Categorical Perception of Emotional Facial Expressions in Video Clips with Natural and Artificial Actors: A Pilot Study

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Abstract

Objective: Facial emotion identification is an important and frequently studied cognitive ability that is of great interest in both the psychological research of typical development and the clinical research of the deviations and impairments occurring in psychiatric disorders such as autism spectrum disorders (ASD) and attention deficit/hyperactivity disorder (ADHD). Until recently, testing was done almost exclusively by means of static material (pictures, photographs). Only in the last years, with developing technical progress, dynamic material with natural actors (video clips) or artificially generated material has begun to be employed. For artificially generated material, however, the well-known morphing technique is of questionable value when assessed with Ekman's Facial Coding System (FACS). In other computer science areas such as computer graphics and/or animation, more adequate techniques have been developed and are eligible for use in basic research in both psychology and cognitive neuroscience. The main objective of this pilot study was to assess the feasibility of using such a new real-time animation system (the "Agent Framework" [AF] of the Institute of Animation, Visual Effects and Digital Postproduction of the Filmakademie Baden-Württemberg) by contrasting artificial actors to video clips of natural actors. In order to test the categorization performance of emotional facial expressions in a sample of children with typical development was compared to children with psychiatric disorders that are supposed to have impairments in emotion identification. Thus, feasibility was assessed from both a technological and from an empirical point of view.

Method: 13 children, aged 6-13 years, 7 of them typically developed, 4 with high-functioning ASD und 2 with ADHD, participated in the Dynamic Emotional Categorization Test (DECT) that was implemented in a standard experimental control program (Presentation®) with an interface to the real-time animation system AF. The DECT comprises material of 4 natural actors and 2 artificial actors displaying dynamic facial expressions of the six basic emotions (anger, disgust, fear, happiness, sadness, and surprise) on three intensity levels (weak, medium, and strong). Children had to categorize the presented video clips and animations in a six-alternative forced choice task with the six basic emotions as options.

Result: Technical and empirical feasibility could be demonstrated in this study as the implementation operated stable and properly, and the children were able to handle and categorize both the video clips with natural actors and the animations with the artificial actors. Accuracy data show that the videos and animations produced no floor or ceiling effects. Especially for the artificial actors, the three levels of intensity are better reflected in the accuracy data. Additionally, there are first hints that emotional facial identification can be assessed validly by using artificial actors.

Conclusions: These promising results suggest that the DECT will be applied in another study with a bigger sample, in which typically developed children, children with ASD and children with ADHD should be compared regarding their ability of categorizing emotional facial expressions. The use of animations in emotion identification will be decisively assessed and validated in this study. If validity can be assured, this real-time animation system with its describability, controllability and manipulability will offer new possibilities in basic empirical research and might also be a useful tool in diagnostic or therapeutic contexts.

1 Theoretical Background

Non-verbal behaviors are important indicators of emotional states or intentions of human beings (Harrigan, Rosenthal, & Scherer, 2005). Thus, essential information is only partly communicated by speech and language (Cohn & Ekman, 2005). It has been suggested that up to 80% of meaning in social interaction is conveyed through non-verbal processes (Thompson, 1973).

Human faces are the main source of information conveying emotional states and mediating social interactions (Gepner, Deruelle, & Grynfeltt, 2001). Facial expressions of emotions are the foundations of social interaction, as they convey vital non-verbal cues for inferences about the motivations and intentions of others (Darwin, 1872/2009).

According to Premack and Woodruff (1978) the recognition of facial expressions, as primary signals of emotional states, is one aspect of the "theory of mind" comprising cognitions in order to understand the behavior and experiences of others. Thus, the ability to accurately recognize the emotional expressions of others is essential for any successful social interaction (Ekman, Friesen, & Ellsworth, 1972).

By the age of 3 months typically developing infants can discriminate static displays of happy, sad, and surprised faces (Young-Browne, Rosenfeld, & Horowitz, 1977), while seven-month-old children are usually able to discriminate dynamic displays of happy and angry faces (Soken & Pick, 1992). By the age of four years, typically developed children are nearly perfect in categorizing prototypical displays of happiness, sadness, and anger, and are becoming better at recognizing fear and surprise (Widen & Russell, 2003). Ten-year-olds without disorders are able to discriminate emotional displays with the same accuracy as adults (Bruce et al., 2000).

The importance of accurate recognition and categorization of facial expressions of emotions for reciprocal communication and social interaction becomes dramatically evident when examining existing deviations or deficits. Impairments in processing facial expressions of emotions are reported for a wide range of disorders including attention deficit/hyperactivity disorder (ADHD), autism spectrum disorder (ASD), affective disorders, anxiety disorders, eating disorders and schizophrenia (see Table 1).

For the present technical report, we aimed at compiling studies working with emotional facial expressions as instruments for eliciting emotion processing deviations in different disorders. Therefore, we searched the databases PsycInfo and Medline for studies on facial emotion recognition by looking for articles referring to “emotion” in their title and/or abstract, that were published between the years 2000 and 2009. We used the following combination of keywords: (1) Emotion AND Recognition, (2) Dynamic AND Emotion AND Recognition, (3) Emotion AND Perception, or (4) Dynamic AND Emotion AND Perception. In order to consider the different disorders linked with deficits in emotion recognition, the total list of studies was reduced to those containing samples of (1) affective disorders, (2) ADHD, (3) anxiety disorders, (4) ASD, (5) eating disorders, or (6) schizophrenia. A total of 52 studies was extracted and categorized (see Table 1). The difficulties in emotion recognition are diverse and multi-faceted due to the core symptomatologies of these disorders.

ASD: A central criterion among the three diagnostic symptom categories (qualitative impairment in social interaction, qualitative impairments in communication, and restricted repetitive and stereotyped patterns of behavior, interests and activities) of autism spectrum disorders is the presence of significant social impairments (American Psychiatric Association, 2000) as can be assessed by abnormal eye-to-eye contact, deficient recognition of facial expression, body postures as well as speech prosody (e.g., Attwood, Frith, & Hermelin, 1988; Korpilahti et al., 2007; Macdonald, Rutter, Howlin, & Rios, 1989).

ADHD: This disorder is mainly characterized by impulsivity, inattention, and hyperactivity (American Psychiatric Association, 2000). Children with ADHD also suffer from cognitive impairments, e.g., executive dysfunctioning such as insufficient inhibition, and increased intra-subject variability (Klein, Wendling, Huettner, Ruder, & Peper, 2006). Although it is not a diagnostic criterion, deficits in emotion understanding are a common feature of the disorder (Yuill & Lyon, 2007).

Eating disorders: Recent empirical data indicates that patients with anorexia and bulimia nervosa have deficits in facial emotion recognition and alexithymia (Parker, Taylor, & Bagby, 1993; Pollatos, Herbert, Schandry, & Gramann, 2008; Zonnevijlle-Bendek, van Goozen, Cohen-Kettenis, van Elburg, & van Engeland, 2002). As part of the problems in all areas of social relations (Böhle, Jörn von Wietersheim, Wilke, & Feiereis, 1991), patients fulfilling the DSM-IV criteria for bulimia nervosa or anorexia nervosa show an impaired development of emotion recognition skills (Kessler, Schwarze, Filipic, Traue, & von Wietersheim, 2006).

Affective disorders: It has been reported that interpersonal factors and deficits in social interaction are decisive for the development and maintenance of depression (Hammen, 1997; Joiner & Timmons, 2009). Impairments in processing emotional information and misinterpretation of social cues have been examined in the majority of studies about depression using facial stimuli (Csukly, Czobor, Szily, Takács, & Simon, 2009; Feinberg, Rifkin, Schaffer, & Walker, 1986; Joormann & Gotlib, 2006; Surguladze u. a., 2004).

Anxiety disorder: Cognitive models of social phobia are based on the assumption that dysfunctional beliefs and fears about evaluation in social situations produce an enhanced attention to sources of potential threat, particularly social threat (Beck, Emery, & Greenberg, 2005; Clark, 2005; Hope, Rapee, Heimberg, & Dombeck, 1990; Maidenberg, Chen, Craske, & Bohn, 1996; Rapee & Heimberg, 1997). In particular, social phobia has been associated clinically with the avoidance of eye contact (Greist, 1995; Marks, 1969; Öhman, 1986), and individuals with social phobia reveal enhanced recognition of negative facial expressions (Foa, Gilboa-Schechtman, Amir, & Freshman, 2000; Lundh & Öst, 1996).

Schizophrenia: Deficits in the recognition of facial emotion in patients with schizophrenia are pointed out in many studies (Addington & Addington, 1998; Archer, Hay, & Young, 1994; Feinberg et al., 1986; Kee, Kern, & Green, 1998; Kohler, Bilker, Hagendoorn, Gur, & Gur, 2000; Salem, Kring, & Kerr, 1996; Schneider, Gur, Gur, & Shtasel, 1995; Walker, McGuire, & Bettes, 1984). These impairments in the categorization, discrimination and identification of facial stimuli appear to be partly related to a more general problem in cognitive functions also including deficits in working memory and attentional processes (Addington & Addington, 1998; Kee et al., 1998; Kohler et al., 2000). While their ability to identify happy facial stimuli is reaching performance levels of typical subjects, schizophrenia patients show impaired performance in recognition and categorization of negative facial emotions, especially for fear, disgust and anger (Archer, Hay, & Young, 1992; Bryson, Bell, Kaplan, Greig, & Lysaker, 1998; Kohler et al., 2003; Schneider et al., 1995).

As also can be seen in the presented literature, the neuroscience of emotion is probably a field of research that assigns a point of main effort to the study of facial expression. Due to the fact that one of the key sources of social interaction in daily life are dynamic facial cues (Yoshikawa & Sato, 2008), one methodological limitation of the literature, as presented in Table 1, is that the vast majority of studies uses static material. About 85% of the cited publications use photographs or drawings as stimulus material.

The application of static facial expressions, however, minimizes the complexity and ambiguity of social challenges, leading to a low degree of ecological validity (Klin, Jones, Schultz, Volkmar, & Cohen, 2002). Moreover, static stimuli are expected to be less effective in eliciting physiological reactions and are mute with respect to dynamic changes in affective states (Pelphrey, Morris, McCarthy, & LaBar, 2007).

The fact that facial motions are important for the perception and recognition of facial affect, and their role in facilitating the perception of faces and facial emotion has been demonstrated in both, very young infants and adults (Harwood, Hall, & Shinkfield, 1999; Nelson, 1987; Soken & Pick, 1992).

As a consequence of technological limitations using dynamic stimuli it is comprehensible that most of the older studies have been reliant on static material. However, with technological progress in computer science in general, and image processing and computer graphics in particular, new possibilities for empirical research arise. The morphing technique as a potentially useful method to produce dynamic stimuli is based on an algorithm that generates an image anywhere along the continuum from an image A to an image B, calculating correspondences between the pixels of the images. By this method, it is possible to map pixels on a segment in the destination image to pixels on the corresponding segment in the source image (Steyvers, 1999). Although this technique allows the generation of dynamic facial expressions it must be said that there are serious doubts that morphing conforms with the Facial Action Coding System (FACS) developed by Paul Ekman and colleagues (1976/2002), referring to action units combining physical contraction or relaxation of muscles in the human face. Thus, morphing techniques by far cannot reach the level of ecological validity displayed by real dynamic facial expressions.

Another source of stimulus material is the application of video clips displaying emotional facial expressions by natural actors. The use of natural actors makes it possible to present facial affect in a believable and appropriate form, enhancing ecological validity. A prerequisite is, however, that the facial displays of basic emotions are performed precisely and without any interfering or overlaying facial expression. Many natural actors, asked to display one of the six basic emotions, actually show heterogeneous facial emotions and tend to exaggerate or understate the intensity of their facial expression, due to the fact that the displayed emotion, after all, is still a "simulation" that does not reflect the real emotional state of the actor.

The motivation to use believable and ecologically valid facial basic emotions combined with the scalability and homogeneity of computer-generated animations led to a collaboration between the Research and Development Group (R&D group) of the Institute of Animation, Visual Effects and Digital Postproduction of the Filmakademie Baden-Württemberg and our research group. Under the direction of Project Lead Volker Helzle, the "Artificial Actors" - Project developed a tool-set generating sophisticated high-quality facial animation with natural, nonlinear, skin deformations. The "Adaptable Setup for Performance Driven Facial Animation" (AFS) builds one core component of this tool-set (Helzle, Biehn, Schlömer, & Linner, 2004). In the following project 'Dynamic real-time Animation', the R&D group did focus on the creation of an open source application framework "Frapper". Based on this foundation several techniques including the AFS approach along with ready to use characters ("Hank" and "Nikita") build the "Agent Framework" (AF). The main goal of this work is the development of character based real-time application prototypes. As such the developers at Filmakademie created a dedicated version of the Agent Framework. Embedding this software into the widely-used stimulus delivery and experimental control program Presentation® (Neurobehavioral Systems, Inc., Albany, CA) led to a computer-based experiment that we termed „Dynamic Emotion Categorization Test" (or DECT for short), a behavioral task to examine the ability of emotion recognition with dynamic facial stimuli.

Table 1

Studies investigating emotional facial expressions in clinical groups

Study	Data Rec.	Static	Dyn.	Stimulus Description
Affective Disorders				
Csukly et al. (2009)	B	x		Photos of faces (six basic emotions)
Derntl et al. (2009)	B	x		Colored photos of facial expressions (anger, disgust, fear, happiness, sadness and neutral)
Kan et al. (2004)	B		x	Videoclips of professional actors portraying one of six basic emotions (happiness, sadness, anger, fear, surprise, and disgust)
Langenecker et al. (2005)	B	x		Photos of happy, sad, fearful, angry and neutral faces
Lennox et al. (2004)	M	x		Morphed static photos of facial expression (happiness and sadness)
Malhi et al. (2007)	M	x		Static facial images (disgust, fear and neutral)
Montagne et al. (2007)	B		x	Morphed images of facial expressions (anger, sadness, happiness and disgust)
Ridout et al. (2007)	M		x	Videoclips of individuals portraying one of the six basic emotions
Summers et al. (2006)	B		x	Morphed images of six basic emotions (anger, sadness, happiness, fear, surprise and disgust)
Attention Deficit/Hyperactivity Disorder				
Boakes et al. (2008)	B	x	x	Static-Cartoon-Faces (six basic emotions), Static-Portrayal-Color-Pictures (six basic emotions), Dynamic-Face-Stimuli w supplemental context-cues, Dynamic-Face-Stimuli w/o context-cues
Brotman et al. (2008)	B	x		Standardized photos of children and adults (happiness, sadness, anger, fear)
Da Fonseca (2009)	B	x		Colored digitalized photos from popular French media magazines
Sinzig et al. (2008)	B	x		Photos of faces and eye-pairs (six basic emotions)
Williams et al. (2008)	E	x		B/w-pictures (anger, disgust, fear, happy, sad)
Anxiety Disorders				
Blair et al. (2008)	M	x		Morphed static photos of fearful angry and neutral faces
Foa et al. (2000)	B	x		Slides of individuals with fearful, angry and neutral emotional expressions
Horley et al. (2004)	T	x		Color-digitized photos of neutral, happy, sad and angry expressions
Joormann, et al. (2006)	B		x	Morphed photos of facial expressions (sad, angry, happy and fearful)
Simonian et al. (2001)	B	x		Photos of faces (neutral, sad, happy, fearful, angry, and disgusted)
Yoon et al. (2007)	M	x		Photos of faces (neutral, sad, happy, fearful, angry, and disgusted)
Autism Spectrum Disorders				
Ashwin et al. (2007)	M	x		B/w-photos of fearful faces
Baron-Cohen et al. (2001)	B	x		Photos of the eye area of the face.
Bölte et al. (2006)	M	x		Photos of whole faces and eye regions including seven fundamental affective states (happy, sad, angry, surprised, disgusted, fearful, and neutral)
Brent et al. (2004)	B	x		Photos of the eye area of the face.
Deruelle (2008)	B	x		Photos of low-pass-filtered, high-pass-filtered and low/high-pass-filtered faces
Dziobek et al. (2006)	B	x	x	15 min movie about four characters getting together for a dinner party and photos which show only the eye area of the face.
Golan et al. (2008)	B		x	Short-scenes of socio-emotional interaction sampled from four children's feature films with expressions of complex emotions and mental states (e.g. relieved, guilty, lonely)
Greimel et al. (2009)	M,T	x		Photos, morphed to happy, sad and neutral faces.
Hernandez et al. (2009)	T	x		Photos of neutral, happy and sad virtual and natural faces.
Kätsyri et al. (2008)	B	x	x	Static grayscale pictures of natural actors with none, slight and strong low-pass-filtering (anger, disgust, fear, happiness), dynamic video sequences of natural actors with none, slight and strong low-pass-filtering (anger, disgust, fear, happiness),
Klin et al. (2002)	T		x	Digitized videotape clips of complex social situations of the movie "Who's Afraid of Virginia Woolf?"
Kuusikko et al. (2009)	B	x		B/w-pictures (six basic emotions)
Miyahara et al.(2007)	B	x	x	Static animation faces (happiness & disgust); static real faces (happiness & disgust); Videoclips: Dynamic animated faces (happiness & disgust); Dynamic real faces (happiness & disgust)

Oberman et al. (2009)	E	x	Photos of faces (six basic emotions)
Pelphrey et al. (2002)	T	x	Photos of faces (six basic emotions)
Silani et al. (2008)	M	x	Pictures categorized into three types of stimuli: unpleasant, pleasant and neutral.
Spezio et al. (2007)	T	x	Facebubbles with randomly revealed selected facial images of basic emotions (fearful and happy). Photos of basic emotions (happiness, sadness, fear, anger, surprise, and disgust)
Sterling et al. (2008)	T	x	Digitized grayscaled photos of familiar and unfamiliar faces
Wright et al. (2008)	B	x	Photos of faces (six basic emotions)
			Photos of a central character showing a facial expression understandable in terms of the context (happy, frightened, angry, disgusted and surprised)
Eating Disorders			
Harrison et al. (2009)	B	x	Photos which show only the eye area of the face
Hassel et al. (2009)	M	x	Photos of happy and fearful faces
Kessler et al. (2006)	B	x	Photos of faces (six basic emotions)
Legenbauer et al. (2008)	B	x	Photos of each of the seven universal emotions (anger, contempt, disgust, fear, happiness, sadness, and surprise)
Pollatos et al. (2008)	E	x	Photos of faces (neutral, sad, happy, fearful, angry, and disgusted)
Zonnevijlle-Bendek et al. (2002)	B	x	Photos of each of the seven universal emotions (anger, contempt, disgust, fear, happiness, sadness, and surprise)
Schizophrenia			
Delaveau et al. (2007)	M	x	Color pictures of fearful and angry faces
Johnston et al. (2005)	M	x	Color photos of facial expressions (anger, disgust, fear, happiness, sadness and neutral)
Loughland et al. (2002)	T	x	Color photos (neutral, happy, sad)
Namiki et al. (2007)	M	x	Photos of faces (six basic emotions)
Norton et al. (2009)	B	x	Photos of happy and fearful faces
Pinkham et al. (2008)	B	x	Color photos of faces expressing one of four basic emotions (happiness, sadness, anger, neutral) by actors of different race,
Silver et al. (2001)	B	x	B/w-pictures (six basic emotions)

Note. B = Behavioral; E = EEG/EKP/EMG; T = Eye-Tracking; M = (functional) magnet resonance imaging;

2 Method

2.1 Participants

Thirteen children, 10 males and 3 females in the age range from 8;0 to 12;11 years and with an IQ > 80, who participated in the research project "Cognitive development and related neurophysiological and neuroanatomical changes in typically and atypically developing children" (http://www.uniklinik-freiburg.de/fbi/live/forschung/cogn-develop_en.html), were asked to accomplish the DECT at the end of the project test battery. Out of the 13 children, 7 were typically developing (TD), 4 had a diagnosis of ASD (ICD-10: 1 x F84.0, 2 x F84.1, and 1 x F84.5), and 2 had a diagnosis of ADHD (ICD-10: 2 x F90.1). Children and their parents gave their written consent. The study was approved by the local ethics committee under No. 241/07. As compensation for participation, children were given a voucher for the cinema.

2.2 Materials

Video clips of natural actors and animations of artificial actors for the Dynamic Emotion Categorization Test (DECT)

Eleven students (3 male, 8 female) volunteered to pose as actors for emotional facial expressions. Each actor was instructed to mimic a basic emotion at a stated level of intensity. For all actors, video clips of the six basic emotions (anger, disgust, fear, happiness, sadness, and surprise) with three levels of intensity (weak, medium, strong) were produced, resulting in 6 x 3 = 18 video clips for each actor. A certified FACS coder screened the video clips for consistency with the FACS, and the best two actors from each gender group were selected for the DECT (see screenshots of the selected actors in Appendix A).

For the artificial actors, one actor (“Hank”) and one actress (“Nikita”) were designed and 18 “plain” animations according to the same scheme as with the natural actors (6 basic emotions with 3 intensity levels, each) were specified with the Agent Framework (AF; see screenshots of the artificial actors in Appendix A). For further testing purposes, some additional 18 “artistically augmented” animations (including head and body movements) were constructed for “Hank”.

Each video clip or animation lasted for 6 s, whereby for the first 3 s the corresponding face was neutral and then started to progress into the emotional expression. This was done in order to give the participant enough time to get familiar with the (neutral) face of the presented actor.

DECT Implementation

Since Presentation®—one of the leading experimental generator software in experimental psychology and cognitive neuroscience—is used as standard stimulus delivery program in our research group, we aimed at connecting it with the AF. By means of Presentation®’s Extension Manager and the MatLab Workspace extension, the R&D group was able to create a real-time shared memory interface to the AF, being able to start animations from Presentation® and collect data from the AF. A drawback of this implementation, however, was that direct interfacing to the graphics adapter was not possible. Therefore, a reduced display of 500 x 667 pixels was necessary in order to get smooth animations.

In the beginning, the DECT contains seven practice trials (with video clips of the seven sorted-out actors) followed by the 108 video clips or animations. The main trials were divided into 18 blocks with videos/animations of the six actors. Facial emotion type and intensity level were distributed in a pseudo-randomized manner with the restriction that in one block of trials all 6 basic emotions were realized exactly once, and each intensity level (weak, medium, strong) exactly twice. Due to the different object classes of video clips and animations in Presentation®, the sequence of trials had to be fixed for all participants.

2.3 Procedure

After being instructed and after passing the seven practice trials, the participant had to process the 108 main trials. One trial consisted of a fixation cross, and after pressing a key the video clip/animation started and after 6 s was followed by a response screen that displayed the six basic emotions via photographs and the labels for the six basic emotions in German language. Both, photographs and words were shown in order to allow also very young children or children with reading difficulties to choose one of the six alternatives. After having said or pointed to a photograph, the experimenter pressed the corresponding key. Thus, chosen answer and time to decision was recorded. The sequence of events can be seen in Figure 1.

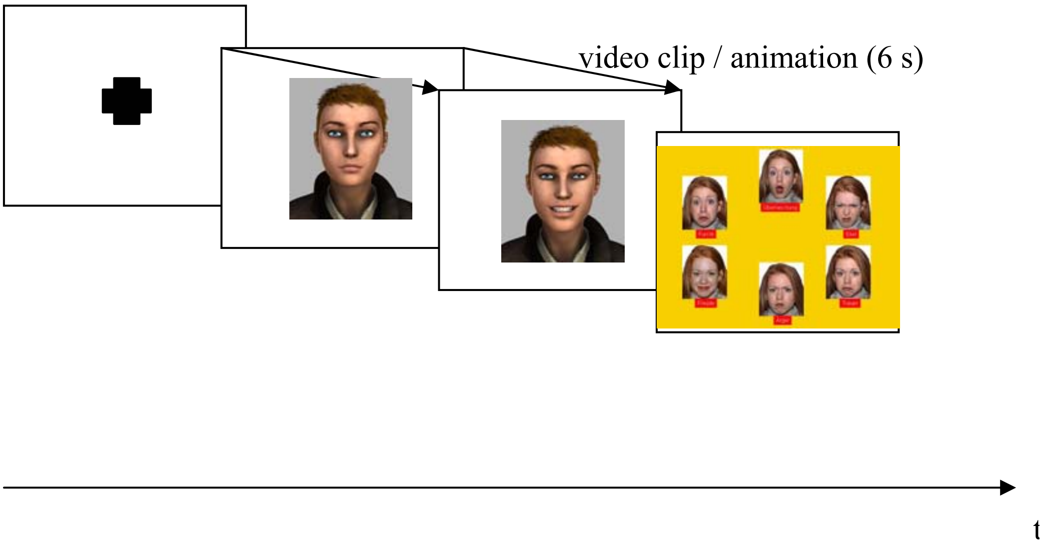

Figure 1. Sequence of events in one trial (here shown for happy "Nikita")

There was no time restriction for each trial. The total test takes approximately 20 min.

2.4 Design

The design consists of the following within-subjects factors: (1) facial emotion type with six levels (anger, disgust, fear, happiness, sadness, surprise); (2) level of intensity with three levels (weak, medium, strong); (3) type of actor with six levels (Actor1, Actor2, Actor3, Actor4, Hank, and Nikita). For alternative analyses, pooling the natural and the artificial actors into two groups of actors resulted in two levels (natural, artificial).

Since this is a pilot study with few observations, no inferential statistics will be computed. Additionally, one between-subjects factor could be considered in principal, namely group with three levels (ADHD, ASD, and TD), but will be not considered in this pilot study for obvious reasons.

2.5 Results

Sample characteristics

The following Table 2 lists the characteristics of the participants, sorted by age at testing. Additionally, it is noted whether the respective participant succeeded to complete the DECT for all trials.

Table 2
List of participants and their characteristics

Participant ID	Gender[a]	Age[b]	Group	Complete Dataset?
P01	m	7;11	ASD	No
P02	f	8;1	TD	No
P03	f	8;4	TD	Yes
P04	f	8;6	TD	No
P05	m	9;5	TD	Yes
P06	m	9;10	ASD	No
P07	m	10;3	ADHD	Yes
P08	m	10;6	ASD	No
P09	m	11;4	TD	Yes
P10	m	11;9	ASD	No
P11	m	12;3	TD	Yes
P12	m	12;4	TD	Yes
P13	m	12;10	ADHD	Yes

Note. [a]m/f = male/female; [b]in years;months; ADHD = Attention Deficit/Hyperactivity Disorder; ASD = Autism Spectrum Disorder; TD = Typically Development

Feasibility

From a technical point of view, the interaction of the Presentation® software and the AF was successful and stable throughout all 13 experimental sessions. From a developmental-experimental point of view, most but not all children were able and willing to accomplish all 108 main trials. The time needed to complete the test varied from 17 min to 25 min. For the drop-outs, there are hints that younger age (see P01, P02, and P04 in Table 2) and presence of clinical condition (especially ASD; see P01, P06, P08, and P10 in Table 2) were the causes of early terminations. Since application of the DECT for younger children (from 6 years onwards) is also planned in future studies, it seems reasonable to decrease the number of trials substantially.

Accuracy results for artificial and natural actors

The total accuracy is 53.2%, that is pretty above chance level (1/6 ≈ 16.7%). So, there are no floor and no ceiling effects. In Table 3, accuracy is given as percentages of correct answers. Accuracy data are additionally broken down by facial emotion type, level of intensity, and type of actor (natural vs. artificial). As can be seen for these two types, percentages are rather similar for the "strong" level of intensity with the exception of "disgust", "fear", and "sadness": For the former two, the natural actors outperform the artificial ones. A more detailed analysis revealed that the "artistically augmented" video clips of Hank led to rather low accuracy. Thus, these animations should be dropped for future applications or have to be worked over in order to be applied as useful test items. In the case of "sadness", this facial expression is identified more frequently for the artificial than for the natural actors.

Since in Table 3 all available data inclusive the drop-outs went into the analysis, cell frequencies are not equal for corresponding conditions and may distort accuracy data. Therefore, in Table 4, the same analysis is listed only for TD-children that successfully passed the DECT (P03, P05, P09, P11, and P12). However, the main pattern of results was the same except that the general level of accuracy is about 5% higher (58.7%) indicating that the children with ASD or ADHD have more difficulties in facial emotion identification—a finding that is consistent with the majority of the results reported in the literature.

Table 3
Percentage of correct responses (All available data: N=13)

		Weak	Medium	Strong	Total
Anger	N	23.9	35.0	25.0	27.7
	A	36.4	37.5	33.3	35.9
Disgust	N	68.8	75.5	86.0	76.4
	A	4.2	20.8	50.0	24.3
Fear	N	24.0	27.1	25.6	25.5
	A	13.0	13.6	4.2	10.1
Happiness	N	70.2	89.1	95.6	84.8
	A	86.4	95.8	100.0	94.2
Sadness	N	71.4	76.1	56.1	68.2
	A	58.3	56.5	76.2	63.2
Surprise	N	42.0	51.2	70.5	54.0
	A	40.9	47.4	75.0	55.4
Total	N	49.5	59.6	60.0	56.2
	A	39.4	45.6	56.8	47.2
	All	46.2	54.9	58.9	53.2

Note. N = Natural actors; A = Artificial actors

Table 4
Percentage of correct responses (Complete datasets of TD group: N=5)

		Weak	Medium	Strong	Total
Anger	N	25.0	50.0	30.0	35.0
	A	40.0	20.0	30.0	30.0
Disgust	N	85.0	85.0	95.0	88.3
	A	0.0	30.0	40.0	23.3
Fear	N	30.0	50.0	40.0	40.0
	A	20.0	10.0	0.0	10.0
Happiness	N	70.0	90.0	90.0	83.3
	A	100.0	90.0	100.0	96.7
Sadness	N	85.0	85.0	55.0	75.0
	A	50.0	50.0	90.0	63.3
Surprise	N	40.0	70.0	75.0	61.7
	A	50.0	60.0	90.0	66.7
Total	N	55.8	71.7	64.2	63.9
	A	43.3	43.3	58.3	48.3
	All	51.7	62.2	62.2	58.7

Note. N = Natural actors; A = Artificial actors

Another interesting result concerns the level of intensity: The graded structure from "weak" over "medium" to "strong" intensity corresponds to accuracy data more for the group of artificial actors than for the group of natural actors and also covers a wider range of accuracy values (see Table 3: Artificial actors: 39.4% → 45.6% → 56.8%; Natural actors: 49.5% → 59.6% → 60.0%). Looking at each type of facial emotion, this graded structure is unfortunately not very stable. Fine-tuning of the animations in the AF, however, should resolve this problem. For natural actors, improvements can be attained only by recording new video clips.

An important result that should be emphasized is that in the condition, where assessment of emotional state should be easiest (in the "strong" condition), accuracy data are nearly equally high (60.0% vs. 56.8% in Table 3; 64.2% vs. 58.3% in Table 4).

Actor assessment

In Table 5, the accuracy data totally as well as broken down by intensity level for the single actors can be found. Inspecting especially the column "strong", it can be seen that Actor2 has a rather low accuracy rate (48.4%) in comparison to his natural male counterpart Actor1 (62.5%). For the two natural female actors, it can be seen that the accuracy profile for Actor4 is more eligible than for Actor3. So, for a shorter version of the DECT, it seems reasonable to keep Actor1 and Actor4.

For "Hank" and "Nikita", the accuracy profile looks good. Maybe, some fine-tuning for the "strong" emotion types should be applied in order to get as high accuracy rates as Actor1 and Actor4.

Table 5
Percentage of correct responses (all available data: N=13)

	Weak	Medium	Strong	Total
Actor1, male	33.8	54.7	62.5	50.0
Actor2, male	37.0	55.3	48.4	46.9
Actor3, female	65.7	63.8	58.3	62.8
Actor4, female	63.6	65.1	70.3	66.3
Hank	40.6	41.8	57.6	46.5
Nikita	38.2	49.3	56.1	47.8
Total	46.2	54.9	58.9	53.2

Concurrent criterion-based validity

In order to evaluate whether the ability to categorize emotional facial expressions can be validly assessed by using artificial actors, the method of concurrent criterion-based validity was chosen from the set of validity methods of psychometrics.

Concurrent criterion-based validity was estimated with respect to accuracy for natural actors (i) on the basis of all 13 participants on the one hand, and (ii) on the basis of the group of TD with complete datasets on the other. The corresponding values are (i) $r = +.22$ and (ii) $r = +.64$. Whereas the first value is rather low (but may be biased because of different number of test items within participants), the latter value is reasonable high. As this big discrepancy shows, the sample size of the pilot study has turned out to be too small for a reliable estimation. For the final evaluation of concurrent criterion-based validity, a bigger sample is urgently needed.

3 Discussion / Conclusions

This pilot study has shown the following results: (1) The identification and categorization of emotional facial expressions has been an important area of research in the past, it is at present, and it will probably be in the future as well. (2) Categorization of emotional facial expressions attracts researchers from a general psychological point of view as well as clinical researchers and neuroscientists being interested in deviations, deficits and impairments occurring in certain clinical groups and disorders. (3) Until recently, the assessment of emotional facial expression abilities has mainly been conducted by using static pictures/photographs and is only now extending to dynamic material that has higher ecological validity. (4) Creation of dynamic material by the technique of “morphing” has been applied in several studies, but suffers from several disadvantages (e.g., limited to 2D bitmap images, questionable FACS consistency). (5) However, more emotion-theory adequate modelings, which can be incorporated in classical experimental settings of psychological research, have become available from computer science and computer graphics. Such a system, namely the AF, was successfully tested for its technical and empirical feasibility in typically developing children and also in children with disorders that are suspected to suffer from impairments in emotion recognition. However, certain improvements can be and have to be made: Some animations should be fine-tuned. In order to test younger children as well, the number of items has to be reduced. From a technological point of view, it would be desirable to display the animation in full screen mode—thus entailing a direct interfacing between Presentation® and the graphics adapter.

Given the validity of facial emotion identification with animated artificial actors—an issue that has to be decisively evaluated in future studies—one can think of many further types of studies bearing upon the precise describability, controllability and manipulability of these animations. First of all, one would like to generalize results to other faces (e.g., with different facial properties, with different ages, with different ethnic origins, …), to other emotions than the basic ones, and to situations in which emotional faces change from one type to another one. Since the integration of the AF system with prominent stimulus delivery and experimental control programs has been successful, extensions to studies using data recordings from eye-trackers, EEG or fMRI should be manageable.

As a diagnostic tool, one could take advantage of the manipulability of the real-time system in order to allow for tailored testing, i.e. the difficulty of generated animations varies in dependence of the accuracy of already passed tasks. Therapeutic application is conceivable as well—maybe also in an adaptable manner.

In sum, there are still some problems that have to be solved or are to be optimized, yet this technology seems to be the best compromise of empirical adequacy and possibilities to generate and manipulate dynamic stimulus material, and therefore it is a promising step for future research of testing the categorization abilities of emotional facial expressions.

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4 References

Addington, J., & Addington, D. (1998). Facial affect recognition and information processing in schizophrenia and bipolar disorder. *Schizophrenia Research*, *32*(3), 171-181.

American Psychiatric Association (2000). *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed, Text Revision. Washington: American Psychiatric Association.

Archer, J., Hay, D. C., & Young, A. W. (1992). Face processing in psychiatric conditions. *British Journal of Clinical Psychology*, *31*(1), 45-61.

Archer, J., Hay, D. C., & Young, A. W. (1994). Movement, face processing, and schizophrenia: Evidence of a differential deficit in expression analysis. *British Journal of Clinical Psychology*, *33*(4), 517-528.

Ashwin, C., Baron-Cohen, S., Wheelwright, S., O'Riordan, M., & Bullmore, E. T. (2007). Differential activation of the amygdala and the 'social brain' during fearful face-processing in Asperger Syndrome. *Neuropsychologia*, *45*(1), 2-14.

Attwood, A., Frith, U., & Hermelin, B. (1988). The understanding and use of interpersonal gestures by autistic and Down's syndrome children. *Journal of Autism and Developmental Disorders*, *18*(2), 241-257.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The 'Reading the mind in the eyes' Test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry*, *42*(2), 241-251.

Beck, A. T., Emery, G., & Greenberg, R. L. (2005). *Anxiety disorders and phobias: A cognitive perspective.* New York: Basic Books.

Blair, K., Shaywitz, J., Smith, B. W., Rhodes, R., Geraci, M., Jones, M., McCaffrey, D., et al. (2008). Response to emotional expressions in generalized social phobia and generalized anxiety disorder: Evidence for separate disorders. *American Journal of Psychiatry*, *165*(9), 1193-1202.

Boakes, J., Chapman, E., Houghton, S., & West, J. (2008). Facial affect interpretation in boys with attention deficit/hyperactivity disorder. *Child Neuropsychology*, *14*(1), 82-96.

Böhle, A., von Wietersheim, J., Wilke, E., & Feiereis, H. (1991). Die soziale Integration von Patientinnen mit Anorexia nervosa und Bulimie. *Zeitschrift für Psychosomatische Medizin und Psychoanalyse*, *37*(3), 282-291.

Bölte, S., Hubl, D., Feineis-Matthews, S., Prvulovic, D., Dierks, T., & Poustka, F. (2006). Facial affect recognition training in autism: Can we animate the fusiform gyrus? *Behavioral Neuroscience*, *120*(1), 211-216.

Brent, E., Rios, P., Happé, F., & Charman, T. (2004). Performance of children with autism spectrum disorder on advanced theory of mind tasks. *Autism*, *8*(3), 283-299.

Brotman, M. A., Guyer, A. E., Lawson, E. S., Horsey, S. E., Rich, B. A., Dickstein, D. P., Pine, D. S., et al. (2008). Facial emotion labeling deficits in children and adolescents at risk for bipolar disorder. *American Journal of Psychiatry*, *165*(3), 385-389.

Bruce, V., Campbell, R. N., Doherty-Sneddon, G., Import, A., Langton, S., McAuley, S., & Wright, R. (2000). Testing face processing skills in children. *British Journal of Developmental Psychology*, *18*(3), 319-333.

Bryson, G., Bell, M., Kaplan, E., Greig, T., & Lysaker, P. (1998). Affect recognition in deficit syndrome schizophrenia. *Psychiatry Research*, *77*(2), 113-120.

Clark, D. M. (2005). A cognitive perspective on social phobia. In W. R. Crozier & L. E. Alden (eds.). *The essential handbook of social anxiety for clinicians* (pp. 193-218). West-Sussex: John Wiley.

Cohn, J. F., & Ekman, P. (2005). Measuring facial action. In J. A. Harrigan, R. Rosenthal, & K. R. Scherer (eds.). *The new handbook of methods in nonverbal behavior research.* (pp. 9-64). Oxford: University Press.

Csukly, G., Czobor, P., Szily, E., Takács, B., & Simon, L. (2009). Facial expression recognition in depressed subjects: The impact of intensity level and arousal dimension. *Journal of Nervous and Mental Disease*, *197*(2), 98-103.

Da Fonseca, D., Seguier, V., Santos, A., Poinso, F., & Deruelle, C. (2009). Emotion understanding in children with ADHD. *Child Psychiatry and Human Development*, *40*(1), 111-121.
Darwin, C. (2009). *The Expression of the Emotions in Man and Animals* (Anniversary.). Oxford: University Press. (Original work published 1872).
Delaveau, P., Salgado-Pineda, P., Micallef-Roll, J., & Blin, O. (2007). Amygdala activation modulated by levodopa during emotional recognition processing in healthy volunteers: A double-blind, placebo-controlled study. *Journal of Clinical Psychopharmacology*, *27*(6), 692-697.
Derntl, B., Seidel, E., Kryspin-Exner, I., Hasmann, A., & Dobmeier, M. (2009). Facial emotion recognition in patients with bipolar I and bipolar II disorder. *British Journal of Clinical Psychology*, *48*(4), 363-375.
Deruelle, C., Rondan, C., Salle-Collemiche, X., Bastard-Rosset, D., & Da Fonséca, D. (2008). Attention to low- and high-spatial frequencies in categorizing facial identities, emotions and gender in children with autism. *Brain and Cognition*, *66*(2), 115-123.
Dziobek, I., Fleck, S., Kalbe, E., Rogers, K., Hassenstab, J., Brand, M., Kessler, J., Woike, J. K., Wolf, O. T., & Convit, A. (2006). Introducing MASC: A movie for the assessment of social cognition. *Journal of Autism and Developmental Disorders*, *36*(5), 623-636.
Ekman, P., Friesen, W. V., & Ellsworth, P. (1972). *Emotion in the human face: Guidelines for research and an integration of findings.* New York: Pergamon Press.
Ekman, P., Friesen, W. V., & Hager, J. C. (2002). *Facial Action Coding System*. Salt Lake City: A Human Face. (Original work published 1976).
Feinberg, T. E., Rifkin, A., Schaffer, C., & Walker, E. (1986). Facial discrimination and emotional recognition in schizophrenia and affective disorders. *Archives of General Psychiatry*, *43*(3), 276-279.
Foa, E. B., Gilboa-Schechtman, E., Amir, N., & Freshman, M. (2000). Memory bias in generalized social phobia: Remembering negative emotional expressions. *Journal of Anxiety Disorders*, *14*(5), 501-519.
Gepner, B., Deruelle, C., & Grynfeltt, S. (2001). Motion and emotion: A novel approach to the study of face processing by young autistic children. *Journal of Autism and Developmental Disorders*, *31*(1), 37-45.
Golan, O., Baron-Cohen, S., & Golan, Y. (2008). The 'Reading the Mind in Films' Task [Child version]: Complex emotion and mental state recognition in children with and without autism spectrum conditions. *Journal of Autism and Developmental Disorders*, *38*(8), 1534-1541.
Greimel, E., Schulte-Rüther, M., Kircher, T., Kamp-Becker, I., Remschmidt, H., Fink, G. R., Herpertz-Dahlmann, B., & Konrad, K. (2009). Neural mechanisms of empathy in adolescents with autism spectrum disorder and their fathers. *NeuroImage*, in press. Epub ahead of print retrieved September 2, 2009.
Greist, J. H. (1995). The diagnosis of social phobia. *Journal of Clinical Psychiatry*, *56*(Suppl 5), 5-12.
Hammen, C. (1997). *Depression.* London: Psychology Press.
Harrigan, J. A., Rosenthal, R., & Scherer, K. R. (Eds.). (2005). The new handbook of methods in nonverbal behavior research. Oxford: University Press.
Harrison, A., Sullivan, S., Tchanturia, K., & Treasure, J. (2009). Emotion recognition and regulation in anorexia nervosa. *Clinical Psychology & Psychotherapy*, *16*(4), 348-356.
Harwood, N. K., Hall, L. J., & Shinkfield, A. J. (1999). Recognition of facial emotional expressions from moving and static displays by individuals with mental retardation. *American Journal on Mental Retardation*, *104*(3), 270-278.
Hassel, S., Almeida, J. R., Frank, E., Versace, A., Nau, S. A., Klein, C. R., Kupfer, D. J., et al. (2009). Prefrontal cortical and striatal activity to happy and fear faces in bipolar disorder is associated with comorbid substance abuse and eating disorder. *Journal of Affective Disorders*, *118*(1-3), 19-27.
Helzle, V., Biehn, C., Schlömer, T., & Linner, F. (2004). Adaptable setup for performance driven facial animation (p. 54). Los Angeles, California: ACM.
Hernandez, N., Metzger, A., Magné, R., Bonnet-Brilhault, F., Roux, S., Barthelemy, C., & Martineau, J. (2009). Exploration of core features of a human face by healthy and autistic adults analyzed by visual scanning. *Neuropsychologia*, *47*(4), 1004-1012.
Hope, D. A., Rapee, R. M., Heimberg, R. G., & Dombeck, M. J. (1990). Representations of the self in social phobia: Vulnerability to social threat. *Cognitive Therapy and Research*, *14*(2), 177-189.
Horley, K., Williams, L. M., Gonsalvez, C., & Gordon, E. (2004). Face to face: Visual scanpath evidence for abnormal processing of facial expressions in social phobia. *Psychiatry Research*, *127*(1-2), 43-53.
Johnston, P. J., Stojanov, W., Devir, H., & Schall, U. (2005). Functional MRI of facial emotion recognition deficits in schizophrenia and their electrophysiological correlates. *European Journal of Neuroscience*, *22*(5), 1221-1232.
Joiner, T. E., & Timmons, K. A. (2009). Depression in its interpersonal context. In I. H. Gotlib & C. L. Hammen (Eds.). *Handbook of depression (2nd ed.)* (pp. 322-339). New York: Guildford Press.
Joormann, J., & Gotlib, I. H. (2006). Is this happiness I see? Biases in the identification of emotional facial expressions in depression and social phobia. *Journal of Abnormal Psychology*, *115*(4), 705-714.

Kan, Y., Mimura, M., Kamijima, K., & Kawamura, M. (2004). Recognition of emotion from moving facial and prosodic stimuli in depressed patients. *Journal of Neurology, Neurosurgery & Psychiatry*, *75*(12), 1667-1671.

Kätsyri, J., & Sams, M. (2008). The effect of dynamics on identifying basic emotions from synthetic and natural faces. *International Journal of Human-Computer Studies*, *66*(4), 233-242.

Kee, K. S., Kern, R. S., & Green, M. F. (1998). Perception of emotion and neurocognitive functioning in schizophrenia: What's the link? *Psychiatry Research*, *81*(1), 57-65.

Kessler, H., Schwarze, M., Filipic, S., Traue, H. C., & von Wietersheim, J. (2006). Alexithymia and facial emotion recognition in patients with eating disorders. *International Journal of Eating Disorders*, *39*(3), 245-251.

Klein, C., Wendling, K., Huettner, P., Ruder, H., & Peper, M. (2006). Intra-Subject Variability in Attention-Deficit Hyperactivity Disorder. *Biological Psychiatry*, *60*(10), 1088-1097.

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry*, *59*(9), 809-816.

Kohler, C. G., Bilker, W., Hagendoorn, M., Gur, R. E., & Gur, R. C. (2000). Emotion recognition deficit in schizophrenia: Association with symptomatology and cognition. *Biological Psychiatry*, *48*(2), 127-136.

Kohler, C. G., Turner, T. H., Bilker, W. B., Brensinger, C. M., Siegel, S. J., Kanes, S. J., Gur, R. E., & Gur, R. C. (2003). Facial emotion recognition in schizophrenia: Intensity effects and error pattern. *American Journal of Psychiatry*, *160*(10), 1768-1774.

Korpilahti, P., Jansson-Verkasalo, E., Mattila, M., Kuusikko, S., Suominen, K., Rytky, S., Pauls, D. L., et al. (2007). Processing of affective speech prosody is impaired in Asperger syndrome. *Journal of Autism and Developmental Disorders*, *37*(8), 1539-1549.

Kuusikko, S., Haapsamo, H., Jansson-Verkasalo, E., Hurtig, T., Mattila, M., Ebeling, H., Jussila, K., et al. (2009). Emotion recognition in children and adolescents with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *39*(6), 938-945.

Langenecker, S. A., Bieliauskas, L. A., Rapport, L. J., Zubieta, J., Wilde, E. A., & Berent, S. (2005). Face emotion perception and executive functioning deficits in depression. *Journal of Clinical and Experimental Neuropsychology*, *27*(3), 320-333.

Legenbauer, T., Vocks, S., & Rüddel, H. (2008). Emotion recognition, emotional awareness and cognitive bias in individuals with bulimia nervosa. *Journal of Clinical Psychology*, *64*(6), 687-702.

Lennox, B. R., Jacob, R., Calder, A. J., Lupson, V., & Bullmore, E. T. (2004). Behavioural and neurocognitive responses to sad facial affect are attenuated in patients with mania. *Psychological Medicine: A Journal of Research in Psychiatry and the Allied Sciences*, *34*(5), 795-802.

Loughland, C. M., Williams, L. M., & Gordon, E. (2002). Visual scanpaths to positive and negative facial emotions in an outpatient schizophrenia sample. *Schizophrenia Research*, *55*(1-2), 159-170.

Lundh, L., & Öst, L. (1996). Recognition bias for critical faces in social phobics. *Behaviour Research and Therapy*, *34*(10), 787-794.

Macdonald, H., Rutter, M., Howlin, P., & Rios, P. (1989). Recognition and expression of emotional cues by autistic and normal adults. *Journal of Child Psychology and Psychiatry*, *30*(6), 865-877.

Maidenberg, E., Chen, E., Craske, M., & Bohn, P. (1996). Specificity of attentional bias in panic disorder and social phobia. *Journal of Anxiety Disorders*, *10*(6), 529-541.

Malhi, G. S., Lagopoulos, J., Sachdev, P. S., Ivanovski, B., Shnier, R., & Ketter, T. (2007). Is a lack of disgust something to fear? A functional magnetic resonance imaging facial emotion recognition study in euthymic bipolar disorder patients. *Bipolar Disorders*, *9*(4), 345-357.

Marks, I. M. (1969). *Fears and phobias.* New York: Academic Press.

Miyahara, M., Bray, A., Tsujii, M., Fujita, C., & Sugiyama, T. (2007). Reaction time of facial affect recognition in Asperger's disorder for cartoon and real, static and moving faces. *Child Psychiatry and Human Development*, *38*(2), 121-134.

Montagne, B., Nys, G. M. S., Van Zandvoort, M. J. E., Kappelle, L. J., de Haan, E. H. F., & Kessels, R. P. C. (2007). The perception of emotional facial expressions in stroke patients with and without depression. *Acta Neuropsychiatrica*, *19*(5), 279-283.

Namiki, C., Hirao, K., Yamada, M., Hanakawa, T., Fukuyama, H., Hayashi, T., & Murai, T. (2007). Impaired facial emotion recognition and reduced amygdalar volume in schizophrenia. *Psychiatry Research: Neuroimaging*, *156*(1), 23-32.

Nelson, C. A. (1987). The recognition of facial expressions in the first two years of life: Mechanisms of development. *Child Development*, *58*(4), 889-909.

Norton, D., McBain, R., Holt, D. J., Ongur, D., & Chen, Y. (2009). Association of impaired facial affect recognition with basic facial and visual processing deficits in schizophrenia. *Biological Psychiatry*, *65*(12), 1094-1098.

Oberman, L. M., Winkielman, P., & Ramachandran, V. S. (2009). Slow echo: Facial EMG evidence for the delay of spontaneous, but not voluntary, emotional mimicry in children with autism spectrum disorders. *Developmental Science*, *12*(4), 510-520.

Öhman, A. (1986). Face the beast and fear the face: Animal and social fears as prototypes for evolutionary analyses of emotion. *Psychophysiology*, *23*(2), 123-145.

Parker, J. D., Taylor, G. J., & Bagby, R. M. (1993). Alexithymia and the recognition of facial expressions of emotion. *Psychotherapy and Psychosomatics*, *59*(3-4), 197-202.

Pelphrey, K. A., Morris, J. P., McCarthy, G., & LaBar, K. S. (2007). Perception of dynamic changes in facial affect and identity in autism. *Social Cognitive and Affective Neuroscience*, *2*(2), 140-149.

Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders*, *32*(4), 249-261.

Pinkham, A. E., Sasson, N. J., Calkins, M. E., Richard, J., Hughett, P., Gur, R. E., & Gur, R. C. (2008). The other-race effect in face processing among African American and Caucasian individuals with schizophrenia. *The American Journal of Psychiatry*, *165*(5), 639-645.

Pollatos, O., Herbert, B. M., Schandry, R., & Gramann, K. (2008). Impaired central processing of emotional faces in anorexia nervosa. *Psychosomatic Medicine*, *70*(6), 701-708.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences*, *1*(4), 515-526.

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy*, *35*(8), 741-756.

Ridout, N., O'Carroll, R. E., Dritschel, B., Christmas, D., Eljamel, M., & Matthews, K. (2007). Emotion recognition from dynamic emotional displays following anterior cingulotomy and anterior capsulotomy for chronic depression. *Neuropsychologia*, *45*(8), 1735-1743.

Salem, J. E., Kring, A. M., & Kerr, S. L. (1996). More evidence for generalized poor performance in facial emotion perception in schizophrenia. *Journal of Abnormal Psychology*, *105*(3), 480-483.

Schneider, F., Gur, R. C., Gur, R. E., & Shtasel, D. L. (1995). Emotional processing in schizophrenia: Neurobehavioral probes in relation to psychopathology. *Schizophrenia Research*, *17*(1), 67-75.

Silani, G., Bird, G., Brindley, R., Singer, T., Frith, C., & Frith, U. (2008). Levels of emotional awareness and autism: An fMRI study. *Social Neuroscience*, *3*(2), 97-112.

Silver, H., & Shlomo, N. (2001). Perception of facial emotions in chronic schizophrenia does not correlate with negative symptoms but correlates with cognitive and motor dysfunction. *Schizophrenia Research*, *52*(3), 265-273.

Simonian, S. J., Beidel, D. C., Turner, S. M., Berkes, J. L., & Long, J. H. (2001). Recognition of facial affect by children and adolescents diagnosed with social phobia. *Child Psychiatry and Human Development*, *32*(2), 137-145.

Sinzig, J., Morsch, D., & Lehmkuhl, G. (2008). Do hyperactivity, impulsivity and inattention have an impact on the ability of facial affect recognition in children with autism and ADHD? *European Child & Adolescent Psychiatry*, *17*(2), 63-72.

Soken, N. H., & Pick, A. D. (1992). Intermodal perception of happy and angry expressive behaviors by seven-month-old infants. *Child Development*, *63*(4), 787-795.

Spezio, M. L., Adolphs, R., Hurley, R. S. E., & Piven, J. (2007). Abnormal use of facial information in high-functioning autism. *Journal of Autism and Developmental Disorders*, *37*(5), 929-939.

Sterling, L., Dawson, G., Webb, S., Murias, M., Munson, J., Panagiotides, H., & Aylward, E. (2008). The role of face familiarity in eye tracking of faces by individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *38*(9), 1666-1675.

Steyvers, M. (1999). Morphing techniques for manipulating face images. *Behavior Research Methods, Instruments & Computers*, *31*(2), 359-369.

Summers, M., Papadopoulou, K., Bruno, S., Cipolotti, L., & Ron, M. A. (2006). Bipolar I and bipolar II disorder: Cognition and emotion processing. *Psychological Medicine: A Journal of Research in Psychiatry and the Allied Sciences*, *36*(12), 1799-1809.

Surguladze, S. A., Young, A. W., Senior, C., Brébion, G., Travis, M. J., & Phillips, M. L. (2004). Recognition accuracy and response bias to happy and sad facial expressions in patients with major depression. *Neuropsychology*, *18*(2), 212-218.

Thompson, J. J. (1973). *Beyond Words: Nonverbal Communication in the Classroom*. New York: Citation Press.

Walker, E., McGuire, M., & Bettes, B. (1984). Recognition and identification of facial stimuli by schizophrenics and patients with affective disorders. *British Journal of Clinical Psychology*, *23*(1), 37-44.

World Health Organization (1992). *International statistical classification of diseases and related health problems* (10th ed.). Geneva, Switzerland: WHO.

Widen, S. C., & Russell, J. A. (2003). A closer look at preschoolers' freely produced labels for facial expressions. *Developmental Psychology*, *39*(1), 114-128.

Williams, L. M., Hermens, D. F., Palmer, D., Kohn, M., Clarke, S., Keage, H., Clark, C. R., & Gordon, E. (2008). Misinterpreting emotional expressions in attention-deficit/hyperactivity disorder: Evidence for a neural marker and stimulant effects. *Biological Psychiatry*, *63*(10), 917-926.

Wright, B., Clarke, N., Jordan, J., Young, A. W., Clarke, P., Miles, J., Nation, K., Clarke, L., & Williams, C. (2008). Emotion recognition in faces and the use of visual context in young people with high-functioning autism spectrum disorders. *Autism*, *12*(6), 607-626.

Yoon, K. L., Fitzgerald, D. A., Angstadt, M., McCarron, R. A., & Phan, K. L. (2007). Amygdala reactivity to emotional faces at high and low intensity in generalized social phobia: A 4-Tesla functional MRI study. *Psychiatry Research: Neuroimaging*, *154*(1), 93-98.

Yoshikawa, S., & Sato, W. (2008). Dynamic facial expressions of emotion induce representational momentum. *Cognitive, Affective & Behavioral Neuroscience*, *8*(1), 25-31.

Young-Browne, G., Rosenfeld, H. M., & Horowitz, F. D. (1977). Infant discrimination of facial expressions. *Child Development*, *48*(2), 555-562.

Yuill, N., & Lyon, J. (2007). Selective difficulty in recognising facial expressions of emotion in boys with ADHD: General performance impairments or specific problems in social cognition? *European Child & Adolescent Psychiatry*, *16*(6), 398-404.

Zonnevijlle-Bendek, M. J. S., van Goozen, S. H. M., Cohen-Kettenis, P. T., van Elburg, A., & van Engeland, H. (2002). Do adolescent anorexia nervosa patients have deficits in emotional functioning? *European Child & Adolescent Psychiatry*, *11*(1), 38-42.

Appendix A

Actor1

Actor2

Actor3

Actor4

„Hank“

„Nikita“

Figure 2. Screenshots of the six actors shown in the video clips or animations, respectively.