A pilot study to assess the usability of a novel psychotherapeutic interactive gaming application as a tool to measure facial emotion recognition in patients with schizophrenia

A thesis presented

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ABSTRACT

This work presents the development and the assessment of Feeling Master, a novel psychotherapeutic interactive gaming application that uses cartoon stimuli to measure facial emotion recognition in schizophrenic patients.

A pilot study among 24 patients with schizophrenia (PS) and 17 healthy control (HC) subjects was conducted to assess the usability of Feeling Master as a tool to measure facial emotion recognition ability in schizophrenic patients. The usability assessment of the application was based on three criteria: adaptability, effectiveness, and efficiency of the tool (Nielsen, 1994; Schwebel, McClure, & Severson, 2014).

The study also attempted to determine whether people with schizophrenia would show emotion recognition deficits and if such deficits would vary among the basic emotions described by Ekman and Friesen (1971). Moreover, our team aimed to relate the results of facial emotion recognition within the schizophrenia group to clinical variables such as the Personal and Situational Attribution Questionnaire (IPSAQ).

Descriptive data reveal that Feeling Master is a useful tool for measuring facial emotion recognition in patients with schizophrenia.

Schizophrenia patients showed impairments in the emotions recognition. PS subjects remained slower than HC (Average time: $F(1.38) = 15.1$, $p = 0.000$). On the other hand, we did not find significant values for the overall emotion discrimination (average accuracy: $F(1.38) = 0.733$, $p>0.05$), but we found significant error rates for discrimination in fear: $F=(1.38)=8.2$, $p < 0.007$)) using Fisher's exact test to compare errors between PS and HC groups.

Using the Feeling Master tool, the performances of patients with schizophrenia were compared to those of healthy control volunteers on computerized tasks of emotion recognition, and the Personal and Situational Attribution Questionnaire (IPSAQ) was administered to determine whether emotion processing deficits were correlated with the attributional style. The correlations between correct response on the Feeling Master and Personal and Situational Attribution Questionnaire (IPSAQ) were not significant, but they showed interesting relations: Sad vs. External Situational Negative, Rho= 0.346, p=0.106; Sad vs. External Situational Positive, Rho=0.320, p=0.136.

Finally, the Technology Acceptance Model (TAM) was used to study the acceptance among professionals of the Feeling Master as a tool to measure facial emotion recognition in rehabilitation psychiatric units. The TAM study was conducted among 66 experienced mental health professionals. Except for Perceived Ease of Use (PEOU), which has a high value, the other TAM construct values (i.e., Perceived usefulness (PU), Attitude Toward Using (ATU),

Enjoyment (E), and Behavioral Intention (BI)) should be improved.

In conclusion, the study puts forward the usability of a novel, psychotherapeutic interactive gaming tool used in Facial Emotion Recognition for people with schizophrenia. These findings lend support to the notion that difficulties in emotion recognition are associated with key cognitive deficits among individuals with schizophrenia. These findings were consistent with previous studies.

RESUMEN

Este trabajo presenta el desarrollo y la evaluación de Feeling Master, un novedoso videojuego psicoterapéutico que utiliza ilustraciones faciales como estímulos para medir el reconocimiento de emociones en pacientes esquizofrénicos.

Se realizó un estudio piloto a 24 pacientes con diagnostico de esquizofrenia (PS) y 17 controles voluntarios (HC) para evaluar la usabilidad de Feeling Master como herramienta para la medición del reconocimiento de emociones faciales en pacientes esquizofrénicos. La evaluación de la usabilidad de Feeling Master se baso en tres criterios: la adaptabilidad, la eficacia y la eficiencia de la herramienta (Nielsen, 1994; Schwebel et al., 2014).

Conjuntamente, se intentó determinar si las personas enfermas de esquizofrenia muestran déficits en el reconocimiento de las emociones faciales y si tales déficits varían entre las distintas emociones básicas descritas por Ekman y Friesen (1971). Además, se relacionaron los resultados del reconocimiento de emociones faciales del grupo de personas enfermas de esquizofrenia con variables clínicas como el cuestionario de atribuciones internas, personales y situacionales (IPSAQ).

Los resultados obtenidos en este estudio revelan que Feeling Master es una herramienta efectiva para la medición del reconocimiento de emociones faciales en personas enfermas de esquizofrenia. Los pacientes con diagnostico de esquizofrenia mostraron un déficit de reconocimiento de las emociones faciales. El grupo PS necesitó mas tiempo que el grupo HC para el reconocimiento de las emociones (tiempo medio: $F(1,38) = 15{,}1$, $p = 0{,}000$). El estudio no evidenció valores significativos para la discriminación en general de emociones faciales (precisión media: $F(1,38) = 0.733$, $p > 0{,}05$). Por otra parte, se encontró una tasa de error significativo para la discriminación en el miedo: $F = (1, 38) = 8{,}2$, $p < 0.007$)) con la prueba exacta de Fisher para comparar errores entre los grupos PS y HC.

Los resultados del reconocimiento de emociones faciales del grupo PS obtenidos con el Feeling Master, se relacionaron con el IPSAQ para determinar si existen correlaciones entre el déficit de reconocimiento de las emociones y el estilo atribucional. Las correlaciones entre los resultados obtenidos por el Feeling Master y el IPSAQ no fueron significativas, pero se encontraron las siguientes relaciones interesantes: tristeza vs. externa situacional negativa, Rho = 0,346, p = 0,106; tristeza vs. externa situacional positiva, Rho = 0,320, p = 0,136.

Por último, se utilizo el modelo de aceptación de la tecnología (TAM) para estudiar la adopción de Feeling Master como herramienta para el reconocimiento de emociones faciales en unidades psiquiátricas de rehabilitación. El estudio TAM se realizó a 66 profesionales experimentados de la salud mental. Excepto por la facilidad de uso percibida,

que ha obtenido un alto valor, el resto de los constructos del TAM (utilidad percibida , actitud hacia el uso, placer de uso y la intención hacia el uso) deben mejorar sus valores.

Como conclusión podemos afirmar que, este trabajo demuestra la correcta usabilidad de Feeling Master como herramienta para la medición del reconocimiento de emociones faciales en personas enfermas de esquizofrenia. Conjuntamente, los resultados de nuestra investigación confirman la existencia de un déficit de reconocimiento de las emociones faciales en las personas enfermas de esquizofrenia. Estos resultados son consistentes con el resto de la literatura científica.

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1 INTRODUCTION

Emotive facial expressions are the foundation of social interaction, and the ability to identify them is an important social skill. Indeed, nonverbal cues are often more important than verbal content in conveying emotional information that is crucial for developing successful relationships (Ellis et al., 1997). Both expressing and experiencing emotions lie at the core of being human and it is critical for the psychological well-being of individuals to be able to express these emotions (D. W. Johnson, 2014). Though emotion is an abstract concept, developing children as young as three years old who have exposure and practice are able to infer basic emotions from facial expressions (DeKlerk, Dada, & Alant, 2014). At three years of age, typically developing children start to acquire the ability to conceptualize and name different emotions (Greenspan, 2004).

It is widely agreed that schizophrenic patients show a reduced ability to perceive and express facial emotions. A deficit in emotion recognition has been found to be a characteristic feature of this pathology (Addington & Addington, 1998; Baudouin, Martin, Tiberghien, Verlut, & Franck, 2002; P. J. Davis & Gibson, 2000; Hooker & Park, 2002; Kirkpatrick, Buchanan, McKenney, Alphs, & Carpenter, 1989; Kohler, Bilker, Hagendoorn, Gur, & Gur, 2000; Mueser et al., 1996). Evidence for this comes from numerous studies that have used emotional facial expressions as stimuli (Archer, Hay, & Young, 1994; Heimberg, Gur, Erwin, Shtasel, & Gur, 1992; Novic, Luchins, & Perline, 1984; Walker, McGuire, & Bettes, 1984).

Controversy exists, however, regarding the nature of such a deficit in schizophrenia. Some investigators believe that the deficit is emotion-specific. This supposition is based on the fact that schizophrenic patients are impaired in the recognition of emotions, especially negative emotions, such as those portrayed by angry faces (Cramer, Weegmann, & O'Neil, 1989; Dougherty, Bartlett, & Izard, 1974; Leppänen et al., 2006; M K Mandal & Rai, 1987; Muzekari & Bates, 1977; Zuroff & Colussy, 1986).

Several hypotheses have been put forward to explain the disparities between positive and negative facial emotion recognition by patients with schizophrenia. Phillips et al. (1999) and Gur et al. (2002) have proposed that amygdala activation specific to negative facial emotion is reduced in patients with schizophrenia. Other studies (Johnston, Devir, & Karayanidis, 2006; Johnston, McCabe, & Schall, 2003) have argued that patients with schizophrenia perform poorly at recognizing negative facial emotions because positive facial emotions are generally easier to recognize than negative emotions (and are thus less likely to be adversely affected by the illness).

According to the social-cognitive hypothesis, schizophrenic patients avoid stimuli that induce negative emotions (Walker, Marwit, & Emory, 1980). Social cognition refers to the application of cognitive capabilities in social situations, and consists of a group of cognitive processes that enable the effective use of social conventions in real-world situations. Emotional perception and recognition is one component of social cognition. Social cognition also includes theory of mind and attributional style (Harvey & Penn, 2010). Theory of mind is the ability to understand the potential mental states and intentions of others, while attributional style is a person's pervasive tendency to explain personally significant events in a particular manner. Relationships between emotional recognition deficits and clinical variables have been reported (Schneider, Gur, Gur, & Shtasel, 1995; Weniger, Lange, Rüther, & Irle, 2004), including a relationship between psychotic symptoms and a deficit in the recognition of facial emotions. On the other hand, cognitive functioning and social functioning have been related to emotional recognition (Hall et al., 2004; Kohler et al., 2000). According to Couture et al. (2006), impairments in several domains of social cognition, including emotion perception and theory of mind, correlate with reduced social functioning. Social cognitive deficits, in turn, have a strong correlation with real-world social outcomes (Pinkham & Penn, 2006; Sachs, Steger-Wuchse, Kryspin-Exner, Gur, & Katschnig, 2004). Thus, improvements in emotional recognition could be associated with improvements in the clinical state, social functioning, and social cognition of patients.

Most developmental studies concerned with the perception and identification of facial emotions have used some adaptation of Matsumoto and Ekman's picture set, which consists of prototypical, intense displays of basic emotions (e.g., Pollak, Cicchetti, Hornung, & Reed, 2000; Simonian, Beidel, Turner, Berkes, & Long, 2001). The number of facial emotions has usually ranged from four (fear, sadness, anger, and joy) to seven (adding disgust, surprise, and contempt). Other studies have used even more stylized stimuli, such as cartoon faces (e.g., Cassidy, Parke, Butkovsky, & Braungart, 1992; Pons, Harris, & de Rosnay, 2004). It is recognized that cartoons have a strong advantage in expressing emotions and feelings. Previous findings suggest that utilizing stimuli with relatively reduced complexity, like cartoons, to teach emotions to children and adolescents is a beneficial therapeutic option. Moreover, training studies have suggested that children with autism show greater improvements in facial emotion recognition when programs utilize cartoons rather than photographs of real faces (Silver & Oakes, 2001).

A range of social cognitive deficits have been reported for both autism and schizophrenia (Abdi & Sharma, 2004; Pelphrey, Adolphs, & Morris, 2004; Pinkham, Penn, Ph, Perkins, & Lieberman, 2003), particularly in the theory of mind (Baron Cohen, 1995; Rhiannon Corcoran, 2005; Yirmiya, Erel, Shaked, & Solomonica-Levi, 1998), the perception of social cues (Archer et al., 1994; Klin, Jones, Schultz, Volkmar, & Cohen, 2002), and facial affect recognition (Celani, Battacchi, & Arcidiacono, 1999; Kohler & Brennan, 2004). Both autism and schizophrenia are characterized in part by pervasive social dysfunction that impairs the ability to initiate and maintain reciprocal interaction (APA, 1994). Notwithstanding, no study to date has attempted to explore the performance in emotion recognition of individuals with schizophrenia when interactive applications include cartoons rather than photographs of real faces.

This thesis presents the development and assessment of Feeling Master, a novel psychotherapeutic interactive gaming application that uses cartoon stimuli to measure facial emotion recognition in schizophrenic patients.

The objectives proposed for the present study were as follows:

1. To assess the usability of Feeling Master as a tool to measure the facial emotion recognition capabilities of schizophrenic patients
2. To verify whether people with schizophrenia would show emotion recognition deficits, and if such deficits would vary among different emotions
3. To predict the acceptance of Feeling Master as a tool to measure facial emotion recognition in rehabilitation psychiatric units

Our first objective was to evaluate the usability of Feeling Master. For this, we conducted a pilot study utilizing Feeling Master as a tool to measure the facial emotion recognition capabilities of both schizophrenia patients and healthy control volunteers. The usability assessment of the application was based on three criteria: the adaptability, effectiveness, and efficiency of the tool (Nielsen, 1994; Schwebel et al., 2014). In order to assess the application's usability, data were collected for each participant, and descriptive analyses were conducted.

To verify whether people with schizophrenia would show emotion recognition deficits, and if such deficits would vary among different emotions, we compared the performance of facial emotion recognition among schizophrenia patients and healthy control volunteers during the pilot study. Furthermore, we analyzed the accuracy (correct answers in emotion recognition) of the schizophrenia patients for each emotion. Moreover, we related the results of facial emotion recognition to clinical variables (Personal and Situational Attribution Questionnaire [IPSAQ]) in the schizophrenia group to determine whether emotion-processing deficits correlated with attributional style. Finally, we examined whether the possible facial emotion recognition impairments of the schizophrenia patients would corroborate previous findings.

In order to achieve our third objective, predicting the acceptance of Feeling Master as a tool to measure facial emotion recognition in rehabilitation psychiatric units, the Technology Acceptance Model (TAM) was applied. A survey based on the TAM was conducted among various experienced mental health professionals from different psychiatric health centers. The survey consisted of sixteen items designed to assess five constructs of the proposed model. The five constructs were the following: perceived usefulness (PU), perceived ease of use (PEOU), attitude toward using (ATU), enjoyment (E), and behavioral intention (BI). Each item was adapted from previous studies and was refined to be specifically relevant to the present study.

The work proposal begins with an explanation of the objectives then goes on to explain the methodology used to accomplish these objectives. The Theoretical Background section provides an overview of key aspects believed, so far, to be the theoretical basis for the empirical work to be conducted. Topics such as the importance of recognizing emotional facial expressions, theories and models for the perception and identification of facially expressed emotions, and psychotherapeutic gaming applications are mentioned, defined, and/or investigated. Next, a description of the proposed empirical work is made, specifying the system to be developed, the actors involved, and the conjunction of this work with the previously defined methodology. The Results and Discussion chapter presents the analysis and interpretation of the major findings of the research.

Finally, the Conclusions section offers the observable contrasts between the findings and the conceptual framework. This section also presents additional insights discovered during the fieldwork that we considered relevant, as well as the study limitations that we were able to identify.

2 OBJECTIVES

2.1 To assess the usability of Feeling Master as a tool to measure the facial emotion recognition capabilities of schizophrenic patients

Emotive facial expressions are the foundation of social interaction, and the ability to identify them is an important social skill. Indeed, nonverbal cues are often more important than verbal content in conveying emotional information that is crucial for developing successful relationships (Ellis et al., 1997). Both expressing and experiencing emotions lie at the core of being human and it is critical for the psychological well-being of individuals to be able to express these emotions (D. W. Johnson, 2014). Though emotion is an abstract concept, developing children as young as three years old who have exposure and practice are able to infer basic emotions from facial expressions (DeKlerk et al., 2014). At three years of age, typically developing children start to acquire the ability to conceptualize and name different emotions (Greenspan, 2004).

Several studies have examined the perception of emotion in schizophrenic patients, and the majority have reported an impaired ability in recognizing facial emotions (Addington & Addington, 1998; Baudouin et al., 2002; P. J. Davis & Gibson, 2000; Hooker & Park, 2002; Kirkpatrick et al., 1989; Kohler et al., 2000; Mueser et al., 1996). Evidence for this comes from numerous studies that have used emotional facial expressions as stimuli (Archer et al., 1994; Heimberg et al., 1992; Novic et al., 1984; Walker et al., 1984). However, the cerebral basis of this dysfunction is still unclear. Several researchers believe the deficit is emotion-specific. This supposition is based on the fact that schizophrenic patients are worse at recognizing negative, as opposed to positive, facial emotions (Cramer et al., 1989; Dougherty et al., 1974; M K Mandal & Rai, 1987; Muzekari & Bates, 1977; Zuroff & Colussy, 1986).

Despite the importance of recognizing and perceiving facial expressions in everyday life, there is no comprehensive test battery for the assessment of these abilities. Most developmental studies concerned with the perception and identification of facial emotions have used some adaptation of Matsumoto and Ekman's picture set, which consists of prototypical, intense displays of basic emotions (e.g., Pollak et al., 2000; Simonian et al., 2001). The number of facial emotions has usually ranged from four (fear, sadness, anger, and joy) to seven (adding disgust, surprise, and contempt). Other studies have used even more stylized stimuli, such as cartoon faces (e.g., Cassidy et al., 1992; Pons et al., 2004). It is recognized that cartoons have a strong advantage in expressing emotions and feelings. Previous findings suggest that utilizing stimuli with relatively reduced complexity, like cartoons, to teach emotions to children and adolescents is a beneficial therapeutic option. Moreover, training studies have suggested that children with autism show greater improvements in facial emotion recognition when programs utilize cartoons rather than photographs of real faces (Silver & Oakes, 2001).

A range of social cognitive deficits have been reported for both autism and schizophrenia (Abdi & Sharma, 2004; Pelphrey et al., 2004; Pinkham et al., 2003), particularly in the theory of mind (Baron Cohen, 1995; Rhiannon Corcoran, 2005; Yirmiya et al., 1998), the perception of social cues (Archer et al., 1994; Klin et al., 2002), and facial affect recognition (Celani et al., 1999; Kohler & Brennan, 2004). Both autism and schizophrenia are characterized in part by pervasive social dysfunction that impairs the ability to initiate and maintain reciprocal interaction (APA, 1994). Notwithstanding, no study to date has attempted to explore the performance in emotion recognition of individuals with schizophrenia when interactive applications include cartoons rather than photographs of real faces.

There has been increasing investigation into the use of computer games as a form of therapy. New technologies can provide auditory and visual stimuli that may otherwise be difficult to generate (Hutinger, 1996), and which create a new environment for engaging in therapy. Both researchers and clinicians are dynamically investigating the use of computer games in different areas of mental health.

A variety of psychotherapeutic gaming application therapies, interventions, and tools for patients with mental health problems have recently been developed that include play therapy, cognitive-behavioral therapy, and applied behavior analysis. The popularity of computer games has grown exponentially in the last decade and they are widely enjoyed by children, adolescents, and adults alike. Mental health specialists have therefore been exploring the use of these games to complement traditional treatment methods (Goh, Ang, & Tan, 2008).

Recent research and reviews of electronic games identified four general areas of beneficial effects: cognitive, motivational, emotional, and social (Bisoglio, Michaels, Mervis, & Ashinoff, 2014; Granic, Lobel, & Engels, 2014). Cognitive benefits included increased speed and accuracy of attention and visual special abilities, improved learning and memory, executive functions, problem-solving skills, and creativity. Motivational benefits included improved diligence and persistence. Emotional benefits included improved mood or increases in positive emotions and adaptive regulation strategies for managing negative emotions such as anger, anxiety, and sadness. Finally, Granic et al. (2014) noted the social benefits of electronic games included increased cooperation, support, helping behaviors, and civic engagement.

By incorporating game mechanics into the development of a psychotherapeutic interactive gaming tool, we provide not only some of the games' benefits described above, but we also take advantage of new technologies. In contrast to traditional assessments of emotion recognition, these technologies provide therapists with many new opportunities for interacting with patients. With smart devices that are carried with them, therapists are able to utilize these new tools, gather information, and disseminate information in ways that are less cost/time-consuming, more interesting, and more readily available. Also, the use of cartoons may serve to create a more engaging learning environment and increase patients' motivation to interact with materials, as is suggested by the widespread use of cartoon images within the intervention literature (especially in teaching emotion recognition skills).

Furthermore, accumulated research now indicates computer and Internet-based assessment and therapy tools have the potential to increase the cost-effectiveness of current psychotherapeutic interventions by reducing therapist contact time, increasing client participation in therapeutic activities in non-clinical settings, and streamlining the input and processing of client data from therapeutic activities (Kaltenthaler & Cavanagh, 2010; Newman, Szkodny, Llera, & Przeworski, 2011; Taylor & Luce, 2003).

In the present study, our first objective was to assess the usability of Feeling Master as a tool to measure facial emotion recognition capabilities in schizophrenic patients. The usability assessment of the application was based on three criteria: the adaptability, effectiveness, and efficiency of the tool (Nielsen, 1994; Schwebel et al., 2014). In order to assess the application's usability, data were collected for each participant, and descriptive analyses were conducted.

2.2 To verify whether people with schizophrenia would show emotion recognition deficits, and if such deficits would vary among the basic emotions

It is widely agreed that schizophrenic patients show a reduced ability to perceive and express facial emotions. A deficit in emotion recognition has been found to be a characteristic feature of this pathology (Addington & Addington, 1998; Baudouin et al., 2002; P. J. Davis & Gibson, 2000; Hooker & Park, 2002; Kirkpatrick et al., 1989; Kohler et al., 2000; Mueser et al., 1996). Evidence for this comes from numerous studies that have used emotional facial expressions as stimuli (Archer et al., 1994; Heimberg et al., 1992; Novic et al., 1984; Walker et al., 1984).

Controversy exists, however, regarding the nature of this deficit in patients with schizophrenia. Some investigators believe that the deficit is emotion-specific. This supposition is based on the fact that schizophrenic patients are impaired in the recognition of emotions, especially negative emotions, such as those portrayed by angry faces (Cramer et al., 1989; Dougherty et al., 1974; Leppänen et al., 2006; M K Mandal & Rai, 1987; Muzekari & Bates, 1977; Zuroff & Colussy, 1986).

Several hypotheses have been put forward to explain the disparities between positive and negative facial emotion recognition in schizophrenia. Phillips et al. (1999) and Gur et al. (2002) have proposed that amygdala activation specific to negative facial emotion is reduced in patients with schizophrenia. Other studies (Johnston et al., 2006, 2003) have argued that patients with schizophrenia perform poorly at recognizing negative facial emotions because positive facial emotions are generally easier to recognize than negative emotions (and are thus less likely to be adversely affected by the illness).

According to the social-cognitive hypothesis, patients avoid stimuli that induce negative emotions (Walker et al., 1980). Social cognition refers to the application of cognitive capabilities in social situations, and consists of a group of cognitive processes that enable the effective use of social conventions in real-world situations. Emotional perception and recognition is one component of social cognition. Social cognition also includes theory of mind and attributional style (Harvey & Penn, 2010). Theory of mind is the ability to understand the potential mental states and intentions of others, while attributional style is the positive or negative manner in which people explain to themselves why they experience a particular event. Relationships between emotional recognition deficits and clinical variables have been reported (Schneider et al., 1995; Weniger et al., 2004), including a relationship between psychotic symptoms and a deficit in the recognition of facial emotions. On the other hand, cognitive functioning and social functioning have been related to emotional recognition (Hall et al., 2004; Kohler et al., 2000). According to Couture et al. (2006), impairments in several domains of social cognition, including emotion perception and theory of mind, correlate with reduced social functioning. Social cognitive deficits, in turn, have a strong correlation with real-world social outcomes (Pinkham & Penn, 2006; Sachs et al., 2004). Thus, improvements in emotional recognition could be associated with improvements in the clinical state, social functioning, and social cognition of patients.

In this study, we hypothesized that individuals with schizophrenia would have both diminished sensitivity and different response criteria in facial emotion recognition across different emotions when compared to healthy controls. To test our hypothesis, we utilized Feeling Master to compare the performance of facial emotion recognition among both schizophrenic patients and healthy control volunteers during the pilot study.

Moreover, we related the results of facial emotion recognition to clinical variables (Personal and Situational Attribution Questionnaire [IPSAQ]) in the schizophrenia group to determine whether emotion-processing deficits correlated with the attributional style. Attributional style (also known as explanatory style) was measured using the IPSAQ (Kinderman & Bentall, 1996), which consists of thirty-two items that describe positive and negative social situations. For each item, participants were asked to state the most likely cause of an event and then indicate whether the cause was primarily due to the self (internal attributions), other people (personal attributions), or circumstances (situational attributions).

Finally, we examined whether the possible facial emotion recognition impairments of the schizophrenia patients would corroborate previous findings.

2.3 To predict the acceptance of Feeling Master as a tool to measure facial emotion recognition in rehabilitation psychiatric units

Our third objective focused on predicting the acceptance of a psychotherapeutic interactive gaming application as a tool to measure facial emotion recognition in psychiatric rehabilitation units.

Rapid progress in personal computer technology over the past few decades has greatly expanded the potential of computer-assisted therapy programs (Kaltenthaler & Cavanagh, 2010; Kaltenthaler, Parry, & Beverley, 2004). Accumulated research now indicates computer and Internet-based assessment and therapy tools have the potential to increase the cost-effectiveness of current psychotherapeutic interventions by reducing therapist contact time, increasing client participation in therapeutic activities in non-clinical settings, and streamlining the input and processing of client data from therapeutic activities (Kaltenthaler & Cavanagh, 2010; Newman et al., 2011; Taylor & Luce, 2003).

The impact of these technologies on healthcare will be more prominent as they become more available to individuals suffering from chronic illnesses. Applications made for smartphones and tablets, along with social media networks, could aid in the treatment of individuals with chronic illnesses (Miller, Stewart, Schrimsher, Peeples, & Buckley, 2015).

Furthermore, the popularity of computer games has grown exponentially in the last decade and they are widely enjoyed by children, adolescents, and adults alike. Mental health professionals have therefore been exploring the use of these games to complement traditional treatment methods. To date, however, there has been little concrete evidence of the effectiveness of computer games for the treatment of children and adults with mental health conditions. For such games to be successful, it is key that they are well-designed from the outset (Goh et al., 2008).

The well-known Technology Acceptance Model (TAM) (F. D. Davis, 1989; Viswanath Venkatesh, Davis, & College, 2000) provides a framework for predicting the acceptance of a new technology. In this study, a research model based on the TAM was used to study the acceptance of a psychotherapeutic interactive gaming application as a tool to measure facial emotion recognition in rehabilitation psychiatric units.

In the original version of the Technology Acceptance Model (TAM), the usage of a technological innovation is predicted by two concepts: "perceived ease of use" and "perceived usefulness." Perceived ease of use refers to the degree to which a person believes that using the technology will be effortless, while perceived usefulness is defined as the degree to which a person believes that using a particular technology will enhance his or her job performance. According to Davis (1989), perceived usefulness plays a more important role than ease of use, because users are often willing to cope with usability difficulties if a technology provides critically needed functionality. No amount of ease of use, however, can compensate for a technology that does not perform a useful function. Perceived usefulness has consistently been found to be a strong determinant of usage intentions, whereas perceived ease of use has exhibited a less consistent effect across studies (Viswanath Venkatesh et al., 2000).

Drawing upon recent findings in information systems, human computer interaction, and social psychology, the present research expands upon the TAM by incorporating the motivation variable of enjoyment. Enjoyment refers to the extent to which the activity of using a computer system is perceived to be personally enjoyable in its own right aside from the instrumental value of the technology (F. D. Davis, Bagozzi, & Warshaw, 1992). Prior research has proposed enjoyment both as a determinant of behavioral intention (F. D. Davis et al., 1992; Viswanath Venkatesh, Speier, & Morris, 2002) and a determinant of ease of use (Viswanath Venkatesh et al., 2002; Viswanath Venkatesh, 2000). According to Davis et al. (1992), extrinsic motivation refers to "the performance of an activity because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself," whereas intrinsic motivation refers to "the performance of an activity for no apparent reinforcement other than the process of performing the activity per se." Davis et al. (1992), and more recently Venkatesh and Speier (2000), classified enjoyment as a type of intrinsic motivation, and perceived usefulness as a type of extrinsic motivation.

In conclusion, the TAM was applied to predict the acceptance of Feeling Master as a tool to measure facial emotion recognition in rehabilitation psychiatric units. The TAM study was conducted among sixty-six experienced mental health professionals from different psychiatric health centers in Spain and Argentina. The survey instrument for this research consisted of an online questionnaire of sixteen items designed to assess five constructs of the TAM model. The five constructs were: perceived usefulness (PU), perceived ease of use (PEOU), attitude toward using (ATU), enjoyment (E), and behavioral intention (BI). These items were adapted from previous studies and were refined to be specifically relevant to the present study.

3 METHODOLOGY

3.1 Theoretical Work

The method that we used in order to obtain a clear and precise background in the work and research that has already been completed in this field involved searching different databases and online data bank resources for published work related to the specific keywords and themes mentioned in our current work proposal.

The theoretical background for this study is organized into six sections:

1. Facial expressions of emotion
2. Theories and models for the perception and identification of facially expressed emotions
3. Facial emotion recognition in schizophrenia
4. Cartoon Face Processing
5. Electronic games for psychotherapy
6. Psychotherapeutic computer games for emotion recognition

3.2 Empirical Work

The methodology that we used for our fieldwork included a research strategy, namely, a systematic way of looking at events, collecting data, analyzing information, and reporting the results. We used the "case study" approach, which was conducted in a realistic and full-scale project, and had a defined goal before the data collection occurred.

Yin (1994) describes a case study as "an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and context are not clearly evident." A case study is normally a study conducted in parallel with the execution of a project. It should be planned out in advance, and though there is an attempt to control the data collection to ensure data validity, normally there is little control over the actual execution. In other words, the researchers are external observers of a "real" software project (Wohlin et al., 2012). According to Robson (1993), the design of a case study provides the link between the study goal, the data to be collected, and the conclusions drawn from the data. Key decisions when designing a case study revolve around the determination of the conceptual framework, the set of research questions, a sampling strategy, and the data collection instruments.

As mentioned by Barbara Kitchenham and Lesley Pickard (1995), if researchers choose the case study method, it is advantageous to establish a pilot project to assess the effects of implemented changes. Also, in order to more easily generalize the case study results, the pilot project should be as representative as possible of the environment in which the study will take place.

Hence, a pilot study was conducted to assess the usability of a new psychotherapeutic interactive gaming application (Feeling Master) as a tool to measure facial emotion recognition capabilities in schizophrenic patients. The usability assessment of the application was based on three criteria: the adaptability, effectiveness, and efficiency of the tool (Nielsen, 1994; Schwebel et al., 2014).

The pilot study was also an attempt to determine if people with schizophrenia would show emotion recognition deficits, and if such deficits would vary among the basic emotions described by Ekman and Friesen (1971). Moreover, we aimed to relate the results of facial emotion recognition to clinical variables (Personal and Situational Attribution Questionnaire [IPSAQ]) in the schizophrenia group.

The pilot study was conducted among patients with schizophrenia in five rehabilitation psychiatric units from Parc Sanitari Sant Joan de Déu (PSSJD) in Barcelona, Catalonia, Spain. A total of twenty-four patients with schizophrenia participated in the study, and seventeen healthy control subjects were recruited to match the patient cohort in terms of age, gender, and education. In the patients' first individual sessions with the psychologist, inclusion and exclusion criteria were reviewed. These sessions dealt mainly with the standard psychiatric interview of the DSM-IV diagnostic criteria and the Personal and Situational Attribution Questionnaire (IPSAQ). The study took place across two "one-on-one" sessions, conducted on separate days within a one-week period. The patients were tested in a quiet area, away from the other patients in their rehabilitation psychiatric unit. Each session, which took approximately ten to fifteen minutes to complete, was administered by a psychologist and the application designer. Throughout each session, patients interacted with the application two times (two games, with randomly selected emotions for the overall session). By the end of the study, each patient used the psychotherapeutic interactive gaming tool prototype a total of four times. For each game, the system automatically recorded all of the patient's answers (right and wrong), the patient's profile, the system configuration, response times for each question, and the score for each game. This topic is further developed in section: Pilot Study

The overall design of Feeling Master was created with an iterative user-centered approach, which places an emphasis on users' needs and stresses the importance of designing products that are functional, applicable, and usable for a broad range of people (Baek, Cagiltay, Boling, & Frick, 2008; Norman, 2002). Iteration is fundamental to this design process; it occurs by cycling through the overall process multiple times, as well as by reiterations within individual steps. In this process, user/expert testing connects each major iteration. Interviews, surveys, and questionnaires were the tools that we used for this testing in tandem with the case study approach. The interviews were very useful when gathering data to design the application's structure and to test the variables chosen for the monitoring model and the graphics. Additionally, interviews were extremely important for the design and development of Feeling Master due to the fact that the project had a multidisciplinary team, which included medical professionals with expertise in psychology, and since there were several objectives that needed constant user feedback. This subject is further developed in section: Design Methodology.

Finally, a survey based on the Technology Acceptance Model (TAM) was conducted among sixty-six experienced mental health professionals to predict the acceptance of Feeling Master as a tool to measure facial emotion recognition in rehabilitation psychiatric units. The TAM (F. D. Davis, 1989; Viswanath Venkatesh et al., 2000) explains the determinants of technology acceptance over a wide range of end-user computing technologies and user populations. For example, TAM is shown to have good predictive validity for the use of e-mail, Websites, and Web Course Tools, etc. (Chuan-Chuan Lin & Lu, 2000; Fenech, 1998; Gefen & Straub, 1997; Y.-C. Lee, 2006; Ngai, Poon, & Chan, 2007). The survey consisted of an online questionnaire of sixteen items designed to assess five constructs of the proposed model. The five constructs were: perceived usefulness (PU), perceived ease of use (PEOU), attitude toward using (ATU), enjoyment (E) and behavioral intention (BI). These items were adapted from previous studies and were refined to make them specifically relevant to the present study. We described this subject more widely in section: Technology Acceptance Model (TAM) of Feeling Master.

4 STATE OF THE ART

4.1 Facial expressions of emotion

Expressing and experiencing emotions lie at the core of being human and it is critical for the psychological well-being of individuals that they are able to express these emotions (D. W. Johnson, 2014). Though emotion is an abstract concept, developing children as young as three years old with exposure and practice are able to infer basic emotions from facial expressions (DeKlerk et al., 2014). At three years old, typically developing children start to develop the ability to conceptualize and name different emotions (Greenspan, 2004). They can express emotions symbolically by using spoken language.

Facial expression of emotions is vital to the regulation and development of interpersonal relationships (Ekman, 1999b). “Facial expressions are caused by the movement of muscles that connect to the skin and fascia in the face. These muscles move the skin, creating lines and folds and causing the movement of facial features, such as the mouth and eyebrows. These muscles develop from the second pharyngeal arch in the embryo. The temporalis, masseter, and internal and external pterygoid muscles, which are mainly used for chewing, have a minor effect on expression as well. These muscles develop from the first pharyngeal arch” (Rinn, 1984).

Some authors regard recognizing basic emotions from facial expressions as a universal phenomenon (Elfenbein & Ambady, 2003; Ekman, 1994; Izard, 1994). While others (Boyatzis, Chazan, & Ting, 1993) caution that differences between individuals and cultural differences also play a role and should be taken into account when studying emotions and the facial expressions linked to such emotions.

The pioneer in the study of nonverbal behavior is Darwin, who said that there are universal expressions. In 1872, Charles Darwin published his work on The Expression of the Emotions in Man and Animals (1872). It was published 13 years after his revolutionary On the Origin of Species (1859). Darwin claimed that we could not understand human emotional expression without understanding the expressions of animals, for, he argued, our emotional expressions are in large part determined by our evolution.

These allegations were later challenged by Landis (1924) and Klineberg (1940), which contradicted Darwin's theory, believing that emotional facial expressions are influenced only by culture. While Klineberg acknowledged that a few patterns of behavior are universal, such as crying, laughing and trembling, Klineberg (1940) said that facial expressions of fear, anger, sadness, disgust, etc. are not. Klineberg mentioned many observations of cultural differences in expressions noted by anthropologists, but the decisive evidence for Klineberg was a study that found that humans could not understand a chimpanzee's facial expressions.

The universality position issued by Darwin is revived in the 1960s by some theories (Swanson, Tomkins, & Karon, 1963) and empirical cross-cultural evidence.

Ekman et al. (1969) had conducted research in which they showed pictures of faces to people in Borneo, Brazil, Japan, Guinea, and the United States. Participants of each country successfully recognized the same facial expressions as corresponding to the same facial expression. The researchers presented their results as a signal of universality in these expressions. Nevertheless, Ekman et al. pointed out that these conclusions were open to criticism, since all participants studied had all been exposed to international media (magazines, television, movies), which is full of facial expressions. What were needed to prove the universality of emotional expression were people that had not been exposed to any of these things.

In 1971, Ekman and Friesen (1971) went to the Eastern Highlands Province of Papua New Guinea to find subjects for their research among the Fore community who lived then as an isolated Stone Age culture. This community had experienced little or no contact with Eastern or Western modern cultures. Hence, they had not been exposed to facial expressions of emotions other than those of their people.

The theory underlying Ekman and Friesen's work was that the specific facial expressions corresponding to basic emotions are universal. Ekman and Friesen (1971) stated about this study : "The purpose of this paper was to test the hypothesis that members of a preliterate culture who had been selected to ensure maximum visual isolation from literate cultures will identity the same emotion concepts with the same faces as do members of literate Western and Eastern cultures".

Forty photographs of 24 different people were used as examples of the six facial emotional expressions (happiness, anger, sadness, disgust, surprise and fear). All photographs were validated previously by showing them to members of various other cultures. The researchers discovered through trial and error that the most efficient manner of asking the Fore people to identify facial emotions was to show them three photographs of different facial expressions and read a short description of an emotion-producing scene that corresponded to one of the pictures.

By the end of the study, Ekman and Friesen (1971)agreed that: "The results for both adults and children clearly support our hypothesis that particular facial behaviors are universally associated with particular emotions". This assumption was based on the fact that the South

Fore had no opportunity to learn anything about Western expressions and, therefore, had no way of identifying them unless the expressions were universal.

As a way of double-checking their findings, Ekman and Friesen videotaped members of the isolated Fore community portraying the same six facial expressions. Then, when these videos were shown to students in the United States, the college students accurately recognized the expressions corresponding to each of the facial expression.

Finally the researchers agreed that "The evidence from both studies contradicts the view that all facial behavior associated with emotion is culture-specific, and that posed facial behavior is a unique set of culture-bound conventions not understandable to members of another culture" (Ekman & Friesen, 1971). This research by Ekman and Friesen served to demonstrate that facial expressions of emotions are universal. Since facial expressions for the six emotions (happiness, anger, sadness, disgust, surprise and fear) used in this study appear to be almost not influenced by cultural differences, it is likely to conclude that they must be innate.

Nowadays, cross-cultural studies on the universality of facial emotions (Beaupre ́ & Hess, 2005; Shioiri, Someya, Helmeste, & Tang, 1999; Yik & Russell, 1999) still presented evidence of cross-cultural agreement in the judgment of facial expression of emotions (Ekman et al., 1987). According to DeKlerk et al. (2014), "The recognition of emotion across cultures is similar, while the way in which emotions might be represented or labeled appears to be more culture specific. The symbolic representation and interpretation of emotions may be influenced by cultural differences in the experience of emotions, which might be reflected in how individuals from different cultures identify graphic symbols that represent emotions".

An important consensus exists on the universal recognition of six emotions: sadness, happiness surprise, disgust, fear and anger, although culturally differences in the normal population are possible (Ekman et al., 1987; Shioiri, Someya, Helmeste, & Tang, 1999).

During the last decades, micro-expressions are gaining more attention in both the scientific field and the mass media. Based on Previous studies done by Ekman et al. (1969; 2009), Yan et al. (2014) define a micro-expression as "a brief facial movement which reveals an emotion that a person tries to conceal ". Because we cannot control micro-expression as it happens in a fraction of a second. They are very brief, lasting only 1/25 to 1/15 of a second (Ekman, 2015). Unlike regular facial expressions, it is extremely difficult (or impossible) to hide micro-expression reactions.

Micro-expressions express the six universal emotions: disgust, anger, fear, sadness, happiness, and surprise. However, in the 1990s, Paul Ekman extended the list of the basic emotions, adding a variety of positive and negative emotions. These emotions are shame, contempt, embarrassment, anxiety, guilt, pleasure, relief, contentment, pride, and amusement (Ekman, 1992, 1999a).

4.2 Theories and models for the perception and identification of facially expressed emotions

Facial expressions constitute possibly the most significant stimuli in social interactions. It has been described that the identification and perception of facially expressed emotions have been defined as one of the basic abilities. These abilities are situated at the lowest level of a hierarchical taxonomic model of Emotional Intelligence (Mayer, Roberts, & Barsade, 2008).

In a review about Processing Faces and Facial Expressions Posamentier et al. (2003, p. 113) explained the basic process:

> When we see a face, we need to infer two main types of information. First, the face has to be identified as belonging to a unique individual, taking into account transformations resulting from changes in viewing angle and facial expressions, as well as changes in appearance and aging. Second, the facial expression has to be interpreted for emotional context, which sets the tone for the social interaction. The relative ease and speed with which facial identity and facial expression processing are accomplished suggest the engagement of a highly specialized system or systems. Face recognition has been described as the acme of human visual perception, as such, we really appreciate the elegance and complexity of the system when it fails: when, for example, patients cannot recognize familiar faces or basic facial expressions.

The facial identity and expression information mechanisms processes have been extensively studied in the neurocognitive literature. In a review about measuring the perception and recognition of facial expressions of emotion, Wilhelm et al. (2014) described the basic theories and models of perceiving and recognizing facial expressions.

> Models of face processing (Bruce & Young, 1986; Andrew J. Calder & Young, 2005; Haxby & Gobbini, 2010) delineate stages of processing involved in recognizing two classes of facial information: (1) pictorial aspects and invariant facial structures that code facial identity and allow for extracting person- related knowledge at later processing stages; and (2) changeable aspects that provide information for action and emotion understanding (most prominently eye gaze and facial expressions of emotion). In their original model, Bruce and Young (1986) suggested that at an initial stage of structural encoding, during which view-centered descriptions are constructed from the retinal input, the face processing stream separates into two pathways— one being involved in identifying the person and the second involved in processing changeable facial information such as facial expression or lip speech.

> Calder (2011) reviewed evidence from image-based analyses of faces, experimental effects representing similar configural and holistic processing of identity and facial expressions, but also neuroimaging and neuropsychological data. He concluded that at a perceptual stage there seems to be a partly common processing route for identity and expression- related facial information (see also Young & Bruce, 2011, p. 115).

Posamentier et al. (2003) described Bruce and Young model of face recognition and the Haxby model of a "distributed human neural system for face perception" in a brief way.

> The Bruce and Young model provided researchers with a general framework for face processing. For example, the Bruce and Young model predicts that processing of familiar faces should be automatic and rapid, whereas processing of unfamiliar faces should require more effort and time. Additionally, the model predicts that judgments about facial expressions should not be influenced by the familiarity of the face. Such predictions were tested by Young et al. (1986), who examined the effect of face familiarity in identity and expression matching tasks. In an identity-matching task, subjects had to decide whether simultaneously presented photographs of faces were pictures of the same or different persons. In agreement with the Bruce and Young model, subjects were faster to decide that the persons were the same when they were familiar than when they were unfamiliar. In an expression- matching task, subjects had to decide whether people in photographs displayed the same or different facial expressions. Again, the prediction of the model held up: There was no difference in reaction times for expression judgment of familiar and unfamiliar faces. These results support independence in processing facial identity and expressions.

Casting findings from behavioral and neuropsychological observations and the experimental approach into a unified framework, Bruce and Young (1986) developed a now classic model of face recognition expressed in terms of processing pathways and modules for recognition of familiar faces (see **Figure 1**). They suggested that seven types of information can be derived from faces: pictorial, structural, visually derived semantics (age and sex), identity- specific semantics, name, expression, and facial speech (movements of the lips during speech production) codes (p. 115).

Bruce and Young Model (1986)

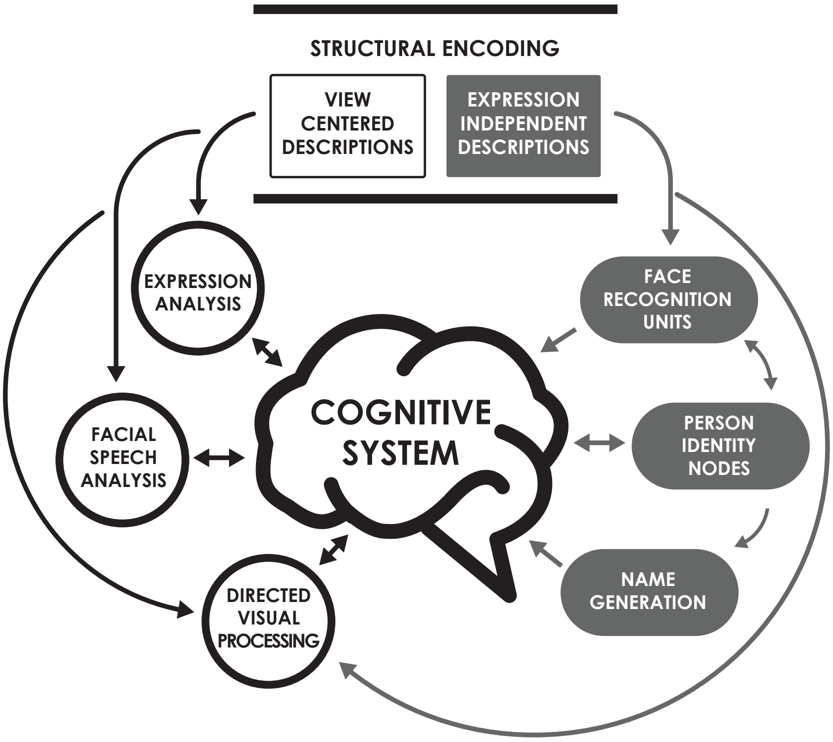


Figure 1. The Bruce and Young model of face recognition

The last decade has seen developments in functional neuroimaging methods that provide a measure of the brain at work. Functional Magnetic Resonance Imaging (fMRI) and Positron Emission Tomography (PET) are the two main techniques used to image face-processing tasks. Brain imaging studies of different face-processing tasks have yielded a wealth of information, but not until recently did we see a serious effort to consolidate the findings into a coherent framework (p. 121).

On the basis of their own work and other groups' imaging studies of face processing, ERP studies, as well as animal models and studies, Haxby et al. (2002; 2000) took another step forward by proposing a model for a "distributed human neural system for face perception" (see Figure 2). The Haxby model takes into account the two important tasks that an effective face-processing system must accomplish. First, the system must be able to establish an invariant face representation that allows for recognition across encounters. Second, the system must also be able to effectively interpret changeable aspects of faces, such as facial expressions, eye gaze, and lip movement, which mediate social interactions and communication (cf. O'Toole et al., 2002, for an expanded discussion of recognition of moving faces). The model is hierarchical and is divided into a core system and an extended system. The core system is composed of three bilateral regions in the occipitotemporal visual extrastriate cortex and includes the inferior occipital gyri, the lateral fusiform gyrus, and the superior temporal sulcus. The inferior occipital gyri are involved in the early perception of facial features and provide input to the lateral fusiform gyrus and the superior temporal sulcus. The fusiform gyrus analyzes the invariant aspects of faces or unique identity, whereas the changeable aspects of faces are mediated by face-responsive regions in the superior temporal sulcus. The extended system supplements further face processing in concert with other neural systems: Emotional content is processed by the amygdala, the insula, and the limbic system, the auditory cortex is recruited in processing speech-related mouth movements, and the intraparietal sulcus processes spatially directed attention such as eye gaze. Personal identity, name, and biographical information are accessed in the anterior temporal region (p. 127).

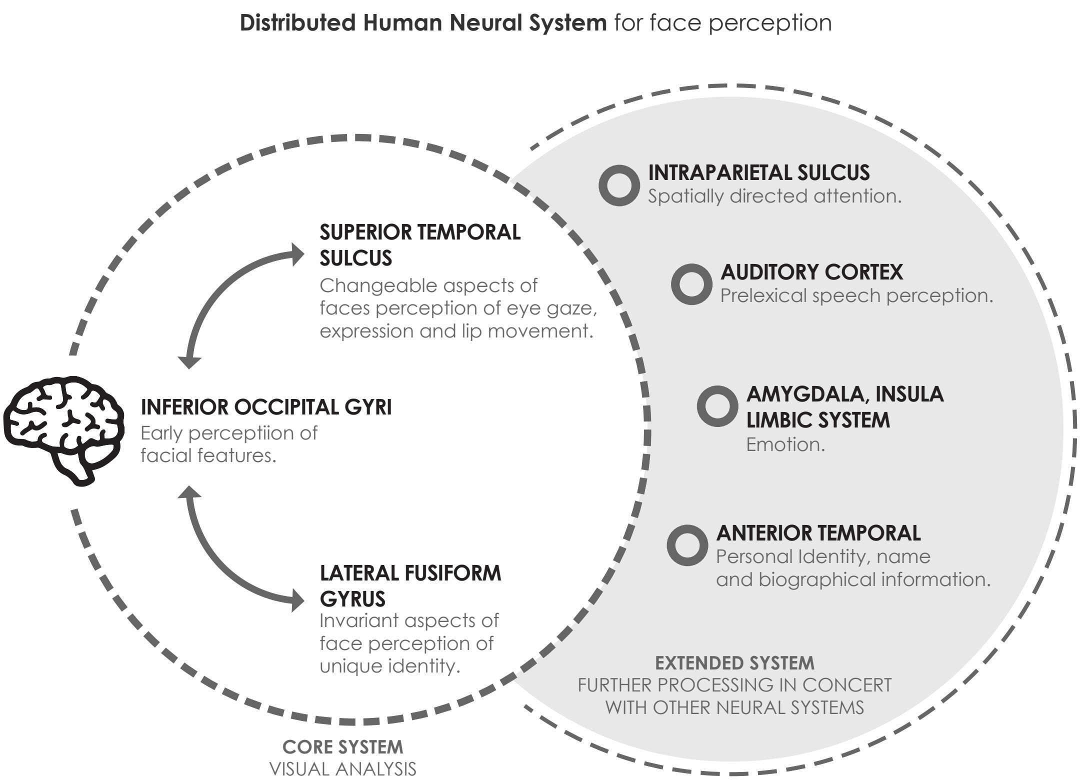


Figure 2. The Haxby model of a "distributed human neural system for face perception"

During the last decades, we have seen rapid developments in functional neuroimaging systems that provide a way to measure the brain at work. Posamentier et al. (2003, pp. 128-129) reviewed different brain imaging studies of emotions, that allow them to extract some conclusions:

> Results from studies of facial expression processing suggest that different emotions are also processed by different regions of the brain. For example, Adolphs et al. (1996) investigated facial expression recognition in a large number of subjects with focal brain damage. The authors hypothesized that cortical systems primarily responsible for recognition of facial expressions would involve discrete regions of higher-order sensory cortices. Recognition of specific emotions would depend on the existence of partially distinct systems. This predicts that different patterns of expression recognition deficits should depend upon the lesion site. In general, none of the subjects showed impairment in processing happy facial expressions, but several subjects displayed difficulty in recognizing negative emotions (especially fear and sadness). The authors propose that deficits in processing negative emotions can be due to the fact that the number of negative emotions is larger than the number of positive emotions. In fact, there is only one positive emotion, namely happiness. As such, a happy smile should be easily recognizable. It is also possible that negative emotions show a deficit because they can be easily confused, such as mistaking fear for surprise, or anger for disgust.

Posamentier et al. (2003) also reviewed the processing of the six basic emotions (fear, anger, sadness, disgust, happiness, and surprise). Each emotion was examined from both human subjects and neuroimaging studies.

> **Fear: Behavioral Studies**
>
> Close links have been established between the emotion of fear and the amygdala. For example, LeDoux (1998) proposes that the fear reaction system involves parallel transmissions to the amygdala from both the thalamus and the sensory cortex, which he refers respectively to as the “low” and “high” roads. The direct pathway from the thalamus to the amygdala is the shortest and fastest transmission route. This “low road” provides the amygdala with a crude representation of the stimulus and allows for immediate response to the present danger. The “high road” involves elaborated processing in the sensory cortex before the input reaches the amygdala and is slower but more precise. In agreement with LeDoux’s theorization, neurons in the monkey amygdala have been shown to respond to the affective significance of sensory

stimuli, and lesions of the amygdala render the animal insensitive to stimuli that normally evoke fear. In humans, the amygdala has been studied as a result of surgical lesions and electrical stimulation, in particular in epileptic patients.

The role of the amygdala in processing fear and aggression in social behaviors has been firmly established (Aggleton, 1992; M. Davis, Whalen, & others, 2001). Animals studies have shown that the amygdala also receives highly processed visual input, and contains neurons that respond selectively to faces (Rolls, 1992) (p. 129).

In summary, results from both human subjects and animals, lesion, and neuroimaging studies concur on the importance of the amygdala in the processing of fearful stimuli, including facial expression. On the other hand, the amygdala is also activated by other facial expressions and even faces in general, and shows rapid habituation effects. One possible explanation for this generalized response to faces is that there may be differential responses by subsets of nuclei within the amygdala structure. The amygdala is a small structure situated deep within the brain and there- fore is hard to image. However, the use of higher field strength magnets (3T vs. 1.5T magnets) and more refined image acquisition techniques would increase the ability to detect more subtle activation changes in deep brain structures (p. 132).

Disgust: Behavioral Studies

Evidence for a specific neutral substrate dedicated to the processing of stimuli involving disgust comes from nonhuman primate studies. Yaxley et al. (1988) identified the primate anterior insular cortex as the gustatory cortex, because this structure contained neurons that respond to pleasant and unpleasant tastes. Can a similar area be identified in the human brain that would respond to "disgusting" stimuli, in particular the perception of disgusted facial expressions? In what follows, impaired perception of disgust is illustrated different patient groups [Huntington's, obsessive–compulsive disorder (OCD), and Tourette's syndrome patients with and without OCD]. Then, evidence from neuroimaging studies supporting a specific neural substrate for disgust is presented (p. 132).

In addition to the involvement of the basal ganglia structure, the processing of the facial expression of disgust would likely take place in a neural structure or network that includes the insular cortex and the orbitofrontal cortex. This network should be able to integrate visual, auditory, as well as olfactory information (p. 133).

Following up the clinical evidence that suggests dedicated neural substrates for different emotions, Phillips et al. (1997) sought to find distinct neural substrates for the perception of fear and disgust (p. 133).

The study of the expression of disgust further supports the idea that different structures are involved in the perception of different facial expressions. The link between the amygdala and fear has already been established. It now appears that the basal ganglia structure and the insular cortex are involved in the perception of disgust (p. 134).

Sadness and Anger: Behavioral Studies

The expression and perception of emotions such as sadness and anger are closely related to the concept of empathy - the identification with and understanding of another's situation, feelings, and motives. Sociopathy is characterized by disregard for others and aggressive behaviors. In a first study to investigate the relationship between expression recognition and behavioral problems, Blair and Coles (2000) showed that in their sample of adolescent children, the ability to recognize sad and fearful expressions was inversely related to levels of affective - interpersonal disturbance, impulsiveness, and conduct problems (p. 134).

Further, Blair and Cipolotti (2000) reported on a patient with damage to the right frontal region, including the orbitofrontal cortex, who showed a case of what they termed "acquired sociopathy." The patient showed difficulties in the area of social cognition, in particular facial expression recognition of anger and fear. The patient's impairment was attributed to a reduced ability to generate expectation of other's negative emotional reactions and to suppress inappropriate behaviors. The authors propose that the orbitofrontal cortex is implicated in the generation of such expectations and suppression of behaviors (p. 134).

Both animal and human lesion studies have implicated the orbitofrontal cortex in behavioral extinction and reversal learning (Rolls, 2000). Therefore, the amygdala and orbitofrontal cortex would be likely structures for processing facial expressions for sadness and anger respectively (p. 134).

A recent study by Blair et al. (1999) reports findings of dissociable neural responses to the facial expressions of sadness and anger(p. 134).

The statistical analysis identified differential responses to sad and angry faces. Signal intensity also increased as a function of degree of emotional intensity displayed by the face. Sad expressions showed activation in the left amygdala and the right middle and inferior temporal gyrus. Angry expressions showed significant activation in the right orbitofrontal cortex (as predicted) and bilateral activation in the anterior cingulate cortex. Conjoint activation was found in the right temporal pole and anterior cingulate cortex as a function of increased emotional intensity. The unilateral response in the left amygdala to sad expressions parallels the response to fearful faces observed in other imaging studies (p. 135).

Happiness: Behavioral Studies

Smiling appears to be innate. An infant will produce the first smile anywhere from 2 to 12 hours after birth. In fact, even blind and deaf babies smile. Ekman has identified several different types of smiles; enjoyment, dampened, miserable, qualifier, compliance, coordination, flirtatious, and embarrassed (McNeil, 1998, pp. 206-208). The type of smile most used in facial expression studies is that of enjoyment or the so-called Duchenne smile. According to the norms published by Ekman and Friesen (1976), mean accuracy for recognition of the facial expression of happiness reached 100% for the subset of faces used by Young et al. (1996), which makes the smile the most easily recognized expression (p. 135).

So far, no patient groups have displayed problems in recognizing happy facial expression. Both patients with amygdala damage (SM and DR) and patients with Huntington's disease performed at normal levels in processing happy facial expressions. Similarly, Adolphs et al. (1996) did not find any patients that displayed problems in recognizing happy facial expressions. In fact, recognition scores for happy expression did not correlate with the recognition of any other emotion. Taken together, these results suggest that a happy facial expression may be processed differently than all other expressions (p. 135).

Neuroimaging studies of the perception of happy facial expressions have usually contrasted this expression with the perception of negative facial expressions (i.e., fear, anger, and disgust). So far, no consistent pattern of activation has been found in response to smiling. Morris et al. (1996) found no activation in the amygdala for the contrast of happy–fearful expressions (p. 135).

Surprise

So far, no major studies have focused on the facial expression of surprise. The few data available on the perception, classification, and identification of surprised facial expressions have been collected in conjunction with assessment of the five other basic emotions (Adolphs, Tranel, Damasio, & Damasio, 1994, 1995; Andrew J. Calder, 1996; Young et al., 1995, 1996). For example, patient SM rated facial expressions of surprise, anger, and fear as less intense than controls. Bi- lateral damage to the amygdala has been shown to impair judgment of the intensity of fearful expressions, and also of expressions normally judged to be similar to fear, such as surprise. As the main focus of these studies was fear and the involvement of the amygdala, any observed deficit related to the perception of surprise was not further addressed. The expression of surprise bears strong resemblances with fear: eyes and mouth wide open. Surprise is also the briefest expression, lasting less than 1 s. An important point to consider is that emotional states are dynamic. This is especially important for surprise, because an expression of surprise can quickly turn into fear or happiness, depending upon the nature of the surprise. In fact, *surprise* can be defined as a transitory emotion which leads into the appropriate reaction for the emotional event facing the person. Given the short-lived nature of a surprised expression and given that surprise often transitions into an expression of fear, it is quite likely that the amygdala is also involved in processing the perception of surprise (p. 136).

Finally, Posamentier et al. (2003) concluded:

> Evidence from behavioral and lesion studies do suggest that different structures are activated by different emotions. The role of the amygdala in processing fearful stimuli has been well established. Recall that the patients who presented lesions of the amygdala and were impaired at processing negative emotions with fear being most strongly affected. Activation of the amygdala by fearful expressions should come as no surprise as reported by Morris et al. (1996; 1998) and Breiter et al. (1996). But, note that the facial expressions of sadness and happiness also activated the amygdala. Amygdala activation has been also reported in a categorization task of unknown faces (Dubois et al., 1999). Further, the results from the imaging studies of disgust implicate the basal ganglia structure as well as the insular cortex in the processing of this emotion (Gorno-Tempini et al., 2001; Phillips et al., 1997; Sprengelmeyer et al., 1997). Interestingly, the two facial expressions for which consistent patterns of activation have been established are fear and disgust. These are emotions that are evoked in direct threats to the system. In summary, we have accumulated considerable evidence that facial expression processing is supported by highly specialized circuits or neural substrates (pp. 137 - 138).

An important variable that we need to take into account when people process faces and facial expressions is the exposure time. Wilhelm et al. (2014) analyzed the importance of the exposure time for the stimuli regarding the recognition of emotions.

> Under conditions of unlimited time, unimpaired subjects frequently perform at ceiling

> in such tasks. In order to avoid such ceiling effects researchers frequently manipulate task difficulty by using brief exposition times for stimuli. Such manipulations, if done properly, will decrease accuracy rates as desired - but they do not eliminate speed-related individual differences. Limited exposition times are likely to favor participants high in perceptual speed. (p. 129).

In the following passage, Posamentier et al. (2003) summarized the conclusions of their study about processing faces and facial expressions:

> Although the Bruce and Young model states that identity processing follows a different route than facial expression processing, findings from experimental and behavioral studies alone failed to a certain degree to establish functional independence between the two subsystems, because the testing paradigms employed often confounded facial expression and facial identification tasks. From the field of neurophysiology, single-cell recordings in primates have identified differential neuronal responses to facial identity and expressions, as well as different brain areas (p. 138).
>
> The Bruce and Young model for face recognition integrated findings from experimental, behavioral, and neuropsychological studies and provided a sound frame- work for future experimental probes of face processing. As we have seen, 15 years later the Bruce and Young model still guides researchers using new technologies. The model proposed by Haxby and colleagues also integrates the findings from numerous imaging studies of various face-processing tasks and shows promise of providing a similar framework for future work. It is however prudent to remember that the discipline of neuroimaging is still relatively young. Issues pertaining to both imaging techniques, statistical analysis, as well as experimental design, must be carefully evaluated and refined before we can ascertain the reliability of this approach in not only dissociating facial identity and facial expression processing, but also assessing the functionality of the different areas of activation as well as the temporal sequence of face processing (p. 139).

4.3 Facial emotion recognition in schizophrenia

The American Psychiatric Association define "the term schizophrenia as a group of psychotic disorders that are characterized by cognitive symptoms such as thought disorder and delusions, and by behavioral symptoms such as catatonia or negative symptoms" (APA, 1994). From a clinical perspective, the most outstanding characteristic of schizophrenia is the inapt, often bizarre behavior of affected individuals. In other words, it is almost always the deviant social behavior in schizophrenia that renders patients "abnormal".

Brüne describe in his work about "Emotion recognition, theory of mind, and social behavior in schizophrenia" (2005, pp. 135 - 136) the schizophrenic pathology:

> The importance of social behavioral problems in schizophrenia cannot be overestimated, since impaired social functioning in schizophrenic patients frequently precedes the onset of psychosis. Social deficits are often already present in first-episode patients, and may be relatively impervious to antipsychotic treatment. Moreover, social impairments in schizophrenia frequently worsen over the course of the disorder and probably contribute to the rate of relapse (recently summarized by Pinkham et al. (2003)). Over the past decades, however, most neuropsychiatric studies in schizophrenia have largely focused on disorders of nonsocial cognitive processes such as executive functioning, attention, or memory (e.g., Cirillo & Seidman, 2003; Evans, Chua, McKenna, & Wilson, 1997), deficits that certainly affect patients' psychosocial skills. Only quite recently have researchers shifted their attention towards social cognition in schizophrenia (D L Penn, Corrigan, Bentall, Racenstein, & Newman, 1997; Pinkham et al., 2003), questioning to what extent an impaired perception of social signals or impaired social cognition may directly account for the poor social functioning in schizophrenia. There is indeed some evidence that, statistically, social cognitive measures may better distinguish between patients and no patients than nonsocial tests (D L Penn et al., 1997). The association of social perceptual and cognitive skills in schizophrenic patients with patients' actual social behavior is, however, to a certain extent still unclear. It seems to turn out that patients with chronic schizophrenia suffering from marked negative symptoms are more impaired in their ability to recognize emotions from facial expressions and in their social skills, relative to less chronic patients (Mueser et al., 1996; David L. Penn, Spaulding, Reed, & Sullivan, 1996).
>
> With regard to social cognition, a compelling theoretical framework to explain certain cognitive aspects of the marked social deficits in schizophrenia was put forward by Frith (2015). He hypothesized that many symptoms typical of schizophrenia may be

> accounted for by a specific cognitive incapacity of schizophrenic patients to accurately attribute mental states to themselves or others (commonly referred to as having a theory of self and others' minds; ToM), leading to what Frith called disorders of willed action, disorders of self- monitoring, and disorders of monitoring other persons' thoughts and intentions (Frith, 2015).
>
> For example, if patients with schizophrenia have difficulties in perceiving their behavior as the result of their own enacted goals or to suppress inappropriate responses, their behavior may become disorganized. Secondly, if patients are unable to appreciate their behavior as the result of their own intentions, they may falsely interpret their actions as being under alien control or experience voice- commenting hallucinations. Thirdly, if patients confuse their subjective representations with reality, they may maintain false beliefs about other people's intentions, for instance, in the form of delusional convictions of being poisoned or persecuted.

"In social interaction, Theory of Mind (ToM) enables us to construct representations of others' mental states, and to use those representations flexibly to explain or predict others' behavior"(Wang et al., 2015, p. 332). Ng et al., (2015) described the Theory of mind in their work about " Insight and theory of mind in schizophrenia":

> Theory of mind (ToM; also called mental state attribution) is "the ability to infer intentions, dispositions and beliefs of others" (Green et al., 2008). This ability to understand the mental states of others is important for a variety of social functions, including understanding pragmatic speech, pretending, deception, imagining, understanding jokes, and empathy (Rhiannon Corcoran, 2001; Shamay-Tsoory, Shur, Harari, & Levkovitz, 2007; Sperber & Wilson, 2002). Several studies have found ToM deficits in individuals with schizophrenia (R Corcoran, Mercer, & Frith, 1995; Garety & Freeman, 1999; Green et al., 2008), and this impairment has been shown to be associated with social functioning and social competence in schizophrenia (Brekke, Hoe, Long, & Green, 2007; Brüne, Abdel-Hamid, Lehmkämper, & Sonntag, 2007; Brüne, 2005b; Couture, Granholm, & Fish, 2011; Couture et al., 2006; Green et al., 2008; Roncone et al., 2002). Therefore, ToM may be an important treatment target to improve real-world functioning in schizophrenia.

It is generally agreed that schizophrenia patients show a markedly reduced ability to perceive and express facial emotions. A deficit in emotion recognition has been found to be a characteristic feature of this pathology (Addington & Addington, 1998; Baudouin et al., 2002; P. J. Davis & Gibson, 2000; Hooker & Park, 2002; Kirkpatrick et al., 1989; Kohler et al., 2000; Mueser et al., 1996).

Evidence for this comes from numerous studies that have used facial expressions of emotion as stimuli (Archer et al., 1994; Heimberg et al., 1992; Novic et al., 1984; Walker et al., 1984). Controversy exists, however, regarding the nature of such a deficit in schizophrenia. Some investigators believe that the deficit is emotion-specific. This supposition is based on the fact that schizophrenic patients are impaired in the recognition of emotions, especially negative emotions (Cramer et al., 1989; Dougherty et al., 1974; M K Mandal & Rai, 1987; Muzekari & Bates, 1977; Zuroff & Colussy, 1986).

Consistent findings show that schizophrenic patients experience difficulty in the perception of negative emotional displays when compared with that of positive emotional displays (Edwards, Jackson, & Pattison, 2002). However, there is a lack of consistency among reports regarding the category of negative emotions that cannot be recognized by schizophrenia patients. The majority of studies reported that the greatest difficulty was in recognizing fear (Edwards et al., 2002; M K Mandal, Pandey, & Prasad, 1998); however, some reported impairment in recognizing negative emotions other than fear (Bediou et al., 2005).

Namiki et al. (2007, p. 24) described the importance of the amygdala in facial emotion recognition on their studies about "Impaired facial emotion recognition and reduced amygdalar volume in schizophrenia"

> The neural system implicated in facial emotion recognition has been proposed to include the amygdala, the fusiform gyrus and the superior temporal sulcus (Adolphs, 2002). In particular, the amygdala is suggested to be closely involved in the recognition of negative facial emotions, and this theory has been supported by both lesion studies and imaging studies. Human lesion studies have consistently found impaired recognition of facial emotion following bilateral amygdala damage; this impaired recognition is often disproportionately prominent for fear (Adolphs et al., 1994, 1995; A J Calder, Lawrence, & Young, 2001; Phillips et al., 1998), but sometimes encompasses multiple negative emotions including fear, anger, disgust, and sadness (Schmolck & Squire, 2001; Scott et al., 1997). Functional magnetic resonance imaging (fMRI) studies have also reported that the amygdala is activated in a disproportionately greater fashion by negative facial emotions (Phillips et al., 1998; Whalen et al., 2001).
>
> Meanwhile, a number of morphometric MRI studies on schizophrenia demonstrated abnormalities in various cortical and subcortical structures (Shenton, Dickey, Frumin, & McCarley, 2001), including the areas that are considered to be involved in emotional

processing as described above. The amygdala has thus been measured in several morphometric studies in schizophrenia. However, the results of these studies are not consistent. Some studies indicated that amygdalae of schizophrenia patients were smaller bilaterally than those of normal controls (Joyal et al., 2003; Niu et al., 2004), although one study showed right-unilateral amygdalar volume reduction in schizophrenia (Pearlson et al., 1997). There were also several studies with more complex results. Gur et al. (2000), for example, reported that only men with schizophrenia had smaller amygdalar volume, while Kalus et al. (2005) found volume reduction only in raw volumes, but not in adjusted volumes. Contrary to this, other studies showed no difference in amygdalar volume between schizophrenia subjects and normal controls (Altshuler et al., 2000; Niemann, Hammers, Coenen, Thron, & Klosterkötter, 2000; Staal et al., 2000; Szeszko et al., 2003). More recently, studies of comparatively larger populations have also reported no difference (Tanskanen et al., 2005; Velakoulis et al., 2006), and neither did a recent meta-analysis study (Vita, De Peri, Silenzi, & Dieci, 2006).

However, others believe the deficit to be general, encompassing all emotions (Archer, Hay, & Young, 1992; Feinberg, Rifkin, Schaffer, & Walker, 1986; Heimberg et al., 1992; Novic et al., 1984).

Manas et al. (1999, p. 40) reviewed some recent studies about the emotion-recognition deficit in schizophrenic patients:

> Some recent studies that used a differential deficit design (Chapman & Chapman, 1978) to nullify the possibility of a more general performance deficit (e.g. deficit on a non-emotional face recognition task) rather than an emotion-specific impairment documented a generalized performance deficit on measures of facial emotion recognition in schizophrenia (Kerr & Neale, 1993; Salem, Kring, & Kerr, 1996). It was also argued that illness chronicity had a positive relationship with generality of performance deficit in schizophrenia (Mueser et al., 1996).
>
> The emotion-specific deficit is assumed to be the result of social-cognitive deterioration in which schizophrenic patients, in an effort to avoid exposure to arousing stimuli, withdraw from social interactions and, with continuous avoidance, manifest a deficit to the recognition of certain emotions, particularly negative emotions (Walker et al., 1980). In contrast, the generalized emotion- recognition deficit in schizophrenia is thought to stem from cognitive impairment that globally affects the patient's emotion-processing ability and thus results in a marked reduction

of emotional sensitivity.

Although much controversy can be found in the literature, few researchers expand on the issue of variations in sample characteristics that may give rise to the differential patterns of outcome deficit. It may be that the emotion-recognition deficit in schizophrenia is a function of onset of disorder (early vs. late), course of psychopathology (acute vs. chronic), subtype (paranoid vs. non-paranoid), and prognosis of schizophrenic pathology (positive vs. negative) symptomatology.

4.4 Cartoon Face Processing

Tracking eye movements has proven to be a useful process for determining the nature of atypical social gaze. Looking at faces is important to interpreting facial cues, and gaze behavior can provide insights into face-related skills. A wealth of studies has used eye tracking to identify how individuals view socially relevant information.

Riby and Hancock (2009) described in their study about eye-tracking that:

> Exploring gaze behavior can reveal components of the attentional system (Henderson, 2003) as well as social interests (Kingstone, Smilek, Ristic, Friesen, & Eastwood, 2003) and studying where individuals look to gain information can provide insights into the difficulties shown in everyday social interactions (Boraston & Blakemore, 2007).

As noted by Riby and Hancock (2009) the use of cartoon images in eye tracking methodology may allow for an assessment of facial processing while removing a degree of social demand inherent in viewing more naturalistic human interactions (e.g. photographs and movie clips with human actors). Increasing evidence suggests that, in contrast to atypical real-face processing, individuals with autistic spectrum disorders (ASD) do not differ from typically developing controls in cartoon-face processing. For instance, when presented with cartoon scenes, individuals with ASD tend to fixate longer and more often on cartoon characters than objects (Van Der Geest, Kemner, Camfferman, Verbaten, & Van Engeland, 2002). Moreover, training studies have suggested that children with autism show greater improvements in emotion recognition when programs include cartoons rather than photographs of real faces (Silver & Oakes, 2001). Note that clinical and parental reports also state that children with ASD spend long periods of time looking at cartoons (Miyahara, Bray, Tsujii, Fujita, & Sugiyama, 2007). The idea that children with ASD show increased interest for cartoon faces relative to real faces has also been supported by recent neuroimaging case study (Grelotti et al., 2005).

Rosset et al. (2008) described in their study about "Typical Emotion Processing for Cartoon but not for Real Faces in Children with Autistic Spectrum Disorders" that:

> Increasing evidence suggests that, in contrast to atypical real-face processing, individuals with autistic spectrum disorders (ASD) do not differ from typically developing controls in cartoon-face processing. For instance, when presented with cartoon scenes, individuals with ASD tend to fixate longer and more often on cartoon characters than objects (Van Der Geest et al., 2002). More over, training studies have

> suggested that children with autism show greater improvements in emotion recognition when programs include cartoons rather than photographs of real faces (Silver & Oakes, 2001). Note that clinical and parental reports also state that children with ASD spend long periods of time looking at cartoons (Miyahara et al., 2007). The idea that children with ASD show increased interest for cartoon faces relative to real faces has also been supported by recent neuroimaging case study (Grelotti et al., 2005).

According to Rosset et al. (2008), "one possible explanation for the differences found for real and cartoon faces in autism is that in contrast to human faces, cartoons are stimuli with which no social interaction is possible. In this case, children with ASD process cartoons in a typical manner because their social impairments do not interfere with this (less-sociable) type of stimuli".

It is widely accepted that cartoons have a clear benefits in expressing emotions and feelings. Xu et al. (2006) describe these benefits in their work about "Expressive image generation: Towards expressive Internet communications".

> Compared to human facial images, cartoon images have their own characteristics, i.e. firstly, the cartoon facial expressions can be extreme. Cartoons can show extreme expressions and extreme behavior without causing any negative feelings (e.g. the cartoon Simpson family's behavior in TV shows). Secondly, parts of the characteristics presented in human images may be distorted or even disappear in cartoon images. For example, a cartoon image may have extremely large eyes without eyebrows or an upper lip.

Moreover, the use of cartoons may serve to create a more engaging learning environment and increases motivation to interact with materials. Given the wide spread use of cartoon images within the intervention literature (especially in teaching emotion recognition skills).

A range of social cognitive deficits have been reported for both autism and schizophrenia (Abdi & Sharma, 2004; Pelphrey et al., 2004; Pinkham et al., 2003), particularly in theory of mind (Baron Cohen, 1995; Rhiannon Corcoran, 2005; Yirmiya et al., 1998), the perception of social cues (Archer et al., 1994; Klin et al., 2002) and facial affect recognition (Celani et al., 1999; Kohler & Brennan, 2004).

Both autism and schizophrenia are characterized in part by pervasive social dysfunction that impairs the ability to initiate and maintain reciprocal interaction (APA, 1994). Notwithstanding, to date, no study has attempted to explore the performance in emotion recognition of individuals with schizophrenia when programs include cartoons rather than photographs of real faces.

4.5 Electronic games for psychotherapy

Electronic Games have become extremely popular for capturing the attention of children and adults in the promotion of healthy lifestyles (Watters et al., 2006). This success across a broad demographic has led researchers to consider that video game interaction can be used to advantage in health contexts.

Using video games as a research instrument in psychology is not new (Hirsig & others, 1990). Video games have been successfully employed in a variety of research topics. On a general level, Bainbridge (2007) stated that video games have great potential as sites for research in the behavioral, economic and social sciences, as well as in human-centered computer science.

Latest estimates of the prevalence of computer and video game play said that "more than 150 million Americans play video games and 42 percent play video games regularly, or at least three hours per week"(Computer & Game, 2015). New technologies provide therapists with many new opportunities of intervening with patients. Social media, smart devices that are carried with us, the Internet, e-mail, we are able to collect information and disseminate information in ways that are less time-consuming, more interesting, and more readily available.

Horne-Moyer et al. (2014, pp. 1 - 2) described how electronic games and electronic games for psychotherapy have been used in health promotion and to improve physical and psychosocial functioning of patients.

> The first commercially successful electronic games (EG) were developed in the 1970s for entertainment and played in arcades, but they soon found their way into homes (Salonius-pasternak & Gelfond, 2005). Almost simultaneously, health and mental health care providers started using computer and video games as part of therapy (Allen, 1984) and others began developing EGs for psychotherapy (EGP) (Clark & Schoech, 1984).
>
> EGP and EGE have been used in health promotion and to improve physical and psychosocial functioning of patients. Both types of games may be used to increase motivation, attention/engagement, knowledge, or physical efficacy; to allow for physical activity, practice, or immediate feedback; and to provide therapeutic imagery and emotional expression. Comprehensive reviews indicate that EGP have been used successfully to improve diet and physical activity in children, and EGE for chemotherapy-related nausea, pre- operative anxiety, fitness, physical therapy, and

cognitive rehabilitation (Baranowski, Buday, Thompson, & Baranowski, 2008; Kato, 2010). EGP allow for tailoring game design and interfaces to specific needs of patients (Proffitt, Alankus, Kelleher, & Engsberg, 2011).

Most approaches to incorporating technology into the therapist's office use games or programs specifically designed to serve one or more therapeutic needs. Computer-assisted cognitive behavior therapy (cCBT) includes computer-delivered information and interventions designed to implement established treatment models. In some cases, a specific game is developed or the interventions exhibit a game-like quality, but some elements may be less interactive, such as video demonstrations or relaxation inductions. For example, online self-help for anxiety disorders (Berger, Boettcher, & Caspar, 2014) and handheld devices with diaries and prompting for individuals with obsessive compulsive disorder have been shown to facilitate CBT (Newman, Przeworski, Consoli, & Taylor, 2014).

In a systematic review, Horne-Moyer et al. (2014) examined the use of electronic games in treating various anxiety disorders and depression.

Newman et al. (2011) concluded that computer-assisted treatment is effective overall and suggested that compliance might be maximized through more therapist exposure. Mohr et al. (2013) remarked that the "serious game movement" is finding "entertaining games" being designed for therapeutic purposes, especially in the field of mental health (EGP).

In addition to anxiety and mood disorders, EGP have been developed to enhance psycho-education, attitude change, relaxation, pain management, social skills, problem-solving skills, emotional modulation, self-control skills, motivation, and therapist-client interaction (Santamaria et al., 2011). Of 11 EGP, five were found to have been systematically assessed for effectiveness: Re-Mission, Personal Investigator, Treasure Hunt, Play Attention, and one unnamed game. The authors concluded that EGP can be effective in increasing compliance, learning, and behavior and affective change (Santamaria et al., 2011).

Numerous computer games have been lately designed to test the ability of patients particularly with mental disorders to identify basic facially expressed emotions.

Prior studies have proved that computer games and emotion research can benefit a lot from each other (Kaiser, S.; Wehrle, Kaiser, & Wehrle, 1996).

A number of studies have demonstrated that computer interventions appear to be particularly appropriate for people with autistic spectrum disorders for different reasons (Panyan, 1984). These authors note how technology can equalize opportunities for people with disabilities, encourage cognitive and social development and lead to improved independence and self-esteem.

Lewis (2000) and Robertson and Hix (2002) note that for the moment little literature has been written about software being beneficial for children and adolescents diagnosed with mental health; on the other hand it is significant that everyday there are more and more available software tools that augment the child's training.

Goh et al. (2008, pp. 2221 - 2222) examined in their review about psychotherapeutic gaming interventions the strengths and weaknesses of using games as psychotherapeutic tools.

> There is a growing body of evidence highlighting the more negative aspects of play, particularly for children and adolescents. Some of these adverse effects include video game addiction and increased aggressiveness (C. Johnson, 1999; Vorderer & Bryant, 2006). However, Bensley and Van Eenwyk (2001) argued that computer games with violent content can be viewed as a form of aggressive play, which is inherently different from actual aggression because of its lack of intent to injure a living person.
>
> Separately, Lawrence (1986) argued that computer games lack attention to the specifics of an individual's difficulties and feelings in the context of a unique life experience. Such games lack the element of empathy that is built upon direct communication with and acceptance by another human being.
>
> Computer games also allow the child to compare varied possibilities of the natural and social world and to clarify reality while they are experimenting with altering it. These aspects of being able to explore in a ''safety zone'' allows the child to self-regulate and calm those feelings of fear and anxiety associated with danger (Salonius-pasternak & Gelfond, 2005).
>
> Prensky (2005) also highlights several benefits for game-playing especially in the educational context, including:
>
> 1. Enjoyment and pleasure since games are a form of fun and play
> 2. A sense of structure since almost all games have rules
> 3. Motivation, as most players aim to achieve the goals of their game(s)
> 4. Activity, since games are interactive, that is, between the players and the game
> 5. Flow, since games are adaptive
> 6. Learning, as games have outcomes and are able to provide feedback on

the players' progress throughout the game

7. Ego gratification especially when the player is able to reach the goals or complete each stage of the game
8. Excitement, since games have conflict, competition, challenge and/or opposition
9. Creativity, as most games involve problem solving
10. Emotion, since games can be emotional via their story lines
11. Social group learning, since games can provide a platform on how to interact with diverse groups of people.

Another advantage of using a computer game in therapy is that it is a readily accepted platform for most children and adolescents. People in these age groups usually have positive associations with video game technology and as such, covert learning takes place with- out the normal resistance to overt educational approaches (Casey, 1992; Kafai, 1996; Prensky, 2005).

The resulting exhilaration of world- hoping contrasts with the static feeling of the conventional classroom and is especially helpful for children and adolescents with ADHD (Gifford, 1991). The acceptance of computer games also allows them to be used as complements to traditional methods for the treatment of mental health conditions. For example, in CBT, which mainly utilizes instruction, homework and other exercises (Lawrence, 1986; Wright et al., 2005), computer games can be used to capture the attention and interest of the child, and also enable the therapist to track the child's progress.

In summary, while computer games have certain drawbacks, the benefits that have been discussed suggest great potential in using such games as a psychotherapeutic tool. In the following, we focus our analysis on existing research to draw guidelines and strategies for the development and deployment of computer games for the treatment of children and adolescents with mental health conditions.

A good game must be able to capture and even to prolong the interest of its target users, in this case children with mental disorders. However this cannot be achieved if the game does not have a careful design (Novak, 2008). It should also be noted that the degree of challenge in psychotherapeutic games could be different when compared to computer games meant for entertainment. Game designers should take into account that in this case it is important to keep the game and rules simple enough to be learnt easily or players will feel frustrated or demoralized after spending long periods trying to figure out the rules of the game, causing them to eventually give up (Mitchell & Savill-Smith, 2004). Interactions within a game may be difficult to master for those with various mental health concerns (Cole, Dehdashti, Petti, & Angert, 1993). For example, communicating with virtual characters may be easy for the general population but may not be so for a child with autism in need of social skills training.

On the other hand psychotherapeutic games are best used as adjunctive treatment; this is, as a complement to existing face-to-face methods with a mental health professional. Some authors support this theory in their studies (Durkin & Barber, 2002; Griffiths, Davies, & Chappell, 2003). In fact, the work reviewed share a common trait in that computer games were used as an assistive tool to actual therapy. It has been found that with appropriate design and use, computer games can be effective psychotherapeutic tools, especially if used as a complement to other techniques (e.g. therapy session with psychologists) and with well-trained psychotherapists. These games were rarely used alone as a therapeutic method. Consequently, it is important that game designers work closely with mental health professionals to develop indications and guidelines for the use of games as part of a comprehensive intervention plan (Goh et al., 2008).

Horne-Moyer et al. (2014) finalized their review about the use of electronic games in therapy with these words:

> In our survey of the research, electronic methods, including games and other types of computer-assisted therapies, have been shown to be equivalent but not superior in efficacy for a wide variety of medical health and mental health issues, in group, individual, and self-guided treatment. There is evidence that some electronic methods are more acceptable, enjoyable, or engaging than treatment as usual and that greater therapist engagement may be associated with better outcomes. Methodological limitations include the predominance of quasi-experimental, pre-post designs, and case studies.
>
> The area of therapeutic electronic games is promising, despite the need for more rigorous outcome studies. If, as has been suggested here, electronic methods produce similar results and are more acceptable than established treatments to clients, or to a subset of clients, their utility will be established based on ability to effectively serve a broader range of the population. Electronic games for psychotherapy have the advantage of being tailored to specific client groups, diagnoses, and settings and are more standardized, but are relatively expensive to produce and must be specifically up- dated.

Finally, it is important to mention the concerns about the adoption of the use of new technologies in psychotherapy by therapists. Horne-Moyer et al. (2014) summarized from the work of Barrett and Gershkovich (2014) the six legal, economic, and clinical concerns:

1. The challenge of keeping up with advances in technology
2. The potential detriment of computer-assisted technology to the therapeutic relationship
3. Time requirements for the therapist and compensation for that time in a significantly different format
4. The potential for clients to access interventions not appropriate for them when online interventions are made openly available to the community
5. Implications of the decrease of face-to-face interaction between the client and therapist, including informed consent and assessment of dangerousness towards self or others
6. Potential changes in content, maintenance, and confidentiality of records

In summary, video games have increasingly been used as tools for the treatment of mental health conditions, they can be effective when designed and used appropriately (Katz & Wertz, 1997). Mental health professionals can use video games to conduct treatment-related activities and gather data to monitor their patients' progress. Additional, patients can use these games on their own time, expanding the scope of treatment, and possibly even enjoying lower treatment costs. Nevertheless, there are limits to what video games can achieve as psychotherapeutic tools, and they should not be used in isolation nor seen as replacements for existing therapeutic methods.

4.6 Psychotherapeutic computer games for emotion recognition

Several electronic games have been recently designed to test the ability of individuals especially with mental disorders to identify basic facially expressed emotions.

Previous studies have proved that video games and emotion research can benefit a lot from each other (Kaiser, S.; Wehrle et al., 1996; Silver & Oakes, 2001).

Electronic Games are interactive and dynamic in nature and these features make them a good candidate to use as a tool for investigating and eliciting human emotions in different experimental setups specially if the outcome of a game is controllable in a systematic manner (Lazzaro, 2004). On the one hand, video games can be used as a tool for eliciting emotions but on the other hand the whole game experience can be enhanced under the 'affective computing' paradigm where games monitor/interpret human emotions and the respond in an appropriate manner for maintaining an optimal level of enjoyment (Nacke, Kalyn, Lough, & Mandryk, 2011).

Many pedagogical ways of teaching affect are possible by means of technology. Automated stimulus to get a response with consequential feedback is a simplistic model of behavior analysis. It is clear that there has been increasing investigation into the use of computer games as a form of therapy in which patients can be easily engaged, among some other reasons because of the new environment for the patient and therapist that new technologies provide. Technology can supply users with visual and auditory stimuli that may be otherwise difficult to generate (Hutinger, 1996).

The following review provides a brief overview of the most important Psychotherapeutic computer games for facial expression recognition.

'Guess Who?' (Imtiaz Ahmad, Tariq, Saeed, Shahid, & Krahmer, 2011) is a good example of a customizable interactive platform, which was designed as a tool for researching human emotions in a variety of experimental environments. "In its essence, 'Guess Who?' is actually a game, which includes typical game elements (winning, losing, scoring) and can also be played purely for entertainment purposes. Early user evaluations demonstrated that 'Guess Who' video game is not just an excellent research tool for researchers, where researchers can record important data in different experimental conditions in a natural way, but also a great source of entertainment for children" (Imtiaz Ahmad et al., 2011, pp. 543 - 544).

JeStiMulE is a computer-based game based on logical skills to teach emotions to individuals with Autism Spectrum Conditions, independently of their age, intellectual, verbal and academic level. The developers of the game describe this video game in their work about

“Facing the challenge of teaching emotions to individuals with low- and high-functioning autism using a new serious game: a pilot study” (Serret et al., 2014, pp. 3 - 4):

> JeStiMulE is a virtual reality game with a multi-sensory environment. It was specifically designed for children and adolescents with Autism Spectrum Conditions (ASC). It aims at training emotion recognition skills, including facial expressions, emotional gestures, and social situations. For this purpose, nine expressions are presented in the game: six basic emotions (which are happiness, anger, disgust, fear, sadness, surprise), one complex emotion (that is pain) and two complementary expressions (which are neutral and ‘funny face’). These emotions are displayed on both static and animated avatars. The expressions of pain were included in order to promote the development of empathy (Minio-Paluello, Baron-Cohen, Avenanti, Walsh, & Aglioti, 2009). Furthermore, complementary expressions were included to facilitate the distinction between emotional and non- emotional expressions. This is particularly important for children and adolescents with ASC without functional language, to whom a verbal explanation of this distinction is often inefficient. In this way, a face without emotional expression corresponded to a neutral/non-emotional facial expression and a ‘funny face’ reflected an intentional inappropriate facial expression. Each expression was associated to one facial expression and three gestures. Each facial expression was different from another by mouth, eyes and eyebrows shape, opening or tilt. Only one emotional valence was presented for each emotion.

The Emotion Trainer is another computer game designed to teach people with Autism Spectrum Conditions to recognize and predict human emotional responses. “The Emotion Trainer is an interactive multimedia computer program designed to teach a person how to recognize and predict emotions in other people. The Emotion Trainer uses real photographs and examples relevant to daily life, to gradually teach some of the skills underlying emotional understanding in an entertaining way” (Emotion Trainer, 2015). Goh et al. (2008) described the work of Silver and Oakes (2001) utilizing this Psychotherapeutic game:

> They conducted a randomized controlled trial with measurements taken pre- and post-intervention using a multimedia computer game called The Emotion Trainer. The video game consisted of five sections of increasing levels of difficulty ranging from identifying facial expressions to associating emotions with different events and objects. A total of 22 children (11 experimental and 11 control) diagnosed with ASD between age 10 and 18 from two special schools catering for children with ASD participated. The experimental group used The Emotional Trainer during 10 daily computer sessions (about 2–3 weeks) while the control group received their normal lessons only. The authors found encouraging results on participants’ performance

> and concluded that computer training programs could be effective tools for people with ASD. This was because these programs were able to keep the children focused on their tasks due to their design appeal, and further, these programs allowed each child to learn at their own individual pace.

Another example of a psychotherapeutic video game for emotion recognition to help children with autistic spectrum diagnoses is the 'Gaining Face' (Silver & Oakes, 2001). "It helps children to learn to read expressions therefore helping to teach more about the non-verbal signal which we all use in daily life. The quiz idea is great as it gives the player positive feedback on how they are doing and the fact that you can check which answer is the correct one if you get it wrong is helpful for the next time you play. It enables the player to learn as they go a long and encourages them to look carefully at each expression, which they can then take into their daily life" (Adders.org, 2015).

Additionally to these video games, we should mention The FaceMaze. Gordon et al. briefly describe this computer game in their paper 'Training Facial Expression Production in Children on the Autism Spectrum' (Gordon, Pierce, Bartlett, & Tanaka, 2014, pp. 2486 - 2488).

> FaceMaze is an interactive, PacMan-like video game in which participants navigate through a maze of obstacles while collecting ''tokens''. Obstacles in the maze are overcome by producing facial expressions as measured by the computer recognition emotion toolbox (CERT). CERT analyzes the child's facial expressions via the webcam and provides real-time feedback to the user with respect to the quality of their expression productions. For this study, a group of children with autism spectrum disorder (ASD) and IQ-matched, typically developing (TD) children were trained to produce ''happy'' and ''angry'' expressions with the FaceMaze computer game. FaceMaze uses an automated computer recognition system that analyzes the child's facial expression in real time. Before and after playing the Angry and Happy versions of FaceMaze, children posed ''happy'' and ''angry'' expressions. Naïve raters judged the post-FaceMaze ''happy'' and ''angry'' expressions of the ASD group as higher in quality than their pre-FaceMaze productions. Moreover, the post-game expressions of the ASD group were rated as equal in quality as the expressions of the TD group.

Finally, We would like to mention the 'Affective Social Quest' (ASQ) interactive game, designed by K. Blocher and R. W. Picard (2002). ASQ is a computer, interactive software, and toy-like objects through which the child communicates to the console. "ASQ displays an animated show and offers pedagogical picture cues -- the face of the plush dwarf doll, the emotion word, and the Mayer-Johnson standard icon -- as well as an online guide that provides audio prompts to encourage appropriate response behavior from the child"

(Blocher & Picard, 2002, p. 3). The video game synthesizes interactive social situations to promote the recognition of affective information. ASQ is designed to teach emotion recognition to autistic children with a heterogeneous disorder. Though the interactive application developed for this study does not come close to the abilities of a highly trained human practitioner, it is intended to offload some of the most tedious parts of the work.

5 SYSTEM OVERVIEW

5.1 Introduction

Feeling Master is a psychotherapeutic interactive game for facial emotion recognition with three levels of difficulty (see **Figure 3**). The game was developed as a tool to investigate the deficit in facial expression recognition in patients with schizophrenia. There is a maximum time allowance for solving all questions that may differ from level to level, and it is the practitioner who customizes the game for each patient. Designed as a modular game, once the level has been chosen, the patient will be prompted to correctly guess the answers to the questions posed or, depending on the activity, simply match an emotion to the corresponding face. According to Ekman and Friesen (1971), there are six basic facial expressions of emotion, and it is these emotions that were selected for use in the application: happiness, sadness, anger, surprise, disgust, and fear. In addition, therapists will have the ability to manage information regarding patients' data, see patients' performance, and configure future sessions and activities within the application. Taking into account the type of patient, the therapist may choose an easier or more complex activity, with more or less time dedicated to each activity. A distinctive feature of Feeling Master is the use of cartoon stimuli instead of the prototypical picture set of the basic emotions.

Figure 3. Three levels of difficulty in Feeling Master

5.2 System Description

Once the practitioner has logged in using his or her username or e-mail address and password, he or she will be able to add personal information and customize certain preferences; these information and preference fields are: first name and surname, date of birth, e-mail address, username, password, and language (English or Spanish). When the changes have been saved, the "dashboard page" will open and the practitioner will have the possibility to add the profile of a new user or to select one from a given list. When adding a new profile, the practitioner will enter some basic data, such as the user´s first name and surname, date of birth, e-mail address, the preferable language (English or Spanish), and the desirable username. A password will be generated and sent to the user's or a parent's e-mail address.

On the other hand, if the practitioner selects an existing profile of a user from the list, he or she will have the opportunity to edit it or to add a photograph of the user.

The changes made to a profile can always be cancelled or saved, after which the practitioner can navigate back to the dashboard where he or she will be able to define the game settings for each user. The game consists of three levels; the number of emotions, the number of questions, and the time given for each question can be customized for each level. As previously mentioned, the recognition of six emotions or feelings are being tested (sadness, happiness, disgust, surprise, anger, and fear). The practitioner will determine how many and which feelings will be tested in each level. The number of questions may vary from 1 to 16 and the time allotted for each question may be anywhere from 3 to 30 seconds. Once the game configuration for the user has been chosen or changed, the practitioner will always have the option to cancel, save, or save and test the settings.

Also on the dashboard, the practitioner may select any of the users' performance reports. A PDF version of the report can either be downloaded or viewed online. There will be an option available that enables the therapist (or family or caregiver) to save a record of all the results provided by the patient.

First, a performance report summary is available. The report consists of a table displaying the data of each session listed individually and including: the total number of questions, the number of correct and incorrect answers and the percentage of each, the total time used to perform the task within that session, and the score.

Second, more detailed tables for each session are available. These include the date and time of a particular session and the number of correct, incorrect, and unanswered questions for each emotion level by level. For those emotions that were not previously selected by the practitioner for that particular level a "not selected" label is used. The table includes the configuration that the practitioner chose for that session (the number of questions and time for each level). The total number of correct, incorrect, and unanswered questions is also provided, however, the total number of questions in the configuration column includes the questions from the previous session.

Next, the practitioner can check the same data as that on the performance report summary, but for an individual session. There will be an option available that enables the therapist (or family or caregiver) to save a record of all the results provided by the patient.

Finally, a user's profile can be deleted on the dashboard page. The practitioner can also change his or her own preferences or log out of the game at any time.

5.3 Technical description

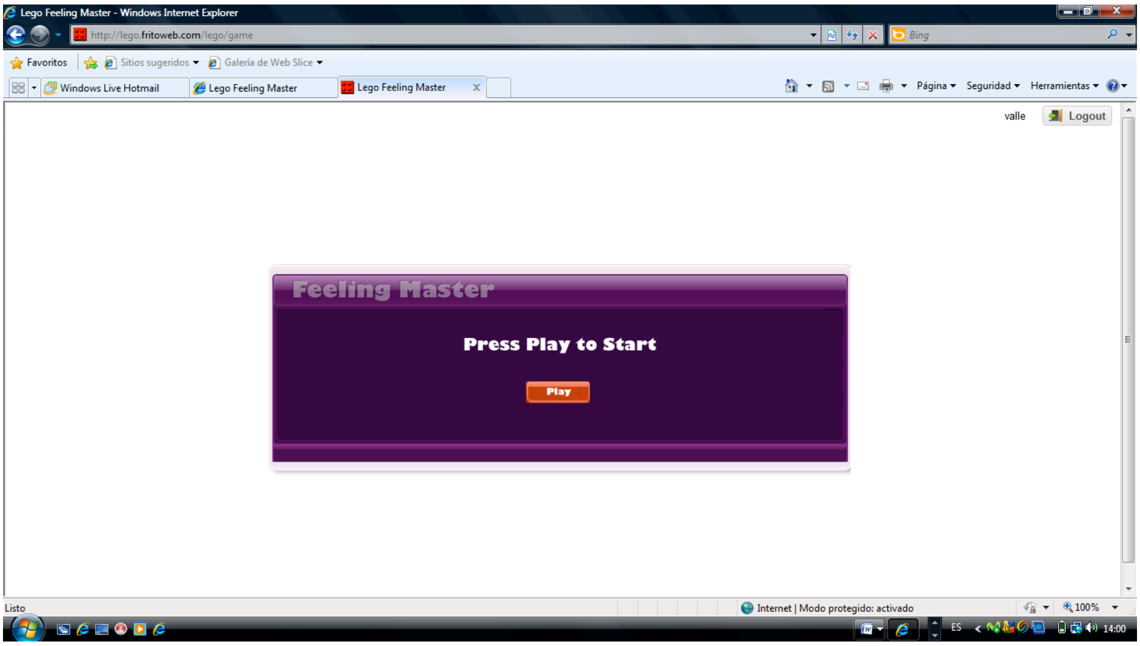
Feeling Master is a Flash game programmed with ActionScript and XML. Flash was used to guarantee platform independence, as only a Flash-compatible Internet browser is needed and no program needs to be installed. This facilitates giving homework to users independent of the computer hardware and operating system they have access to at home. User interaction will be recorded in files to help therapists analyze users' performance and progress. The Security Measures considered for the system were:

- Feeling Master will only be available on an intranet, thus minimizing security issues. Patient records will have restricted access and will not be integrally available.
- A built-in authentication system will limit access to known users who provide a valid username and password.
- Encrypted access using HTTPS (Hypertext Transport Protocol Secure) technology that enables a secure communication channel, data encryption, authenticity certificates and signing will also be provided.

5.4 Game description

As previously mentioned, the user will receive an e-mail including the link for the game and their log in details.

Once the user has clicked on the link, the Feeling Master page will open, asking for a username and password. The user will introduce his or her e-mail or username and the password previously sent by e-mail. If these are correct, a new page will open in which the user's username appears next to the "Log out" option. In the middle of the page there is a very appealing purple rectangle in which the user can read "Press Play to Start" and an orange play button underneath.



The moment the play button is pressed, the game starts. There is a particular sound at the beginning of each level as well as a happy sound for correct answers and an annoying sound for wrong answers.

In the first level (see **Figure 4**) the user is presented with the following question: "How does this person feel?" Next to that question, a typical cartoon face or character expressing one of the emotions previously selected by the practitioner for that level is depicted. The user will have to read the question and select one of the possible emotions given.

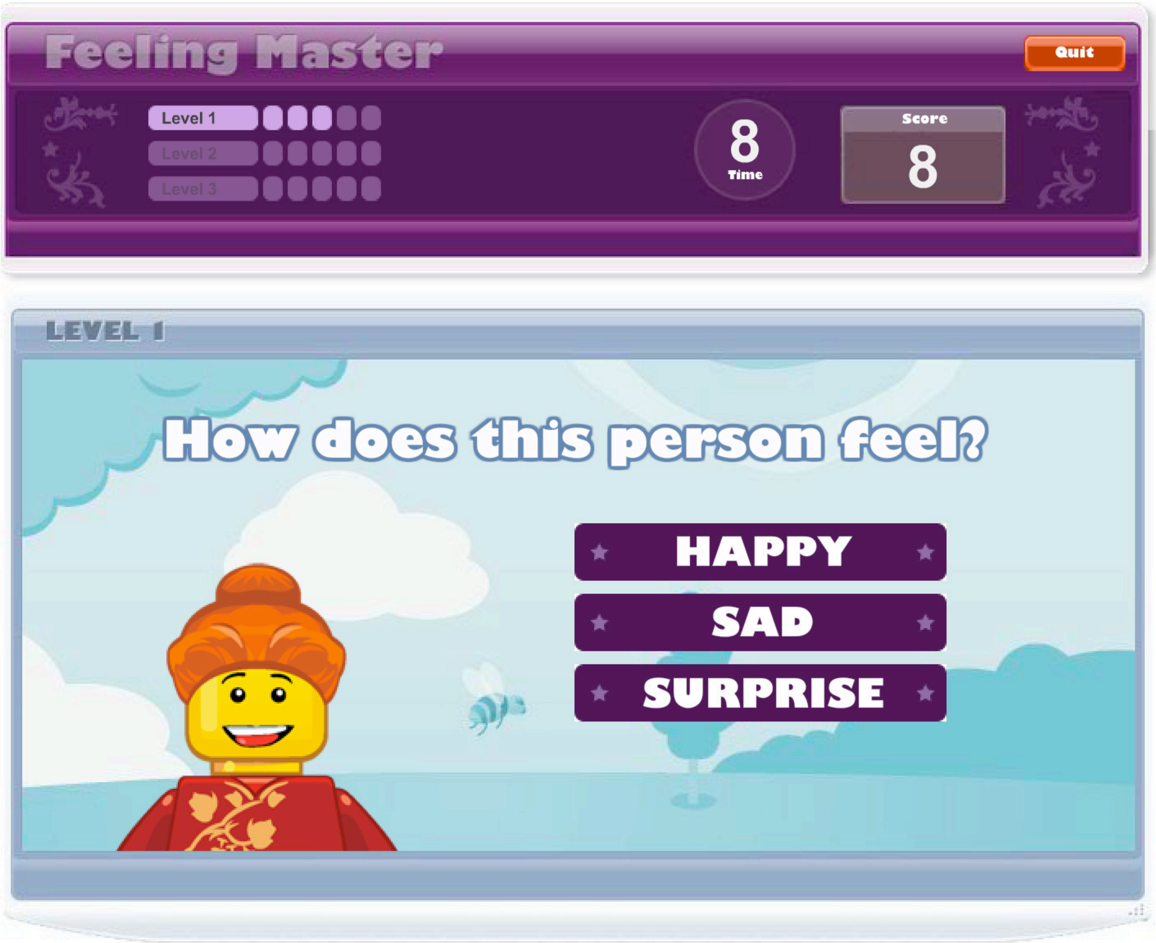


Figure 4. Feeling Master – Level 1

In the second level (see **Figure 5**), there is only one face or character but it appears three times, each depiction showing a different emotion. The user will have to select the image that answers the question: "Who is [name of the emotion selected by the therapist for that level]?"

Figure 5. Feeling Master – Level 2

In the third level, (see **Figure 6**), the question posed is the same as in the previous level ("Who is [name of the emotion]?"), but in this level the three possible emotions are depicted by three different faces or characters. As it has been mentioned before, the emotions for this level have already been customized by the practitioner, as have the number of questions and the allotted time.

Figure 6. Feeling Master – Level 3

The program automatically records all of the answers, right or wrong, and correlates the answers with the emotion the user had been asked about in each question. It also records the total time the user has used in that session and the score he or she has attained. This information feeds into summary tables, which include the percentages of right and wrong answers, and made instantly available for the practitioner to view. Thus the practitioner will know exactly how many times the user was either correct or failed to distinguish a particular emotion and how long it took him or her to complete each level.

Once the game is over, the user will able to play it again or log out. When logging out, the system will prompt the user to confirm that he or she wants to log out.

6 DESIGN METHODOLOGY

The overall design of Feeling Master was created with an iterative user-centered approach, which places an emphasis on users' needs and stresses the importance of designing products that are functional, applicable, and usable for a broad range of people (Baek et al., 2008; Norman, 2002). The name of this methodology is user-centered design (UCD). Iteration is fundamental to this design process, and occurs by cycling through the overall process multiple times, and also by reiterations within a step—for example, by the creation of multiple versions of the same facial expression. In this process, user/expert testing connects each major iteration. In the progression from the early concept to the final prototype, feedback from users and experts helps validate all major design decisions. The design and development process of the game includes three major phases: 1) facial expressions design, 2) application design and development, 3) design evaluation with users through protocol analysis or the think-aloud method.

6.1 Facial expressions design

The precise detection of the position of the face and prominent facial features such as the eyes, eyebrows and mouth is the most important step towards automatic recognition of facial expressions (Tsalakanidou & Malassiotis, 2010). In this study, facial expressions are emphasized using cartoon techniques. It is widely acknowledged that cartoons have a strong advantage in expressing emotions and feelings (Xu et al., 2006). To simplify the development process of our cartoon characters, we used the famous LEGO Minifigures illustrations (see **Figure 7**). The face of the Minifigure was of particular importance, since it gives the strongest indicator of the emotional state of the character.

Figure 7. LEGO Minifigures

In order to generate expressive cartoons for each of the six basic emotions defined by Ekman and Friesen (1971), we adopted the following ground rules to customize the character's facial expressions. These rules were summarized and simplified from Parke and Waters' book (1996).

- Happiness: The mouth is wide with the corners pulled up toward the ears and the eyebrows are relaxed.
- Sadness: The mouth is relaxed and the inner portions of the eyebrows are piled up above the upper eyelid.
- Fear: The mouth is dropped slightly open. The eyebrows are raised, pulled together, and curved upward.
- Surprise: The mouth is dropped open, the eyebrows are raised, and the upper eyelids are open.
- Disgust: The mouth is slightly open with the upper lip squared off and the middle eyebrows are pulled upward.
- Anger: The mouth is closed with the upper lip slightly compressed or squared off. The eyebrows are pulled downward and together.

The customization process of the character's facial expressions began with a small number of hand-drawn pencil sketches for each of the six basic facial expressions. An illustrator modified the facial expression (eyes, eyebrows, and mouth) of the original character illustrations based on the rules we defined for each emotion. An example of these sketches is shown in **Figure 8**

(a). Once we completed the pencil sketches for each facial expression, we applied these changes to the original vector illustrations (see **Figure 8 (b)**). Then we added the upper torso and arms to the illustration, as shown in **Figure 8 (c)**. During the customization process of the character's facial expressions, we used the same character to illustrate the six different emotions. At this point, we were ready to start the first round of user testing (**Figure 8 (c)**). The users' feedback was noted and analyzed, and then the illustrations were refined. The user testing cycle for the facial expressions was repeated five times until the representation of each emotion was ready to be applied to more characters. Throughout the illustration phase, we mainly focused our effort on two emotions: disgust and anger.

During the testing process, user feedback made us realize that these two emotions (disgust and anger) were the most challenging to illustrate in comparison to the other four basic emotions (happiness, sadness, fear, and surprise). Between each iteration, the illustrator adjusted the facial features—such as the eyes, eyebrows, and mouth—that defined each emotion. Once each emotion was thoroughly tested, the detail of each illustration increased with further rounds of testing and iteration until each emotion illustration was finalized (**Figure 8 (d)**).

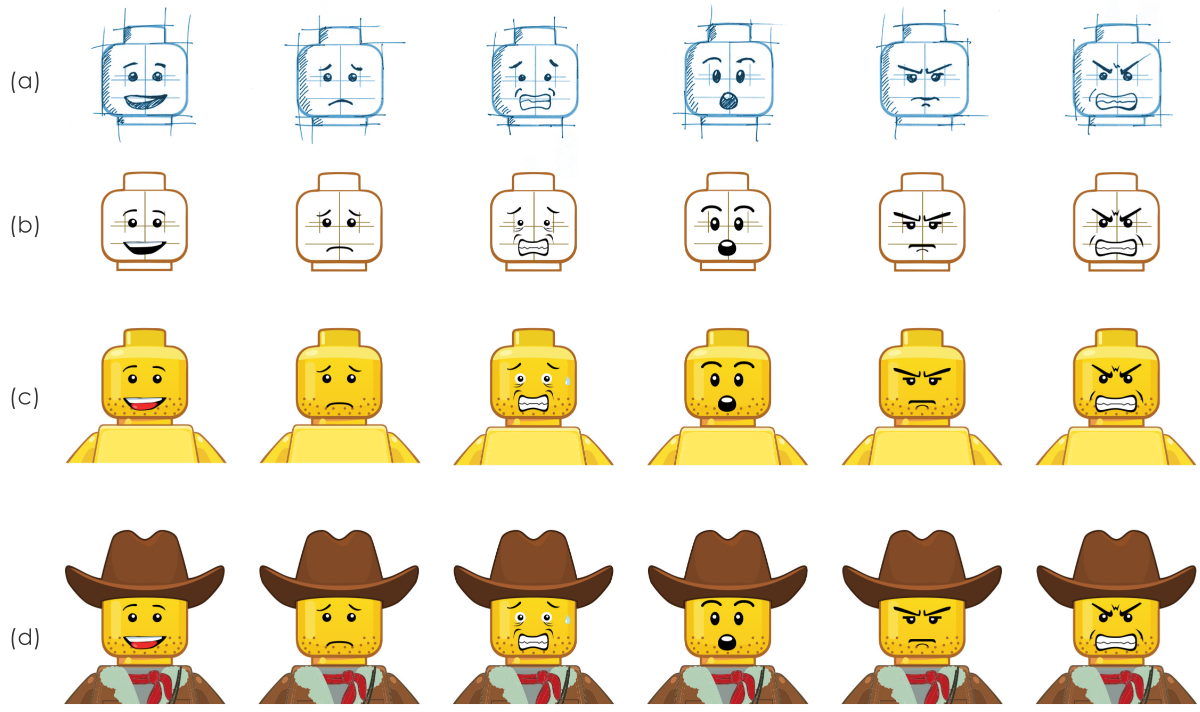


Figure 8. Facial expressions design process: happiness, sadness, fear, surprise, disgust, and anger. (a) Facial expressions: pencil sketches. (b) Facial expressions: vector illustrations. (c) Minifigures for user testing. (d) Final Minifigures with accessories.

Once the majority of users had successfully recognized the six different facial expressions using the same character, we started expanding the amount of cartoon characters for the game. To extend the family of characters, we applied the same synthesis of the facial features (eyes, eyebrows, and mouth) on new Minifigures with diverse features and accessories (see **Figure 9**).

Figure 9. Final Minifigures with accessories

The Head accessories used vary widely and include hats, helmets, beards, moustaches and hair. Accessories are also often found on the body of the Minifigures, such as scarves, bows, shirts, uniforms, dresses and capes (see Figure 10).

Figure 10. Minifigures accessories

Finally, we combined the head and the body accessories with two different skin colors (yellow and dark brown) to develop the final eighty characters needed for the game. Subsequently, we applied the six basic facial expressions to each of the eighty characters of the game (see Figure 11).

Figure 11. The final eighty characters with the six basic facial expressions: happiness, sadness, fear, surprise, disgust and anger

6.2 Application design and development

Throughout the game design process, interviews with game designers were held. Their considerations were taken into account particularly in regard to external appearance (i.e. aesthetic and sensory appeal), since, according to the designers, this is of primary importance in enabling users to feel engaged with an application. Some other aspects of engagement such as challenge, control, novelty, customization, motivation, and how to hold a users' interest in the game were discussed. Equally important, marketing professionals and UI analysts were asked for their personal opinions of the application based on their professional and technical knowledge. Medical staff, mainly psychologists and therapists, was also interviewed. It was extremely important to include medical professionals in the entire process and take their ideas and professional remarks into consideration.

During the first stage of the application design process, we developed several low-fidelity sketches of the game interface. These sketches were paper-based and do not allow any user interaction. Low-fidelity sketches were faster to create and modify. Utilizing low-fidelity sketches was helpful in facilitating early visualization of alternative design solutions. An additional benefit of this methodology is that when using rough sketches, users may feel more comfortable proposing changes. Once we defined the basic layout of the interface, we started using computer-based tools (Adobe Photoshop and Illustrator) to increase the fidelity of the mockups. Creating wireframes and user interface elements with these tools took more time and effort, but looked more realistic and refined. At this stage, we asked the experts (game designers, marketing professionals, and medical staff) to focus on the visual design, including the look and feel of color, fonts, layout, and images.

The next step was to develop a number of partially functioning computer prototypes that simulated the basic game interaction. These prototypes were developed in order to explore the functionality, interactivity, and degree of difficulty of the game. The design of these prototypes was kept quite simple so they could be easily modified and adapted to the requirements of the users without demanding enormous programming and extraneous work. In general, developing a final application in one go is never advisable since no matter how fine-grained a design model may be, there will always be emergent design problems. It was crucial during this stage to design and test the customization of the game's interface with medical staff. Within this interface, therapists can manage information regarding patients' data, see patients' performance, and configure the complexity of the game.

The observations made during the above stages were used as guidelines for the design of the final interactive graphical interface and for its final implementation. Some useful conclusions were drawn during the design of the prototypes about the simplicity of the interface and the level of interaction needed for the game. It was decided that the graphical interface must be kept simple so users would be able to play the game without considerable training. Furthermore, the degree of enjoyment and surprise resulting from the interaction with the interface was very important. Finally, we documented the preferences of the experts regarding game mechanics, color, and contrast choices for the visualization of the graphical interface, and their enthusiastic reaction to the introduction of sounds.

6.3 Design evaluation with users: protocol analysis or the think-aloud method

Despite the problems identified in the evaluations of the experts, the final design evaluation of Feeling Master fell to the users. For this purpose, we utilized a systematic qualitative technique known as protocol analysis or the think-aloud method. This technique requires users to express their feelings, thoughts, and opinions during the test. One objective of this approach is to enable designers to get a better understanding of the users' mental model during their interaction with the application. Importantly, protocol analyses of digital interfaces are based on the direct observation of a real interaction between the user and the application. In each protocol analysis session, the user is asked to perform a specific task using the system and to verbalize his/her thoughts concurrently by "thinking aloud." Users are asked to give a continuous explanation on what they are attempting to do, what problems they are confronting, and other task-related thoughts (Carroll, Mack, Lewis, Grischkowsky, & Robertson, 1985).

These techniques demand a usability expert and a minimum of four participants who are to be observed; the more users that can be observed, the better the outcomes (Khannur & Kumar, 2011). For our analysis, six users participated in the think-aloud test. Before the assessment, the purpose of the research and think-aloud test was explained to the participants and they were given information about the scenario. During the testing, the participants were asked to think aloud while using the game and the usability expert wrote down their comments. After the think-aloud test, the data obtained from the participants was used for the analysis of the game and the final adjustments to the application were then made.

In general, all users found the application easy to use and entertaining. They commented favorably on the look and feel of the application and on the overall game mechanics. However, some participants experienced serious difficulties recognizing the disgust emotion illustration. After being reminded to verbalize their thoughts about the disgust illustration, they said that the disgust illustration was unclear and confusing. On the other hand, most of the participants did not perceive any difficulty in recognizing all of the other emotions (happiness, sadness, fear, surprise, and anger). A possible explanation of the increased difficulty in recognizing the disgust emotion in this evaluation, when compared to the evaluation of the facial expressions in the design phase, is that the users in this assessment had a limited amount of time (8 seconds) to recognize the emotions. Previously, during the facial expressions design phase, we gave users an unlimited amount of time for recognizing each emotion. The results were likely influenced by the "ceiling effect." The ceiling effect appears when a high value in scores is achieved for a high number of participants. Generally, this situation is favored by using long stimulus exposure times that range from 500 milliseconds (Edwards, Pattison, Jackson, & Wales, 2001) to 15 seconds (Addington, Saeedi, & Addington, 2006).

Results suggest that using protocol analysis or the think-aloud method was extremely helpful to define the usability problems at the end of the development process before we utilized the Feeling Master prototype in a pilot study with schizophrenia patients and healthy control volunteers in numerous rehabilitation psychiatric units in Barcelona, Catalonia, Spain.

To our knowledge, there are no previous instances of an interactive tool being used for the assessment of emotional recognition designed with the UCD methodology. This process attempted to demonstrate the advantages of using UCD as the framework for a psychotherapeutic interactive game design process. Key to this development process, and definitive of the approach, was the fact that UCD gathered consensus from the medical community throughout the design process. This, in turn, allowed the design and development to move forward smoothly. Furthermore, the patients and therapists helped to convey a positive message regarding the improved interface, which resulted in a boost in the users' initial acceptance of the product.

7 PILOT STUDY

As mentioned by Barbara Kitchenham and Lesley Pickard (1995), if researchers are choosing the case study method, it is advantageous to establish a pilot project to assess the effects of implemented changes. The design of a case study requires a careful selection of the pilot project, i.e. the project in which the case study takes place. In order to more easily generalize the case study results, the project should be as representative as possible of the environment in which the study takes place. This methodology had applied profusely in studies with schizophrenic patients (Rus-Calafell, Gutiérrez-Maldonado, & Ribas-Sabaté, 2014; Russell, Chu, & Phillips, 2006).

Therefore, a pilot study was conducted to assess the usability of a new psychotherapeutic interactive gaming application (Feeling Master) as a tool to measure facial emotion recognition ability in schizophrenic patients. The usability assessment of the application was based on three criteria: adaptability, effectiveness and efficiency of the tool (Nielsen, 1994; Schwebel et al., 2014).

It was also attempted to determine if people with schizophrenia would show emotion recognition deficits, and if such deficits would vary among the basic emotions described by Ekman and Friesen (1971). Moreover, we aimed to relate the results of facial emotion recognition of the schizophrenia group to clinical variables such as the Personal and Situational Attribution Questionnaire (IPSAQ).

7.1 Participants

The study was conducted among patients with schizophrenia in five rehabilitation psychiatric units from Parc Sanitari Sant Joan de Déu (PSSJD) in Barcelona, Catalonia, Spain. The PSSJD rehabilitation psychiatric units were: Servicio de rehabilitación psicosocial de Viladecans, Servicio de rehabilitación psicosocial de El Prat, Servicio de rehabilitación psicosocial de Cerdanyola, Servicio de Rehabilitación psicosocial de Cornellà, and El Servicio Especializado en Rehabilitación psiquiátrica Intensiva (SERPI). The latter provides inpatient psychiatric inpatient rehabilitation services.

The criteria for inclusion in the study were as follows:

- DSM IV-TR criteria (American Psychiatric Association, 2000) for schizophrenia, schizoaffective disorder or schizophreniform disorder.
- The patients were 18–45 years of age
- All of the patients recruited had completed high school education
- Patients were only included if they had baseline IQ scores ≥ 85 (estimated using WAIS) (Wechsler, 2004).

A total of 24 patients with schizophrenia (PS) participated in the study, and a healthy control group (HC) of 17 subjects were recruited to match the patient cohort at a group level in terms of age, gender, and education.

7.2 Study procedures

The Ethics Committee of PSSJD reviewed and approved the present study's protocol. Patients were selected and contacted through the PSSJD team and referred to the clinical psychologists in charge of the study. In the patients first individual sessions with the psychologists, inclusion and exclusion criteria were reviewed. These sessions dealt mainly with the standard psychiatric interview of the DSM-IV diagnostic criteria. The study and treatment information were provided to the patients, and they signed a consent release form to participate in the study.

7.3 Assessments

Subsequently, the following questionnaires and scales were administered to the patients by the clinical psychologists during these sessions:

7.3.1 Personal and situational attribution questionnaire (IPSAQ)

Attributional style (also known as explanatory style) was measured using the Internal, Personal and Situational Attribution Questionnaire (IPSAQ) (Kinderman & Bentall, 1996). The IPSAQ consists of 32 items, which describe positive and negative social situations. For each item, participants were asked to state the most likely cause of the event and then indicate whether that cause was due primarily to the self (internal attributions), other people (personal attributions), or circumstances (situational attributions). Six subscale scores were generated by adding up the number of internal, personal, and situational attributions chosen for both the positive and negative items. Two cognitive bias scores were obtained from the subscale scores. The externalizing bias (EB) score was calculated by subtracting the number of internal attributions for negative events from the number of internal attributions for positive events. An EB scoreN0 indicates a bias to over-attribute positive outcomes to oneself. The personalizing bias (PB) score (the tendency to attribute negative events to others rather than to situational factors) was calculated by dividing the number of personal attributions for negative events by the sum of both personal and situational attributions for negative events. A PB score greater than 0.5 indicates a bias to blame other people rather than circumstances for negative events.

This was the only questionnaire used by the healthy control group.

7.3.2 Theory of mind (ToM)

Theory of Mind (ToM) was measured using the Hinting Task (R Corcoran et al., 1995), which consists of 5 brief written vignettes, including social hints that the participant was asked to interpret. Total scores range from 0 to 10, with higher scores indicating better performance. The Hinting Task taps into the social-cognitive domain.

7.3.3 Assertion inventory

Assertion inventory (AI) (Gambrill & Richey, 1975; Martin et al., 2012) is a self-reported questionnaire in which the subject is presented with 40 different social situation and must indicate their degree of discomfort on a 5-point scale that ranges from 1 (no discomfort) to 5 (a lot of discomfort), as well as the probability of displaying the behavior described in the presented situation on a 5-point scale ranging from 1 (always display the behavior) to 5 (never display the behavior). Two measures were derived from the subject's answers:

discomfort and response probability. The scale is an inverse scale; higher scores indicate poorer functioning.

7.3.4 The Screen for Cognitive Impairment in Psychiatry (SCIP-S)

The Screen for Cognitive Impairment in Psychiatry (SCIP) is a brief scale designed for detecting cognitive deficits in several psychotic and affective disorders. The SCIP has three alternate forms with good reliability among healthy controls in the original English version (Purdon, 2005), and the Spanish translation (SCIP-S) (Pino et al., 2006). It consists of five subscales that each require approximately two to three minutes to administer in order to provide an estimate of working memory, immediate verbal learning, delayed verbal learning, verbal fluency, and psychomotor speed.

7.3.5 Facial Expression Recognition Application

The interactive application Feeling Master was used to assess facial expression recognition (FER). While designing the study, several professionals were consulted. A prototype of Feeling Master was reviewed in several meetings. In attendance were psychologists from PSSJD and members of Universitat Politècnica de Catalunya (UPC). The application variables for this study—such as number of questions, maximum amount of time per question, and the selection of levels—were defined during these meetings and tested in pre-study trials.

On the other hand, the selection of emotions was based on user feedback during the development phase of the application. Throughout the development phase of the application, the final design evaluation of Feeling Master fell to the users. For this purpose, we utilized a systematic qualitative technique known as protocol analysis or the think-aloud method. This technique requires users to express their feelings, thoughts, and opinions during the test. In general, all users found the application easy to use and entertaining. They commented favorably on the look and feel of the application and on the overall game mechanics. However, some participants experienced serious difficulties recognizing the disgust emotion illustration. After being reminded to verbalize their thoughts about the disgust illustration, they said that the disgust illustration was unclear and confusing. On the other hand, most of the participants did not perceive any difficulty in recognizing all of the other emotions (happiness, sadness, anger, fear, and surprise). Based on this user feedback throughout the design process, we decided to use only 5 emotions (happiness, sadness, anger, fear, and surprise) out of the 6 basic emotions described by Ekman and Friesen (1971) for the pilot study.

In pre-study trials, we found that the program was simple to administer, undemanding, and well received by patients. Patients took approximately 15 minutes to complete all three levels of the program. Cooperation was excellent and participants enjoyed the sessions.

For the final study, we installed the Flash application Feeling Master on a tablet Samsung Wi-Fi Galaxy Tab 10.1-inch powered by Android 3.1 Honeycomb operating system. Once the application was installed, we tethered the tablet to a smartphone Apple iPhone 4S configured to work as a Wi-Fi hotspot, and got online using the smartphone's Internet connection.

Once the application was installed and tested on the tablet, the practitioner customized the number of questions for each of the three levels (7 questions), the maximum amount of time per question (12 seconds), and chose the emotions needed for the study (happiness, sadness, anger, fear, and surprise). The total number of questions for each game was 21 (see Figure 12).

The study took place across two "one-on-one" sessions, conducted on different days within a one-week period. The patients were tested in a quiet area, away from the other patients in their rehabilitation psychiatric unit. Each session, which took about 10–15 minutes to complete, were administered by a psychologist and the application designer.

Throughout each session, patients interacted with the application two times (two games per session). By the end of the study, each patient used the FER application a total of four times.

For each game, the system automatically recorded all of the patient's answers (right and wrong), the patient's profile, the system configuration, response times for each question, and the score for each game.

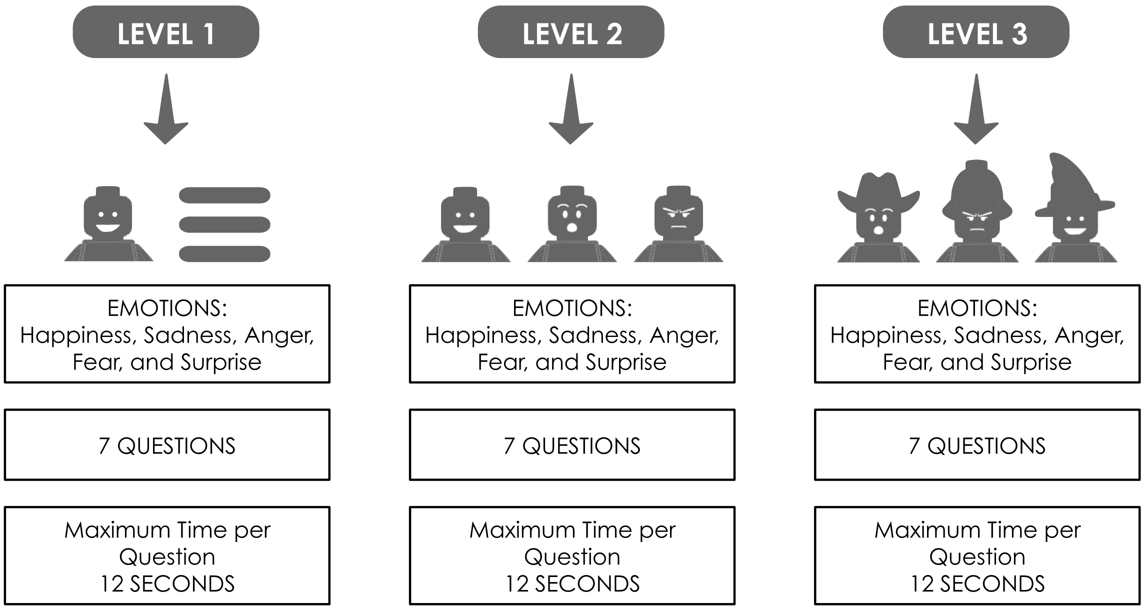


Figure 12. Interactive Feeling Master tool. Summary of Levels

8 TECHNOLOGY ACCEPTANCE MODEL (TAM) OF FEELING MASTER

8.1 Introduction

Rapid progress in personal computer technology over the past few decades has greatly expanded the potential of computer- assisted therapy programs (Kaltenthaler & Cavanagh, 2010; Kaltenthaler et al., 2004). Accumulated research now indicates computer and internet-based assessment and therapy tools have the potential to increase the cost-effectiveness of current psychotherapeutic interventions by reducing therapist contact time, increasing client participation in therapeutic activities in non-clinical settings, and streamlining the input and processing of client data from therapeutic activities (Kaltenthaler & Cavanagh, 2010; Newman et al., 2011; Taylor & Luce, 2003).

The impact of these technologies on healthcare will be more prominent as they become more available to individuals suffering from chronic illness. Applications made for smartphones and tablets along with social media network websites could aid in the treatment of individuals with chronic illness (Miller et al., 2015).

Also, the popularity of computer games has grown exponentially in the last decade and has been widely accepted by children, adolescents and adults alike. Mental health professionals have therefore been exploring the use of these games to complement traditional treatment methods. To date however, there has been little known concrete evidence of the effectiveness of computer games for the treatment of children and adults with mental health conditions. Key to the success of such games is that at the outset, they must be well-designed (Goh et al., 2008).

The well-known Technology Acceptance Model (TAM) (F. D. Davis, 1989; Viswanath Venkatesh et al., 2000) provides a framework for predicting the acceptance of a new technology. In this study, a research model is based on the TAM to study the acceptance of a novel psychotherapeutic interactive gaming application as a tool to measure facial emotion recognition in rehabilitation psychiatric units.

8.2 Theoretical background

Research in Human- Computer Interaction (HCI) tradition has long asserted that the research of human factors (1) is a key to the successful design and implementation of technological applications and (2) should include cognitive and affective motives (Sánchez-Franco & Roldán, 2005).

The Technology Acceptance Model (TAM) explains the determinants of technology acceptance over a wide range of end-user computing technologies and user populations. For example, TAM is shown to have good predictive validity for the use of e-mail, Web, Web Course Tools, etc. (Chuan-Chuan Lin & Lu, 2000; Fenech, 1998; Gefen & Straub, 1997; Y.-C. Lee, 2006; Ngai et al., 2007).

Specifically, Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) are hypothesized and empirically supported as fundamental determinants of user acceptance of a given Information and Communications Technology (ICT). Both users' beliefs determine the behavioral intentions (BI) to use ICT (Sanchez-Franco, 2010).

8.2.1 Perceived Usefulness (PU)

Perceived usefulness is the degree to which a person believes that using a particular system would enhance his or her job performance. There is also extensive research in the IS community providing evidences of the effect of perceived usefulness on behavioral intention to use (Viswanath Venkatesh & Morris, 2000).

8.2.2 Perceived Ease of Use (PEOU)

Perceived ease of use is the degree to which a person believes that using a particular system would be free of effort. It is expected to influence perceived usefulness, behavioral intention to use, and perceived credibility. Extensive research over the past decade has provided evidence that perceived ease of use has a significant effect on behavioral intention to use, either directly or indirectly, through its effect on perceived usefulness (Agarwal & Prasad, 1999; Viswanath Venkatesh, 1999).

8.2.3 Attitude Toward Using (ATU)

The TAM posits that perceived usefulness and perceived ease of use has a direct effect on attitudes towards using a new technology. Attitude is the degree to which the user is interested in specific systems, which has a direct effect on the intention to use those specific systems in the future (F. D. Davis, Bagozzi, & Warshaw, 1989) and the actual usage of the systems (Bajaj & Nidumolu, 1998).

8.2.4 Behavioral intentions (BI)

The most proximal antecedent to Information Technology (IT) use is behavioral intention to use it (BI), and this is now commonly what is meant when one refers to acceptance (F. D. Davis et al., 1989; Mathieson, 1991; Szajna, 1996), although another common conceptualization of acceptance is end-user satisfaction (Brown, Massey, Montoya-weiss, & Burkman, 2002; Ives, Olson, & Baroudi, 1983). Because BI is thought to reliably predict actual use, and the latter is difficult to measure, BI is sometimes the only measured outcome of interest in a study of TAM (P Y K Chau & Hu, 2001; Patrick Y. K. Chau & Hu, 2001). BI is influenced by one's attitude toward using the IT (ATU). Attitude, in turn, has two determinants: perceived usefulness (PU) and perceived ease of use (PEOU). Additionally, PU is specified to have an independent effect on BI, and PEOU has an effect on PU.

8.2.5 Enjoyment (E)

Enjoyment refers to the extent to which the activity of using a computer system is perceived to be personally enjoyable in its own right aside from the instrumental value of the technology (F. D. Davis et al., 1992). Prior research proposed enjoyment as a determinant of behavioral intention (F. D. Davis et al., 1992; Viswanath Venkatesh et al., 2002) and as a determinant of ease of use (Viswanath Venkatesh et al., 2002; Viswanath Venkatesh, 2000). According to Davis et al. (F. D. Davis et al., 1992), extrinsic motivation refers to ''the performance of an activity because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself,'' whereas intrinsic motivation refers to ''the performance of an activity for no apparent reinforcement other than the process of performing the activity per se.'' Davis et al. (F. D. Davis et al., 1992) and recently Venkatesh and Speier (V Venkatesh & Speier, 2000) classified enjoyment as a type of intrinsic motivation and perceived usefulness as a type of extrinsic motivation.

Comparing two training methods (traditional training vs. game-based training), Venkatesh and Speier (2000) and Venkatesh (1999) found that the game-based training method aimed at enhancing intrinsic motivation resulted in higher enjoyment and higher ease of use perceptions than the traditional training method. Later, Venkatesh (2000) showed that the effect of enjoyment on ease of use became stronger as users gained more direct experience with the system. Venkatesh et al. (2002) also reported that enjoyment (intrinsic motivation) had no direct effect on behavioral intention over and above ease of use and usefulness. These findings indicate that the ease of use perceptions is influenced by the degree to which people perceive using the system to be personally enjoyable. Consequently, we hypothesize that Enjoyment will have a positive effect on ease of use.

The effect of enjoyment on perceived usefulness is relatively unknown. Davis et al. (1992) found that usefulness and enjoyment were significant determinants of behavioral intention, but the effect of enjoyment on perceived usefulness was not examined. Venkatesh (2000) showed that enjoyment influenced usefulness via ease of use, without assessing its direct effect on usefulness over and above ease of use. It is well known that, when people are intrinsically motivated, they become productive and effective (Csikszentmihalyi, 1990). Thus, we hypothesize that Enjoyment will have a positive effect on usefulness.

Various research activities have been conducted around TAM. However, TAM has been rarely employed in health-related research areas, especially in Medical Informatics. The technologies considered there are PDA support systems for emergency medical services and spoken dialogue systems, respectively (Chang, Hsu, Tzeng, Hou, & Sang, 2004; Chang, Hsu, Tzeng, Sang, et al., 2004). Barker et al. and Chismar and Wiley- Patton (Barker, van Schaik, Simpson, & Corbett, 2003; Chismar & Wiley-Patton, 2002) also present other examples of TAM applications to Medical Informatics.

8.3 Sample of subject matter experts (SME's)

The study was conducted among 66 experienced mental health professionals from different psychiatric health centers in Spain and Argentina.

8.4 Development of instruments

The survey instruments consisted of an online questionnaire of sixteen items to assess five constructs of the proposed model. The five constructs were the following: Perceived usefulness (PU), Perceived ease of use (PEOU), Attitude Toward Using (ATU), Enjoyment (E) and Behavioral Intention (BI).

These items were adapted from previous studies and were refined to make them specifically relevant to the present study (see Figure 13).

The TAM constructs of Perceived Usefulness, Perceived Ease of Use and Behavioral Intention were adapted from Davis (1989) and Yi and Davis (2001). The Attitude Toward Using construct was adapted from Ajzen and Fishbein (1980) and Enjoyment was adjusted from Yi et al. (2003). The instrument consisted of four items for the usefulness construct, three items for the ease of use construct, three items for Behavioral Intention, three items for Attitude Toward Using and three items for Enjoyment. These five constructs were measured on a seven-point Likert scale ranging from (1) ''strongly disagree'' to (7) ''strongly agree''.

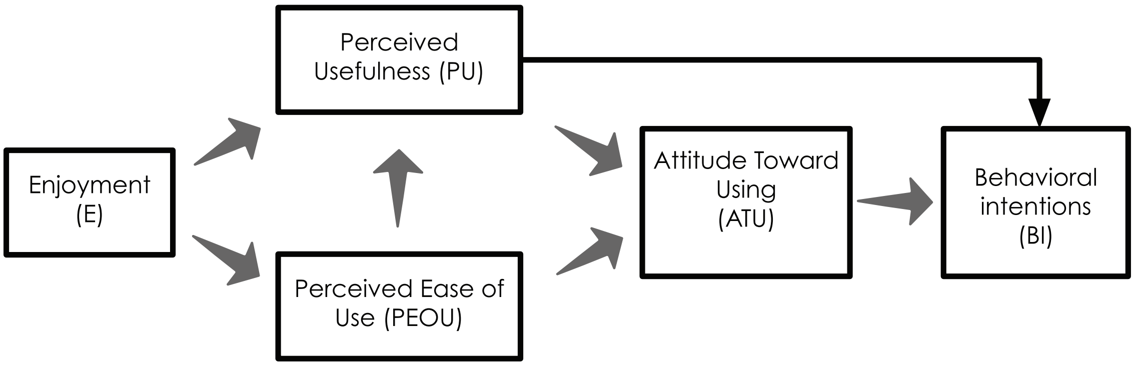


Figure 13. Hypothesis of TAM constructs applied in the study

Our survey instrument was pre-tested for content analysis. The measures of the constructs adapt scales already proposed and validated in the literature. However, this research applied various refinement procedures for clarity, completeness, and readability. To make sure that important aspects of constructs were not omitted, we conducted personal interviews with experienced psychiatrists. Moreover, three professors – majoring in Information and Communications Technology (ICT) – check the suitability of the wording and format of the questions.

8.5 Study Procedures

Experienced psychologists were invited to participate in the study by email. In this email, the purpose and procedure of the research were explained and a link to the questionnaire was provided. Invitees were reminded twice by email to complete the survey.

Of the 80 surveys, 66 useful responses were returned and thus the response rate was 82.5%. We invested much effort in obtaining a high response rate. The high response rate in our study was due to the personal approach, but other factors of our study design also contributed.

We marked the survey itself with the Universitat Politècnica de Catalunya (UPC) logo and explained to the respondent the purpose of the investigation and motivated him/her to reply personally. Also, the confidentiality of the results had been stressed.

9 DATA ANALYSIS AND RESULTS

All data were analyzed using PASW Statistics (Predictive Analytics Software), version 18 (SPSS, Inc.; Chicago, IL, USA). The significance level was established at 0.05.

9.1 Pilot Study

The data collected for analysis were (1) the answers of Feeling Master, (2) the time spent by users, (3) the demographic data, and (4) the IPSAQ questionnaire. The Analysis of variance (ANOVA) applied over accuracy (number of correct answers) and time (to completion of the Feeling Master) were the dependent variables, compared using an ANOVA. Repeated measures ANOVA was used to analyze subjects' performance in the Feeling Master, with group (PS/HC). Fisher's exact test was also used to compare error patterns between the PS and the HC groups.

Sperarman's Rho were applied to find correlations between the emotions values achieved in Feeling Master and the IPSAQ scores.

9.1.1 Demographic data

The chi-square test (gender) = 1.373, $p>0.05$, and the t-test (age)= 1.484, $p>0.05$ were used to compare demographic characteristics between the schizophrenia group and normal control groups. We found not significant values in our pilot study.

9.1.2 Usability assessment

The usability assessment of Feeling Master was based on three criteria: its adaptability, its effectiveness, and its efficiency. In order to verify Feeling Master's usability, data were collected for each participant (accuracy, time), and a descriptive analysis was conducted.

9.1.2.1 Adaptability

Some tool adaptations were introduced in the interaction device, the learning phase, and the introduction of three game levels. Feeling Master's design took into account the interaction device, allowing tactile stimulation, setting aside other gadgets that introduce more difficulties to handle (mouse, joystick, gamepad, etc.). We introduced a learning phase in an explanatory tutorial. All sessions were conducted with a researcher. Each session lasted 15 minutes maximum. The focus was on the easy interaction, trying to sustain the attention throughout the whole activity. The introduction of three levels of difficulty aims to adapt the game to the cognitive style of the participants. The application variables for this study—such as number of questions, maximum amount of time per question, and the selection of emotions—were tested in pre-study trials. Regarding adaptability, results indicate that 100% of individuals in the sample were able to use the application without any major issue.

Finally, the levels of the game allowed for a progressive introduction to the emotional recognition difficulties presented by Feeling Master, sustaining the motivation of the participants throughout the session.

9.1.2.2 Effectiveness

Feeling Master is based on the emotional recognition of cartoon faces. The design ensures that the participants can effectively play the game. As ican be seen in the results, the accuracy (i.e., correct answers in emotion recognition) reaches high values in PS and HC groups. Considering all emotions, the percentage of hits fluctuates between 81.1 to 94.1 in the HC group in the first session and between 67.0 to 88.5 in the PS group. Furthermore, we found significant error rates for discrimination in fear: $F = (1.38) = 8.2$, $p < 0.007$) using Fisher's exact test to compare errors between PS and HC groups. Each of the five emotions were analyzed by examining the ratings from all the participants who used the Feeling Master tool. In a first session, the accuracy for each emotion ranged from 81.2% to 94.1% in HC group (Figure 14).

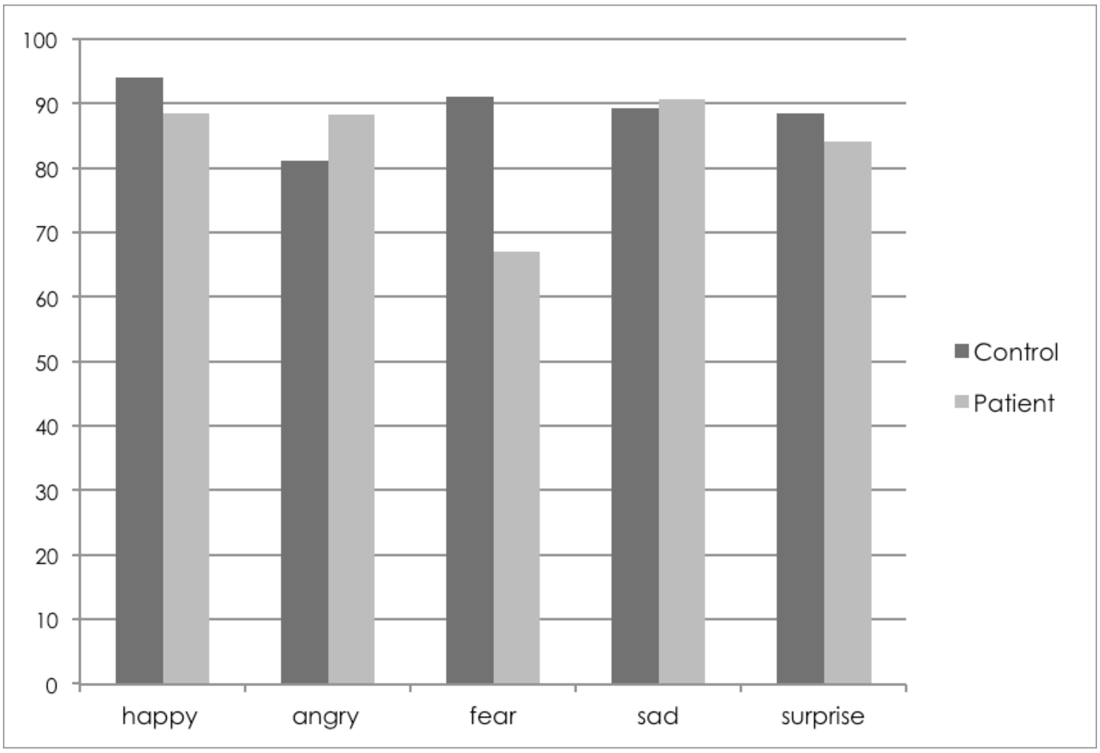


Figure 14. Percentage of correct answers in emotion recognition for patient and control groups in the first session

9.1.2.2.1 Statistical significance. ANOVA

Patients with schizophrenia showed impairments in emotion recognition. On the other hand, we did not find significant values for the overall emotion discrimination (average accuracy: F[1.38] = 0.733, p > 0.05), but we found significant error rates for discrimination in fear (F = [1.38] = 8.2, p < 0.007 [Table 1]).

		Sum of Squares	df	Mean Square	F	Sig.
Happy	Between Groups	2.738	1	2.738	.656	.423
	Within Groups	162.775	39	4.174		
	Total	165.512	40			
Angry	Between Groups	.007	1	.007	.002	.962
	Within Groups	121.017	39	3.103		
	Total	121.024	40			
Fearful	Between Groups	13.716	1	13.716	8.265	.007
	Within Groups	64.723	39	1.660		
	Total	78.439	40			
Sad	Between Groups	2.320	1	2.320	.736	.396
	Within Groups	122.900	39	3.151		
	Total	125.220	40			
Surprised	Between Groups	.285	1	.285	.191	.665
	Within Groups	58.154	39	1.491		
	Total	58.439	40			

Table 1. Accuracy (number of correct answers) in emotion recognition, compared using an ANOVA with groups (PS/HC)

9.1.2.2.2 Content validity and reliability

A subject-matter expert evaluation was done in the design process to determine if the cartoons were appropriate. In the design process, the majority of users had successfully recognized the five different facial expressions on the same character.

Both reliability and construct validity were evaluated. Reliability of the instrument was evaluated using Cronbach's alpha. Inconclusive results were obtained, although all values were above 0.8 (thus exceeding the common threshold value recommended by Nunnally). The results did not have significant statistical value due to the characteristics of the sample: seven designers and eighty alternative designs (items) for each of the five emotions. The same constraints appeared when a test-retest correlation study was applied between the participants' results in different sessions.

A correlation matrix approach and a factor analysis were applied to examine the convergent and discriminant validity. To summarize, the inter-item correlations were: happiness = 0.9; sadness = 0.9; fear = 0.8; surprise = 0.8; and anger = 0.8.

In addition, each inter-item correlation was considerably higher among items intended for the same construct than among those designed to measure different constructs. This suggests an adequate convergent and discriminant validity of the measurement.

More work must be done to check the statistical reliability of each cartoon and its contribution to each construct or emotion.

9.1.2.3 Efficiency

Once participants learned how to play the game, they efficiently completed the majority of the tasks for each level of Feeling Master in the predetermined period of time set for the study. Only the PS group reported a low number of uncompleted tasks

The response time was significantly delayed in the patient group compared to the control group. The average time for the first session was 0.919 minutes for the HC group and 1.546 minutes for the PS group (Figure 15).

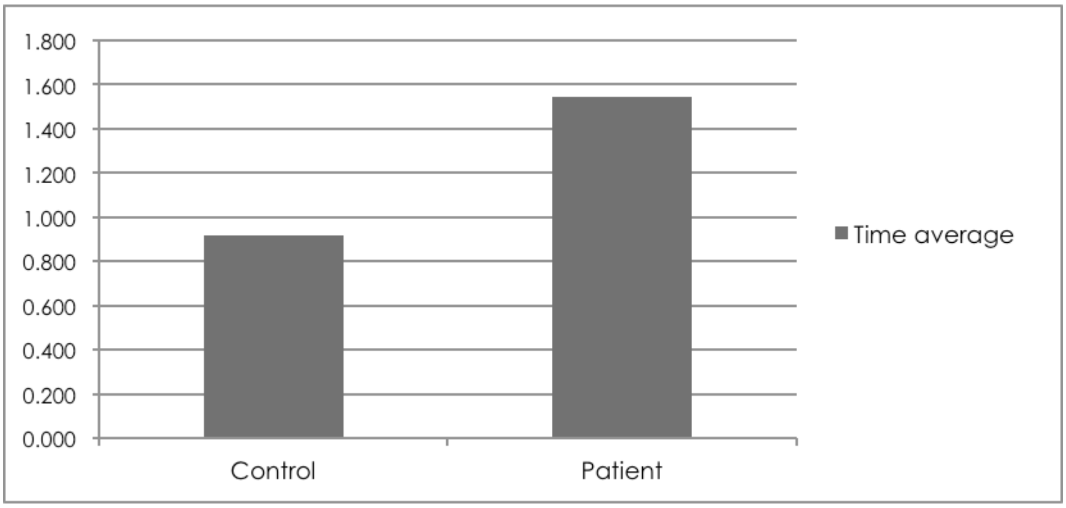


Figure 15. Response time of facial recognition test for the first session of PS and HC groups; time in minutes

9.1.3 Relationship between emotion recognition performance and IPSAQ

Spearman's correlations were performed to detect the relationship between cognitive impairments and performance on the Feeling Master in the schizophrenia group. The correlations between correct responses on the Feeling Master and Personal and Situational Attribution Questionnaire (IPSAQ) were not significant (**Table 2**), but we found interesting correlations between some IPSAQ components and the emotions "sad" and "surprised."

Sad vs. External Situational Negative, Rho = 0.346, p = 0.106;

Sad vs. External Situational Positive, Rho = 0.320, p = 0.136

		Sad	Surprise	IPSAQ_EB	IPSAQ_PB	Internal Negative 1	External Personal Negative 2	External Situational Negative 3	Internal Positive 1	External Personal Positive 2	External Situational Positive 3
IPSAQ_PB	Coefficient	.252	-.028	-.197	1,000	-.813	.996	.102	-.404	.603	.070
	Sig. (2-tailed)	.247	.900	.367	.	.000	.000	.644	.056	.002	.750
	N	23	22	23	23	23	23	23	23	23	23
Internal Negative 1	Coefficient	-.055	.068	.364	-.813	1,000	-.820	-.606	.641	-.487	-.396
	Sig. (2-tailed)	.802	.765	.087	.000	.	.000	.002	.001	.019	.061
	N	23	22	23	23	23	23	23	23	23	23
External Personal Negative_2	Coefficient	.237	-.053	-.176	.996	-.820	1,000	.119	-.430	.627	.090
	Sig. (2-tailed)	.277	.814	.421	.000	.000	.	.588	.040	.001	.682
	N	23	22	23	23	23	23	23	23	23	23
External Situational Negative 3	Coefficient	-.346	-.089	-.231	.102	-.606	.119	1,000	-.554	.062	.642
	Sig. (2-tailed)	.106	.695	.290	.644	.002	.588	.	.006	.780	.001
	N	23	22	23	23	23	23	23	23	23	23
Internal Positive 1	Coefficient	.295	.277	.361	-.404	.641	-.430	-.554	1,000	-.601	-.666
	Sig. (2-tailed)	.171	.212	.091	.056	.001	.040	.006	.	.002	.001
	N	23	22	23	23	23	23	23	23	23	23
External Personal Positive 2	Coefficient	-.059	-.273	.013	.603	-.487	.627	.062	-.601	1,000	-.006
	Sig. (2-tailed)	.788	.219	.954	.002	.019	.001	.780	.002	.	.977
	N	23	22	23	23	23	23	23	23	23	23
External Situational Positive 3	Coefficient	-.320	-.329	-.504	.070	-.396	.090	.642	-.666	-.006	1,000
	Sig. (2-tailed)	.136	.135	.014	.750	.061	.682	.001	.001	.977	.
	N	23	22	23	23	23	23	23	23	23	23

Table 2. Relationships between IPSAQ test and facial recognition test within schizophrenia group

9.2 Technology Acceptance Model (TAM) of FEELING MASTER

9.2.1 TAM reliability

Both reliability and construct validity were evaluated. Reliability of the instrument was evaluated using Cronbach's alpha. All the values were above 0.8 (see Table 3), and thus exceeded the common threshold value recommended by Nunnally.

Reliability Statistics

TAM's Constructs	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
Perceived Usefulness (PU)	0.940	0.943	5
Perceived Ease of Use (PEOU)	0.944	0.950	4
Attitude Toward Using (ATU)	0.885	0.898	4
Behavioral Intention to use (BI)	0.914	0.920	4
Enjoyment (E)	0.968	0.969	4

Table 3. Cronbach's alpha of TAM's constructs

A correlation matrix approach and factor analysis were applied to examine the convergent and discriminant validity. To summarize, the inter-item correlations are: perceived usefulness (PU) = 0.769; perceived ease of use (PEOU) = 0.826; attitude toward using (ATU) = 0.688; behavioral intention to use (BI) = 0.742 and Enjoyment (E) = 0.887.

In addition, each inter-item correlation was considerably higher among items intended for the same construct than among those designed to measure different constructs. This suggests adequate convergent and discriminant validity of the measurement.

A principal component factor analysis was performed, and five constructs were extracted, exactly matching the number of constructs included in the model. As shown in Table 4, there was a first correspondence between components and items. In a future work, further rotations and items debugging should be introduced in order to attain a stronger correlation between items and constructs.

Additionally, items intended to measure the same construct exhibited prominently and distinctly higher factor loadings on a single construct than on other constructs, suggesting adequate convergent and discriminant validity.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.376
Bartlett's Test of Sphericity	Approx. Chi-Square	602.526
	df	10
	Sig.	.000

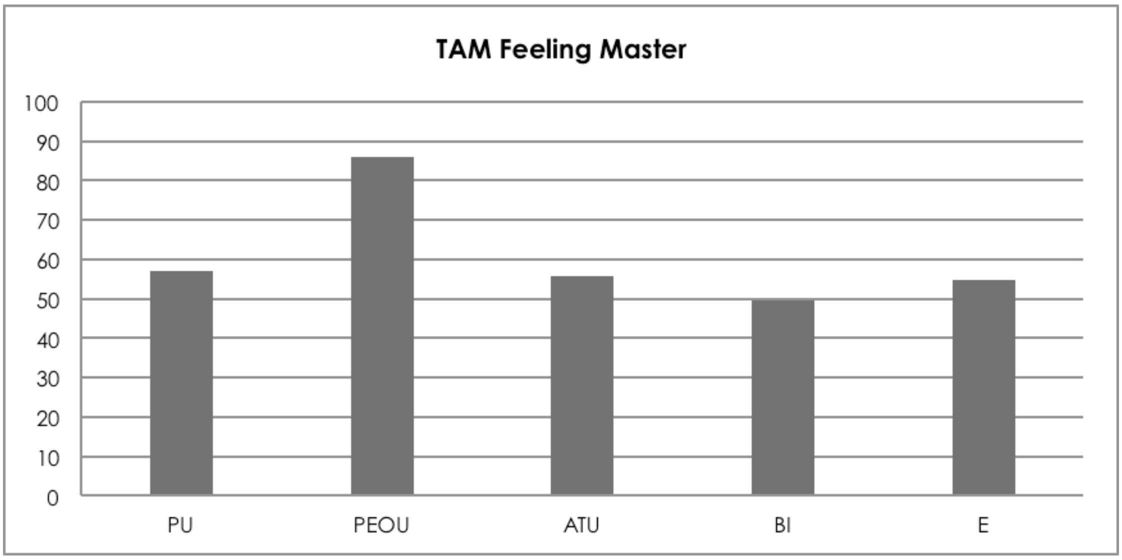
Rotated Component Matrix

	Component				
	1	2	3	4	5
C1	.700	.077	.439	.254	.264
C2	.572	.164	.579	.167	.313
C3	.461	.347	.724	.128	.016
C4	.158	.123	.879	.176	.183
C5	.097	.120	.137	.932	.009
C6	.181	.132	.144	.915	-.054
C7	.086	.026	.023	.770	.537
C8	.425	.289	.445	.144	.614
C9	.296	.475	.539	-.018	.388
C10	-.091	.859	.157	.140	.167
C11	.695	.011	.251	.238	.394
C12	.503	.396	.202	.100	.610
C13	.235	.232	.153	.023	.814
C14	.427	.723	.147	.180	.195
C15	.632	.653	.243	.027	.189
C16	.669	.580	.234	.083	,211

Table 4. Rotated component matrix of TAM

9.2.2 Results of TAM Feeling Master

Except the Perceived Ease of Use (PEOU), which has a high value, the other construct values should be improved. We consider those results as a baseline, and we will introduce new design specifications to increase those values in the future.



10 DISCUSSION

This study aimed to assess the usability of a novel psychotherapeutic interactive gaming application as a tool to measure facial emotion recognition in patients with schizophrenia. The usability study was based on three criteria: adaptability, effectiveness, and efficiency (Nielsen, 1994; Schwebel et al., 2014).

Regarding adaptability, results indicate that all participants found the application easy to use and entertaining. In this study, we demonstrated the advantages of using user-centered design (UCD) to improve the adaptability of the system. The overall design of Feeling Master was created with an iterative user-centered approach, which places an emphasis on users' needs and stresses the importance of designing products that are adaptable enough to serve a wide range of individuals from diverse backgrounds, levels of expertise, demographics, and psychological or cognitive characteristics (Baek et al., 2008; Norman, 2002). Throughout the process, we took into account the interaction device allowing tactile stimulation, setting aside other gadgets that introduce more difficulties to handle (e.g., a mouse, joystick, gamepad, etc.). Another important variable to improve the adaptability of the system was the training of the participants (Gerrit C. Van Der Veer, 1989; Gerrit Cornelius van der Veer, 1990). We introduced a learning phase based in a tutorial explanation. A researcher conducted all sessions. Each session lasted fifteen minutes maximum. The focus was on easy interaction, trying to sustain the patients' attention throughout the entire activity. The introduction of three levels of difficulty aimed to adapt the game to the cognitive styles of the participants. The application variables for this study—such as number of questions, maximum amount of time per question, and the selection of emotions—were tested in pre-study trials.

The level of efficiency of Feeling Master, based on the effort and the time taken by the participants to complete each task of the game, is extremely satisfactory. Once participants learned how to play the game, they completed the majority of the tasks in the predetermined period of time set for the study. Only the PS group reported a low number of uncompleted tasks. We assumed that this number of uncompleted tasks in the PS group is related to some difficulties common to the clinical features of schizophrenia patients. The overall high level of efficiency is directly associated to the accessibility and reachability (the ease and speed of reaching content) factors of the application.

As we described before, the effectiveness of Feeling Master is based on the emotional recognition of cartoon faces. The design ensured that the participants could effectively play the game. As can be seen by the results, the accuracy (correct answers in emotion recognition) reaches high values in PS and HC groups.

Regarding the deficit in the recognition of facial emotions in patients with schizophrenia, results corroborated that patients with schizophrenia have both diminished sensitivity and different response criteria in facial emotion recognition across different emotions compared with healthy controls. These findings were consistent with numerous studies that have used emotional facial expressions as stimuli (Archer et al., 1994; Heimberg et al., 1992; Novic et al., 1984; Walker et al., 1984).

Furthermore, these results proved the idea that difficulties in emotion recognition are associated with key cognitive deficits in patients with schizophrenia, specifically in the recognition of fearful facial expressions. The majority of studies reported that the greatest difficulty was in recognizing fear (Edwards et al., 2002; M K Mandal et al., 1998); however, some reported impairment in recognizing negative emotions other than fear (Bediou et al., 2005).

Interestingly, we observed that the healthy subjects usually scored at or near the maximum possible performance level in the Feeling Master recognition test for all emotions ("ceiling effect"). The ceiling effect appears when a high value in scores is achieved for a high number of participants. The reliability can be shown when the results are similar and the small variations can be justified by the ceiling effect. This situation is favored by using long stimulus exposure times that ranged from five hundred milliseconds (Edwards et al., 2001) to fifteen seconds (Addington et al., 2006). The ceiling effect was clearly observed when more than one session was introduced. A learning process reinforces the ceiling effect. Take into account the increasing accuracy values (Table 5).

One possible method to avoid the ceiling effect is to modify stimulus presentation duration. This method has some references (Kirouac & Doré, 1984; Ogawa & Suzuki, 1999).

Control Group	Fearful				Sad			
	Session #1	Session #2	Session #3	Session #4	Session #1	Session #2	Session #3	Session #4
Average	90.982	80.829	93.544	92.188	89.318	96.571	95.882	96.875
Median	100	85.7	100	100	100	100	100	100
Std. Typ.	15.5654	26.1601	14.9264	25.362	17.6827	9.7914	9.2255	8.5391
Minimum	50	0	50	0	50	66.7	75	75
Maximum	100	100	100	100	100	100	100	100
N	17	17	16	16	17	17	17	16

Table 5. Comparative statistics for the percentage of hits with the options "fearful" and "sad" in four sessions in healthy control group

The reaction time for all five emotions was longer in the patients with schizophrenia than in the control group. These findings were consistent with previous studies carried out with different ethnic groups, suggesting cross-cultural similarities in facial recognition impairment in schizophrenia (S. J. Lee, Lee, Kweon, Lee, & Lee, 2010).

In this study, we additionally related the results of facial emotion recognition to clinical variables. The Personal and Situational Attribution Questionnaire (IPSAQ) was used in the schizophrenia group to determine whether emotion-processing deficits correlated with the attributional style. Though no significant correlations were found, the emotional recognition results seem to be related to attributional style (IPSAQ) regarding the “sad” and “surprised” faces in the group of patients with schizophrenia. This trend should be considered when the therapists apply the tool.

It is important to mention that the effect of medication was not controlled in this study, although medication data have been recorded. In some studies these effects were considered with an unmedicated clinical group (Kerr & Neale, 1993). Medication affects facial emotion perception (Edwards et al., 2002; M K Mandal & Rai, 1987; Sachs et al., 2004). The professionals treat patients with new antipsychotics because of potential side effects of conventional neuroleptics. The use of different antipsychotics may also lead to different results (Beninger et al., 2003). However, all of the patients included in the study were taking medication at the time of the study, so this effect could be similar for all the participants.

Computer games have increasingly been used as tools for the treatment of mental health conditions and—as discussed in this paper—they can be effective when designed and used appropriately (Katz & Wertz, 1997). Notwithstanding, the ludology of interactive gaming applications used in psychotherapy is still very new, and there is a lack of well-documented research and evidence on their effectiveness (Goh et al., 2008).

Based on the novelty of this application, we utilized the TAM To predict the acceptance of Feeling Master as a tool to measure facial emotion recognition in rehabilitation psychiatric units. The TAM constructs used were: perceived usefulness, perceived ease of use, and behavioral intention, adapted from Davis (1989) and Yi and Davis (2001); attitude toward using, adapted from Ajzen and Fishbein (1980); and enjoyment, adjusted from Yi et al. (2003). The findings of the TAM study reveal that except for the perceived ease of use, which has a high value, the other construct values must be improved. We consider these results as a baseline, and we will introduce new design improvements to increase these values in the upcoming version of Feeling Master.

While these design improvements are necessary steps toward improving the acceptance of user satisfaction, it is still not enough. Human factors engineering investigation has shown that the way in which new technologies are implemented needs to be carefully considered if optimum benefits are to be realized.

As reported by previous authors (Karsh, 2004), the degree of job change produced by the implementation of novel technologies is also an important matter to take into consideration. Previous studies explained how new technologies may change job structure and consequently impact perceptions of the technology, and there are empirical results to corroborate the proposition. Specifically, research has found that perceptions of negative impacts on users were found more often when new technology implementations led to important changes in work structure. Yarbrough and Smith (2007) concluded, after a systematic review of the literature on physician acceptance of information technology, that the requirement of additional time is one of the major barriers to technology acceptance. Ultimately, given the fast and ever-increasing pace of technology implementation in health care, it is fundamental for the science of technology implementation to be comprehended and incorporated into efforts to improve patient benefits.

In addition to the above findings, we also encountered two unexpected, but very important, findings to take into account for the final research: first, the weak Internet connection in the rehabilitation psychiatric units; second, the need for a proper testing environment.

At the beginning of the pilot study, the application was installed on a tablet connected to the Internet via the rehabilitation psychiatric unit router. The Internet signal of this router was extremely weak in the testing room, so the application did not perform well and crashed frequently. To solve this issue, we tethered the tablet to a smartphone configured to work as a Wi-Fi hotspot and got online using the smartphone's Internet connection. This connection problem generated a delay of about 45 minutes to the overall testing, creating some annoyance among the patients. On the other hand, dealing with this difficulty during the usability phase prevented us from using the rehabilitation psychiatric unit's Internet connection for the final study.

It is important to remark that during the pilot study with the patients, we noticed that some participants experienced some difficulties common to the clinical features of schizophrenia patients (such as lack of attention, thought disorder, and movement disorder). To minimize the patients' attention problems, it was crucial to prepare a special room for this testing to reduce, as much as possible, any kind of distraction. The testing room was informal and non-threatening for the patients and had a welcoming atmosphere.

Several limitations should be considered when interpreting the results of this study. First, Impaired emotion recognition in this study was limited to a group of patients with schizophrenia who were clinically stable yet chronic. Second, the effect of medication was not controlled in this study, although medication data have been recorded. Third, we did not examine the full range of basic emotions. We omitted from this study the emotion of disgust, as well as neutral faces. Fourth, the number of participants in this study was small. Additional investigation with a larger number of subjects is required.

11 FUTURE WORK

In future studies, we will deliberately use time as a variable to reduce the accuracy of responses, in order to minimize the "ceiling effect" (Kirouac & Doré, 1984; Ogawa & Suzuki, 1999). The improvement in the detection caused by the ceiling effect suggests the development of a learning Feeling program for improving social skills in patients with schizophrenia. In order to assess the progress, a cognitive post-test analysis should be introduced (Russell, Chu, & Phillips, 2006).

In order to obtain significant statistical studies of Feeling Master, a larger sample of participants must be achieved to determine the reliability and the validity of each cartoon in relation to the construct or the emotion.

Methodological discrepancies should be analyzed, such as subject selection according to their state of illness (Addington & Addington, 1998; Edwards et al., 2001; Lewis & Garver, 1995) or the illness progression (Gessler, Cutting, Frith, & Weinman, 1989). Additionally, we should investigate the performance of Feeling Master with individuals with autism. As we mentioned in this study, a range of social cognitive deficits have been reported for both autism and schizophrenia (Abdi & Sharma, 2004; Pelphrey, Adolphs, & Morris, 2004; Pinkham, Penn, Ph, Perkins, & Lieberman, 2003), particularly in theory of mind (Baron Cohen, 1995; Rhiannon Corcoran, 2005; Yirmiya, Erel, Shaked, & Solomonica-Levi, 1998), the perception of social cues (Archer et al., 1994; Klin, Jones, Schultz, Volkmar, & Cohen, 2002), and facial affect recognition (Celani, Battacchi, & Arcidiacono, 1999; Kohler & Brennan, 2004). Training studies have suggested that children with autism show greater improvements in emotion recognition when programs include cartoons rather than photographs of real faces (Silver & Oakes, 2001).

In future works we could enhance the usability assessment of Feeling Master, adding the user satisfaction criteria as an extra component of the study. User satisfaction, in layman's terms, has to do with the fulfillment of a desire or a need through the users' feelings and attitudes towards a service or product (Bahari & Ling, 2010). The phenomenon of the users' experiences involving the their emotions reflects the users' satisfaction and whether or not the service outcome is of quality (Nenonen, Rasila, Matti, & Karna, 2008). Generally, the measurement of satisfaction is taken from post-study questionnaires with the study participants.

Even though no significant correlations were found, the emotional recognition with Feeling Master seems to be related to attributional style (IPSAQ) regarding the "sad" and "surprised" faces in the group of patients. This trend should be considered when therapists apply the tool. Furthermore, we should relate the patients' results of facial emotion recognition to clinical variables, such as the Theory of Mind (ToM) using the Hinting Task and the Assertion Inventory (AI).

Specifically, neutral faces should be included to see if patients with schizophrenia misidentified neutral cues as unpleasant or threatening relative to normal controls. Also, we should add the disgust emotion to the study, in order to analyze the complete set of six basic emotions defined by Ekman and Friesen (1971). Besides, the pattern of erroneous misattributions should be introduced to all six basic emotions, as well as neutral faces.

While the design improvements are necessary steps towards improving the usability of Feeling Master, it is important to investigate the best way to implement this novel application in rehabilitation psychiatric units. Previous studies mention several concerns about the adoption of the use of new technologies in psychotherapy by therapists (Horne-Moyer, Moyer, Messer, & Messer, 2014). Research needs to be conducted on effective deployment strategies for new technologies available to mental health professionals.

There have been good experiences using Computer-Based Treatment or training in psychiatric patients with depression (Proudfoot et al., 2004) and autism (Silver & Oakes, 2001). Further investigation into computer-based treatment packages for emotion-recognition remediation in patients with schizophrenia should be done.

12 CONCLUSIONS

To our knowledge, this is the first study to assess the usability of a psychotherapeutic interactive gaming application as a tool to measure facial emotion recognition in patients with schizophrenia designed with the user-centered design (UCD) methodology. In this study, we evidenced the advantages of using UCD to improve the usability of Feeling Master based on three criteria: adaptability, effectiveness, and efficiency (Nielsen, 1994; Schwebel et al., 2014), throughout the development process. Key to this study, and key to the approach, was the fact that UCD gathered a consensus from the medical community during the process. This, in turn, allowed the design and development to move forward smoothly. Furthermore, the patients and therapists helped to convey a positive message regarding the improved interface, which resulted in a boost in the users' initial acceptance of the product.

Results reveal that Feeling Master is a useful tool to measure facial emotion recognition in patients with schizophrenia. This application discriminates between healthy controls and patients with schizophrenia regarding their impairment in emotion recognition. Preliminary findings using Feeling Master have consistently shown that difficulties in emotion recognition are associated with key cognitive deficits in patients with schizophrenia, specifically in the recognition of fearful facial expressions. These findings are consistent with previous studies carried out with different tools for the assessment of emotional recognition in schizophrenic people.

Even though no significant correlations with clinical variables were found, the emotional recognition results with Feeling Master seem to be related to attributional style (IPSAQ) regarding the "sad" and "surprised" faces in the group of patients with schizophrenia. This trend should be considered when the therapists apply the tool.

Finally, for this study, TAM was adapted and used to describe factors predicting the acceptance of Feeling Master as a tool to measure facial emotion recognition in rehabilitation psychiatric units. The findings of the TAM study indicate that except for perceived ease of use (PEOU), which has a high value, the other construct values should be improved. We consider these results as a baseline, and we will introduce new design specifications to increase these values in the future.

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