Errorless learning of emotional facial expressions in Korsakoff's syndrome

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Abstract

Korsakoff's syndrome is a neuropsychiatric disorder that is caused by thiamine (vitamin B) deficiency, which is often the result of alcoholism. Korsakoff's syndrome patients often suffer from impaired emotional facial recognition. As a consequence, interpersonal difficulties arise between patients but also between patients and their caregivers. Up until now, no research has been conducted on the (re)learning of emotional facial expressions by Korsakoff's syndrome patients. Therefore, the present study investigated whether KS patients could (re)learn emotional recognition. Errorless learning seemed like an effective teaching strategy in Korsakoff's syndrome, as it is based on the intact implicit memory functioning and already has proven its effectiveness in several other studies regarding Korsakoff's syndrome patients. To compare the effectiveness of errorless learning, another patient group received an errorful training program. The aim of the present study was to investigate if Korsakoff's syndrome patients could (re)learn the recognition of emotional facial expressions of others and to compare the effectiveness of errorless learning with errorful learning in the acquisition of this ability. The relevance of the present study is to reduce the interpersonal difficulties that Korsakoff's syndrome patients encounter due to the mislabeling of emotional facial expressions of others. After completing all sessions, errorless learning did not improve the performance on the recognition of emotional facial expressions. In contrast, errorful learning only showed improved performance on the training sessions, suggesting that attention is important to learn in Korsakoff's syndrome patients.

Introduction

Korsakoff's syndrome is a neuropsychiatric disorder that is caused by thiamine (vitamin B) deficiency, which is often the result of alcoholism. Typical neurological damage is found in the medial thalamus, hippocampus, mammillary bodies, periventricular region, periaqueductal gray matter and frontal lobes (Jung, Chanraud & Sullivan, 2012; Kopelman, 1995). A major impairment that is seen in Korsakoff's syndrome patients is profound amnesia, with severe impairments particularly in declarative memory (Kopelman, 1995), whereas procedural memory is relatively spared (Oudman et al. 2013; Postma, Antonides, Wester & Kessels, 2008).

Emotional facial expressions provide cues about the mood and behavior of others, interpersonal communication even consists to a large extent on the accurate interpretation of emotional facial expressions of others (Kessels, Montagne, Hendriks, Perret & de Haan, 2014). Disturbances of the affective and interpersonal abilities are well known in Korsakoff's syndrome patients (Douglas & Wilkinson, 1993; Labudda, Todorovski, Markowitsch & Brand, 2008). In their review, Brion, D'Hondt, Davidoff and Maurage (2015) found that in alcohol dependent patients, there is an imbalance between an over-activated affective-automatic system and an under-activated reflective system causing affective disturbances (Brion et al., 2015). The affective-automatic system is involved in the impulsive processing of a stimulus and depends on implicit learning. The reflective system inhibits cognitive processing of stimuli. Their expectation is that these systems are even more disturbed in Korskoff's syndrome patients causing disturbances in the affective and interpersonal abilities (Brion et al., 2015). The disturbances in interpersonal abilities are probably caused by the difficulties in recognizing emotional facial expressions of others (Montagne, Kessels, Wester & de Haan, 2006). Korsakoff's syndrome patients particularly mislabel anger, fear and surprise (Montagne et al., 2006). Failures in recognizing emotional facial expressions can lead to major interpersonal misunderstandings (Frigerio, Burt, Montagne, Murray & Perret, 2002). It is likely that frequently occurring behavioral problems in Korsakoff's syndrome, such as aggression and agitation are related to deficiencies in emotion recognition (Gerridzen & Goossensen, 2014). Although mislabeling of emotional facial expressions of others in Korsakoff's syndrome patients leads to various issues in the communication with, and treatment of these patients, no research has yet been conducted in re-learning these patients to better recognize emotional facial expressions.

A good candidate for an effective teaching strategy in Korsakoff's syndrome is errorless learning. Errorless learning is a teaching technique using feed-forward instructions, thereby preventing mistakes during the learning process. (Oudman et al., 2013). Errorless learning has been frequently applied in the rehabilitation of memory-impaired people, because of its proven effectiveness as a technique to learn novel skills in many forms of amnesia (e.g. Evans et al., 2000; Kessels & de Haan, 2003). Errorless learning has already proved to be a successful learning strategy in different studies with Korsakoff's syndrome patients (e.g. Komatsu, Mimura, Kato, Wakamatsu & Kishima, 2000; Oudman et al., 2013). In healthy subjects, skills and knowledge are consciously acquired by using explicit memory, but explicit memory is severely impaired in Korsakoff's syndrome patients (Kessels & de Haan, 2003). Explicit memory refers to the conscious made and used memories, whereas implicit memory refers to the memories and skills which are unconsciously made and used. Errorless learning is predominantly based on unconscious, implicit memory, which is often relatively spared in Korsakoff's syndrome patients (Kessels & de Haan, 2003). It is a learning method in which making mistakes is strictly avoided. The instructions and cues are straight forward, so that the participant nearly only has the option of learning the right answer. Patients learn new skills by seeing, hearing and acting in the right manner. This way the correct response becomes strengthened in the brain, helping memory-impaired patients to consolidate an obtained skill in the right way (Page, Wilson, Shiel, Carter & Norris, 2006). Memory impaired patients can learn with errorless learning, although they do not know when, where or how they acquired the learned skill. The recognition of emotional facial expressions however depends to a great extent on implicit memory (Brion et al., 2015).

Errorless learning has often been applied in (re)learning motor skills (e.g. Oudman et al., 2013; Prather, 1971). In the present study however, patients will learn a cognitive skill, namely emotion recognition, instead of a motor skill. We included a motor component in our study to learn a cognitive skill in a motorial way. In real life healthy persons first tend to look to the eyes, then shift to the mouth and then see the entire face (Eisenbarth & Alpers, 2011). It is known that for example schizophrenic, autistic and depressed patients examine faces in a different way than healthy people (Eisenbarth & Alpers, 2011) and the same is expected for Korsakoff's syndrome patients. We simulated the normal way of scanning faces used by healthy people, to examine if it support patients to better recognize the emotional facial expressions.

The relevance of the present study is to reduce the interpersonal difficulties that Korsakoff's syndrome patients encounter, in part caused by their inability to accurately recognize emotional facial expressions. Accurately recognizing emotional facial expressions is very important in interpersonal interaction and communication. If patients can learn to better recognize emotional facial expressions, this ability can hopefully support them in more correctly interpret someone's mood and adjust their behavior to the situation. This study can therefore help in reducing the interpersonal tensions that can lead from misinterpreting emotional facial expressions between the Korsakoff's syndrome in-patients in Slingedael, but also their caregivers.

The central aim of the present study was to investigate whether Korsakoff's syndrome patients still have potential for learning and maintaining accurate recognition of emotional facial expressions of others by means of an intensive training program. Moreover, the second aim is to examine whether errorless learning could more effectively support the (re)learning and maintenance of accurately recognizing the emotional facial expressions of others compared to errorful learning. Different studies already used errorless learning to (re)learn an activity to Korsakoff's syndrome patients and some appeared to be successful (Komatsu, Mimura, Kato, Wakamatsu & Kishima, 2000; Oudman et al., 2013). The expectation is that after training, the group that received the errorless training can more accurately recognize emotional facial expressions than the group that did receive the errorful training.

Methods

Participants

24 patients (mean age = 62.3; SD = 7.1; 20 males) diagnosed with Korsakoff's syndrome participated in this study. They were all inpatients of Korsakoff Centre 'Slingedael', Rotterdam, the Netherlands. All patients met the diagnostic criteria of the DSM V for substance induced major neurocognitive disorder (American Psychiatric Association, 2013), as well as the Korsakoff's syndrome criteria described by Kopelman (2002). Korsakoff's syndrome patients suffering from additional brain injury, severe psychiatric symptoms or reduced eyesight which interfere with testing were not included in the study protocol. Patients that suffered from serious motivational problems interfering with the test sessions were also not included..

12 patients were assigned to the errorless learning protocol and 12 patients were assigned to the errorful learning protocol. To make sure that these groups started

at the same baseline, assignment to one of the groups was based on the patients pretest scores.

Task and Stimuli

Pretest

To measure the ability to recognize emotional facial expressions at the start of the program, a pretest was conducted. This task included the static emotion task, a computer based emotion recognition task (see Terburg et al., 2012 for more details). In each trial one of four faces (two male and two female faces) was shown, displaying one of six emotions. Different images were available of each face, ranging from a neutral face (0%) to a full blown emotion (100%) and four differentiating pictures in between. The emotions that were used were anger, disgust, happiness, sadness, fear and surprise.

In the present study, one image was shown during a trial starting at the lowest range with the least recognizable emotions and eventually showing the full blown emotions (100% morphed). The duration of the images was about 1700 ms after which the buttons with the names of the emotions appeared. Patients were then asked to choose the emotion that described the face the best. The fixation cross between trials appeared on screen with a minimal duration of 60 ms. All participants received the same (pre- and post-) test. Based on the accuracy of performance on this task, participants were enrolled in one of the two learning conditions.

Training stimuli

The present study used a task that was assembled specifically for this research project. The stimuli used in the task were the Nimstim faces, this set of different facial expressions was created by Tottenham and colleagues (2009). The Nimstim set consists of 25 male faces and 18 female faces from different racial backgrounds, each showing 8 different emotions. Only 6 emotions were used in the present study: anger, disgust, fear, happy, sad and surprised. Neutral and calm are also included in the original Nimstim set, but are omitted here. Of the 258 images that were available, 60 images with the highest validation scores were selected for the training protocol. A high validation score reflects a relatively high potency to be recognized in in a healthy norm group (see Tottenham et al., 2009 for more information).

Training Procedure

The Korsakoff's syndrome patients participating in the present study were assigned to one of the two groups based on their pretests scores. In the errorless learning training condition patients first received the instructions to recognize one of the displayed emotions by clicking on the emotion. First, a black screen appeared for 1500 ms on the computer screen. An audio file of a female voice naming the upcoming emotion was played. After this, a blurred image of a Nimstim face with clear eyes was shown for 1000 ms, while the rest of the face is blurred out. Then the picture shifted to the mouth and was shown for 1000 ms with the rest blurred out and eventually the whole picture of the face was shown for 1000 ms as well. Subsequently 6 buttons appeared, each button representing one of the six emotions (angry, disgust, fear, happy, sad and surprised). The patient was asked to choose the emotion that best described the images that was seen. After each trial a black screen was shown for 1500 ms (see Figure 1). In the training conditions participants first saw an image of a blurred face with clear eyes, next the same blurred face with a clear mouth and then the whole clear face. This way the normal way of scanning faces is imitated in the errorless training condition hoping that it will aid the patients towards a better learning curve. With this series of images we tried to add a motorial component instead of making it exclusively a cognitive task. The training lasted about 10 minutes, in which the 60 images were displayed in random order.

Figure 1. The series of images used in the errorless learning training sessions, all images are shown for 1000 ms. In the errorful training condition, only the last picture was shown for 3000 ms.

In the errorful training condition, patients received the instructions to recognize one of the displayed emotions by clicking on the emotion. Then a black screen appeared for 1500 ms, then the whole face appeared for 3000 ms, but without the naming of the upcoming emotion. The training also lasted about 10 minutes, in which the same 60 images were shown as the errorless learning condition, also in random order.

After the training phase, the measuring task was conducted. This task was the same in both groups. First the instructions were shown on the screen and were read out loud by the test administrator. Subsequently a black screen was shown for 1500 ms. Than a Nimstim face was shown for 3000 ms. After this 6 buttons appear, each button representing one of the six emotions (angry, disgust, fear, happy, sad and surprised). Patients had to choose between one of the six emotions, there was no time restriction. The task consisted of 60 trials, every emotion was represented 10 times in the task. The conducting of the task approximately took 10 minutes. The training and test together lasted approximately 20 minutes.

Table 1. The similarities and differences between the errorless learning program and the errorful program.

	Pretest	**Training and task**	**Follow-up**	**Posttest**
Errorless learning program	Static emotion task	Errorless learning training + task	Task	Static emotion task
Errorful program		Errorful training + task		

Posttest

To measure the ability to recognize emotional facial expressions after the training program, a posttest was conducted. The posttest was the same task as the pretest (static emotion task, Terburg et al., 2012).

Procedure

Randomly, 24 Korsakoff's syndrome patients were asked to participate in the present study. Both the selection and training sessions took place in Korsakoff Centre Slingedael. The aim and procedure of the study was explained before the start of the study. Patients had the right to quit the study at every moment. If the patient agreed to participate, an informed consent was signed. The training consisted of a pretest, 7 training sessions, 3 follow-up sessions and a posttest. This timetable is also summarized in Figure 2. The first training session consisted of a pretest, this test is included to measure how accurate patients perform in recognizing emotional facial expressions at baseline. Each training session consisted of a training phase and a recall phase. First one of the two training sessions was completed, after which the

Emotion Recognition task was subsequent conducted. This together took about 20 minutes. This combination of training and test was conducted 7 times: in the first week only 1 time, after the first week 2 times a week for four weeks. After this, the patients had a two week break. This break was included to find out if the learning effect of the training was long lasting and maintained after a period of no training. After this break, only the Emotion Recognition task was tested 3 times, two times in the first week after the break and only 1 time in the second week after the break. At last, a posttest with different faces will be conducted to see if the learning effects are also applicable to other emotion recognition tasks.

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
Pretest	Session 1	Session 2 & 3	Session 4 & 5	Session 6 & 7	Break	Break	Follow-up 1 & 2	Follow-up 3 & Posttest

Figure 2. Timetable of the sessions.

Analyses

A generalized linear mixed model (GLMM) was used to measure the learning effect over the seven training sessions for both groups separately. A generalized model was used because the data was binomially distributed, (correct and false answers) and because it is more robust than repeated measures ANOVA. A linear model was used, because we assumed after inspection of the scatter plots that the learning effect would fit best with a linear curve. A mixed effect model was chosen to include both a fixed and a random effect. Our fixed effect in this model was the session, which defines the slope of the model. The random effect in this model was the patient, because each patient started at a different performance level and this influenced the intercept of the model.

A chi-squared test was used to examine if the practiced skill was maintained after a two week break. Therefor we compared the differences in performance between the follow-up sessions and the last learning session.

We also used a chi-squared test to measure if Korsakoff’s syndrome patients could recognize emotional facial expressions on other faces than the ones that were used in the training and test sessions . Here we compared the posttest to the pretest, because they used the same images, but with the training and test sessions (time and different images) in between.

The chi-squared test was also used to examine which of the emotions were most correctly chosen. To examine if there was a difference between a female face showing the emotional facial expressions compared to a male face, a chi-squared test was used.

Results

Initially 24 Korsakoff's syndrome patients participated in this study. 16 patients completed all sessions. Eight patients quitted during the course of the tests due to motivational problems. This means that they did not provide us with a score for every session and as such we could only analyze the scores of the sessions in which they participated.

Pretest

After conducting the pretest, the participants were enrolled in one of the two learning conditions based on the accuracy of their judgments on the pretest. The cumulative score of the patient group assigned to the errorless learning condition was 829 (SD = 40.5) out of 3456 items and the cumulative score of the group assigned to the errorful condition was 830 (SD = 40.0)., suggesting that both groups performed equally in recognizing emotions at the start of the training course.

Six participants scored above a predefined value for the proportion of correctly answered questions on the fully morphed faces in the pretest and because of their possible ceiling effect, we excluded them from the learning effect analyses.

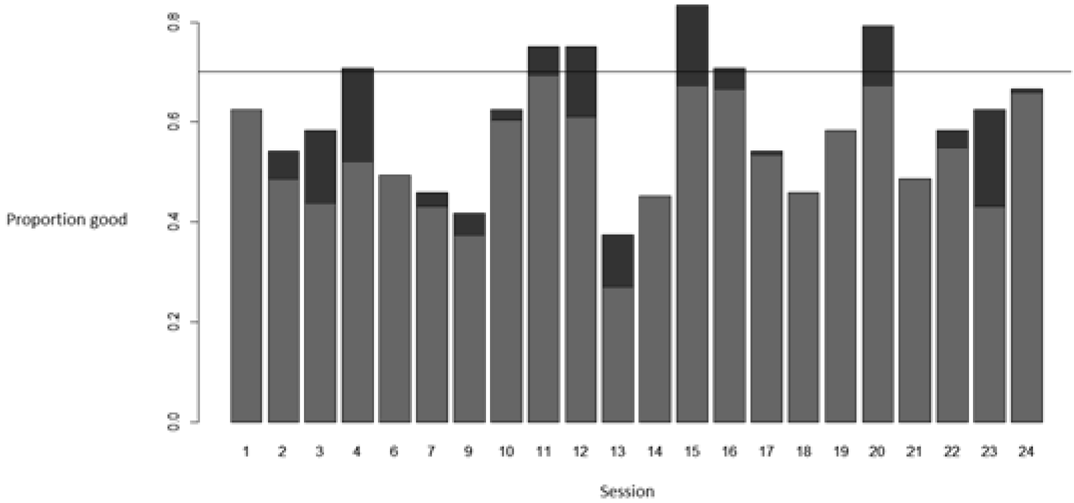

Figure 3. Proportion of good answers on the complete static emotion task (light grey) and only on the full blown images (dark grey).

Learning phase

The six patients with a high score on the pretest were excluded from this analysis, due to a possible ceiling effect. In the learning phase the errorless learning condition did not significantly improve over the training sessions (β = -.028; p = .145), whereas the errorful condition did improve slightly (β = .064; p < .001). As can be seen in Figure 4, the learning curve of errorless learning does not show a clear slope over the training sessions, where the errorful condition shows a positive slope. Thus a learning effect was only found for the errorful condition.

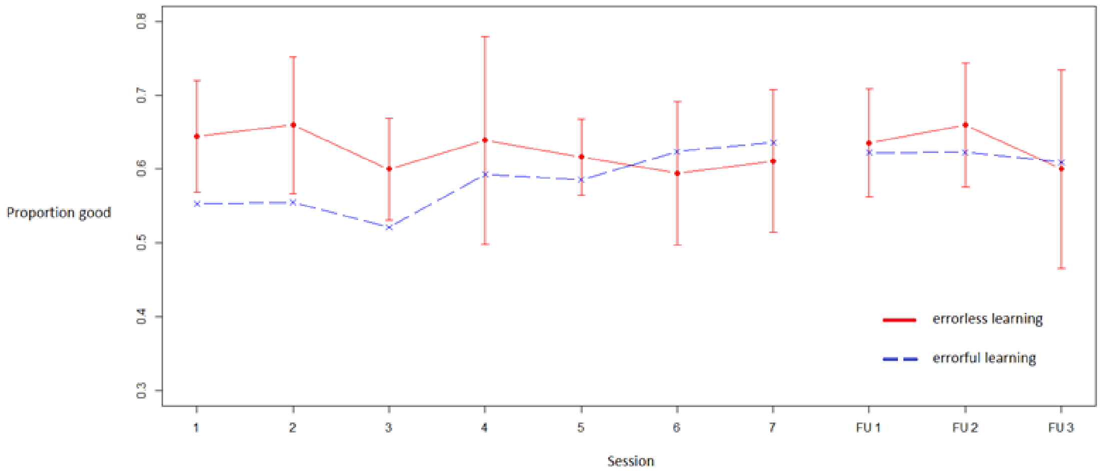

Figure 4. Performance of Korsakoff's syndrome patients (n = 24) on each learning session in the errorless learning and errorful learning condition. The scores are adjusted to proportions. .

Without training

The patients had two weeks without training to test whether the results of the training programs maintained over a prolonged period. To inspect whether two weeks without training resulted in an inferior performance compared to the last learning session, the last learning session was compared with the follow-up sessions. This analysis was not statistically significant for the errorless learning condition, χ^2 (df = 1) = .470 , p = .493. The errorful condition was not statistically significant as well, χ^2 (df = 1) = .778 , p = .378. These results suggest that performance of both groups after the two week break were not significant improved nor deteriorated.

Posttest

Performance on the posttest was compared to the follow-up test sessions. The scores on the fully morphed faces were used in this analysis. The errorless learning condition showed a significant difference on the performance on the test sessions and the posttest χ^2 (df = 1) = 5.022 , p = .025. The errorful condition showed a significant difference as well, χ^2 (df = 1) = 4.796 , p = .029. Both learning groups scored better on the test sessions than the posttest, suggesting that the patients found the emotions of the images of the test sessions easier to recognize compared to the different images of the posttest.

The pre- and posttest were also compared to examine if there was a difference in performance on both tasks. Both conditions showed no significant difference on the performance on the pre- and posttest, with the errorless learning condition χ^2 (df = 1) = .240 , p = .624 and the errorful condition χ^2 (df = 1) = .308 , p = .579. This suggests that the Korsakoff's syndrome patients did not improve over the complete training course.

Correctly chosen emotions and gender

The best recognized emotions were happy, surprised and anger. The chi-squared test was significant χ^2 (df = 5) = 2759.1 , p = <.001, showing that the distribution of correctly chosen emotions was not equally distributed (Figure 5. The emotions surprise, happy and fear were also the most chosen emotions.

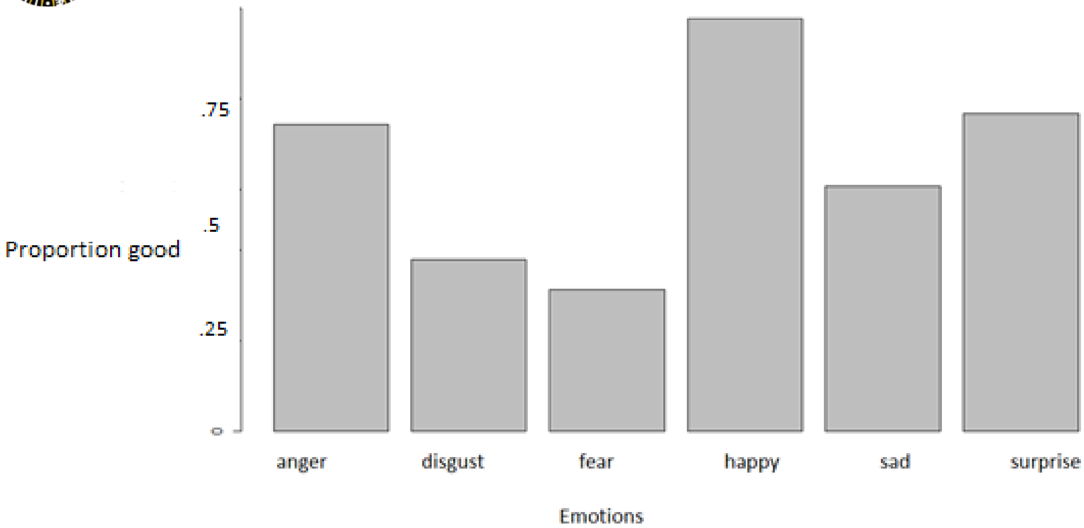

Figure 5. Number of correctly chosen emotions in learning and follow-up sessions.

To examine if choosing the right emotion depends on the gender of the person showing the emotional facial expression, a chi-squared test was used to compare the performance between female and male faces. The chi-squared test showed no significant difference χ^2 (df = 1) = .094 , p = .760 , showing that the gender of the person showing the emotional facial expression has no influence on the accuracy of the patients' judgements (Figure 6).

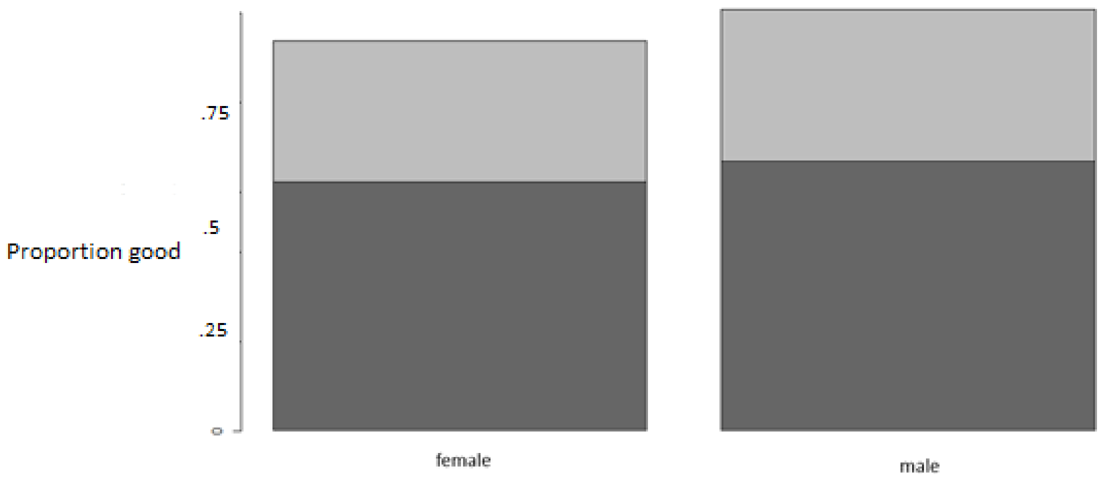

Figure 6. Proportion of chosen (light grey) and well-chosen (dark grey) emotions on female and male faces.

Discussion

The present study examined whether Korsakoff's syndrome patients could (re)learn to accurately recognize emotional facial expressions, since earlier research indicated large difficulties regarding emotion recognition in Korsakoff's syndrome patients (Montagne et al., 2006). The second aim was to examine whether an errorless training procedure was more beneficial than an errorful training procedure. Errorless learning relies on the mostly intact implicit memory in Korsakoff's syndrome patients, it therefore seemed like an effective teaching strategy in the present study. Emotion recognition relies to a great extent on implicit memory (Brion et al., 2015). Different studies already showed that errorless learning was beneficial in (re)learning activities in Korsakoff's syndrome patients (Komatsu et al., 2009; Oudman et al., 2013).

Contrary to our expectations, the Korsakoff's syndrome patients participating in the errorless training procedure did not improve over the learning sessions, where patients in the errorful learning did show improvement over the learning sessions. The performance in the follow-up sessions compared to the last learning session showed no difference in both conditions, suggesting that the Korsakoff's syndrome patients in the present study did not show improvement after a two week break, nor deterioration. Nor did the absence of a training program in the three follow-up sessions negatively or positively influence the performance. We also included a posttest with images of other faces than those that were learned during the learning sessions, to find out if the learning effect was generalizing. Performance on the posttest compared to the pretest showed however a negative learning effect, showing that performance on recognizing emotional facial expressions was not generalizable.

In the present study, performance of the Korsakoff's syndrome patients enrolled in the errorful training condition improved slightly in recognizing emotional facial expressions over the seven training sessions. This could possibly suggest that Korsakoff's syndrome patients learn better with a training procedure that demands more attention, because this was one of the greater distinctions between the errorless and errorful learning conditions. In the present study a comparison between the posttest (static emotion task) and the pretest was made. The posttest was included to see if the learned skill was generalizable to other tasks and therefor to real life. The results that were found in the present study indicate that there is a discrepancy between the learned faces in the training sessions and the faces of the posttest. It is possible that the emotional facial expressions of the posttest images were harder to identify, or the Korsakoff's syndrome patients actually learned to only recognize the emotional facial expressions of the trained images and could not transfer the learned skill to new faces. This is supported by a study using emotion recognition training to train children with autism spectrum disorder, in which they found no clear link between the training and improving social skills (Berggren et al., 2017). They state that there are some improvements in the emotion recognition training itself, but that these improvements are not noticeable with images of other faces or normal life (Berggren et al., 2017).

One aim of the study was to examine if Korsakoff's syndrome patients could (re)learn emotional facial expressions with the errorless learning strategy. This is the first study to investigate whether the proper recognition of emotional facial expressions can be (re)learned by Korsakoff's syndrome patients. With the results that were found, we conclude that the present study did not find a way to improve the skill of the patients in recognizing emotional facial expressions using errorless learning. Kessels and colleagues (2007) found in their study that Korsakoff's syndrome patients were not better able to learn a spatial route with the errorless learning technique compared to the errorful condition. Other studies did however found a better learning curve with errorless learning in Korsakoff's syndrome patients (Komatsu et al., 2000; Oudman et al., 2013). Up until now, this study is the first to examine if it was possible to learn a group of Korsakoff's syndrome patients recognize emotional facial expressions with the errorless learning paradigm.

An assumption concerning the lack of improvement in errorless learning are possible motivational problems in the Korsakoff's syndrome patients. Motivational problems are more often noticed in Korsakoff's syndrome patients (Oudman, Nijboer, Postma, Wijnia & Van der Stigchel, 2015). The errorless learning condition was quite straightforward and therefore less attention demanding than the errorful condition. Patients could complete the training without looking at the images on the screen and without making mistakes, because the correct answer was named prior to each trial. None of the patients in this condition was completely uninterested, but few did pay less attention during the training. This can cause the training to be less successful than when full attention was paid, because divided attention can reduce the encoding of the combination between the heard emotion and the face on the screen (Naveh-Benjamin, Craik, Perretta & Tonev, 2010) In the errorful condition patients could lose their interest as well, but because of the lack of the spoken cue they had to watch to give a proper answer.

During the conduction of the present study, it was noticed by the examiner how the participants especially early in the training sessions only chose between three out of the six shown emotions: anger, happy and surprised. When the image on the screen showed a fearful face, it was very often misjudged as “surprised” and a disgusted face was misjudged for “anger”. Over the sessions, patients started to better chose between the six emotions, but disgust and fear remained behind in count. This is clearly an impairment in the recognition of emotional facial expressions. The most chosen emotions, independent on right or wrong, were surprise, happy and anger. The emotion happy is well-known as the simplest emotion to recognize (Montagne et al., 2006). The most well-chosen emotions were happy, surprised and anger. This is in line with the previous founding that surprised, happy and anger were the most chosen emotions. Montagne and colleagues (2006) found however that anger, fear and surprised are the most mislabeled emotions, while in our study anger and surprised are best recognized among happy. A possibility is the use of other images. The images that were used in the present study all had the same features: happy for example always showed a smiling face with bare teeth, with anger the face on the images showed a frown etc. All emotions appeared the same, but on different faces. It is possible that this explains the discrepancy between the studie of Montagne and colleagues (2006) and the present study. We also examined if there was a difference between the recognition of emotional facial expressions on male or female faces, but this was not the case.

Because it is important to reduce the interpersonal conflicts caused by the mislabeling of emotional facial expressions of others, it is important to consider what could improve the recognition of emotional facial expressions in Korsakoff’s syndrome patients. During overall testing we saw patients mimicry the images on screen more accurately recognized the shown expression. Penn and Combs (2000) saw better results when schizophrenia patients had a learning condition with mimicry. Mimicry could be a good potential candidate in future studies in learning Korsakoff’s syndrome patients to better recognize emotional facial expressions of others.

In conclusion, the present study indicates that errorless learning did not improve performance on the recognition of emotional facial expressions. The errorful condition did however show a small improvement over the learning sessions, although emotion recognition was not generalizable to other faces than the ones used in the training. The current study suggests that Korsakoff's syndrome patients can learn to better recognize emotional facial expressions of others, but it appears that it is only applicable to a small group of often seen faces.

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