Gosselin and Kirouac (1995), participants were asked to identify the emotion or emotions conveyed by a series of facial expressions. Accuracy was above 70% for most facial expressions, with the exception of fear and disgust. For fear, the facial expression with the highest accuracy was only recognized 52% of the time. For disgust, only two of six facial expressions were recognized more than 67% of the time. Furthermore, research has suggested that participants require more time to accurately recognize the facial expression of fear than of other emotions (Tracy & Robins, 2008; Calvo & Lundqvist, 2008; Milders, Sahraie, & Logan, 2008).

The finding that the facial expressions of fear and disgust are recognized less accurately than the facial expressions of the other basic emotions has been replicated using numerous methodologies. In some studies, participants were shown photographs of facial expressions and asked to indicate whether or not the facial expression conveyed a target emotion (Kohler et al., 2004). In studies using a forced choice task, participants have been asked to determine the emotion conveyed by a set of facial expressions, from a list of choices (Wiggers, 1982; Gosselin & Kirouac, 1995; Ekman & Friesen, 1986; Matsumoto & Sung Hwang, 2011; Palermo & Colheart, 2004). Other research has looked at accuracy rates when facial expressions are presented without the participant's conscious awareness, using backwards masking tasks (Calvo & Lundqvist, 2008). Although most research has been done using still photographs of facial expressions, research using videotapes of facial expressions has also led to the same conclusion

(Wiggers, 1982). Each line of study suggests that, although adults typically perform well when recognizing emotional facial expressions, they struggle most with identifying fear and disgust.

When adults mislabel fear and disgust, research has shown that their errors are not random. Research shows that fear is often confused with surprise and that disgust is commonly confused with anger (Wiggers, 1982; Gosselin & Kirouac, 1995; Calvo & Lundqvist, 2008; Palermo & Coltheart, 2004; Matsumoto & Sung Hwang, 2011). It is important to note that these confusions are mostly unidirectional. In other words, fear tends to be confused with surprise, but surprise is not commonly confused with fear. Only a few studies have shown that surprise is confused with fear (Wiggers, 1982; Calvo & Lundqvist, 2008; Palermo & Coltheart, 2008). Other studies have failed to find such a confusion (Gosselin & Kirouac, 1995). Furthermore, the frequency of the confusion of fear with surprise appears to be higher than the confusion of surprise with fear. For example, in Palermo and Coltheart (2004), surprise was confused with fear 5% of the time. In contrast, fear was confused with surprise 31% of the time. Similar results have been found by other researchers (Calvo & Lundqvist, 2008).

Similarly, only a handful of studies have found that anger is confused with disgust (Wiggers, 1982; Calvo & Lundqvist, 2008), whereas others have not demonstrated that anger is confused with disgust (Gosselin & Kirouac, 1995; Matsumoto & Sung Hwang, 2011). Again, disgust seems to be confused with anger more often than anger is confused with disgust (Calvo & Lundqvist, 2008; Palermo & Coltheart, 2004). However, the magnitude of the difference is smaller than is seen with the confusion between fear and surprise. For example, in Palermo and Coltheart, disgust was confused with anger 11.8% of the time, whereas anger was confused with disgust 4.8% of the time.

In sum, the available research suggests that although adults are generally very accurate in recognizing facial expressions of emotion, they struggle most with identifying fear and disgust. When errors are made, they do not appear to be random. The facial expression of fear tends to be confused with surprise, whereas that of disgust is often confused with anger.

Development of Emotional Understanding in Children

Emotions play a significant role in human life from infancy onwards (Abe & Izard, 1999). Before children are able to speak, they rely on emotional displays to communicate their needs to their caregivers. Furthermore, emotional interactions between the parent and infant are thought to be crucial to the development of a secure attachment bond. Later, during the toddler years, children exhibit more anger as they develop greater autonomy and a sense of an identity separate from the parent. For older children, the emotions of guilt and shame appear to have an important role in shaping appropriate social behaviour (Abe & Izard, 1999). Given the importance of emotions throughout early development, it is not surprising that researchers have studied both the development of emotional understanding and facial expression recognition throughout childhood.

What is known about infants' understanding of emotion is based on research about how infants react to facial expressions of emotion. Within as early as the first few hours of life, infants begin to show a visual preference for the human face in comparison with other stimuli (Nelson, 2001). Furthermore, naturalistic studies of parent-infant interactions have suggested that, by as early as two to six months, infants begin to imitate the facial expressions of their parents and other significant family members (Pratikaki, Germanakis, & Kokkinaki, 2011).

Unfortunately, little is known about infants' understanding of emotions and their link to facial expressions (Gosselin, 2005). However, habituation studies have permitted researchers to make inferences about infants' ability to discriminate between different facial expressions (Bornstein & Arterberry, 2003; Schwarzer & Jovanovic, 2010; Walker-Andrews, Krogh-Jespersen, Mayhew, & Coffield, 2011). In these types of tasks, researchers repeatedly expose infants to images of the same facial expression, while measuring visual fixations. With repeated exposure to the same stimulus, fixations decrease. If researchers suddenly show a different facial expression and visual fixations increase, this would indicate that the infant perceived the two facial expressions as being different. Using these types of tasks, researchers have revealed that infants less than a year old can distinguish between fear and happiness (Bornstein & Arterberry, 2003), positive and negative emotions (Schwarzer & Jovanovic, 2010), and between happiness and sadness (Walker-Andrews et al., 2011). Habituation tasks allow researchers to infer whether or not infants perceive a difference between facial expressions, not to test their understanding of the emotion conveyed by facial expressions.

More information about infants' understanding of emotion and facial cues can be discerned from social referencing studies (Moses, Baldwin, Rosicky, & Tidball, 2001; Phillips, Wellman, & Spelke, 2002; Campos, 1980-1981). In these studies, researchers look to determine whether infants' behaviour will be influenced by the facial cues of adults. These studies allow researchers to infer that infants are aware of emotional states in others, and of the link between an emotional state and an object or situation (Abe & Izard, 1999). For example, Campos (1980-1981) examined whether infants' reactions to a visual cliff experiment would be affected by facial cues of the infants' mother. The results showed that infants were more likely to cross onto the deeper side of the visual cliff when the mother expressed joy than when the mother expressed fear or anger. In a more recent study, Moses, Baldwin, Rosicky, and Tidball (2001) demonstrated that by eleven months, infants' reactions to an ambiguous stimulus (i.e. a novel toy) can be affected by the facial reactions of adults in the child's environment. When the adult exhibited a positive reaction to the toy, the child was more likely to approach the toy than when the adult displayed a negative reaction. This study demonstrated that, not only were the infants attuned to the facial expressions of adults in their environment, but also that they were able to differentiate between positive and negative facial expressions, and that they understood the link between the facial expression and the object.

Information regarding children's conceptual understanding of emotion becomes easier to access by age two when the capacity for language begins to develop (Gosselin, 2005). Naturalistic studies of children's speech have shown that by age two, children begin to speak about emotions experienced by themselves and others. Their conceptualizations of emotion were sophisticated enough to allow them to reference emotions experienced in the past, currently experienced emotions, and emotions that might occur in the future. Furthermore, children have been shown to spontaneously speak about a variety of positive and negative emotions (Harris, 2008).

Other research has looked at children's understanding of specific emotions (Camras & Allison, 1985; Russell & Widen, 2002; Widen & Russell, 2002; Widen & Russell, 2003). Emotional understanding is thought to involve several components. Children need to link an emotional label with typical causes of the emotion, an understanding that the appraisal of an event will impact the subsequent emotional reaction, the subjective feeling associated with the emotion, the facial expressions commonly elicited during that emotion, bodily changes, and typical behaviour that occurs while experiencing a given emotion (i.e. crying while sad) (Widen & Russell, 2013). Widen and Russell (2013) have suggested that each of these components emerge at different points during development.

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Several studies have compared children's understanding of the causes and behavioural consequences of emotions with their recognition of facial expressions (Camras & Allison, 1985; Widen & Russell, 2002; Russell & Widen, 2002; Widen & Russell, 2004; Widen, 2013). These studies have shown that between the ages of three to five, children are more accurate in recognizing or providing causes and behavioural consequences of emotions than recognizing facial expressions. Understanding of the causes of emotions increases between the ages three to seven (Camras & Allison, 1985; Russell & Widen, 2002; Widen & Russell, 2004). In addition, there appears to be a sequence to which emotions are understood first. Some studies have shown that preschool children understand the causes of happiness and sadness better than other emotions (Camras & Allison, 1985; Widen & Russell, 2002; Widen & Russell, 2004). Furthermore, children seem to develop an understanding of the causes of fear and disgust more slowly than the other emotions (Camras & Allison, 1985; Widen & Russell, 2002; Widen & Russell, 2004).

The ability to recognize emotional facial expressions begins to develop between the ages two and three (Camras & Allison, 1985; Widen & Russell, 2003; Bullock & Russell, 1985; Camras, 1980). However, as previously mentioned, facial expression recognition tends to lag behind understanding of the causes and behavioural consequences of an emotion (Camras & Allison, 1985; Russell & Widen, 2002; Widen & Russell, 2002; Widen & Russell, 2004; Widen, 2013). As was the case with understanding of the causes of emotions, there also appears to be a pattern in which facial expressions are recognized earlier and later in development. Research suggests that by preschool, children are able to accurately recognize the facial expressions of happiness, surprise, anger, and sadness with accuracy levels greater than eighty percent. During the preschool years, the facial expressions for fear and disgust are correctly recognized 61% and

64% of the time respectively (Camras & Allison, 1985). Between the ages of two and eight however, the accuracy rates for all facial expressions show an increase (Camras & Allison, 1985; Bullock & Russell, 1985; Gosselin, 1995).

Evidence indicates that children's accuracy rates in tasks assessing emotional expression recognition vary according to the demands of the task (Gosselin, 2005; Markham & Adams, 1992). When the task is simple, children can accurately recognize basic facial expressions at the age of two years old. Tasks that tend to be easier for young children include those where children view pairs of facial expressions and are asked to identify a target expression or where children listen to emotional narratives and are asked to identify which facial expression, from a set of choices, best expresses how the character in the story would be feeling. A third option that typically results in higher accuracy with young children is to present a photograph of a facial expression and to ask the child to identify the emotion expressed in the photograph from a set of choices (Gosselin, 2005). Free-labeling tasks, where the child is presented with a photograph of a facial expression and asked to provide the emotional label without choices is more difficult, typically resulting in lower accuracy results (Markham & Adams, 1992).

As with adults, accuracy varies across emotions. Children too tend to be less accurate in recognizing the facial expressions of fear (Gosselin, 1995; Widen & Russell, 2010a; Szekely et al., 2011; Widen & Russell, 2003) and disgust (Gosselin, 1995; Widen & Russell, 2008; Widen & Russell, 2010a; Widen & Russell, 2003; Widen & Russell, 2013) than other emotions. In Widen and Russell (2010), children were asked to indicate the emotions conveyed by a set of facial expressions. Accuracy for sadness, anger, and happiness was above 65%. For fear and disgust, accuracy rates were 36.9% and 9.4% respectively. In a recent review of the research on children's recognition of disgust from facial expressions, Widen and Russell (2013) noted that before age eight, only a small percentage of children are able to spontaneously label a facial expression as conveying disgust. For nine year olds, only approximately 50% seem to be able to do so.

The errors made by children in these sorts of tasks are not random. They confuse specific emotions with one another. Research has shown that children aged two through ten also confuse the facial expressions of fear with surprise (Gagnon et al. 2010; Gosselin & Simard, 1999; Gosselin, 1995). Studies have also shown that children between the ages of three and ten confuse disgust with anger (Gagnon et al., 2010; Widen & Russell, 2008; Widen & Russell, 2010a; Widen & Russell, 2013). Indeed, Widen and Russell (2013) suggested that between the ages three to eight, the majority of children label disgust as anger. These results have been found using a variety of different methodologies. In some studies, children are simultaneously presented with two images of facial expressions and are asked to choose the image that conveys a target emotion (Gagnon et al., 2010; Gosselin & Simard, 1999). In another type of task, children listen to short stories describing situations that would elicit specific emotions and are asked to choose the facial expression that would match the emotion experienced by the character in the story (Gosselin, 1995). Other research has used free labeling tasks, where children are shown images of facial expressions and asked to identify the emotion conveyed by the person in the photograph (Widen & Russell, 2008; Widen & Russell, 2010a).

Taken together, the above-mentioned research suggests that children's ability to accurately recognize facial expressions improves between the ages of two and eight (Camras & Allison, 1985; Bullock & Russell, 1985; Gosselin, 1995). Happiness, sadness, surprise, and anger are identified with reasonable levels of accuracy by the age two or three, whereas fear and disgust are more difficult to recognize, even in older children (Camras & Allison, 1985). Studies of the errors made when children mislabel the fear facial expressions indicate that they often confuse the fear facial expression with surprise (Gosselin, 1995; Bullock & Russell, 1985). When the disgust facial expressions are mislabeled, the most common error seems to be in confusing disgust with anger (Bullock & Russell, 1985; Widen & Russell, 2008; Widen & Russell, 2010a; Widen & Russell, 2010b).

The finding that certain facial expressions tend to be confused with one another appears difficult to reconcile with psycho-evolutionary theories of emotion (Ekman, 1992, 1999; Erickson & Schulkin, 2003; Campos, Frankel, & Camras, 2004). If the ability to produce facial expressions and recognize emotions in others provides an evolutionary advantage, it would be expected that the facial expressions of all basic emotions would be recognized with a high degree of accuracy. Experiencing and recognizing disgust in others is believed to be crucial to avoiding illness and disease (Oaten, Stevenson, & Case, 2009). Similarly, being able to quickly recognize fear in others is thought to be linked to the ability to detect the presence of predators, and therefore increase likelihood of survival (Ohman, 2009). Given that the recognition of these specific emotions in others is thought to be evolutionarily advantageous, it seems counterintuitive that these facial expressions would have lower rates of recognition than other emotions. With that in mind, the next question that needs to be addressed is why these specific facial expressions tend to be confused.

Explanations for the Confusion of Emotional Facial Expressions

There are several possible hypotheses that have been proposed explaining why certain facial expressions tend to be confused during childhood. There are two possibilities relating to children’s conceptual understanding of emotion. Widen and Russell (2013) have proposed that disgust may be confused because during early childhood, children’s emotional scripts for disgust and anger have yet to differentiate. According to this theory, children initially understand emotions in very broad categories (i.e. pleasant versus unpleasant). Throughout childhood, these categories become further differentiated, until children develop the discrete categories of emotions seen in adults. Adult-like categories of emotion are not thought to emerge until the teenage years (Widen, 2013). According to Widen and Russell (2013), the confusion between disgust and anger peaks at age six, at which point children may not have acquired separate categories for disgust and anger. Another potential explanation could be that children lack a sufficiently sophisticated conceptual understanding of fear and disgust, and therefore they tend to mislabel their associated facial expressions. However, neither of these theories appears to be completely satisfactory given that adults also confuse fear with surprise (Gosselin, 1995; Bullock & Russell, 1985) and disgust with anger (Bullock & Russell, 1985; Widen & Russell, 2008; Widen & Russell, 2010b). Assuming that adults have a reasonable conceptual understanding of the emotions studied, it would seem that a conceptual explanation is not alone sufficient to explain these confusions.

A third hypothesis that has been proposed is that the confusion between facial expressions occurs because of limitations in the ability of the visual perception system to detect a difference between these facial expressions (Camras, 1980, Wiggers, 1982). This hypothesis will be the focus of this thesis. The visual perception system is not fully developed when a child is born (Bezrukikh, Morozova, & Terebova, 2009; Semenov, Chernova, & Bondarko, 2000). The visual perception system involves several brain structures, which are thought to mature at different rates throughout childhood (Bezrukikh & Terebova, 2009). As children develop, their visual processing becomes more precise and sensitive. For example, visual acuity has been found to increase throughout childhood, with children not achieving adult-like visual acuity until age seven (Semenov, Chernova, & Bondarko, 2000). Other research has shown that most significant maturation of the structures involved in the visual system occurs between the ages five to seven (Bezrukikh & Terebova, 2009).

Recognizing facial expressions requires the processing of a significant amount of visual information. The human face is capable of producing a wide range of complex facial expressions. Ekman (1992a) has proposed that each of the basic emotions is conveyed by a series of facial expressions, also referred to as prototypes. These facial expressions are composed of specific combinations of *action units*. An *action unit* refers to the movement of a muscle or set of muscles that together form the various prototypes of the basic emotions (Ekman & Friesen, 1978). Ekman and Friesen (1978) have identified 44 such action units in the human face. The way specific *action units* combine to create different facial expressions has been implicated in why certain expressions are confused.

Both Camras (1980) and Wiggers (1982) have noted that the facial expressions that tend to be confused share *action units*. For example, fear and surprise both involve the activation of the inner brow raiser, the outer brow raiser, and the upper lid raiser (Gosselin & Simard, 1999). The nose wrinkle that is seen in disgust is also visually similar to the lowered brows that are seen in anger (Camras, 1980). These authors have proposed that facial expressions are confused because they share visual similarities (Camras, 19980; Wiggers, 1982). They have suggested that individuals come to inaccurate conclusions because they are fooled by the visual similarity between certain facial expressions, notably fear and surprise as well as disgust and anger. In order for individuals to correctly recognize these facial expressions, they would need to perceive the distinctive features associated with each facial expression without being fooled by the features that are common to both.

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

The perceptual-attentional limitations hypothesis fits with Gibson's differentiation theory of perception. According to Gibson's theory, perception involves a process of differentiating the features of a stimulus (Gibson, 1955). This theory has important implications for understanding the development of visual perception in children (Gibson, 1987). According to the theory, infants take an active role in directing their attention to specific features of the stimuli in their visual environment. At first, attention is focused on moving stimuli in the environment because infants' acuity for static stimuli is poor. As acuity increases, so does attention to static features of the environment. Perceptual development involves recognizing the constant features of a stimulus as well as detecting features that differentiate between stimuli (Gibson, 1987). Applying this theory to facial expression recognition would suggest that children need to learn the features that consistently characterize the facial expressions of a given emotion, as well as the features that enable one to distinguish between facial expressions. In the case of fear and disgust, the sharing of muscle movements between facial expressions may hamper that process.

The objective of the current study was to test the perceptual-attentional limitations hypothesis as an explanation for the confusion between fear and surprise, and between anger and disgust, in a child sample. The study was composed of two experiments. The first tested the confusion between fear and surprise, and the second the confusion between disgust and anger. These confusions were tested in two separate studies because two different methodologies needed to be employed. As will be discussed in more detail later, fear and surprise can share a core set of *action units*, and differ by the addition of one or two distinctive *action units* in fear. As such, it was possible to manipulate the level of visual similarity between fear and surprise and examine corresponding changes in accuracy. Anger and disgust differ from one another in a more complex manner. Anger and disgust share some *action units.* However, there are other *action units* that are specific to anger, and some that are specific to disgust. As such, it was not possible to manipulate the level of visual similarity between anger and disgust as was done with fear and surprise. Instead, participants viewed each of the prototypes of disgust and anger described by Ekman and Friesen (1978).

Experiment 1

The purpose of experiment one was to examine the perceptual-attentional limitations hypothesis as a possible explanation for the confusion between the facial expressions of fear and surprise in children. To date, two previous studies have tested the ability of the perceptual-attentonal limitations hypothesis to account for the confusion between fear and surprise. The first study to do so was Gosselin and Simard (1999). In this study, children between the ages of five to six and nine to ten were presented with pairs of facial expressions, one depicting fear and the other depicting surprise. During each trial, the experimenter named an emotion, either fear or surprise, and the child was asked to indicate which photograph expressed the emotion that had been named. The experimenters tested the perceptual-attentional limitations hypothesis by manipulating the level of visual similarity between the fear and surprise facial expressions. The authors noted that surprise can be expressed by raising the inner and outer brows, raising the upper eyelid, and the mouth being open. The same *action units* can also be activated in fear. The two are differentiated by the presence of one or two additional action units in fear. These are the brow lowerer and the lip stretcher. For each trial, the same prototype of surprise was shown, involving the activation of the four *action units* mentioned above. There were three prototypes of fear that were shown. Each of the fear prototypes contained the same *action units* as surprise, with the addition of one or two *action units* distinctive to fear. In the first, only the brow lowerer was present differentiating the fear expression from the surprise expression. In the second, the lip stretcher was activated. In the third prototype, both the lip stretcher and brow lowerer were activated. The results indicated that accuracy was significantly higher when both *action units* distinctive to fear were present than when only one was activated. When only the brow lowerer or the lip stretcher were activated, there was no significant difference in accuracy rates. The Gosselin and Simard (1999) study provided initial evidence for the validity of the perceptual-attentional limitations hypothesis in explaining the confusion between fear and surprise in children. As expected, children had higher accuracy in recognizing fear when the fear facial expression was most visually different from the surprise expression. Also, children in the older age group (ages 9-10) were significantly more accurate than those in the younger age group (ages 4-5).

Another study, conducted by Gagnon and colleagues (2010) failed to find support for the perceptual-attentional limitations hypothesis as an explanation for the confusion between fear and surprise. Unlike Gosselin and Simard (1999), these researchers used a discrimination task. In this study, children were shown a target facial expression and asked to choose the facial expression that looked most like the target from two choices. The researchers hypothesized that, if the perceptual-attentional limitations hypothesis is accurate, participants would struggle to correctly discriminate fear when the fear facial expression was paired with surprise. Their results showed that children in both age groups had perfect performance in discriminating between fear and surprise. Therefore, they concluded that their research did not support the perceptual-attentional limitations hypothesis in the case of the confusion between fear and surprise.

However, the high degree of accuracy seen by Gagnon and colleagues (2010) in discriminating between fear and surprise may be accounted for by the stimuli used. The fear prototype used by Gagnon and colleagues (2010) contained both of the *action units* distinctive to fear. This was the contrast which in Gosselin and Simard (1999) generated the highest accuracy for children in both age groups. Significantly lower accuracy was seen in Gosselin and Simard (1999) when only one distinctive *action unit* was present differentiating fear from surprise. Gagnon and colleagues (2010) noted in their discussion that their discrimination task was only one means for testing the perceptual-attentional limitations hypothesis. They further suggested that given contrasting findings by Gosselin and Simard (1999), further research is necessary to better understand the processes involved in this confusion.

The goal of this study was to examine the role of attentional and perceptual processes in the confusion of fear and surprise. This study replicated the methodology of Gosselin and Simard (1999), in addition to using eye movement measures to directly test the perceptual-attentional limitations hypothesis. In Gosselin and Simard (1999), the researchers attempted to determine whether children perceived the distinctive *action units* to fear using an explicit knowledge task. After each trial, the researchers asked the child to identify the region of the face that was most important in their decision, either the eyes, eyebrows, or mouth. This type of question relies on the child's explicit knowledge of their decision-making process. For knowledge to be explicit, the child must be consciously aware of the information and be able to verbally express that knowledge. Implicit knowledge, in contrast, refers to understanding at the procedural level,that is often without conscious awareness (Ebersbach & Resing, 2008). Research indicates that implicit knowledge develops prior to explicit knowledge (Ebersbach & Resing, 2008). Furthermore, implicit knowledge remains stable during childhood whereas explicit knowledge increases, beginning when the child is approximately three years old and continuing to adulthood (Murphy, McKone, & Slee, 2003). Since implicit knowledge has been found to be more stable, and to develop before explicit knowledge, this study employed an implicit measure to determine whether children perceive the *action units* that are distinctive to fear. During the task, the child's eye movements were measured to determine whether children devoted attention to the portions of the face containing the *action units* distinctive to fear.

Analyses of participants' eye movements tested the perceptual-attentional limitations hypothesis in two ways. Firstly, eye movement data was used to determine the relative contribution of specific facial regions to the facial expression recognition process. The *action units* which differentiate fear from surprise are located in the mouth and eyebrows. Analyses of participants' eye movements would demonstrate whether children used information in the mouth and eyebrows equally, or whether they favoured one region over the other. Greater importance of a facial region is suggested by longer or more frequent fixations (Boraston, Corden, Miles, & Blakemore, 2008; Eisenbarth & Alpers, 2011; Beaudry et al., 2013). Using an explicit knowledge task, Gosselin and Simard (1999) found that children tended to focus on the mouth more than on the eyebrows when differentiating between fear and surprise. It is possible then, that children are more attuned to differences in the mouth than in the eyebrows. A lack of attention to important differences in the eyebrows could explain why fear and surprise are confused.

Secondly, eye movements can be used to determine the difficulty level of specific comparisons. Research indicates that tasks which are more visually demanding generate specific patterns of eye movements. More specifically, when tasks are visually demanding, researchers typically observe a higher number of fixations and saccades (Rayner, 2009). Gosselin and Simard (1999) found that accuracy recognizing fear varied according to the level of visual similarity between fear and surprise. If fear is more difficult to recognize when only one distinctive *action unit* is present, it would be expected that this would be reflected in a higher number of saccades between the prototype of fear and that of surprise. A higher number of saccades would indicate that participants compared facial expressions more often.

The present study replicated the methodology of Gosselin and Simard (1999) to test the perceptual-attentional limitations hypothesis as an explanation for the confusion between fear and surprise in children. Like the study conducted by Gosselin and Simard (1999), this study also examined age differences in the recognition of facial expressions. In addition, eye movement data was collected to determine the relative contribution of information in specific regions of the face to facial expression recognition as well as to determine the difficulty level of specific comparisons.

Hypotheses

The first hypothesis was that the accuracy rate for surprise would be higher than that for fear. This hypothesis was based on previous research indicating that children are typically more accurate in recognizing the facial expression of surprise than fear (Gosselin & Simard, 1999; Gosselin, 1995; Widen & Russell, 2003).

The second hypothesis for the current study was that accuracy rates would be higher for the children between the ages of nine and ten than for the child between the ages of four to five. Previous research has consistently indicated that accuracy rates for the judgment of emotional facial expressions improve throughout childhood, with older children reliably obtaining higher accuracy scores than younger children (Gosselin & Simard, 1999; Gosselin, 1995; Camras & Allison, 1985). If this hypothesis was found to be accurate, the results would replicate Gosselin and Simard (1999) who found that children between the ages of nine and ten had higher accuracy rates than children between the ages of four to five using a similar task.

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

The final hypothesis relating to accuracy rates was that the percentage of correct responses would be higher when both the lip stretcher and brow lowerer were activated differentiating fear from surprise than when only one action unit was activated. Furthermore, it was predicted that there would be no significant difference between the two conditions in which only one distinctive *action unit* was present. In other words, it was anticipated that there would not be a significant difference in accuracy when only the lip stretcher was activated in comparison with the condition where only the brow lowerer was activated differentiating fear from surprise. This result would replicate the findings of Gosselin and Simard (1999). If this hypothesis were correct, the findings would provide further support for the perceptual-attentional limitations hypothesis. The perceptual-attentional limitations hypothesis predicts that facial expressions become confused when they share common action units and are thus visually similar (Camras, 1980; Wiggers, 1982). The prototype with the activation of both distinctive *action units* is the most visually dissimilar to the prototype of surprise and would therefore be expected to provide the highest level of correct responses if the perceptual-attentional limitations hypothesis is true.

Finally, the eye movement data were analyzed by determining the percentage of time spent fixating on each of the areas of the face with a distinctive action unit, the mouth and the eyebrows. No research to date has used a direct measurement to determine what parts of the face children focus on while differentiating between the facial expressions of fear and surprise. However, in Gosselin and Simard (1999), researchers asked the children to identify the part of the face that had indicated the emotion after each trial. They found that overall, the children tended to overestimate the occurrence of difference in the mouth region. Therefore, it was tentatively hypothesized that a higher percentage of time would be spent focusing on the mouth region than on the eyebrows.

In addition to revealing patterns in fixations, the eye movement data also recorded saccade activity. For the purposes of the present study, between-picture saccades were measured. Between-picture saccades refer to instances where the participant's eye moved from one photograph to the other. Previous research suggests that more saccades are made when visual material is more complex and intricate, thereby requiring a more demanding level of visual processing (Rayner, 2009). Research by Gosselin and Simard (1999) showed that fear and surprise were most difficult to distinguish when only one distinctive *action unit* was present differentiating between the two emotions. These comparisons contained the least number of visual differences. Since saccades are a measure of how demanding the visual processing of a stimulus would be, it was hypothesized that participants would make more between-picture saccades when only one distinctive *action unit* was present than when two such *action units* were present. No age effects were hypothesized for the eye movement data, since Gosselin and Simard (1999) found that children in both ages tended to focus on cues in the mouth more than in the eyebrows.

Method

Participants

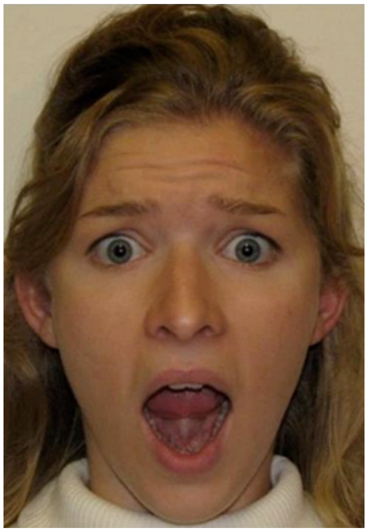
Participants were recruited from the Greater Sudbury Area. The child's parent or guardian was required to provide informed consent before the child participated in the research. Children had the opportunity to participate in the experiment in either English or French. The final sample consisted of ten children between the ages four and five (mean age = 4.9), and eleven children between the ages nine and ten (mean age = 9.4). Twelve of these participants were female, and nine were male. All reported having normal or corrected vision. One participant had to be removed from the analyses of eye movements due to a technological error.

Materials

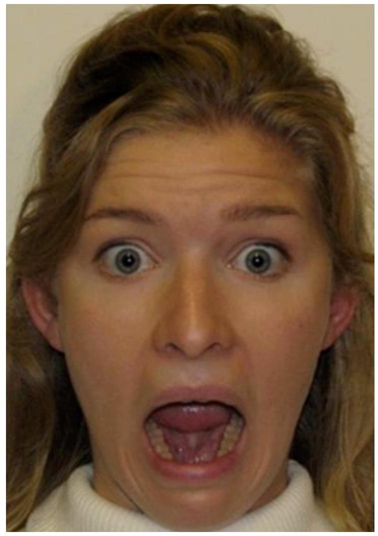
Twenty-four photographs were used in this research study, each expressing either fear or surprise. The facial expressions were posed according to the guidelines from FACS by Ekman, Friesen and Hager (2002). Six participants acted as encoders, two male and four female. During the initial session, the participants were familiarized with FACS and the prototypes that would be involved in the research study. The photographs were taken during a second session, under the supervision of a FACS certified coder. The precision of the facial expressions was then verified by two different FACS coders. Only photographs that reached 100% inter-rater agreement between the coders were used.

One prototype of surprise was used, that involving the inner brow raiser (AU 1), outer brow raiser (AU 2), upper lip raiser (AU 5), and jaw drop (AU 26) respectively. Three different prototypes of fear were used, each containing all of the action units found in surprise in addition to one or two action units that are distinctive to fear. The two action units that are found only in fear are the brow lowerer (AU 4) and the lip stretcher (AU 20). Therefore, the prototypes of fear involved the addition of only the brow lowerer, only the lip stretcher, and finally both distinctive action units. Examples of the stimuli used can be found in Figure 1.

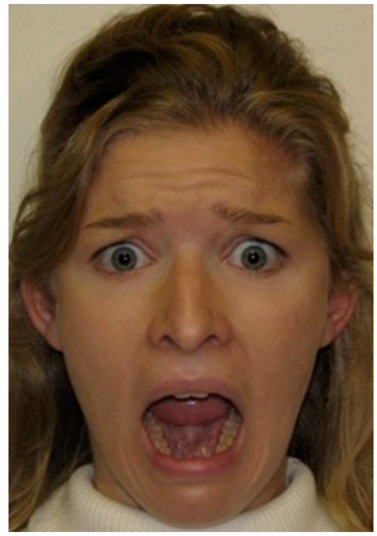
Fear Stimuli



1+2+**4**+5+27

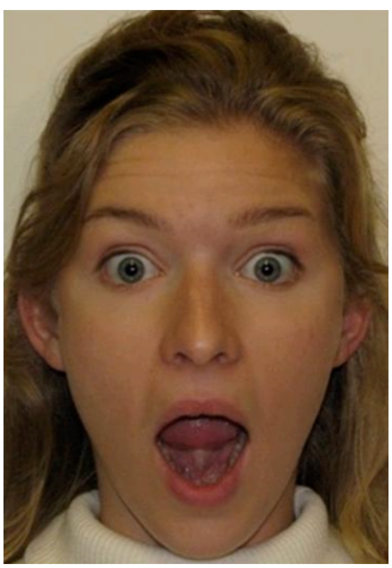


1+2+5+**20**+27



1+2+**4+**5+**20**+27

Surprise Stimulus



1+2+5+27

Figure 1: Examples of Fear and Surprise Stimuli

Eye Movement Apparatus

During the facial expression recognition task, participants' eye movements were monitored using EyeLink 1000 from SR Research. EyeLink 1000 has a high degree of accuracy in measuring eye movements (i.e. 0.25-0.5°) and a high sampling rate (2000Hz). The apparatus uses a camera that sits in front of the computer screen where the stimuli are presented to monitor eye movements. The participants placed their chin on a chin rest in front of the computer and the camera recorded their eye movements for the duration of the task to reduce head movements. The computer screen where the stimuli were presented was linked to the experimenter's computer through an Ethernet cable. The experimental task was preceded by a five-point calibration test to ensure that the camera was measuring the participant's eye movements with a high degree of accuracy. If a maximum error value exceeded 1.0° during calibration and validation, the processes was repeated to achieve a lower error value.

Procedure

Participants were tested individually, with each session lasting approximately thirty minutes. The participants were told that the project involved emotions and facial expressions. The researcher then explained that they would listen to short stories describing different emotions. Next, they would see photographs of people expressing different emotions on the computer screen and the researcher would ask them questions about those photographs.

Once the participant had received the instructions, the session began with the calibration task for the eye movement apparatus. To familiarize the child with the idea of following a moving stimulus with the eyes only, without simultaneously moving his or her head, the child was asked to visually follow the lid of a pen. During the calibration task, the child was asked to follow a picture of Caillou as it moved across the computer screen with his or her eyes. If calibration was successful, the researcher validated the results by repeating the task again. Whenever possible, a maximum error rate of less than 1.0° was taken as the criterion for validation. The maximum error rate was less than 1.0°for all participants but two. Calibration was challenging for two of the children in the younger age group, and a less strict criterion was accepted. The highest calibration criterion accepted was 1.68°.

Following calibration and validation, the participant completed the facial expression recognition task. The participant was instructed that he or she would see two photographs of facial expressions on the computer screen, presented side by side. For each trial, one photograph depicted fear and the other depicted surprise. Each time, a target emotion was indicated above the photographs. For half the trials, the target emotion was fear and for the other half, the target emotion was surprise. The position of the photographs on the screen, either left or right, was counterbalanced. There were six possible combinations of photographs for each target emotion, resulting in twelve possible combinations of photographs for each encoder. Since there were six encoders, there was a total of seventy-two different trials. The order the trials were presented in was randomized. An example trial can be found in Figure 2.

Figure 2: Example Trial from Fear-Surprise Experiment

To ensure that the participants understood both emotions, the researcher first read a short story involving a protagonist who experienced each of the target emotions. Following the story, the child was asked to indicate how the protagonist might be feeling. If the child could not answer, he or she was prompted by the researcher as to whether the character might be feeling fear or surprise. During the experimental trials, the child's task was to indicate, by pointing his or her finger, which of the photographs expressed the target emotion, which was named out loud by the researcher. Figure 2 shows a sample trial of the task. The researcher then recorded the response on an answer key. The images remained on the screen until the child gave a response. The task began with two practice trials, one for fear and one for surprise. The participant was shown two example trials on paper, and responses were mildly praised. Then, when the child was ready to continue, he or she completed the experimental trials. Throughout the task, the participants' eye movements were monitored using EyeLink 1000.

Results

Proportion of Correct Responses

The first set of hypotheses for the present study looked to determine whether the proportion of correct responses would vary as a function of the target emotion, the age group of the child, and the type of distinctive action units present in the photographs expressing fear (i.e. AUs 4+20, AU 4, and AU 20). A description of the *action units* involved in both studies can be found in Appendix A. The target emotion refers to the emotion the child was asked to identify for each trial. Children between the ages of four and five were included in the younger age group and children between the ages of nine and ten were considered part of the older age group. The proportion of correct responses was calculated by dividing the number of correct responses for each participant, by the total number of trials as a function of the target emotion, the age group, and the distinctiveness condition (i.e. the distinctive action units present).

Target Emotion and Age Group

The mean proportion of correct responses as a function of the target emotion and age group can be found in Table 1. A mixed-design ANOVA revealed a significant effect of target emotion [$F(1, 19) = 4.82$, $p<0.05$, partial $\eta^2 = 0.20$]. As shown in Table 1, children in both age groups had higher accuracy when the target emotion was surprise than when the target emotion was fear. The data in Table 1 also suggests that older children were slightly more accurate than younger children, however, the main effect of age group was not found to be statistically significant [$F(1,19) = 3.20$, $p = 0.09$]. The interaction between age group and target emotion was also not significant [$F(1,19) = 0.30$, $p = 0.59$].

Table 1
Means and Standard Deviations for the Proportion of Correct Responses as a Function of the Target Emotion and Age Group

	Target Emotion			
	Fear		Surprise	
Measures	M	SD	M	SD
Age Group				
Younger Children (n=10)	0.73	0.14	0.76	0.17
Older Children (n=11)	0.84	0.19	0.89	0.13

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Distinctiveness Condition and Age Group

The mean proportion of correct responses as a function of the distinctiveness condition and age group can be found in Table 2. These proportions were calculated for each participant as a function of the age group of the child (i.e. either younger or older) and the distinctive action units that were present (i.e. AUs 4+20, AU 4, and AU 20). A 2 x 3 mixed-design ANOVA, comparing the proportion of correct responses as a function of age group and type of distinctiveness condition was conducted. There was a main effect of distinctiveness condition [$F(2, 38) = 3.68$, $p < 0.05$, partial $\eta^2 = 0.16$]. As before, older children tended to have a slightly higher proportion of correct responses than younger children. However, the effect of age group was not found to be significant [$F(1, 19) = 1.86$, $p = 0.19$]. The interaction between age group and distinctiveness condition was likewise not significant [$F(2, 38) = 0.84$, $p = 0.44$]. Post-hoc Tukey comparisons indicated that children in both age groups had a higher proportion of correct responses when both AUs 4+20 were activated than when only AU 4 was activated. No other significant differences were observed.

Table 2
Means and Standard Deviations for the Proportion of Correct Responses as a Function of Age Group and Distinctiveness Condition

	Age Group			
	Younger Children		Older Children	
Measures	M	SD	M	SD
Distinctive Action Units				
AU 4	0.67	0.23	0.80	0.22
AU 20	0.72	0.19	0.85	0.21
AUs 4+20	0.85	0.18	0.87	0.17

Analysis of Eye Movements

Participants' eye movements were recorded by EyeLink 1000. They were analyzed in two ways. Firstly, the number of between-picture saccades was measured as a function of the target emotion and the distinctiveness index. For the purposes of this study, between-picture saccades refer to instances where the participants' eye moved from one photograph to the other. Secondly, the proportion of fixation time was calculated as a function of the distinctiveness condition, expressed emotion (i.e. fear or surprise), and zones (i.e. mouth or eyebrows). An important distinction needs to be made between the target emotion and the expressed emotion. For each trial, the experimenter indicated a target emotion (either fear or surprise) and the child was asked to point to the photograph of the person experiencing that emotion. The target emotion then, refers to the emotion the child was asked to identify. For each trial, one photograph on the screen expressed fear, and the other surprise. The expressed emotion refers to the emotion that is being conveyed in each photograph. The expressed emotion was analyzed instead of the target emotion since there was no effect of target emotion on saccade behaviour. Furthermore, a primary focus of the present study was to determine whether the mouth and eyebrows contribute equally or in different proportions to facial expression recognition of fear and surprise. More information relevant to this question would be gained by examining fixations to the mouth and eyebrows based on the emotion expressed in the photograph than the target emotion. The two zones considered in this study were the mouth and eyebrows as these are the parts of the face that contain the action units specific to fear. One participant was removed from the analysis of the eye movement data due to a technological problem.

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Between-Picture Saccades

Table 3 displays the mean number of between-picture saccades as a function of the target emotion and the type of distinctiveness condition. Since age group had not been significant in the accuracy analyses, it was not included in the eye movement analyses. A repeated-measures ANOVA revealed a significant main effect of type of distinctiveness condition [$F(2, 38) = 19.11$, $p<0.05$, partial $\eta^2 = 0.50$]. There was no effect of target emotion [$F(1, 19) = 0.03$, $p = 0.87$] and the interaction between target emotion and distinctiveness condition was not significant [$F(2, 38) = 1.20$, $p = 0.34$]. Post-hoc Tukey comparisons indicated that participants made significantly more between-picture saccades when only AU 4 was activated than when AUs 4+20 were activated or when AU 20 was activated in isolation. No other significant differences were observed.

Table 3
Means and Standard Deviations for the Number of Between-Picture Saccades as a Function of Target Emotion and Type of Distinctiveness Condition

	Target Emotion			
	Fear		Surprise	
Measures	M	SD	M	SD
Distinctive Action Units				
AU 4	3.65	1.50	3.73	1.40
AU 20	2.65	0.99	2.75	0.90
AUs 4+20	2.60	0.80	2.48	0.74

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Proportion of Fixation Time

The proportion of fixation time as a function of the expressed emotion (i.e. fear and surprise) and zone (i.e. mouth or eyebrows) can be found in Table 4. The proportion of fixation time was calculated per participant as a function of the expressed emotion and zone. Fixation time was calculated as the amount of time looking at each zone, based on the expressed emotion, divided by the total time for the trial. The figures in Table 4 indicate that participants spent more time fixating on the faces expressing fear than those expressing surprise. In addition, participants also spent a higher proportion of time fixating on the mouth than on the eyebrows. A repeated-measures ANOVA was conducted, with zone and expressed emotion as factors. Age group was not included since the previous results had not found an effect of age. There was a significant main effect of expressed emotion [$F(1, 19) = 17.44$, $p<0.05$, partial $\eta^2 = 0.48$]. Overall, participants spent a higher proportion of time fixating on the faces expressing fear than those expressing surprise. Furthermore, there was also a main effect of zone [$F(1, 19) = 10.33$, $p<0.05$, partial $\eta^2 = 0.35$]. As seen in Table 4, participants spent more time fixating on the mouth than on the eyebrows. The interaction between the expressed emotion and zone was not significant [$F(1, 19) = 0.10$, $p=0.76$].

Table 4
Means and Standard Deviations for the Proportion of Fixation Time as a Function of Expressed Emotion and Zone

	Expressed Emotion			
	Fear		Surprise	
Measures	M	SD	M	SD
Zones				
Eyebrows	0.11	0.08	0.09	0.05
Mouth	0.22	0.12	0.20	0.10

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

The proportion of fixation time as a function of zone and type of distinctiveness condition for fear as the expressed emotion can be found in Table 5. The proportion of time fixating as a function of zone and type of distinctiveness condition was only calculated for fear since only when the expressed emotion was fear were there distinctive action units present; the faces expressing surprise had the same combination of action units activated each time. Reviewing Table 5 demonstrates that, for the faces expressing fear, participants spent a higher proportion of time on the mouth than on the eyebrows, regardless of which type of distinctiveness index was present. A repeated-measures ANOVA confirmed that there was a main effect of zone [$F(1, 19) = 7.88$, $p<0.05$, partial $\eta^2 = = 0.29$]. Participants spent significantly more time fixating on the mouth than on the eyebrows when the expressed emotion was fear. There was no main effect observed for the type of distinctiveness condition [$F(2, 38) = 2.23$, $p = 0.12$]. However, the interaction between zone and type of distinctiveness condition was significant [$F(2, 38) = 19.30$, $p<0.05$, partial $\eta^2 = 0.50$]. Tests of simple effects were conducted to clarify the nature of the interaction. Participants spent significantly more time fixating on the mouth when AU 20 and AUs 4+20 were activated than when only AU 4 was activated. In contrast, participants spent significantly more time fixating on the eyebrows when AU 4 and AUs 4 + 20 were activated than when AU 20 was present alone. However, when AU 20 and AUs 4 + 20 were activated, participants overall spent more time fixating on the mouth than on the eyebrows. When only AU 4 was activated, there was no significant difference in the proportion of fixation time between the mouth and eyebrows.

Table 5
Means and Standard Deviations for the Proportion of Fixation Time as a Function of Zone and Distinctiveness Condition for the Faces Expressing Fear

	Zone			
	Eyebrows		Mouth	
Measures	M	SD	M	SD
Distinctiveness Index				
AU 4	0.12	0.09	0.18	0.11
AU 20	0.09	0.07	0.24	0.14
AUs 4+20	0.11	0.10	0.24	0.14

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Discussion

As has been found in other research (i.e. Gosselin, 1995; Widen & Russell, 2010a; Szekely et al., 2011; Widen & Russell, 2003), this study showed that children were more accurate in recognizing surprise than fear. In this respect, this study replicated the results of Gosselin and Simard (1999), who examined recognition of fear and surprise in children using the same methodology. The lower recognition of fear seen in the present study signifies that children were confusing fear with surprise. Several other studies have shown that children between the ages four to ten often confuse the facial expression of fear with surprise (Gagnon et al., 2010; Gosselin, 1995; Gosselin & Simard, 1999).

This study also examined age differences in the recognition of fear and surprise. No difference in accuracy was found between children in the older age group and those in the younger age group. This finding appears to be atypical, since many other studies have shown that accuracy in identifying emotional facial expressions increases throughout the elementary school years (Herba et al., 2010; Camras & Allison, 1985; Gagnon et al., 2010). Children in both age groups were accurate over 70% of the time. There was a trend in the expected direction; younger children were accurate between 73-76% of the time, and older children 84-89% of the time. However, this difference was not significant. Since children in both age groups performed reasonably well at differentiating between fear and surprise, age differences were difficult to detect. Furthermore, research has shown that even adults confuse fear with surprise as much as 30% of the time (Palermo & Coltheart, 2004).

The main contribution of the present study was to test the perceptual-attentional limitations hypothesis as an explanation for the confusion between fear and surprise. Gosselin and Simard (1999) had tested the perceptual-attentional limitations hypothesis by manipulating the level of visual similarity between fear and surprise. This study also contributed to the literature in this area by testing the perceptual-attentional limitations hypothesis in a more direct way, by monitoring eye movements during the task. The results showed that participants were more accurate when two distinctive *action units* were present than when the brow lowerer was the only distinctive cue differentiating between fear and surprise. These findings are slightly different than those reported by Gosselin and Simard (1999). In their study, participants were more accurate when both distinctive *action units* were present than when either the lip stretcher or the brow lowerer were present. In this study, when the lip stretcher was the only distinctive *action unit*, accuracy was slightly lower than the condition where both distinctive actions units were present, but the difference was not significant. Similarly, accuracy was slightly higher when when only the lip stretcher was present than when only the brow lowerer was present but the difference was again not significant.

The patterns of eye movements observed during the task help explain these findings. When the brow lowerer was the only distinctive *action unit*, participants spent an equal proportion of time fixating on the mouth and the eyebrows. Furthermore, participants made more between-picture saccades for this comparison than for any other. This means that participants looked between the two facial expressions more frequently before producing a response. Saccades are known to be affected by the complexity of visual processing required by a stimulus (Rayner, 2009). When visual information is denser, more complex, or the details are subtle, visual processing is more demanding. When visual processing is more demanding, researchers typically observe a specific pattern of eye movements; notably, individuals tend to make longer and more frequent fixations, and therefore a higher number of saccades (Rayner, 2009). Extending this observation to the present findings suggests that visual processing was more costly when only the brow lowerer was present. The difficulty of visual processing when the brow lowerer was the only distinctive *action unit* may also be reflected in the lower accuracy for this comparison; when the brow lowerer was the only distinctive *action unit*, participants were more likely to confuse fear with surprise than when both distinctive *action units* were present.

The eye movement data also revealed interesting information about children's use of cues in the mouth during facial expression recognition. The results showed that overall, children spent more time fixating on the mouth than on the eyebrows. When there were distinctive *action units* in both the mouth and eyebrows, participants still spent a higher proportion of time fixating on the mouth than the brows. Even when there were no distinctive cues in the mouth, participants still spent an equal amount of time looking at the mouth and the eyebrows. Similar results were also found by Gosselin and Simard (1999) when children were asked to report the region of the face that had led them to identify a facial expression as conveying fear or surprise.

In sum, these findings appear to suggest that when identifying facial expressions, children allocate their attention to different regions of the face in disproportionate ways. They tend to spend more time focusing on cues in the mouth than those in the eyebrows. In addition, recognizing the brow lowerer appears to require a more demanding level of visual processing than cues in the mouth. When differences in the eyebrows were the only distinctive emotional cue, participants made more comparisons between facial expressions and tended to have lower accuracy. The significance of these results for the perceptual-attentional limitations hypothesis will be explored in the general discussion.

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Experiment 2

The objective of experiment two was to test the perceptual-attentional limitations hypothesis as an explanation for the confusion between anger and disgust in children between the ages of four to five and nine to ten. As mentioned previously, the perceptual-attentional limitations hypothesis suggests that confusion between facial expressions is due to shared *action units* between facial expressions (Camras, 1980; Wiggers, 1982). Camras (1980) noticed that the nose wrinkle (AU 9) seen in disgust is visually very similar to the lowered eyebrows (AU 4) found in anger. Similarly, Wiggers (1982) suggested that the confusion between disgust and anger could be attributed to the presence of muscle movements that occur in both facial expressions. More specifically, Wiggers (1982) highlighted that the upper lip raiser (AU 10) and the lower lip depressor (AU 16) tend to occur in both anger and disgust.

To date, only Gagnon and colleagues (2010) have assessed the perceptual-attentional limitations hypothesis as an explanation for the confusion between disgust and anger with children. The researchers tested children between the ages five to ten using a discrimination task. For each trial, the researchers showed children a target facial expression, expressing anger, disgust, fear, happiness, or surprise. The children were asked to identify which, of two facial expressions, looked most like the target expression. This specific task was designed to assess whether children would still confuse these facial expressions when only asked to judge their physical characteristics. The researchers made no reference to the emotion conveyed by the facial expressions. Their results confirmed that, even when relying solely on the physical characteristics of the facial expressions, children still had lower accuracy in identifying disgust when paired with anger than any other combination. As such, the researchers noted that these findings provided at least partial support for the perceptual-attentional limitations hypothesis in explaining the confusion between disgust and anger by children.

The study conducted by Gagnon and colleagues (2010) provided some support for the perceptual-attentional limitations hypothesis in explaining the confusion between disgust and anger, but was also limited in the stimuli that were used. The researchers only used one prototype of each emotion. It therefore remains unclear whether children confuse all prototypes of disgust with anger, or only specific prototypes. It is possible that some prototypes of disgust share more visual similarities with anger than others. However, this idea is difficult to test given that disgust and anger do not differ from one another in a systematic way. In experiment 1, fear and surprise shared a common set of *action units* and differed by the addition of one or two distinctive *action units* in fear. The situation for disgust and anger is much more complex. There are some *action units*, such as the brow lowerer (AU 4) and the upper lid raiser (AU 5) that are only found in anger. Other *action units*, notably the nose wrinkler (AU 9) and the lower lip depressor (AU 16) are only found in disgust. Some prototypes of disgust and anger share the activation of the upper lip raiser (AU 10), the lips part (AU 25) or the chin raiser (AU 17). Given that disgust and anger do not differ from one another in a systematic way, it was not possible to manipulate the level of visual similarity between disgust and anger as was done in experiment 1. Instead, participants were shown individual photographs of each of the prototypes of disgust and anger proposed by Ekman and Friesen (1978) and asked to determine whether the individual in the photograph was experiencing disgust or anger. To date, no other study has looked at accuracy across all six prototypes of anger and disgust with a child sample. As in experiment 1, the participants' eye movements were monitored to determine the contribution of specific features to the recognition of disgust and anger. Saccades were not measured given that participants viewed only one photograph at a time.

Hypotheses

The first hypothesis of the proposed research is that the percentage of correct responses will be higher for anger than for disgust. This finding is expected based on research indicating that anger is recognized with higher accuracy levels in children than disgust (Widen & Russell, 2008; Wiggers, 1982; Gosselin & Kirouac, 1995). If these findings are replicated in the proposed research, the percentage of accurate responses will be higher for the photographs depicting angry facial expressions than for those depicting disgusted facial expressions.

The second hypothesis of the proposed study is that the percentage of correct responses will be higher for the older age group (children between the ages of nine to ten) than for the younger age group (children between the ages of five to six). This hypothesis is made on the basis of research indicating that older children recognize the facial expressions for disgust and anger with higher accuracy rates than younger children (Widen & Russell, 2003; Gosselin, 1995).

The third hypothesis of this experiment pertains to the percentage of correct responses among the prototypes of anger. The independent variable in question is the prototype of anger (see Figure 3 for the prototypes of anger) and the dependent variable is the percentage of correct responses. The prototypes of anger involve the activation of the brow lowerer (AU 4) as well as upper lid raiser (AU 5) and the lid tightener (AU 7) in the eye region. In the mouth, the anger prototypes involve the upper lip raiser (AU 10), the lip funneler (AU 22) the lip tightener (AU 23), the lip pressor (AU 24), and the lips part (AU 25). In addition, the chin raiser (AU 17) is also activated in anger. Whether or not there are differences in accuracy ratings between the prototypes of anger has yet to be addressed with a child sample. Therefore, the only predictions that can be made must rely on data collected with adults. When Gosselin and Kirouac (1995) tested adult's ability to recognize the prototypes of anger, they found that prototypes 4+5y+7+17+23 and 4+5y+23+25 were recognized with the highest accuracy and prototype 4+5y+7+10y+22+23+25 was recognized with the lowest level of accuracy. Given that these results were found with adults and that this question has not been answered for a child sample, this hypothesis is tentative.

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Figure 3: Examples of Anger Stimuli

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

The fourth hypothesis of the proposed research concerns the percentage of correct responses between the different prototypes of disgust. The independent variable is the prototype (see Figure 4 for the prototypes of disgust) and the dependent variable is the percentage of correct responses. Like anger, disgust also involves the activation of the Lips Part (AU 25), the Chin Raiser (AU 17) and the upper lip raiser (AU 10). Disgust also includes the Nose Wrinkler (AU 9) and the Lower Lip Depressor (AU 16). With adults, Gosselin & Kirouac (1995) found that two prototypes of disgust were associated with significantly lower accuracy rates: 9+16+25 and 10+16+25. Therefore, it is hypothesized that in the proposed research, the same prototypes will be less accurately recognized. However, it must be recognized that this research was conducted with an adult population and therefore it cannot be known whether or not the same results will be obtained from a child sample. Unfortunately, research with children has not systematically analyzed accuracy rates among the prototypes of disgust to be able to answer this question.

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Figure 4: Examples of Disgust Stimuli

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

The final hypothesis involves the percentage of time spent fixating on different regions of the face during the task. This part of the study will be exploratory. Unlike the confusion between fear and surprise, where some research had indicated that children may focus on the mouth while discriminating between facial expressions (Gosselin & Simard 1999), no such research has been conducted for disgust and anger in children. Therefore, no predictions can be made as to what areas of the face will attract the most attention while children decide if a given photograph expresses disgust or anger. The independent variable in question is the area of the face. The dependent variable is the percentage of time spent fixating in a given region, calculated as the amount of time spent in that area divided by the total time spent on the task.

Method

Participants

The same participants took part in Experiment 2 as in Experiment 1, with the exception of one child who only completed the experiment focused on fear and surprise. The order in which participants took part in the two studies was counterbalanced and each session lasted approximately half an hour. The final sample was comprised of nine children between the ages of four and five (mean age = 5.0) and eleven children between the ages nine and ten (mean age = 9.4). Twelve participants were female and eight were male.

Materials

Forty-four photographs were used in this study. Five prototypes of anger and six prototypes of disgust were used. Examples of the prototypes of anger can be seen in Figure 3. The five prototypes of anger involve *action units* 4+5+7+10+22+23+25, 4+5+7+17+23, 4+5+7+17+24, 4+5+7+23+25, and 4+5+23+25. The brow lowerer (AU4) and upper lid raiser

(AU7) are seen in all prototypes of anger. The upper lid raiser (AU 10), chin raiser (AU 17), lip funneler (AU 22), lip tightener (AU 23), lip pressor (AU 24), and lip part (AU 25) are also seen in the various prototypes of anger. Images of the prototypes of disgust can be found in Figure 4. There are six prototypes of disgust, involving *action units* 9, 9+16+25, 9+17, 10, 10+16+25, and 10+17. Three of the prototypes of disgust involve the nose wrinkler (AU 9). The remaining three involve the activation of the upper lid raiser (AU 10). In addition, the lower lip depressor (AU 16), chin raiser, (AU 17) and lip part (AU 25) also occur in disgust. There were four encoders, two male and two female. The photographs were posed according to the same procedure as used in Experiment One.

Procedure

The participants first completed the calibration task, following the same instructions that were described in Experiment One. Once calibration and validation had been achieved, the participant began the facial expression recognition task. Like in Experiment One, participants were first introduced to the emotions in question, disgust and anger, using short stories. The children listened to brief short stories describing a protagonist who experienced each of the emotions, and were asked to identify what the character in the story might be feeling. If the child could not provide an answer, the researcher prompted him or her as to whether the character might be feeling disgust or anger.

The task then began with two practice trials to ensure that the children understood the task. The participants were instructed that they would be presented with photographs, one at a time, at the centre of the computer screen. Their task was to determine whether the person in the photograph was feeling disgust or anger. Two paper examples of photographs were shown to the participants and responses were mildly praised. Once participants were ready and understood the task, they began the experimental trials on the computer. For half of the trials, the photographs expressed disgust and for the other half, the photographs expressed anger. The order in which the photographs were presented was randomized.

Results

Proportion of Correct Responses

The proportion of correct responses was calculated by dividing the number of correct answers by the total number of trials. The proportion of correct responses was analyzed as a function of the emotion expressed in each photograph (i.e. disgust or anger), the age group of the child, and as a function of prototype for disgust and anger separately.

Type of Emotion and Age Group

The mean proportion of correct responses as a function of emotion and age group can be found in Table 6. The proportion of correct responses was calculated per participant for each emotion and between the age groups. The data in Table 6 suggests that children in the older age group tended to have a higher proportion of correct responses than children in the younger age group. A mixed-design ANOVA confirmed the finding that children in the older age group had a higher proportion of correct responses than the younger children [$F(1, 18) = 10.76$, $p<0.05$, partial $\eta^2=0.37$]. Although participants were slightly more accurate in identifying anger than disgust, this difference was not found to be statistically significant [$F(1, 18) = 1.62$, $p = 0.22$]. Furthermore, the interaction between emotion and age group was also not significant [$F(1, 18) = 0.43$, $p = 0.52$].

Table 6
Means and Standard Deviations for the Proportion of Correct Responses as a Function of Age Group and Emotion

	Emotion			
	Anger		Disgust	
Measures	M	SD	M	SD
Age Group				
Younger Children	0.60	0.27	0.44	0.28
Older Children	0.67	0.12	0.62	0.11

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Prototype and Age Group

Separate analyses were conducted for the prototypes of anger and disgust. In addition, since there was a significant difference in the proportion of correct responses as a function of age group, the age group of the children was also taken into consideration. The mean proportion of correct responses, as a function of age group and prototype for anger can be found in Table 7. Table 7 shows a lower proportion of correct responses for anger prototypes 4+5+7+17+23 and 4+5+7+17+24. A mixed-design ANOVA found a significant main effect of prototype [F4, 72) = 11.23, $p<0.05$, partial $\eta^2 = 0.38$]. Tukey post-hoc comparisons indicated that participants in both age groups had a significantly higher proportion of correct responses for prototypes AUs 4+5+7+10+22+23+25, 4+5+7+23+25, and 4+5+23+25 than for prototypes 4+5+7+17+23 and 4+5+7+17+24. No other significant differences between the prototypes were observed. Furthermore, there was no significant main effect of age group [$F(1, 18) = 0.62$, $p = 0.44$]. The interaction between age group and prototype was also found to be non-significant [$F(4, 72) = 0.66$, $p = 0.62$].

Table 7
Means and Standard Deviations for the Proportion of Correct Responses for Anger as a Function of Prototype and Age Group

	Prototypes									
Measures	4+5+7+10+22+23+25		4+5+7+17+23		4+5+7+17+24		4+5+7+23+25		4+5+23+25	
	M	SD	M	SD	M	SD	M	SD	M	SD
Age Group										
Younger Children	0.70	0.27	0.50	0.39	0.49	0.38	0.69	0.27	0.65	0.29
Older Children	0.79	0.16	0.58	0.17	0.47	0.15	0.74	0.17	0.80	0.17

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

The mean proportion of correct responses as a function of prototype and age group for disgust can be found in Table 8. The data in table 8 suggests that participants had a lower proportion of correct responses for disgust prototypes 9+16+25 and 10+16+25. The results of a mixed-design ANOVA confirmed a main effect of prototype [$F(5, 90) = 16.3$, $p<0.05$, partial $\eta^2= 0.48$]. Tukey post-hoc comparisons indicated that participants had a higher proportion of correct responses for prototypes 9, 9+17, 10, and 10+17 than for prototypes 9+16+25 and 10+16+25. No other significant differences were found. Both the main effect of age group [$F(1, 18) = 3.85$, $p = 0.07$] and the interaction between age group and prototype [$F(5, 90) = 1.11$, $p = 0.36$] were not statistically significant.

Table 8
Means and Standard Deviations for the Proportion of Correct Responses for Disgust as a Function of Prototype and Age Group

	Prototypes											
	9		9+16+25		9+17		10		10+16+25		10+17	
Measures	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Age Group												
Younger Children	0.58	0.38	0.22	0.26	0.22	0.40	0.64	0.37	0.17	0.19	0.51	0.42
Older Children	0.69	0.20	0.23	0.18	0.78	0.13	0.78	0.31	0.43	0.35	0.80	0.24

Analysis of Eye Movements

Data from the eyes, eyebrows, nose, mouth, and chin was collected by EyeLink 1000 for the purpose of this experiment. It was initially planned to study the proportion of time fixating in each of these zones as a function of the emotion being expressed and the prototype. However, an interesting pattern emerged in the accuracy analyses discussed above. For anger, participants in both age groups had a significantly higher proportion of correct responses when the mouth was open, when the Lip Part (AU 25) was activated. When AU 25 was not activated for anger, participants had a significantly lower proportion of correct responses. Inversely, for the disgust prototypes, participants had a significantly lower proportion of correct responses when AU 25 was present, meaning that the mouth was open. These findings seem to suggest that when the mouth was open, participants tended to identify the emotion as anger. When the mouth was closed, participants tended to identify the emotion was disgust. Since the mouth appears to be of great importance in differentiating between the facial expressions of disgust and anger for children, the analyses of the eye movements that were conducted focused on the zone in the mouth.

Proportion of Time

The proportion of time spent in the mouth was calculated by dividing the amount of time each participant spent fixating on the mouth, by the total amount of time fixating on all five zones (i.e. the eyes, eyebrows, nose, mouth, and chin) per trial. Table 9 shows the mean proportion of time spent fixating on the mouth for each of the prototypes of anger. The figures in Table 9 suggest that participants spent more time on the mouth for prototypes 4+5+7+10+22+23+25, 4+5+7+23+25, and 4+5+23+25. A repeated-measures ANOVA confirmed a significant main effect of prototype [$F(4, 76) = 9.47$, $p<0.05$, partial $\eta^2 = 0.33$]. Post-hoc Tukey tests were done to clarify the nature of the effect. They revealed that among the prototypes of anger, participants spent significantly more time fixating on the mouth for prototypes 4+5+7+10+22+23+25, 4+5+7+23+25, and 4+5+23+25 than for prototypes 4+5+7+17+23 and 4+5+7+17+24. There were no other significant differences.

Table 9
Means and Standard Deviations for the Proportion of Time Fixating on the Mouth for the Prototypes of Anger

	Prototypes				
Measures	4+5+7+10+22+23+25	4+5+7+17+23	4+5+7+17+24	4+5+7+23+25	4+5+23+25
M	0.32	0.22	0.23	0.30	0.29
SD	0.16	0.12	0.11	0.14	0.14

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

The mean proportion of time spent fixating on the mouth for the prototypes of disgust can be found in Table 10. The means in Table 10 indicate that participants spent more time on the mouth for prototypes 9+16+25 and 10+16+25. A repeated-measures ANOVA found a significant effect of prototype [$F(5, 95) = 24.69$, $p<0.05$, $pn^2= 0.57$]. Follow-up Tukey tests indicated that participants spent significantly more time focusing on the mouth for prototypes 9+16+25 and 10+16+15 than for prototypes 9, 9+17, 10, and 10+17. There were no other significant differences.

Table 10
Means and Standard Deviations for the Proportion of Time Fixating on the Mouth for the Prototypes of Disgust

	Prototypes					
Measures	9	9+16+25	9+17	10	10+16+25	10+17
M	0.20	0.36	0.21	0.23	0.39	0.23
SD	0.13	0.18	0.14	0.13	0.19	0.13

An attempt was made to determine whether the proportion of time spent fixating on the mouth varied as a function of the accuracy of the responses (i.e. correct vs. incorrect). However, since children in both age groups had an overall low accuracy rate for both anger and disgust, there were too many empty cells to perform the analysis.

Discussion

The results of this study showed that children had low accuracy in recognizing both disgust and anger. That being said, there were important age differences. Overall, children in the older age group had higher accuracy than those in the younger age group. This finding replicates other research showing that accuracy in identifying disgust and anger improves throughout the elementary-school years (Camras & Allison, 1985; Widen & Russell, 2010a; Widen & Russell, 2003; Gosselin, 1995). This increase was mostly due to improvements in the recognition of disgust. There was no difference in accuracy for anger between the younger and older age groups. However, there was a trend approaching significance with older children showing higher accuracy in recognizing the prototypes of disgust than younger children. Several studies have shown that children develop the ability to recognize disgust and anger at different stages in development. Typically, studies show that children develop proficiency in recognizing anger earlier than disgust (Widen & Russell, 2002; Widen & Russell, 2004; Widen & Russell, 2010; Gosselin, 1995). For example, Widen and Russell (2010) showed that children recognize anger with a high degree of accuracy by age five, and accuracy for anger remained stable at age nine. In contrast, only a small percentage of children could recognize disgust at age five, and there were significant improvements by age nine.

Although there were important age differences, accuracy in this study was still low for both emotions. Accuracy was below 70% for most prototypes of disgust and anger. This finding was unexpected, given that other research has shown that elementary-school-aged children typically have higher accuracy for the facial expression of anger than disgust (Camras & Allison, 1985; Widen & Russell, 2010a; Widen & Russell, 2003; Gosselin, 1995). The results of the present study imply that not only were children confusing disgust with anger, but they were also confusing anger with disgust. Many studies have demonstrated that children often confuse disgust with anger (Gagnon et al., 2010; Widen & Russell, 2008; Widen & Russell, 2010ab). Some studies have found that children also confuse anger with disgust (Camras, 1980; Widen & Russell, 2010a; Widen & Russell, 2008). That being said, the confusion of anger with disgust appears to be less robust, with other studies failing to find such a confusion (Gosselin, 1995; Widen & Russell, 2008). These conflicting results might be accounted for by the prototypes which are selected by researchers. The results of the present study suggest that only specific prototypes of disgust and anger are confused with one another.

This study contributed to the literature in this area by examining accuracy across the prototypes of anger and disgust proposed by Ekman and Friesen (1978) in a child sample. No previous research, to date, had addressed this issue with a child sample. The results suggested that the confusion of anger and disgust is related to one specific *action unit*, the lips Part. When the lips part is activated, the lips open slightly. This *action unit* occurs in both anger and disgust. In this study, children were more accurate in identifying anger when the lips part was present. For disgust, they were more accurate when the lips part was absent. These results suggest that children tended to identify facial expression as conveying anger when the lips part was present, and disgust when the lips part was absent. This tendency leads to confusion between facial expressions, since the lips part occurs in both anger and disgust.

This study also contributed to the literature by monitoring participants' eye movements throughout the task. Since differences in the mouth appeared to be related to children's decision to label a facial expression as disgust or anger, this study focused on the instances in which children focused on the mouth. For both emotions, participants spent a significantly higher proportion of time fixating on the mouth when AU 25 was present. The proportion of time fixating on a facial region is an indicator of the extent to which a facial region contributes to facial expression recognition (Boraston, Corden, Miles, & Blakemore, 2008; Eisenbarth & Alpers, 2011; Beaudry et al., 2013). The findings of the present study help clarify the situations in which children rely on cues in the mouth to recognize anger and disgust. This study suggests that, although children tend to focus on cues in the mouth to recognize anger and disgust, they do so more when the mouth is open. The significance of these findings will be explored in the general discussion.

General Discussion

Two experiments were conducted testing the perceptual-attentional limitations hypothesis as an explanation for the confusion of specific facial expressions by children. Experiment 1 tested this hypothesis for the confusion between fear and surprise and Experiment 2 for the confusion between disgust and anger. According to the perceptual-attentional limitations hypothesis, facial expressions are confused with one another because they share visual similarities (Camras, 1980; Wiggers, 1982). Fear and surprise can both involve the activation of the inner brow raiser, outer brow raiser, upper lip raiser, and the jaw drop. They are differentiated by the presence of two distinctive *action units* in fear, the brow lowerer and the lip stretcher. Disgust and anger are more visually different from one another than fear and surprise, however, they do share some *action units*. Both emotions can involve the activation of the lip raiser, the lips part, and the chin raiser. In order for children to correctly recognize these facial expressions, they would need to identify the features that differentiate these facial expressions from others, and not be fooled by the features these expressions have in common. In support of this hypothesis, Gosselin and Simard (1999) found that children's accuracy varied according to the level of visual similarity between fear and surprise. More specifically, children were more accurate when two distinctive *action units* were present differentiating between fear and surprise than when there was only one distinctive *action unit* present. Gagnon and colleagues (2010) found support for the perceptual-attentional limitations hypothesis for the confusion between disgust and anger. They showed children a target facial expression and asked them to indicate which, of two facial expressions, looked most like the target expression. They found that accuracy for disgust was lowest when disgust was paired with anger. Furthermore, this hypothesis is in line with Gibsonian theory, which suggests that visual perception becomes more differentiated as children develop (Gibson & Gibson, 1955). More specifically, this theory suggests that children are first able to differentiate between stimuli that are clearly different from one another. As children develop, they are better able to differentiate between stimuli which differ from one another in more subtle ways (Gibson, 1955).

Experiment 1 tested the perceptual-attentional limitations hypothesis for the confusion between fear and surprise by replicating the methodology of Gosselin and Simard (1999) while adding eye movement recording. The researchers had shown children pairs of photographs, one expressing fear and one expressing surprise. For each trial, participants were asked to identify a target emotion, either fear or surprise. Each of the images of fear and surprise contained all of the *action units* that are common to both fear and surprise. The fear expressions differed from the surprise expressions by the addition of either one or both *action units* distinctive to fear. The current study contributed to the literature in this area by also measuring eye movements as a more direct measure of the perceptual processing. Collecting eye movement data helped test the perceptual-attentional limitations hypothesis in two ways. First of all, measuring eye movements would demonstrate the contribution of specific facial regions to facial expression recognition. Eye tracking enables researchers to directly determine where individuals are looking when presented with a visual stimulus (Karatekin, 2007). The muscle movements specific to fear are found in the mouth (i.e. the stretching of the lips) and the eyebrows (i.e. the lowering of the inner eyebrows). Analyses of participants' eye movements would demonstrate whether individuals use information from each of these two areas equally, or whether they concentrate more on one facial region than the other. Greater use of one facial region over the other would be indicated by more time spent fixating on either the mouth or the eyebrows (Beaudry, Roy-Charland, Perron, Cormier, & Tapp, 2013). Secondly, eye movements can be used to determine the difficulty level of specific comparisons. Research indicates that tasks which are more visually demanding generate specific patterns of eye movements. More specifically, when tasks are visually demanding, researchers typically observe a higher number of fixations and saccades (Rayner, 2009; Charland & Perron, 2013). As such, a higher level of saccades would indicate that a specific comparison involves more costly visual processing.

The results of Experiment 1 showed that children were more accurate when both distinctive *action units* were present than when the brow lowerer was the only distinctive *action unit*. This finding can be understood by examining the patterns of eye movements during the task. Overall, participants spent more time fixating on the mouth than on the eyebrows. When there were distinctive emotional cues in both regions, participants spent more time fixating on the mouth than on the eyebrows. When the only distinctive visual cue was in the eyebrows, participants still spent an equal amount of time looking at the eyebrows and mouth. These findings suggest that children were more attentive to emotion cues in the mouth than to cues in the eyebrows. Furthermore, children made more between-picture saccades when the brow lowerer was the only distinctive *action unit*. This means that children compared the facial expressions more often when the only difference was in the eyebrows before giving a response. A higher number of saccades reflects more complex visual processing (Rayner, 2009; Roy-Charland & Perron, 2013). This finding suggests that visual processing was more difficult when only the brow lowerer was present.

Experiment 2 employed a different task than Experiment 1. Fear and surprise share a core set of *action units* and are differentiated by the presence of one or two distinctive *action units* in fear. As such, it was possible to manipulate the level of visual similarity between fear and surprise. Disgust and anger do not differ from one another in a systematic way. There are some *action units* which occur only in disgust, some which occur only in anger, and some which are shared between some prototypes of both emotions. Since these two emotions do not differ in a systematic way, Experiment 2 needed to use a different methodology. In Experiment 2, participants viewed each of the prototypes of disgust and anger described by Ekman and Friesen (1978) individually. Their task was to determine whether the facial expression conveyed anger or disgust. As in Experiment 1, eye movements were monitored throughout the task. The results showed that participants had low accuracy for both emotions, indicating that they were confusing anger with disgust and vice versa. Older children were significantly more accurate than younger children. This finding was mostly due to the increase in the recognition of disgust. The confusion between disgust and anger appeared to be due to one specific *action unit*, the Lips Part. When the lips part was presented, children tended to identify the facial expression as conveying anger.

When the lips part was absent, they tended to identify the emotion as disgust. This tendency lead to confusion since the lips part occurs in some prototypes of both anger and disgust. When the lips part was absent in anger, participants were more likely to confuse anger with disgust. When the lips part was present in disgust, participants were more likely to confuse disgust with anger. Furthermore, the eye movement data revealed that participants spent more time fixating on the mouth when the lips part was present than when the lips part was absent. This is the only study, to date, to examine accuracy across all of the prototypes of disgust and anger described by Ekman and Friesen (1978).

The results of the present experiments help to add to the perceptual-attentional limitations hypothesis. In particular, the eye movement data revealed that different regions of the face do not contribute equally to facial expression recognition. The findings from both studies demonstrated a preference for cues in the mouth. In Experiment 1, participants spent more time fixating on the mouth than the eyebrows. Even when there were distinctive *action units* in both the mouth and the eyebrows, participants spent more time fixating on the mouth. When there were no distinctive emotional cues in the mouth, participants still spent a significant amount of time looking at the mouth. In Experiment 2, children tended to label anger and disgust according to the presence or absence of the lips part. The results of both studies speak to the importance children allocate to the mouth when identifying emotional facial expressions.

There has been some other research that has looked the regions of the faces children fixate on while viewing faces. Most of the research examining children's patterns of fixations when viewing faces has focused on comparing clinical and non-clinical samples (Chawarska & Shic, 2009; Pruett et al., 2013; Rose et al., 2013; van der Geest, Kemner, Verbaten, & van Engeland, 2002). These studies have indicated that when viewing faces, children between the ages two to ten tend to fixate on the eyes, nose, and mouth (Chawarska & Shic, 2009; Rose et al., 2013; van der Geest et al., 2002; Schwarzer et al., 2005; Karatekin, 2007). However, there are several limitations to these findings that should be mentioned. None of these studies have examined patterns of fixations during a facial expression recognition task. As such, the relevance of these findings to the understanding of facial expression recognition can be questioned. The present two experiments expanded on previous research in this area by examining fixations during a facial expression recognition task, and including the eyebrows as an area of interest. Future research should further address the regions of the face children fixate on during facial expression recognition tasks to expand upon the results of these studies and to determine patterns of fixations for other emotions (i.e. happiness or sadness). Other studies might also address which region of the face children fixate on first during facial expression recognition tasks.

These findings add to the perceptual-attentional limitations hypothesis. The confusion between these facial expressions appears to be related, not only to the level of visual similarity between them as was found by Gosselin and Simard (1999), but also to the fact that children allocate their attention to different regions of the face in disproportionate ways. The findings of these two experiments suggest that children focus their attention preferentially on cues in the mouth. Focusing on cues in the mouth could lead to confusion in two ways. First of all, a tendency to fixate on the mouth could lead children to miss emotional cues in other regions of the face. For example, the brow lowerer may sometimes be the only cue that differentiates fear from surprise. Furthermore, the nose wrinkle is an important cue for disgust; the nose wrinkle occurs in half of the prototypes of disgust and never occurs in anger or any other emotion. Secondly, the facial expressions which are confused also share *action units* in the mouth, meaning that the mouth is not always a reliable way to distinguish between emotions. Both fear and surprise can involve the activation of the jaw drop. Similarly, the lip raiser, lips part, and chin raiser can all occur in both disgust and anger. As such, differences in the mouth are not always a reliable way of differentiating between these emotions.

If emotional cues occur in several areas of the face (i.e. the mouth, eyes, eyebrows, nose, chin), it might seem odd that children seem to focus their attention on the mouth. Several explanations are possible. Researchers have noted that the extent to which children fixate on different regions of the face changes throughout childhood. Infants between the ages of two to four months have been found to focus primarily on the eyes (Gallay, Baudouin, Durand, Lemoine, & Lecuyer, 2006; Maurer & Salapatek, 1976). This finding makes sense given that eye contact is important to infant-caregiver attachment (Cohen & Campos, 1974; Parker & Forrest, 1993; Robson, 1967). Between ages two to four, fixations to the mouth increase, whereas those to the eyes tend to decrease (Chawarska & Shic, 2009). The increase in attention to the mouth is thought to be related to the development of language (Chawarska & Shic, 2009). As children speak their first words, expand their vocabulary, and gain greater receptive knowledge they may allocate more attention to the mouth as they learn to speak. It is possible then, that children focus a disproportionate amount of attention on the mouth due to the role of the mouth in speech. Future studies might address whether the extent to which children fixate on different regions of the face continues to shift throughout late childhood to adolescence and into adulthood, particularly during facial expression recognition tasks.

Increased attention to the mouth also makes sense in light of the importance of muscle movements in the mouth in distinguishing between positive and negative emotions. The basic emotions are typically divided into those that are positive and those that are experienced as being negative (Izard, 2009). The most noticeable characteristic of positive emotions (i.e. happiness) is the smile. An enjoyment smile is produced by the activation of the zygomaticus major, a muscle which pulls up the corners of the mouth (Frank & Ekman, 1993). Smiling does not occur during the genuine expressions of negative emotions, as described by Ekman and Friesen (1978). As such, verifying whether or not a smile is present would provide a quick means of determining whether a facial expression conveys a positive or negative emotion. If a smile was not present, the child would then need to determine which negative emotion was portrayed by the facial expression. Research regarding children's drawings of emotional facial expressions is in line with this idea. Brechet, Baldy, and Picard (2009) analyzed drawings of happiness, sadness, fear, anger, and disgust produced by children between the ages six to eleven. The children depicted each of these emotions by manipulating the mouth and eyes of the figures. Happiness was expressed by a smile. The other negative emotions were depicted with a downturned or open mouth. In combination, these findings suggest that the mouth plays a crucial role in differentiating between negative and positive emotions.

It is also possible that children focus disproportionately more on the mouth because of the size of the mouth in comparison with other facial features (Roy-Charland, Perron, Beaudry, & Eady, 2014). For example, the lip stretcher creates a physically larger difference in the face than the brow lowerer. The brow lowerer affects only the inner eyebrows whereas the changes created by the brow lowerer can be noticed in the widening of the mouth and into the neck. It may be that children spend more time fixating on the mouth because muscle movements in the mouth create the most noticeable changes. According to Gibsonian theory, children start by learning the minimal features that distinguish between stimuli, including faces (Gibson, 2000). It is possible that changes in the mouth are noticed first, since changes in the mouth are more obvious. It is also possible that both of these explanations help account for the high level of fixations to the mouth seen in children.

Limitations

There are several limitations to these two studies. Both studies had a relatively small sample size, limiting the generalizability of these findings. Furthermore, this study did not examine fixations to the eyes for fear. Gosselin and Simard (1999) noted that the muscle movements required to produce the brow lowerer and the brow raisers also affect the eye region. As such, they examined whether children reported using information in the eye region. Future research examining the confusion between fear and surprise could use eye movement measures to examine this question in a more direct way. In addition, since accuracy was so low for disgust and anger in this study, it was not possible to examine whether accuracy varied according to the amount of time children spent fixating on the mouth. Future research might examine whether the amount of time spent fixating on the mouth impacts accuracy in facial expression recognition tasks.

Conclusion

The two studies described here tested the perceptual-attentional limitations hypothesis (Camras, 1980; Wiggers, 1982) for the confusion between fear and surprise and between disgust and anger by children. Participants recognized surprise with higher accuracy than fear, replicating the finding that children often confuse fear with surprise. The participants had low accuracy for both anger and disgust, meaning that they were confusing both emotions with one another. The results provided support for an expanded version of the perceptual-attentional limitations hypothesis. The results of this study suggested that not only do children confuse facial expressions due to the level of similarity between them, but also due to the ways in which they allocate their attention to different regions of the face. In particular, children seem to focus their attention on features in the mouth. This tendency could lead to confusion between facial expressions because a preference for cues in the mouth might lead children to miss cues in other regions of the face. In addition, the facial expressions which are confused share *action units* in the mouth, meaning that cues in the mouth are not always a reliable way to distinguish between facial expressions.

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

References

Abe, J. A., & Izard, C. E. (1999). The developmental functions of emotions. An analysis in terms of differential emotions theory. *Cognition and Emotion, 13*(5), 523-549. doi: 10.1080/026999399379177

Besel, L. D. S., & Yuille, J. C. (2010). Individual differences in empathy: The role of facial expression recognition. *Personality and Individual Differences, 49*(2), 107-112. doi: 10.1016/j.paid.2010.03.013

Bear, M. F., Connors, B. W., & Paradiso, M. A. (2001). *Neuroscience: Exploring the Brain*, *Second Edition*. Baltimore, Maryland: Lippincott Williams & Wilkins.

Bezrukikh, M. M., Morozova, L. V., & Terebova, N. N. (2009). Visual perception as an integrated characteristic of the psychophysiological development of six-to eight-year-old children. *Human Physiology*, *35*(2), 248-251. doi: 10.1134/S0362119709020169

Boraston, Z. L., Corden, B., Miles, L. K., Skuse, D. H., & Blakemore, S. (2008). Brief report: Perception of genuine and posed smiles by individuals with autism. *Journal of Autism and Developmental Disorders*, *38*(3), 574-580. doi: 10.1007/s10803-007-9421-1

Bornstein, M. H., and Arterberry, M. E. (2003). Recognition, discrimination and categorization of smiling by 5-month-old infants. *Developmental Science*, *6*(5), 585-599. doi: 10.1111/1467-7687.00314

Brechet, C., Baldy, R., & Picard, D. (2009). How does Sam feel? Children's labelling and drawing of basic emotions. *British Journal of Developmental Psychology*, *27*, 587-606. doi: 10.1348/026151008x345564

Bullock, M., & Russell, J. A. (1985). Further evidence on preschoolers' interpretation of facial expressions. *International Journal of Behavioral Development*, *8*, 15-38.

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN doi: 10.1177/016502548500800103

Calvo, M. G., & Lundqvist, D. (2008). Facial expressions of emotion (KDEF): Identification under different display-duration conditions. *Behavior Research Methods*, *40*, 1, 109-115. doi: 10.3758/BRM.40.1.109

Campos, J. J. (1980-1981). Human emotions: Their new importance and their role in social referencing. *Research & Clinical Center for Child Development*, *4,* 1-7.

Campos, J. J., Frankel, C. B., and Camras, L. (2004). On the nature of emotion regulation. *Child Development*, *75*(2), 377-394. doi: 10.1111/j.1467-8624.2004.00681.x

Camras, L. A. (1980). Children's understanding of facial expressions used during conflict encounters. *Child Development*, *51*, 879-885. doi: 10.2307/1129477

Camras, L. A., & Allison, K. (1985). Children's understanding of emotional facial expressions and verbal labels. *Journal of Nonverbal Behavior, 9*(2), 84-94. doi: 10.1007/BF00995544

Carr, M. B., & Lutjemeier, J. A. The relation of facial affect recognition and empathy to delinquency in youth offenders. *Adolesence*, *40*(159), 601-619.

Chawarska, K., & Shic, F. (2009). Looking but not seeing: Atypical visual scanning and recognition of faces in 2 and 4-year old children with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, *39*, 1663-672. doi: 10.1007/s10803-009-0803-7

Cohen, L. J., & Campos, J. J. (1974). Father, mother, and stranger as elicitors of attachment behaviors in infancy. *Developmental Psychology*, *10*(1), 146-154.

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science*, *11*(1), 86-89. doi: 10.1111/1467-9280.00221

Ebersbach, M., and Resing, W. C. M. (2008). Implicit and explicit knowledge of linear and exponential growth in 5- and 9- year-olds. *Journal of Cognition and Development*, *9*(3), 286-309. doi: 10.1080/15248370802247962

Eisenbarth, H., & Alpers, G. W. (2011). Happy mouth and sad eyes: Scanning emotional facial expressions. *Emotion*, *11*(4), 860-865. doi: 10.1037/a0022758

Ekman, P. (1992). An argument for basic emotions. *Cognition and Emotion*, *6*, 169-200. Retrieved from http://www.paulekman.com/journal-articles/

Ekman, P. (1999). Basic emotions. In T. Dalgleish and T. Power (Eds). *The handbook of cognition and emotion*, pp. 45-60. Sussex, U.K: John Wiley & Sons, Ltd. Retrieved from http://www.paulekman.com/journal-articles/

Ekman, P., & Friesen, W. V. (1978). *Facial Action Coding System: Investigator's Guide*. Pala Alto, CA: Consulting Psychologists Press.

Ekman, P., & Friesen, W. V. (1986). A new pan-cultural facial expression of emotion. *Motivation and Emotion*, *10*(2), 159-168.

Ekman, P., Friesen, W. V., & Hager, J. C. (2002). *Facial Action Coding System* (CD-Rom). Salt Lake City, UT: Nexus.

Ekman, P., Friesen, W. V., O'Sullivan, M., Chan, A., Diacoyanni-Tarlatzis, I., Heider, K., … & Tzavaras, A.. (1987). Universals and cultural differences in the judgments of facial expressions of emotion. *Journal of Personality and Social Psychology*, *53*(4), 712-717. doi: 10.1037/0022-3514.53.4.712

Elfenbein, H. A., & Ambady, N. (2002). On the universality and cultural specificity of emotion recognition: A meta-analysis. *Psychological Bulletin*, *128*(2), 203-235. doi: 10.1037//0033-2909.128.2.203

Erickson, K., & Schulkin, J. (2003). Facial expressions of emotion: A cognitive neuroscience perspective. *Brain and Cognition*, *52*, 52-60. doi: 10.1016/S0278-2626(03)00008-3

Fernandez-Dols, J., & Crivelli, C. (2013). Emotion and expression: naturalistic studies. *Emotion Review*, *5*(1), 24-29.

Gagnon, M., Gosselin, P., Buhs, I., H., Larocque, K., & Milliard, K. (2010). Children's recognition and discrimination of fear and disgust facial expressions. *Journal of Nonverbal Behavior*, *34*, 27-42. doi: 10.1007/s10919-009-007g-z

Gallay, M., Baudouin, J., Durand, K., Lemoine, C., & Lecuyer, R. (2006). Qualitative differences in the exploration of upright and upside-down faces in four-month-old infants: An eye-movement study. *Child Development*, *77*(4), 984-996. doi: 10.1111/j.1467-8624.2006.00914.x

Gibson, E. J. (1987). Introductory essay: What does infant perception tell us about theories of perception? *Journal of Experimental Psychology*, *13*(4), 515-523.

Gibson, E. J. (2000). Perceptual learning in development: Some basic concepts. *Ecological Psychology*, *12*(4), 295-302. doi: 10.1207/S15326969ECO1204_04

Gibson, J. A., and Gibson, E. J. (1955). Perceptual learning: Differentiation or enrichment? *Psychological Review*, *62*(1), 32-41.

Gosselin, P. (1995). Le développement de la reconnaissance des expressions faciales des émotions chez l'enfant. *Revue canadienne des sciences du comportement*, *27*(1), 107-119. doi: 10.1037/008-400X.27.1.107

Gosselin, P., & Kirouac, G. (1995). Le décodage de prototypes émotionnels faciaux. *Revue canadienne de psychologie expérimentale*, *49*(3), 313-329. doi: 10.1037/1196-1961.49.3.313

Gosselin, P. (2005). Le décodage de l'expression faciale des émotions au cours de l'enfance. *Canadian Psychology*, *46*(3), 126-138. doi: 10.1037/h0087016

Gosselin, P., & Simard, J. (1999). Children's knowledge of facial expressions of emotions: Distinguishing fear and surprise. *The Journal of Genetic Psychology*, *160*(2), 181-193. doi : 10.1080/00221329909595391

Harris, P. L. (2008). Children's understanding of emotion. In M. Lewis, J. M., Haviland-Jones, & L. F., Barrett (Eds.), *Handbook of Emotions Third Edition* (320-331). New York, NY: The Guilford Press.

Herba, C. M., Landau, S., Russell, T., Ecker, C., & Phillips, M. (2006). The development of emotion-processing in children: effects of age, emotion, and intensity. *Journal of Child Psychology and Psychiatry*, *47*(11), 1098-1106. doi: 10.1111/j.1469-7610.2006.01652.x

Izard, C. E. (2009). Emotion theory and research: Highlights, unanswered questions, and emerging issues. *Annual Review of Psychology*, *60*, 1-25. doi: 10.1146/annurev.psych.60.110707.

Izard, C. E. (2010). The many meanings/aspects of emotion: Definitions, functions, activation, and regulation. *Emotion Review*, 2, 4, 363-370. doi: 10.1177/1754073910374661

Izard, C. E. (2011). Forms and functions of emotions: Matters of emotion-cognition interactions. *Emotion Review*, *3*(4), 371-378. doi: 10.1177/1754073911410737

Karatekin, C. (2007). Eye tracking studies of normative and atypical development. *Developmental Review*, *27*, 283-348. doi: 10.1016/j.dr.2007.06.006

Kohler, C. G., Turner, T., Stolar, N. M., Bilker, W. B., Brensinger, C. M. Gur, R. E., & Gur, R. C. (2004). *Psychiatry Research*, *128*, 235-244. doi: 10.1016éj.psychres.20040.7.003

Markham, R., & Adams, K. (1992). The effect of type of task on children`s identification of facial expressions. *Journal of Nonverbal Behavior*, *16*(1), 21-39. doi: 10.1007/BF00986877

Marsh, A. A., Kozak, M. N., & Ambady, N. (2007). Accurate identification of fear facial expressions predicts prosocial behaviour. *Emotion*, *7*(2), 239-251. doi: 10.1037/1528-3542.7.2.239

Matsumoto, D., & Sung Hwang, H. (2011). Judgments of facial expressions of emotion in profile. *Emotion*, *11*(5), 1223-1229. doi: 10.1037/a0024356

Matsumoto, D., Olide, A., Schug, J., and Willingham, M. C. (2009). Cross-cultural judgments of spontaneous facial expressions of emotion. *Journal of Nonverbal Behavior, 33*, 213-238. doi: 10.1007s10919-009-0071-4

Matsumoto, D., Keltner, D., Shiota, M. N., O'Sullivan, M., & Frank, M. (2008). Facial expressions of emotion. In M. Lewis, J. M. Haviland-Jones, & L.F. Barrett (Eds.), *Handbook of Emotions, Third Edition* (pp. 211-234). New York, NY: The Guilford Press.

Maurer, D., & Salapatek, P. (1976). Developmental changes in the scanning of faces by young infants. *Child Development*, *47*(2), 523-527.

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotional experience, behavior, and physiology. *Emotion*, *5*(2), 175-190. doi: 10.1037/1528-3542.5.2.1755

Moses, L. J., Baldwin, J. C., and Tidball, G. (2001). Evidence for referential understanding in the emotions domain at twelve and eighteen months. *Child Development*, *72*(3), 718-735. doi: 10.1111/1467-8624.00311

Murphy, K., McKone, E., and Slee, J. (2003). Dissociations between implicit and explicit memory in children: The role of strategic processing and the knowledge base. *Journal of Experimental Child Psychology*, *84*, 124-165. doi: 10.1016/S0022-0965(03)00002-X

Nelson, C. A. (2001). The development and neural bases of face recognition. *Infant and Child Development*, *10*, 3-8, doi: 10.1002/icd.239

Nelson, N. L., & Russell, J. A. Universality revisited. *Emotion Review*, 5, 1, 8-15. doi: 10.1177/1754073912457227

Oaten, M., Stevenson, R. J., & Case, T. I. (2009). Disgust as a disease-avoidance mechanism. *Psychological Bulletin*, *135*(2), 303-321. doi: 10.1037/a0014823

Ohman, A. (2009). Of snakes and faces: An evolutionary perspective on the psychology of fear. *Scandinavian Journal of Psychology*, *50*, 543-552. doi: 10.1111/j.1467-9450.2009.00784.x

Parker, K. C., & Forrest, D. (1993). Attachment disorder: An emerging concern for school counselors. *Elementary School Guidance and Counseling*, *27*(3), 209-215.

Palermo, R., & Coltheart, M. (2004). Photographs of facial expression: Accuracy, response times, and ratings of intensity. *Behavior Research Methods, Instruments, & Computers*, *36*, 4, 634-636.

Perron, M., & Roy-Charland, A. (2013). Analysis of eye movements in the judgment of enjoyment and non-enjoyment smiles. *Frontiers in Psychology*, *4*, 1-11.

Phillips, A. T., Wellman, H. M., and Spelke, E. S. (2002). Infants' ability to connect gaze and emotional expression to intentional action. *Cognition*, *85*, 53-78. doi: 10.1016/S0010-0277(02)00073-2

Pratikaki, A., Germanakis, I., & Kokkinaki, T. (2001). Basic aspects of infant-grandparent ‘interaction’: An eight-month longitudinal and naturalistic study. *Early Child Development and Care*, *181*(9), 1231-1245. doi: 10.1080/3004430.2010.523784

Pruett, J. R., Hoertel, S., Constantino, J. N., Moll, A. L., McVey, K., Squire, E., . . . & Petersen, S. E. (2013). Impaired eye region search accuracy in children with Autistic Spectrum Disorders. *PLOS ONE*, *8*(3), e58167.

Reisenzein, R., Studtmann, M., & Horstmann, G. (2013). Coherence between emotion and facial expression: Evidence from laboratory experiments. *Emotion Review, 5*(1), 16-23. doi: 10.1177/1754073912457228

Robson, K. S. (1967). The role of eye-to-eye contact in maternal-infant attachment. *Journal of Child Psychology and Psychiatry*, *8*, 13-25.

Roy-Charland, A., Perron, M., Beaudry, O., & Eady, K. (in revision). Confusion of fear and surprise: A test of the perceptual-attentional limitations hypothesis with eye movement monitoring. *Cognition and Emotion.*

Rayner, K. (2009). Eye movements and attention in reading, scene perception, and visual search. *The Quarterly Journal of Experimental Psychology*, *62*(8), 1457-1506. doi: 10.1080/17470210902816461

Rolls, E. T. (2007). *Emotion Explained*. New York, NY: Oxford University Press.

Rose, S. A., Djukic, A., Jankowski, J. J., Feldman, J., Fishman, I., & Valicenti-McDermott, M. V. (2013). Rett syndrome: an eyetracking study of attention and recognition memory. *Developmental Medicine & Child Neurology*, 364-371. doi: 10.1111/dmcn.12085

Russell, J. A., & Widen, S. C. (2002). Words versus faces in evoking preschool children's knowledge of the causes of emotion. *International Journal of Behavioral Development*, *26*(2), 97-103. doi: 10.108001650250042000582

Sander, D., & Scherer, K. R. (2009). Traité de psychologie des émotions. Paris, France: Dunod.

Schwarzer, G., & Jovanovic, B. (2010). The relationship between processing facial identity and emotional expresion in 8-month-old infants. *Infancy, 15*(1), 28-45. doi: 10.1111/j.1532-7078.2009.00004.x

Schwarzer, G., Huber, S., & Dummler, T. (2005). Gaze behavior in analytical and holistic face processing. *Memory & Cognition*, *33*(2), 344-354. doi: 10.3758/BF03195322

Semenov, L. A., Chernova, N. D., & Bondarko, V. M. (2000). Measurement of visual acuity and crowding effect in 3-9-year-old children. *Human Physiology*, *26*(1), 16-20. doi: 10.1007/BF02760711

Solomon, R. C. (2008). The philosophy of emotions. In Lewis, M., Haviland-Jones, J. M., & L. F. Barrett (Eds.), *Handbook of Emotions* (pp. 3-16). New York, NY: The Guilford Press.

Sweeny, T. D., Suzuki, S., Grabowecky, M., & Paller, K. A. (2013). Detecting and categorizing fleeting emotions in faces. *Emotion*, *13*(1), 76-91. doi: 10.1037/a0029193

Szekely, E., Arends, L. R., Verhulst, F. C., Tiemeier, H., Jaddoe, V. W. V., Hofman, A., & Herba, C. M. (2011). Recognition of facial expressions of emotion by 3-year olds. *Emotion*, *11*(2), 425-435. doi: 10.1037/a0022587

Tooby, J., & Cosmides, L. (2008). The evolutionary psychology of the emotions and their relationship to internal regulatory variables. In M. Lewis, J. M. Haviland-Jones, & Barrett, L. F. *Handbook of Emotions, Third Edition* (pp. 114-137). New York, NY: The Guilford Press.

Tracy, J. L., & Robbins, R. W. (2008). The automaticity of emotion recognition. *Emotion*, *8*, 81-95. doi: 10.1037/1528-3542.8.1.81

Van der Geest, J. N., Kemner, C., Verbaten, M. N., & van Engeland, H. (2002). Gaze behavior of children with pervasive developmental disorder towards human faces: a fixation time study. doi: 10.1111/1469-7610.00055

Walker-Andrews, A., Krogh-Jespersen, S., Mayhew, E. M. Y., & Coffield, C. N. (2011). Young infants' generalization of emotional expressions: Effects of familiarity. *Emotion*, *11*(4), 842-851. doi: 10.1037/a0024435

Waller, B. M., Cray, J. Jr., & Burrows, A. M. (2008). Selection for universal facial emotion. *Emotion*, *8*(3), 435-439. doi: 10.1037/1528-3542.8.3.435

Widen, S. C. (2013). Children's interpretation of facial expressions: The long path from valence-based to specific discrete categories. *Emotion Review*, *5*(1), 72-77. doi: 10.1177/1754073912451492

Widen, S. C., & Russell, J. A. (2002). Gender and preschoolers' perception of emotion. *Merrill-Palmer Quarterly*,*48*, 3, 248-262. doi: 10.1353/mpq.2002.0013

Widen, S. C., & Russell, J. A. (2003). A closer look at preschooler's freely produced labels for facial expressions. *Developmental Psychology*, *39*(1), 114-128. doi: 10.1037/0012-1649.39.1.114

Widen, S. C., & Russell, J. A. (2004). The relative power of an emotion's facial expression, label, and behavioral consequence to evoke preschoolers' knowledge of its cause. *Cognitive Development*, *19*, 111-125. doi: 10.1016/j.cogdev.2003.11.004

Widen, S. C., & Russell, J. A. (2008). Children's and adults' understanding of the "disgust face". *Cognition and Emotion*, *22*(8), 1513-1541. doi: 10.1080/02699930801906744

Widen, S. C., and Russell, J. A. (2010a). Differentiation in preschooler's categories of emotion. *Emotion*, *10*(5), 651-661. doi: 10.1037/a0019005

Widen, S. C., & Russell, J. A. (2010b). The "disgust face" conveys anger to children. *Emotion*, *10*(4), 455-466. doi: 10.1037/a0019151

Widen, S. C., & Russell, J. A. (2013). Children's recognition of disgust in others. *Psychological Bulletin*, *139*(2), 271-299. doi: 10.1037/a0031640

Wiggers, M. (1982). Judgments of facial expressions of emotion predicted from facial behavior. *Journal of Nonverbal Behavior*, *7*(2), 101-116. doi: 0191-5886/82/1600-0101

Whalen, P. J., Rauch, S. L., Etcoff, N. L., McInerney, S. C., Lee, M. B., & Jenike, M. A. (1998). Masked presentation of emotional facial expressions modulate amygdala activity without explicit knowledge. *The Journal of Neuroscience*, *18*,(1), 411-418.

Winkielman, P., Berridge, K. C., Wilbarger, J. L. (2005). Unconscious affective reactions to masked happy versus angry faces influence consumption behavior and judgments of value. *Personality and Social Psychology Bulletin*, *31*, 1, 121-134. doi: 10.1177/0146167204271309

CONFUSION OF FEAR-SURPRISE AND DISGUST-ANGER IN CHILDREN

Appendix A: Description of Action Units

Number	FACS Name	Description
1	Inner Brow Raiser	Raising the inner portion of the eyebrows
2	Outer Brow Raiser	Raising the outer portion of the eyebrows
4	Brow Lowerer	Furrowing the eyebrows, bringing them closer together
5	Upper Lid Raiser	Raising the upper eyelid, which reveals a larger area of the eyes
7	Lid Tightener	Raising of the lower eyelids
9	Nose Wrinkler	Pulling the nose upwards, wrinkling the nose
10	Upper Lip Raiser	Raising the upper lip, showing the upper teeth
16	Lower Lip Depressor	Pulling the lower lip downwards, showing the lower teeth
17	Chin Raiser	Pushing the lower lip and chin upwards
20	Lip Stretcher	Stretches the lips horizontally
22	Lip Funneler	Pushing the lips upwards, creating a funnel shape
23	Lip Tightener	Tensing of the lips, making them appear thin
24	Lip Pressor	Pressing the lips together
25	Lips Parts	Relaxing the mouth to allow the lips to open slightly
26	Jaw Drop	Dropping of the chin, which opens the mouth without stretching the lips