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Induction Method Influence on Emotion Recognition Based on Psychophysiological Parameters

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ABSTRACT

Recognizing emotions is an essential ability in our daily social interactions. However, there are individuals who have difficulties interpreting emotions, such as patients with autism spectrum disorders (ASD). In order to cope better with everyday life, trainings of emotional and social skills can be a supporting factor for them. New technologies such as virtual reality can also be used for this purpose. To evaluate such new concepts, it is important to make the emotional state of a person measurable. For that reason, the aim of the presented experimental study was to investigate two different methods of emotion induction (visual stimuli, autobiographical recall) for the six basic emotions anger, disgust, fear, happiness, sadness, surprise, and a neutral category. Overall, 14 women and 10 men ($N = 24$) aged between 19 and 59 years ($M = 29.25$, $SD = 11.46$) participated in the study. A multidimensional approach combining subjective assessments and objective psychophysiological measures of the cardiovascular (ECG) and electrodermal (EDA) activity was used within the study. The results show an effect of the different induction methods that is evident in both the subjective and the psychophysiological parameters.

Keywords: Emotion induction, Basic emotions, Psychophysiology

INTRODUCTION

Recognizing emotions is an essential ability in our daily social interactions. However, there are individuals who have difficulties interpreting emotions, such as patients with autism spectrum disorders (ASD; Hartl, 2010). In order to cope better with everyday life, emotion training can be a supporting factor for them (Golan et al., 2010; Kandalaft et al., 2013; Yuan and Ip, 2018). However, emotion training is not only helpful for patients with ASD, but also in the working environment, for example in trainings for managers or teams. Studies have shown that emotion training improves interpersonal effectiveness (Schlegel and Hall, 2021) and negotiation outcomes (Elfenbein et al., 2007). Furthermore, Meléndez et al. (2020) showed that reduced social interactions (e.g., restrictions due to the COVID-19 pandemic) can affect our

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ability to recognize emotional facial expressions. In recent research, there are already approaches to use new technologies, such as virtual reality, to train emotional and social skills (Kandalaft et al., 2013; Yuan and Ip, 2018). In addition, the development of facial emotion recognition (FER) systems based on machine learning techniques is increasing (e.g., Arabian et al., 2021; 2022). These systems mostly focus on the recognition of the following six basic emotions that have been examined in numerous researches by Ekman and colleagues (e.g., Ekman et al., 1969; Ekman, 1970, 1992): anger, disgust, fear, happiness, sadness and surprise. For training FER algorithms, databases containing facial expressions of these six basic emotions and in addition neutral expressions, are often used (e.g., Arabian et al., 2022 using the database Japanese Female Facial Expressions, JAFFE; Lyons et al., 2020).

To investigate and evaluate such facial emotion recognition systems, it is important to induce the basic emotions in an individual. Therefore, a number of induction methods can be found in research. For example, Siedlecka and Denson (2019) reviewed different emotion induction methods for basic emotions. Their results showed that studies often investigate only a few selected emotions from the six basic emotions, e.g., happiness, sadness and fear (Baumgartner et al., 2006; Schmid et al., 2022) or anger and disgust (Dasgupta et al., 2009). As a consequence, there is a lack of studies that examined the emotion induction of all six basic emotions. Following Siedlecka and Denson (2019), the most common methods to induce emotions are visual stimuli, music, autobiographical recall, situational procedures, and imagery. Accordingly, visual stimuli are most effective to induce all six basic emotions. Thus, a number of standardized sets of emotionally salient pictures have been developed in emotion research (e.g., Lang et al., 1997; Wessa et al., 2010; Kurdi et al., 2017). As mentioned before, another induction method is the so-called autobiographical recall (Siedlecka and Denson, 2019). Here, participants are asked to recall emotional situations from their everyday life as clearly and vividly as possible (Ozawa, 2021). Following the review of Siedlecka and Denson (2019), this method seems to be highly effective for the basic emotions anger, happiness, fear, disgust, and sadness, but less effective to induce the emotion surprise.

One of the greatest challenges in emotion research is to make a person's emotional reaction measurable (Frenzel et al., 2009). On the one hand, there are interviews and questionnaires to capture the subjective emotional state of a person (e.g., Bradley and Lang, 1994). On the other hand, psychophysiological measures can be used (Boucsein and Backs, 2000). Based on former research of Boucsein and colleagues (Boucsein et al., 2002; Boucsein and Schaefer, 2008), our research group developed (Birkle et al., 2022) and validated (Schmid et al., 2022) a concept for a multidimensional measurement environment which combines subjective assessments and objective psychophysiological measures. Within this first validation study pictures were used as visual stimuli to induce different emotions. First results show significant differences regarding the subjective assessment of the dimension valence but not regarding the dimension arousal. However, no significant effects can be shown in the psychophysiological parameters. Therefore, the authors suggested to find out if other induction methods would be more suitable to induce

emotions than the used visual stimuli. Furthermore, only the four emotions happiness, serenity, sadness and fear were used in the first validation study (Schmid et al., 2022).

For this purpose, the aim of the presented study was to investigate two different methods of emotion induction (visual stimuli and autobiographical recall) for the six basic emotions anger, disgust, fear, happiness, sadness, and surprise, as well as for a neutral category.

METHOD

A laboratory experiment with repeated measures was chosen for this study. Overall, the experiment consisted of two different parts: First the induction of emotions via visual stimuli and autobiographical recall (presented within this paper) and second a more exploratory part, using virtual reality to induce emotions (not presented within this paper).

Participants

Overall, 24 participants (14 female, 10 male) participated in the study. The participants were between 19 and 59 years old ($M = 29.25$, $SD = 11.46$). They took part in the study voluntarily and received no compensation. All participants provided their informed consent at the beginning of the study. The study was approved by the ethics committee of the Furtwangen University.

Materials

Two different emotion induction methods (visual stimuli and autobiographical recall) were used to induce the basic emotions: anger, disgust, fear, happiness, sadness, surprise, and an additional neutral emotion. Regarding the first induction method "visual stimuli", affective pictures from the following emotional picture databases were used: The International Affective Picture System (IAPS; Lang et al., 1997), the Emotional Picture Dataset (EmoPicS; Wessa et al., 2010) and the Open Affective Standardized Image Set (OASIS; Kurdi et al., 2017). Four pictures were selected for each of the seven emotional categories. For the second induction method "autobiographical recall", participants were asked to imagine past situations of their daily life in which they had felt the targeted emotion. Therefore, the following instruction (given in German) based on Ozawa (2021) was first presented to the participants: *"In the next step, you will be asked to recall emotional interpersonal events in daily life as clearly and vividly as possible. You will not be asked for the recalled contents."* Afterwards, each different emotional category was introduced by: *"Please think now of a situation in which you felt _____ (emotion e.g., sad). Now please try to recall the situation for 30 seconds."* All written instructions as well as the affective pictures (only first induction method) were presented on a 23-inch *HP* screen at a distance of 50 cm.

Subjective Measurement

The two dimensions valence and arousal of the Self-Assessment Manikin (SAM; 9-point scale based on pictograms; Bradley and Lang, 1994) were used to measure the participants' emotional state subjectively. Furthermore, additional items based on Ozawa (2021) were used for an emotion characterization, providing more detailed information about the emotions actually felt by the participants. After every induced emotion, participants were asked to assess [6-point scale from "not at all" (1) to "very" (6)] to what extent they felt each of the six basic emotions as well as "neutral" or "other emotions". For example, how strongly disgust was subjectively assessed, if the condition disgust was actually examined. All subjective assessments were performed on a *Samsung Galaxy Tab A* tablet using an online survey tool (Unipark, 2022).

Psychophysiological Measurement

As objective psychophysiological parameters, cardiovascular (ECG) and electrodermal activity (EDA) were recorded. For this, systems of Movisens (Movisens, 2022a, 2022b) were used. The ECG sensor was attached on a chest strap. Electrodermal activity, was recorded on the inner palm (thenar and hypothenar) of the participants' non-dominant hand. The following measures were used for the statistical analysis: heart rate (HR) in beats per minute and heart rate variability (HRV RMSSD) regarding cardiovascular activity as well as skin conductance level (SCL), amplitude of non-specific electrodermal responses (NS.SCR amp), frequency of non-specific electrodermal responses (NS.SCR freq) and mean sum amplitude (NS.SCR amp/NS.SCR freq) as parameters of the electrodermal activity. A baseline correction has been done for all measured psychophysiological parameters.

Procedure

After a short briefing of the participants, they provided their informed consent and socio-demographic data. Afterwards, the electrodes for the psychophysiological measurements were attached and an electrode check, followed by a baseline measurement of four minutes was performed. After that, the phase in which the different emotions were induced took place. Therefore, the six emotional categories anger, disgust, fear, happiness, sadness, surprise, and the neutral category were conducted.

Within an emotional category, emotion induction was first performed with visual stimuli. The affective pictures (Lang et al., 1997; Wessa et al., 2010; Kurdi et al., 2017) were presented in blocks of 30 seconds. Within each block, four different pictures were used (presentation time of each picture: 7.5s). After the emotion induction, participants had to assess its valence and arousal (SAM; Bradley and Lang, 1994). Subsequently, the items for emotion characterization regarding the actual emotion felt were presented. This was followed by a resting measurement of one minute. After the induction with "visual stimuli", the procedure was repeated for the second method "autobiographical recall". The seven emotional categories were presented in a permuted order to avoid effects caused by the order of the different emotions. The sequence within an emotional category was maintained: First

"visual stimuli", then "autobiographical recall". After the last rest measurement, a break was taken. Afterwards, the second part of the study using virtual reality followed (not presented within this paper). At the end of the study, the sensors of the psychophysiological measurements were removed. Each participant needed about 90 minutes to complete the study.

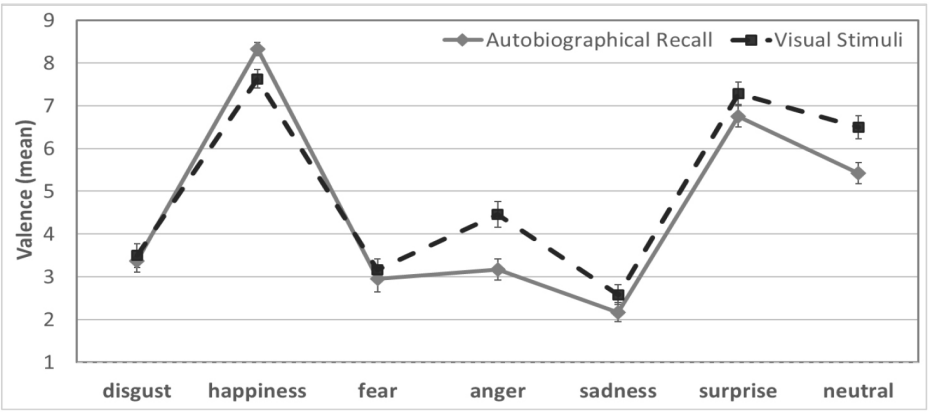
Statistical Analysis

The software IBM SPSS Statistics was used for the statistical analyses. Analyses of variance with repeated measures were performed for calculating the results. The statistical analyses were based on a significance level of 5%.

RESULTS

Subjective Measures

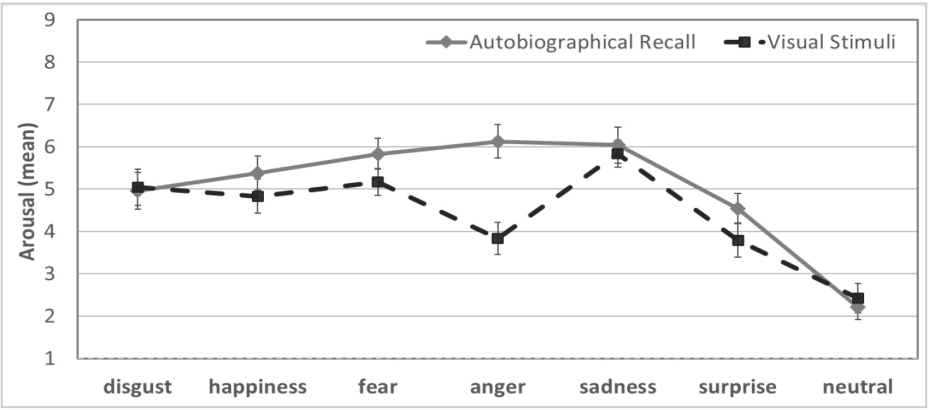
Following, the results of the dimension valence (see also Fig. 1) a significant interaction induction method x emotional category, $F(6, 18) = 6.36$, $p < .001$, $\eta^2_{part.} = .680$, a significant main effect induction method, $F(1, 23) = 6.23$, $p = .020$, $\eta^2_{part.} = .213$, and a significant main effect emotional category, $F_{GG}(3.43, 78.94) = 138.07$, $p < .001$, $\eta^2_{part.} = .857$, can be shown.



Note. 9-point scale: Negative (1) – positive (9); I … standard error of mean

Figure 1: Valence of different emotional categories induced by different induction methods.

The results of post-hoc analyses (Sidak) for the interaction induction method x emotional category show, mainly significant differences regarding the valence of the different assessed emotional categories for both induction methods ($p \leq .05$) with the expectation of the following: Happiness and surprise ($p < .001$) as well as surprise and neutral ($p = .012$) only show a significant difference in the subjectively perceived valence for the induction method autobiographical recall. In contrast, the perceived valence of anger and fear ($p = .031$) was assessed significant different for the induction method visual stimuli. For both induction methods, disgust compared to fear (visual stimuli - vs: $p = 1.000$; autobiographical recall - ar: $p = .999$) and



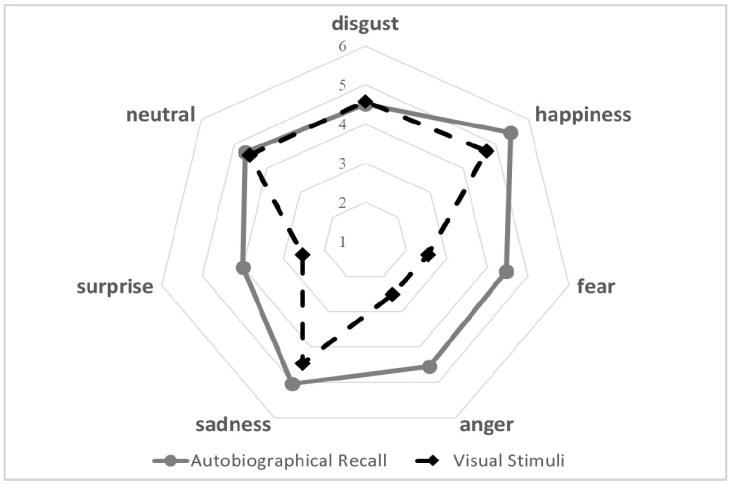
Note. 9-point scale: Low arousal (1) – high arousal (9); I … standard error of mean

Figure 2: Arousal of different emotional categories induced by different induction methods.

compared to anger (vs: $p = .066$; ar: $p = 1.000$) as well as fear compared to sadness (vs: $p = .146$; ar: $p = .065$), were not rated significant different regarding their perceived valence. Furthermore, the emotion induction with visual stimuli was assessed significantly more positive for the emotion category anger ($p = .003$) as well as for the neutral category ($p = .002$) than induction by autobiographical recall. On the other hand, the category happiness ($p < .001$) was assessed significantly more positive using the autobiographical recall method than the visual stimuli.

Regarding the dimension arousal a significant interaction induction method x emotional category, $F_{GG}(3.34, 76.70) = 4.94$, $p = .002$, $\eta^2_{part.} = .177$, a significant main effect induction method, $F(1, 23) = 22.32$, $p < .001$, $\eta^2_{part.} = .493$, and a significant main effect emotional category, $F_{GG}(3.90, 89.69) = 17.92$, $p < .001$, $\eta^2_{part.} = .438$, can be shown (see also Fig. 2).

Following the results of post-hoc analyses (Sidak) for the interaction induction method x emotional category, the emotion category sadness was subjectively perceived as significantly more arousing than anger ($p = .034$) and surprise ($p = .015$), as well as happiness was significantly more arousing than surprise ($p = .023$) when inducing with visual stimuli. Using the induction method autobiographical recall results in subjectively perceived significant more arousal for the emotion category anger than surprise ($p = .025$). In addition, the subjectively perceived arousal of the neutral category was assessed as significantly less arousing than all other emotional categories ($p < .001$) when inducing by autobiographical recall. When inducing with visual stimuli, the neutral category was also assessed as significantly less arousing than all other emotional categories ($p < .010$), except the emotion category anger ($p = .203$). Additionally, it is shown that the emotion induction by autobiographical recall reveals significantly higher arousal for the emotion categories happiness ($p = .025$), anger ($p < .001$) and surprise ($p = .047$) than emotion induction with visual stimuli.



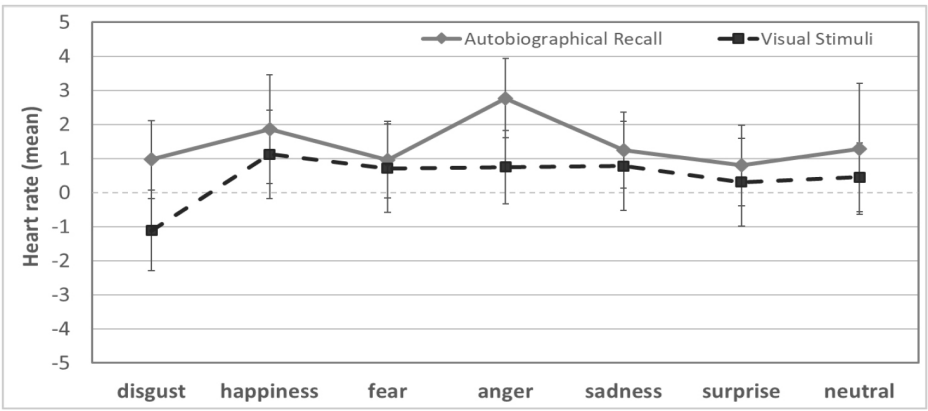
Note. 6-point scale: Not at all (1) – very (6)

Figure 3: Subjective emotion characterization of different emotional categories induced by different methods.

As described in the method section, the participants were further asked to what extent they felt one of the six basic emotions, other emotions or "neutral" during the different induced emotional categories. The results of these subjective emotion characterizations for the particular categories of both induction methods are shown in Figure 3.

Psychophysiological Measures

The psychophysiological results show significant differences of the cardiovascular activity for the parameter heart rate (HR) regarding the different used induction methods, $F(1, 22) = 5.44$, $p = .029$, $\eta^2_{part.} = .198$ (see also Fig. 4).



Note. Baseline-corrected mean values; I … standard error of mean

Figure 4: Heart rate (HR) of different emotional categories induced by different methods.

Overall, the heart rate of the participants was significantly higher when inducing emotions with the induction method autobiographical recall than using visual stimuli. However, no significant interaction induction method x emotion category, $F_{GG}(3.52, 77.37) = .54$, $p = .684$, $\eta^2_{part.} = .024$ and no significant main effect emotion category, $F_{GG}(3.54, 77.80) = .88$, $p = .468$, $\eta^2_{part.} = .039$ can be shown. Furthermore, the results of the analyses of all other psychophysiological measures used within this study did not reach the level of significance.

DISCUSSION

The aim of the study was to investigate the two emotion induction methods "visual stimuli" and "autobiographical recall" regarding the six basic emotions anger, disgust, fear, happiness, sadness, surprise, and an additional neutral category. Therefore, a multidimensional measurement environment combining subjective assessments and psychophysiological parameters was used. The results show a significant interaction induction method x emotional category for both subjective assessments valence and arousal. It was also shown that the emotion categories were, for the most part, assessed significantly different regarding their valence and significantly higher regarding their arousal compared to the neutral emotional category. Therefore, a successful emotion induction using the two induction methods visual stimuli and autobiographical recall can be concluded. Furthermore, the results of the subjectively perceived arousal of the participants show that the induction method autobiographical recall was significantly more arousing for the emotional categories happiness, anger and surprise than the visual stimuli. This is in line with the descriptive results of the emotion characterization, which showed that the emotions were induced more strongly by the autobiographical recall method (except disgust). Also, the results regarding one psychophysiological parameter of the cardiovascular activity of the participants, the heart rate (HR), showed that the autobiographical recall was significantly more arousing than the visual stimuli. Interestingly, in addition, a tendency towards significance that supports this result can also be shown for one parameter of the electrodermal activity, the skin conductance level (SCL), $F(1, 22) = 3.26$, $p = .085$, $\eta^2_{part.} = .129$.

When inducing emotions with visual stimuli, only anger does not show significantly higher arousal in the subjective assessment than the neutral category. This is also consistent with the descriptive results of the emotion characterization, in which anger was the least matched emotion by the visual material used. Following the descriptive results of the emotion characterization, it can be assumed that the emotion categories disgust, happiness, sadness and the neutral category were adequately induced by both methods visual stimuli and autobiographical recall, whereas the emotion categories fear, anger and surprise seem to be induced less well using visual stimuli than the method autobiographical recall. It is interesting to note that in contrast to the review of Siedlecka and Denson (2019), the emotional category surprise was induced effectively with autobiographical recall even better than with visual stimuli. This may also be influenced by the visual material used which was maybe not

strong enough to induce the targeted emotions. In addition, the visual material from the standardized databases is often labelled only with valence and arousal values, but not for specific emotions. Another explanation could be that inducing emotions by autobiographical recall may have the advantage that participants remember a situation in which they actually felt the intended emotion, whereas when inducing emotions with visual stimuli it is possible that the used visual material induces other emotions than those that were actually intended. For example, a picture of a wedding that targets happiness may also induce negative emotions due to the person's previous experiences.

Another limitation of the presented study is that the visual stimuli method has been consistently performed before the autobiographical recall method. To avoid post-effects of the visual stimuli, the subjective assessments and a rest measurement were performed after each trial. Nevertheless, it cannot be excluded that the visual stimuli already immersed the participants more deeply in the emotion that was to be recalled afterwards and therefore evoked stronger emotional reactions in the autobiographical recall conditions. Therefore, in future research, a possible effect of the sequence of the induction method should be eliminated.

To sum it up, the results of the experimental study show an influence of the induction method that is evident in both the subjective and the psychophysiological parameters.

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