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Sex and age differences in facial emotions expressions measured by artificial intelligence

Abstract: *Our aim was to test existing sex and age stereotypes related to emotional expressivity, gender and age. This was a complex analysis of facial expressions of all basic emotions (anger, disgust, fear, happiness, sadness, and surprise) to everyday life stimuli observing a large sample (2,969 unique participants creating 39,694 recordings) using an Emotion Artificial Intelligence. Our data partially support emotion-specific stereotype that women express more affiliate emotions and men express more dominant emotions except for sadness. There were found correlations of emotion expression with age, however intensity and frequency of emotion expression did not follow the same pattern. Not eliminating the differences between men and women in the baseline facial appearance resulted in men expressing dominant emotions (anger and disgust) more intensively, and women expressing more affiliative emotions (happiness, fear, and surprise). To sum up, facial appearance can be one of the origins of the existing gender stereotypic socialisation stereotype.*

Key words: *facial expressions, artificial intelligence, advertisement, age, sex, stereotypes, facial appearance*

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THE SEX DIFFERENCES IN FACIAL EXPRESSIONS OF EMOTIONS

The most robust gender stereotype is that women are more emotionally expressive than men which is a well-studied topic (e.g. Buck et al., 1972; Dimberg & Linquist, 1990; Fabes & Martin, 1991; Hess et al., 2000; Kring & Gordon, 1998; Plant et al., 2000; Shields, 2002; Schwartz et al., 1980) and is pervasive across several different cultures (Timmers et al., 2003). A *stereotype* has a profound impact on how we treat others (Agars, 2004) and how we make judgements about others and self (Cameron & Trope, 2004).

The first to measure the difference between facial expressivity of emotion of men and women was Buck et al. (1972) who revealed higher emotional facial response (fEMG) of females to emotional slides. However, the sample of this study was small and there was no measurement of discrete emotions (Buck et al., 1972). In a western culture, young boys are systematically taught to inhibit and mask many kinds of emotion to a greater extent than are girls (Shields, 2002). Later, results of fEMG findings by Schwartz, Brown, and Ahern (1980) confirmed that females tend to be more facially expressive of emotions than males during a self-generated affective imagery. Also, another study showed that girls and women are faster in accessing and can recall more childhood memories of emotional experiences than their male counterparts (Davis, 1999). Likewise, women use more positive and negative emotion words when recalling vivid memories than men do (Niedzwienska, 2003). One of the most cited studies in the field of emotion and gender differences by Kring and Gordon (1998) concluded that women are more expressive than men while viewing films. However, judges of the emotional expressions coded reactions only on valence and arousal dimensions. As well, authors did not look at expressions of discrete emotions and the films in their first study represented only three emotions which, according to gender stereotypes, are assigned to females (sadness, happiness, and fear). Only one film was selected to elicit an emotion and the film selection was conducted by female authors which may also distort the results toward higher emotion expression by women. Another explanation could be the higher emotional contagion among women. Women reported a higher likelihood of "catching" the emotions of others than men (Doherty, 1997). This self-reported difference in emotional

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contagion was corroborated, for certain emotions, by measuring electromyography while looking at faces with emotional expressions (Dimberg & Lundquist, 1990).

However, stereotypes are also emotion-specific. Such studies usually conclude that women express more powerless or affiliative emotions like sadness, fear, shame, and guilt whereas men feel and especially express more dominant emotions like anger, disgust, and hostility (Brody & Hall, 2000; Fabes & Martin, 1991; Fischer, 1993, Hess et al., 1997; Hess et al., 2000; Chapin & Aldao, 2013; Plant et al., 2000). Powerless emotions are related to feminine vulnerability (fear, sadness, and shame), whereas powerful emotions are related to masculine dominance (anger, contempt, and pride) (Brody, 1997; Fisher, 1993; Shields, 2002). For example, Brody , his research shows that women tend to express more fear, sadness, anxiety, shame, guilt, and pleasure. Men tend to express more emotion on aggression and high self-esteem as anger, contempt or pride. Such conclusions are confirmed by the results of a meta-analysis of children's emotions (Chaplin & Aldao, 2013). To perform the different social roles of women and men successfully, distinct emotions and emotion expressions are required. In this context we speak about *gender-stereotypic socialization* (Jansz, 2000; Shields, 2002) A high-status male role aim at competition, autonomy, and power reinforce powerful emotions, but discourage powerless emotions, whereas the female role would discourage powerful emotions and encourage powerless emotions, because the latter serve to maintain harmony in social relations with a minimum of overt hostility. According to Brody and Hall (2008), *"gender stereotypes of emotional expression have a strong implicit prescriptive aspect, taking the form of "display rules," which are cultural norms regulating how, when, and where emotions can be expressed by males and females in any particular culture"* (p. 396). Violating stereotypic display rules can lead to negative social consequences, such as social rejection, and discrimination (Brody & Hall, 2008). Furthermore, gender stereotypes can generate expectancies about our same-sex and opposite-sex partners that influence and elicit specific behaviours and emotional expressions, becoming self-fulfilling prophecies (Hall & Briton, 1993). As a fulfilling prophecy, gender stereotypes might be supported by the frequent use of self-reports. Fischer (1993) reviewed a large amount of empirical research on sex differences in emotions and concluded that the general idea that women are more emotional than men tell us more about the Western sex stereotypes than about women's actual emotions. Brody and Hall (2008) also alerted that in the domain of emotion research, stereotypes about gender differences in emotion expression tend to correspond with self-reports. Robinson et al. (1998) found that men and women retrospectively remembered their emotions as more gender-stereotypic than they were. As pointed out by Brody (1997), gender and emotion stereotypes are imprecise, are overly general, and ignore the importance of the modality in which an emotion is expressed, as well as the situational and cultural context within which emotional expression occurs. Because stereotypes ignore both the social context and individual differences, they often lead to the erroneous assumption that gender differences are exclusively biological in origin (Brody, 1997).

Contrary, there are also two studies by Levenson and colleagues who concluded no difference in emotion expressivity. For example, Levenson et al. (1991) shows that elderly men and women did not differ in emotional physiology or frequency of facial expression, although elderly women reported experiencing more intense emotions when reliving emotional memories than did elderly men. This study measured all six basic emotions with a FACS (Levenson et al., 1991). Also, in their previous studies of young subjects which considered a larger sample, authors failed to find reliable sex differences for facial expression of emotion assayed by these methods (Levenson, Ekman, & Friesen, 1990).

THE AGE DIFFERENCES IN FACIAL EXPRESSIONS OF EMOTIONS

The age differences in facial expressions of emotions are far less studied than sex differences. The main research focus was on childhood, especially on gradual adoption of social and cultural display rules . With adults, the knowledge seems to be framed especially by a popular stereotype that the abundant emotional energy is cooled down with rationality in middle adulthood and older age (Bromley, 1990; Cumming & Henry, 1961). Pervasive as the stereotype is, relatively little scientific attention was invested into developmental trends in the domain of emotion beyond late childhood or self-reports (Gross et al., 1997; Thompson, 1990). Age-related changes in emotional experience or physiological reaction may or may not lead to changes in emotion-expressive behaviour, and yet it is the emotion-expressive behaviour that may be of greatest significance in shaping social interaction (Gross et al., 1997). Still, changes in facial expressions of emotions were studied only by a few studies.

The stereotype of decreasing emotional intensity with age was supported by findings obtained from self-reports (Diener et al., 1985; Lawton et al., 1992; Stoner & Spencer, 1987). However, these self-report studies did not disintegrate emotional expressivity into expression of basic emotions categories. Theories also suggest, that older adults may be less expressive of some affects because of increasing emotion regulation (Gross et al., 1997; Hoare, 2006). Gross et al. (1997) explained this difference as a shift toward older individuals more effectively regulating their emotions.

Studies using observations usually find no difference in emotion expression, especially for negative emotions. A study by Levenson et al. found no difference in emotion expression. Tsai, Levenson, and Carstensen found no difference for subjective and behavioural responding in sadness and happiness. In a laboratory paradigm in which spouses interact with each other, Carstensen, Gottman, and Levenson (1995) found that compared with middle-aged couples, older couples found no age difference in

listeners behaviour. A study by Magai, Cohen, Gomberg, Malatesta, and Culver (1996) found that emotion expressivity was preserved in later life even under conditions of cognitive decline. A more recent study with three adult age groups and sad and angry events (Magai et al., 2006) found similar duration of anger, sadness, disgust, fear, and interest in all groups. A longer duration of shame, contempt, and joy expression was found in the younger sample and the greater duration of knit brow among the oldest age group (Magai et al., 2006). However, there are also a study with different results. A study by Malatesta-Magai, Jonas, Shepard, and Culver (1992) of younger and older adults participating in four emotion induction procedures designed to elicit interest, sadness, fear, and anger found substantial evidence of greater expressivity with age. In addition, older subjects displayed less joy (masking) during the sadness and fear induction.

Overall, the body of research examining possible developmental changes in the expression of emotion failed to provide conclusive evidence of reduced expressivity with age. Other evidence does, however, suggest that the expressions of older adults may become some-what less readily interpretable. Expressions in the faces of older adults may become more blended because emotional dispositional tendencies appear on the face with age, or because of age-related structural changes in the face (wrinkles and facial hair). For example, induced emotion expressions of older adults are more difficult for naive judges to interpret (Malatesta, Izard, Culver, & Nicolich, 1987). Similarly, Levenson et al. (1991) found that older subjects' expressions had lower quality rating than younger subjects. The results indicated that some facial features of older people might interfere with the expression of emotion (Levenson et al., 1991). Interestingly, Moreno, Borod, Welkowitz, and Alpert found that older women appeared more disgusted in a posed photograph.

CHALLENGES IN MEASURING FACIAL EXPRESSION OF EMOTION

Faces, being multi-signal systems, disclose a variety of important information such as gender, race, attractiveness, age, or even emotion (Ekman, 2003; Hess et al., 2009a). With 42 muscles and 2 bones on their faces people are capable of producing more than 10,000 movements, 3,000 of which are related to emotions. Ekman (2003) lists three types of *facial signals*. Emotional expressions are among *fast signals* because they are formed by the movements of facial muscles, which last a few seconds or minutes . Static signals are relatively stable such as pigmentation, bone size, facial width-to-height ratio, brow ridge distance etc. and help to determine the sex of a person (Ekman, 2003). Slow signals are aging-related changes, for example lasting wrinkles, changes in skin tonus or texture and help to determine the age of a person. In this paper, we conceptualize slow and static signals of a face as *facial appearance* (Hess, Adams, Grammer, & Kleck, 2009c).

Wiggers (1982) pointed out, that the same combination of facial actions on two different people yields different recognition rates for emotions. Deska, Lloyd, and Hugenberg (2018) recently showed, that an expression is judged also based on static features of a face, namely facial width-to-height ratio (fWHR). Perceivers more readily see anger on faces with high fWHR compared with those with low fWHR. Low fWHR facilitates the recognition of fear and happiness. Certain features of facial appearance resemble expressive cues related to facial expressions of emotion. Most of research supporting this notion was done in the domain of sex differences in combination with dominance/affiliation constructs and with selected emotions, mostly anger and happiness, but also fear and sadness. For example, Neth and Martinez (2009) showed that expressionless faces will appear to express either anger or sadness when variations in the facial structure is manipulated, especially the distance between the eyes and the mouth, are made. Hess, Adams, and Kleck (2009b) demonstrated that happiness and fear expressions bias sex discrimination toward women, and anger expressions bias sex perception toward men. By analysing their study, we must point out that the most female expression was a mixed emotion of fear and happiness, which contained enlarged eye region and a rounded face. Becker et al. (2007) brought evidence that faces in which brow ridge distance was manipulated were rated as angrier and in the same degree as more masculine. Also, Le Gal and Bruce (2002) found out that faces were rated as more masculine when showing anger compared to surprise expressions. What drives this effect might not be masculinity/femininity per se, but a more behaviourally relevant construct of dominance/affiliation (Hess et al., 2009a). Specifically, a square jaw and thicker eyebrows evoke perceptions of dominance (Senior, Phillips, Barnes, & David, 1999) and are typical for men's faces (Burton, Bruce, & Dench, 1993), and a rounded baby-face with large eyes is both feminine (Burton et al., 1993) and perceived as more approachable (Berry & Brownlow, 1989) and warm (Berry & McArthur, 1986).

METHODS AND BIAS IN MEASURING FACIAL EXPRESSIONS OF EMOTIONS

By far, the most common method for measuring facial expressions of emotion is a self-report *questionnaire*. Self-report measures serve as the basis of much of the available evidence about emotion and expression (Brody & Hall, 2008). Ekman (2003) criticized that rather than observing what people actually do, researchers ask their subjects to answer questionnaires about what they imagine or remember feeling. A questionnaire is relatively simple, cheap to implement and are quite reliable . However, questionnaires require cognitive processing that can introduce a bias to the results, referred to as "cognitive bias". The act of introspection is challenging to perform in conjunction with another task and may in itself alter that state . Emotion unfolds and changes over time. Self-report

measures typically capture only occasional snapshots of these dynamics, heavily influenced by the end moments when the report is made . Furthermore, people may experience more than one emotion. If moment-to-moment measures are used, this method interrupts a subject's experience. In such cases, it can be too challenging to measure responses on more than two dimensions and still people may become tired of continuously reporting their feelings in different situations. Also, participants may have difficulty making distinction between emotional experience and emotional expression (Brody & Hall, 2008). Most importantly, in line with social desirability, subjects may be willing to report feelings which are congruent with stereotypical views even if they do not have them (Brody & Hall, 2008; Cornelius, 1996).

Another method in measuring facial expressions of emotion is *facial electromyography* (f*EMG)*, which measures muscular activity in the face that may not be observable to a naked eye. However, the fEMG is usually limited to measurement of two to three muscles (Hazlett & Hazlett, 1999). The measurement requires facial electrodes and a laboratory setting which is obtrusive to the subject and decreases the ecological validity of gathered data. Furthermore, necessary hardware makes data collection difficult to scale and increases costs. Comparing to questionnaires, fEMG is dynamic, continuous, implicit, and does not interrupt a person's experience. However, fEMG studies always contain only small samples. Hazlett and Hazlett found that fEMG was a more sensitive discriminator between videos than self-report and that it was more closely related to recall.

The third group of methods which measure facial expressions of emotions are *observational methods***.** In this type of measurement, three types of observers may score facial expressions of subjects directly or captured on a video or a photograph. Such procedure doesn't interrupt a subjects' experience, however, depending on the type of observer (untrained coder, trained coder, emotion AI), constraints to such evaluations arise. It was showed that in observing facial expression, untrained individuals are likely to rely on stereotypes to guide judgements in hypothetical or ambiguous situations (e.g., Augoustinos & Walker, 1995; Collings, 2002; Plant et al., 2000). Further, a number of studies showed that variations in such characteristics as the type of expression, age, gender, culture or race of an emotion expresser can influence how the face is evaluated, processed, and remembered and that this can vary for perceivers of different ages (e.g. Ebner, 2008; Golby, Gabrieli, Chiao, & Eberhardt, 2001; Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Mather & Carstensen, 2003; Ruffman, Henry, Livingstone, & Phillips, 2008). A considerable amount of social psychological research demonstrated that stereotypes often bias judgments about individual group members (e.g. Fiske, 1998; Hamilton & Sherman, 1994; Hilton & von Hippel, 1990). Also, research found that perceivers preferentially seek stereotype–confirming information about others (e.g., Johnston, 1996; Johnston & Macrae, 1994; Leyens, Dardenne, & Fiske, 1998; Leyens & Yzerbyt, 1992; Trope & Thompson, 1997).

Coding systems with trained coders, for example *Maximally Discriminative Facial Movement Coding System (MAX;* Izard, 1979), *Specific Affect Coding System (SPAFF;* Gottman & Krokoff, 1989*)*, or *Facial Action Coding System (FACS;* Ekman, Friesen, & Hager, 1978/ 2002*))* try to increase the reliability of facial emotion coding. The drawback of coding systems with trained coders is that such methods also rely only on reactions that are observable by a naked eye. Even for a trained coder it might be challenging to overcome such biases connected to interpreting facial expressions as shown in above-mentioned studies by Deska et al. (2018) and Adams et al. (2015). However, the most relevant barrier is the high demand on time (McDuff, 2014; Rosenberg, 2005). Also, as with any system that is completed by humans, inconsistencies will emerge as a result of different views and perceptions. This is usually counterbalanced by having multiple human coders look through the same clips – a process that multiplies the time (and cost).

The third type of an observer is *an Emotion artificial intelligence (Emotion AI),* where the observer takes a form of a trained algorithm. We conceptualize an emotion AI as an emotion recognition technology that decodes the emotional information from a facial expression of a human being (Gablikova & Halamova, 2016).There are various software solutions (e.g. Affectiva, Noldus Face Reader, and Emotion ID) based on Ekman's universal emotions capable of an automatic evaluation of human emotions from a video recording of a face. Cohn, Zlochower, Lien, and Kanade (1999) claimed: *"With continued development, automated face analysis will greatly reduce or eliminate the need for manual coding, make feasible the use of larger, more representative data sets, and open new areas of investigation"* (p.42). These authors showed in a cross-validation set, which included subjects of mixed ethnicity, that an Emotion AI demonstrated high concurrent validity with manual FACS coding. An average recognition accuracy for 15 action units in the brow, eye, and mouth regions was 81–91%, which is comparable to the level of inter-observer agreement achieved in manual FACS coding (Cohn et al., 1999). Yitzhak and colleagues (2017), on the other hand, opposes that although a software classifier was highly successful at classifying prototypical expressions, it performed very poorly at classifying the subtle expressions. The authors conclude that although classic prototypical facial expressions are well recognized by an Emotion AI, such expressions appear less naturalistic and may not capture the richness of everyday emotional communication. However, a great constraint to such conclusion is that this study tested a novel dataset with facial expressions that contained non-prototypical expressions labelled as basic emotions. We consider this to be a systematic distortion in construct validity because an Emotion AI that is trained and based on prototypical emotion expression cannot successfully classify non-prototypical expressions that originate in a different theoretical paradigm. In a study by Stoeckli and colleagues (2018),

AFFDEX correctly recognized 73 % of the emotions across three databases and 77 % of the emotions in RaFD. FACET correctly recognized 97 % of the emotions across the three database pictures and 99% of the emotions in RaFD. When images where participants were asked to imitate a prototypical facial expression were used, the performance dropped. However, no control was conducted to evaluate how successful were participants in imitating the facial expressions. The Emotion ID software repeatedly scored with precision that is comparable to human FACS coding in a naturalistic setting (Baránková, Gablíková, Strnádelová, & Korónіová, 2017) while Gablíková, Baránková, Strnádelová, and Koroniová (2017) found out that the software solution was 33 times faster than human coding. Applied studies using Emotion AI were conducted, for example McDuff introduces automatic vision-based facial coding and remote measurement of physiology in a study about affective responses to a video clip.

By having a closer look at abovementioned substantial body of research of facial expressions of emotion we conclude that self-report questionnaire was the most frequently applied method which fuels a fulfilling prophecy, and stereotypes (Robinson et al. 1998). This poses a serious constraint to current knowledge status. In addition, the data were generally collected in a laboratory with limited external validity (e.g. Buck et al., 1972; Dimberg & Linquist, 1990; Kring & Gordon, 1998).

THE GOAL OF THE STUDY

Our goal in this paper is to analyse sex and age differences in facial expressions of each basic emotion under one paradigm using an automated facial expression analysis and Internet-based data gathering within the home of participants in order to challenge existing age and sex stereotypes that women are more expressive than men (e.g. Buck et al., 1972; Dimberg & Linquist, 1990; Fabes & Martin, 1991; Hess et al., 2000; Kring & Gordon, 1998; Plant et al., 2000; Shields, 2002; Schwartz et al., 1980; Timmers et al., 2003) and that expressivity decreases with age (e.g. Diener et al., 1985; Gross et al., 1997; Hoare, 2006; Lawton et al., 1992, Stoner & Spencer 1987). Also, we offer the first complex study that looks at frequency as well as intensity of all basic emotions and tests if the same results appear when facial appearance either is or is not taken into account. We hypothesised that anger, sadness, fear, happiness, disgust, and surprise would be more expressed by women than men (e.g. Brody & Hall, 2000). In addition, we expected that age is significantly negatively correlated with the frequency of the facial expression of anger, sadness, fear, happiness, disgust, and surprise (e.g. Hoare, 2006).

METHODS

The research sample

All respondents of this paper were part of an online panel which is an opt-in community of people who are rewarded for a research participation. The size of the online panel is approximately 15,000 and it consists of members with all basic sociodemographic characteristics. Each video was tested on an adult population sample in terms of gender and age. The sample of this paper consists together 2,969 unique participants from Slovakia with a mean age of M=34 (SD=11.9), 58% of them were women with a mean age of M=33.1 (SD=11.5) and 42% of them were men with a mean age of M=35.5 (SD= 12.2). For each tested video, a subsample was created which consisted of participants that were filtered according to population quota. Each subsample contained from 95 to 254 participants that represented the Slovak adult population in terms of gender and age. It means that most of the participants were measured for multiple stimuli which means for up to 20 videos. This creates the sample of 39,694 participations. Participations were done by participants from all regions of Slovakia. There were also respondents with various highest reached education and the proportions in most part copy the population of Slovak republic (OECD, 2014).

Material

In our study, we were testing 219 video advertisements which were directed to a broad Slovak audience and covered a range of product categories. Video advertisements are an integral part of an everyday life, an adult modern human being faces about 1,500 advertisements per day (Alperstein, 2003), the verbal content of video advertisements regularly enters the public discourse (Alperstein, 1990). We selected stimuli in which respondents are used to elicit as spontaneous reaction as possible rather than trying to elicit each emotion with a selected video. A video advertising is a form of a simple short story that usually lasts from 20-60 seconds and is designed to persuade, entertain or engage the audience where emotional content is frequently used . Tested videos were from different segments and targeted all kinds of Slovak audience in terms of sociodemographic categories. Videos were in Slovak language and did not contain subtitles.

Procedure

Data were gathered from January 2015 to October 2018. Participation in the research was voluntary with respondents explicitly agreeing with recording of their face for research purposes (online informed consent form). Participants were rewarded by points which could be exchanged for material goods in an online shop. Participants watched videos online from home and also completed an online questionnaire. Respondents were contacted with a request to participate in a research via an email. To most of them, this procedure was known. Before watching the tested video, each participant had to test his or her speakers, video player, and image quality. To test and optimize the image quality (image calibration) for future software analysis, a respondent had to allow the program to access his or her webcam. While watching a video, respondents' webcam images (faces) were simultaneously recorded and securely sent to a server for an emotion analysis.

Invalid data elimination

From gathered data we have eliminated those recordings where the respondent was inactive (while watching the video, user switched to a different tab in the browser), no face was detected (for example, the user left or turned off the light after image quality test and it was too dark to detect the face), or the face tracker reported confidence lower than 0, 23 (this happened when a respondent had a hand or glass covering the face or was in a wide angle to the webcam). These data are not stored in the database.

EMOTION ID SOFTWARE

In our study about facial expressions we used an observation methodological approach in form of an Emotion Artificial Intelligence (AI). 39,694 recordings were analysed with an emotion artificial intelligence software Emotion ID. Emotion ID uses computer vision and machine learning to identify emotion-related facial expressions. The software detects the six basic emotions anger, disgust, fear, joy, sadness, and surprise, as well as a neutral expression in a face. Validation of the method is based on ROC (receiver operating characteristic) analysis, which calculates true and false indications of each basic emotion (Hajian-Tilaki, 2013). In order to calculate the ROC, testing data from a publicly available dataset Radboud Faces Data (RaFD) with validated facial expressions of emotions were used. RaFD consists of 536 pictures of 67 face models expressing basic emotions. All face models have been trained by FACS experts to express basic emotions. Furthermore, all pictures have been validated by FACS coders as well as by a large sample (N = 238) of non-expert human judges (Langner et al., 2010). The performance in terms of basic emotions is listed in Table 1. Previously, it has been thought that face processing contains two separate functional routes, one for recognition of facial identity and the other for facial expression (Bruce & Young, 1986). We did not implement a separate classifier for each sex or a sex group. However, more recent reflections indicate, that such model might be an oversimplification and facial expressive cues may interfere with certain aspects of facial identity, such as person's sex or age (Calder & Young, 2005).

Table 1. Precision of detection of facial expressions of basic emotions by the Emotion ID software

Receiver operating characteristic of Emotion ID	
Anger	99,5%
Disgust	99,9%
Fear	98,3%
happiness	100%
Sadness	97,7%
Surprise	99,8%
Neutral	97,5%

DATA ANALYSIS

From gathered data we created two datasets: the raw dataset and the subtracted dataset. The raw dataset considered the absolute values measured for each basic emotion. In raw data we used a beta regression model which is appropriate in this case because dependent variables (measured emotions) are bounded proportions – they are all from interval (0, 1) which express percentages of detected facial expressions.

In subtracted dataset, the baseline (emotion values measured in the first second of each recorded response video for each participant) was subtracted from each following second in that video. The baseline is a factor of facial appearance (Hess et al., 2009a; Ekman, 2003) and random variations in the recording conditions as differences in room illumination or angle of the face to the camera. Subtracting the facial appearance of a participant helped to focus on changes in facial expressions of emotions that happened as a reaction to presented stimuli as previously done in e.g. Lundqvist (1995). The baseline of men and women as well as people in different age groups were different. Facial expression of an emotion was defined as a non-zero value in the subtracted dataset. All negative values were set to zero which led to excessive number of zeros in data. In this situation we used zero-altered models called a hurdle model (Rose & Rudolph, 2006; Yang, Harlow, Puggioni, & Redding, 2017). For all models, we used the statistical program R (R Core Team, 2018), version 3. 5. 1, package glmmTMB (Brooks et al., 2017). Beta model and both submodels (binomial and beta) uses logit link.

All used models (hurdle model with the binomial and beta model for subtracted data, as well as the beta model for raw data) were computed for each basic facial expression of emotion (anger, disgust, fear, happiness, sadness, and surprise). We set two predictors in each model: SEX and AGE. Sex is a two-level factor, and women are the reference group (coefficients for men are estimated). Age is a continuous variable. Raw data represent emotional reaction to tested stimuli as well as facial appearance. Subtracted data represent only the emotional reaction to tested stimuli.

RESULTS

The raw data represented raw facial reactions that do not consider the facial appearance. In raw data we used beta regression models. The assumption of homogenous error variance was not met because proportions were skewed and almost always heteroscedastic. Beta regression models provide a useful tool to cope with such data (Ferrari & Cribari-Netto, 2004). For regression models, the distribution of residuals should be normal. In our data, the distributions of residuals for Gaussian models was not normal, and distributions of residuals for beta models followed normal distribution much better. The subtracted data represented changes that happened dynamically on the face (facial expressions). Subtraction of data increases

reliability of data, for example wrinkles, that come with age or width-to-height ratio. Subtraction of initial values led to excessive number of zeros (Appendix A) in data (proportions cannot be negative, so that all negative values were set to zero). Therefore, we used a zero-altered hurdle model.

Table 2. Estimation of odds ratio of all models for all emotion

	SEX (men to women)	AGE correlation
ANGER		
Frequency for subtracted data	+9%***	-1%***
Intensity for subtracted data	+15%***	ns
Intensity for raw data	+28%***	+1%***
DISGUST		
Frequency for subtracted data	ns	ns
Intensity for subtracted data	+23%***	+1%***
Intensity for raw data	+30%***	+1%***
FEAR		
Frequency for subtracted data	-6%**	ns
Intensity for subtracted data	-11%***	ns
Intensity for raw data	-23%***	+1%***
HAPPINESS		
Frequency for subtracted data	-14%***	-1%**
Intensity for subtracted data	-6%***	ns
Intensity for raw data	-15%***	+1%***
SADNESS		
Frequency for subtracted data	ns	ns
Intensity for subtracted data	ns	-1%*
Intensity for raw data	+1%*	-1%**
SURPRISE		
Frequency for subtracted data	-5%*	ns
Intensity for subtracted data	-11%***	-1%***
Intensity for raw data	-15%***	-1%***

Notes. ns = not significant (P>0.05). * = P ≤ 0.05. ** = P ≤ 0.01. *** = P ≤ 0.001.

Anger

Odds ratio for men is 1.09 (P ≤ 0.001) at binomial part for anger facial expression (Table 2), which means that men have 9 % higher probability than women that they will express anger at all, or in other words, women express significantly less often anger facial expression than men. Looking at intensity of a facial expression, in the beta part of the hurdle model, the odds ratio for men is 1.15 (P ≤ 0.001) which means that men have 15 % higher probability than women that they will express more intensive anger among respondents who expressed anger, or in other words, women express significantly less intensive anger facial expression than men among respondents who express anger. When we look at raw data, the odds ratio is even higher. Here, men have 28 % higher probability than women that their facial reaction will resemble a more intensive anger facial expression. In other words, when facial appearance is not taken into account, women seem to express significantly less intensive anger facial expression than men.

In the binomial model, we can see that age is significantly negatively correlated with the occurrence of facial expression of anger. There is no relation between expressed intensity of anger and age in the beta part of the hurdle model. However, in raw data, the probability that a more intensive anger facial expression will be identified increases with age each year by 1% (P ≤ 0.001). In other words, when facial appearance is not taken into account, age is significantly positively correlated with the higher intensity of the facial expression of anger.

Disgust

In the binomial part of the hurdle model for disgust facial expression (Table 2), there is no significant difference between men and women in the frequency of the facial expression of disgust. However, in Beta part of the hurdle model, women express significantly less intensive disgust facial expression than men among respondents who express disgust. In the raw data of the disgust expression, when facial appearance is not taken into account, women seem to express significantly less intensive disgust facial expression than men.

In the binomial model for subtracted data, we can see that age is not significantly correlated with the occurrence of facial expression of disgust. Looking at intensity of expressed emotion, age is significantly positively correlated with the higher proportions of facial expression of disgust (the beta part of the hurdle model). The same results are found in raw data, when facial appearance is not taken into account, age is significantly positively correlated with the higher intensity of the facial expression of disgust.

Fear

The odds ratio for fear facial expression (Table 2) in the binomial part means that women express significantly more often fear facial expression than men. Similarly, Beta part of the hurdle model shows that women express significantly more intensive fear facial expression than

men among respondents who express fear. When facial appearance is not taken into account, women seem to express significantly more intensive fear facial expression than men.

In the case of age correlations, we can see that in both binomial and beta part of the hurdle model there is no relation between detection (and proportion in case of the beta part) of fear and age. However, in raw data, when facial appearance is not taken into account, age is significantly positively correlated with the higher intensity of the facial expression of fear.

Happiness

The binomial part of the hurdle model for happiness facial expression (Table 2) shows that women express significantly more often happiness facial expression than men. In the beta part of the hurdle model women express significantly more happiness facial expression than men among respondents who express happiness. In the raw data, when facial appearance is not taken into account, women seem to express significantly more intensive happiness facial expression than men.

In the binomial model, we can see that age is negatively correlated with the occurrence of facial expression of happiness. There is no relation between proportion of happiness and age in the beta part of the hurdle model. However, in raw data, when facial appearance is not taken into account, age is significantly positively correlated with the higher intensity of the facial expression of happiness.

Sadness

The binomial part for sadness facial expression (Table 2) shows that there is no significant difference between men and women in detection of sadness. Considering the beta part of the hurdle model that there is no difference between men and women in the intensity of expressed sadness among respondents who expressed sadness. In the raw data, when facial appearance is not taken into account, women seem to express significantly less intensive sadness facial expression than men.

In the binomial model for subtracted data, we can see that age is not significantly correlated with the occurrence of facial expression of sadness. Looking at intensity of expressed emotion in the beta model for subtracted data, age is significantly negatively correlated with the higher proportions of facial expression of sadness. The same results are found in raw data: when facial appearance is not taken into account, age is significantly negatively correlated with the higher intensity of the facial expression of sadness.

Surprise

In the binomial part for surprise facial expression (Table 2) women express significantly more often surprise facial expression than men. As for the beta part of the hurdle model for surprise facial expression, women express significantly more intensive surprise facial expression than men among respondents who express surprise. From raw data, when facial appearance is not taken into account, women seem to express significantly more intensive surprise facial expression than men.

Looking at relationship between age and surprise facial expression, the binomial model for subtracted data shows that age is not significantly correlated with the occurrence of facial expression of surprise. Looking at intensity of expressed emotion in the beta model for subtracted data, we see that age is significantly negatively correlated with the higher proportions of facial expression of surprise. The same results are found in raw data, when facial appearance is not taken into account, age is significantly negatively correlated with the higher intensity of the facial expression of surprise.

DISCUSSION

Our goal in this paper was to look at sex and age differences in facial expressions of each basic emotion separately under one paradigm and test existing stereotypes using a methodological approach – an emotion artificial intelligence, which allows to observe facial expressions of a large sample of participants in a complex manner. Also, we offer the first study that looks at frequency as well as intensity of expressed emotions and tests if the same results appear when facial appearance either is or is not taken into account.

There were correlations between frequency of facial expression of anger and happiness and age. Our results partially correspond with the widespread stereotype that emotional expressivity decreases with age (Diener et al., 1985; Gross et al., 1997; Hoare, 2006; Lawton et al., 1992; Stoner & Spencer 1987). Data showed that either there is no relationship between age and frequency of actual facial expression of a basic emotion (for disgust, fear, sadness, and surprise) or the relationship is negative (for anger and happiness). During adulthood, each additional year presented a 1% decrease in this probability of expressing both anger and happiness while the frequency of other emotions remain constant. Our findings did not indicate that there is a drift toward negative affect with old age, which is consistent with the work of Malatesta and Kalnok (1984) or Malatesta-Magai et al. (1992). Different pattern appeared for intensity of expressed emotions. Disgust increased with age whereas sadness and surprise decreased with age. Other emotions did not show a significant relationship with age. When facial appearance was not taken into account, inconsistent results appeared for intensity of facial expression of anger, fear, and happiness, indicating that the features of these emotion expressions might be part of the facial appearance showing increasingly during the adult lifetime on the face. It seems that age related changes in the face interfere with the evaluation people make about the target person. Fabes and Martin (1991) pointed out that there could exist an age-of-target bias in the evaluation of others' emotions. Such interference of facial appearance may not be only emotional. Ebner (2008) found that faces of old people were evaluated as less attractive, less likeable, less distinctive, less growth-oriented, and less energetic.

Substantial differences were found also between men and women. Our data did not support the general stereotype, that women are overally more expressive than men (Buck et al., 1972; Dimberg & Linquist, 1990; Fabes & Martin, 1991; Hess et al., 2000; Kring & Gordon, 1998; Plant et al., 2000; Shields, 2002; Schwartz et al., 1980; Timmers et al., 2003). However, the gender stereotypical socialisation pattern (Brody & Hall, 2000; Fabes & Martin, 1991; Fischer, 1993) was partially confirmed for frequency as well as intensity of actual facial expressions. In other words, women showed more often and more intensive affiliative emotions (fear, happiness, and surprise, but not sadness) and men show more dominant emotion (anger, and in case of intensity also disgust). Such conclusion is consistent with cross cultural studies of Matsumoto, Takeuchi, Andayani, Kouznetsova, and Krupp (1998) where women report that they exert more control over anger, contempt, and disgust than do men, and men report that they exert more control over fear and surprise than do women across four different cultures. Also, sex differences were bigger for each emotion when facial appearance was not taken into account. Even though we eliminated all known possibilities that could create a gender stereotypic response (human coder, emotion eliciting video, no presence of a male/female researcher, natural environment while being tested, differences in baseline facial appearance), there were still shown sex differences that were in line with gender stereotypic socialisation. Based on these results, we can conclude that the expressions of emotions among sexes follow the gender stereotypical socialisation pattern and were magnified by differences in facial appearance of men and women.

LIMITATIONS AND STRENGTHS

First limitation was that we studied only individuals within one culture thus cultural differences were not taken into account. As we agree with Ekman (2003) that even though facial expressions of basic emotions are biological in their nature, the expression itself is conditioned by existing display rules within each culture. There are also limitations to the methodological approach of an emotion AI observations, which are discussed in Gablikova and Barankova (2017). For example, we focused on facial expressions of "The big six". In an AI algorithm, all measured emotions are interconnected. This means that if one of the emotions is redundant or there is one missing, the emotion AI would be recalibrated and would show proportions for all emotions. Another limitation is that our sample was not representative in terms of accomplished education level. In our paper, there are more participations coming from participants with accomplished tertiary education than is typical for a Slovak population.

Most of the research done so far on the expressions of emotions was inducted outside of a real social situation. We might reach different results if our methodological approach would contain an interpersonal encounter from everyday life. However, in such context it is challenging to control the level of interpersonal relationship and combination of sexes of participants in the encounter, as these factors were shown to correlate with emotion expression (Feldman Barrett et al., 1998; Rimé, Mesquita, Philippot, & Boca, 1991). Feldman Barrett and colleagues (1998) speculate that women's tendencies to rate their interpersonal interactions as more intimate than men's may partially mediate gender differences in emotional intensity. Also, women from a wide variety of cultures also express emotions to a greater number of people than men, who tend to limit themselves to expressing emotions only to intimate partners (Rimé, Mesquita, Philippot, & Boca, 1991). Interactions among sex of judge, sex of poser, and culture were found to exist for at least some emotions (Matsumoto, 1992).

On the other hand, one of the main benefits of this study is that it looks at all basic emotions separately and thus brings a more complex view to emotional expression which is an effective procedure to challenge stereotypes. Previous research either looked only at selected emotions (e.g. Schwartz et al., 1980; Tsai et al., 2000) or muscles in the face (Dimberg & Lindquist, 1990), coded the reactions only on pleasant/unpleasant dimension (e.g. Carstensen et al., 1995, Kring & Gordon, 1998) or used a relatively small sample or a questionnaire (Fabes & Martin, 1993; Hess et al., 2000). As Kring (2000) points out, the contradictory conclusions about expression of anger might be due to the methodological inconsistencies in emotion elicitation, method of measurement, and type of emotional situation. We believe, that the same could be applied to age differences as well as all other emotions. That is why we test both sex and age differences in all basic emotion under one paradigm and one situational context. Due to a new methodology executed by an AI, this paper is the first to provide detailed data about the whole spectrum of basic emotions on a high scale. We supported the line of research (McDuff, 2014; Cohn et al., 1999) which demonstrated that a research method involving large-scale collection and coding of facial data has important implications for how observational studies can be performed. Replicating and extending available research in more naturalistic settings and on a large scale is now possible.

Our paper also provided evidence about the importance of facial appearance in the evaluation of emotional facial expressions and found which expressions under which predictors (sex and age) are affected by facial appearance and which are not. Also, we are the first ones to look at facial expressions of emotions in an everyday situation. We did not focus on eliciting each basic emotion, however, presented everyday stimuli in natural setting and observed what emotions were expressed.

FUTURE RESEARCH

Future research of differences in facial expressions of basic emotions could involve participants from various cultures which would allow for broader generalization of results. Combining our results and results of Hess et al. (2000), who found that ethnicity of a person influence the perceived dominance/affiliation, it would be especially

interesting to see how facial appearance of people with different ancestry, which is a biological term for "race" which reflects the connection of human variations to the geographical origins of their ancestors (Fujimura & Rajagopalan, 2011), interferes with facial expression of basic emotions. We hypothesise that differences in facial appearance of men and women not only correlate with gender stereotypic socialisation (as our data indicate) but might also be one of the origins of such gender stereotypical socialisation. Because people with various ancestry might differ in the static facial, future research should evaluate sex and age differences in emotion expression when facial appearance both is and is not taken into account testing respondents with various ancestry.

We also recommend looking more closely on our data from the perspective of genuine versus non-Duchenne smiles. A detailed FACS analysis might reveal if a more frequent and intensive smile of women originates in a real emotion or belongs to a "social" smile (Ekman, 2003; Ekman et al., 1990; Duchenne, 1862/1990). Also, Magai et al. (2006) demonstrated that the inhibition of emotions (comparing to a non-inhibition condition) resulted in a different pattern of emotion expression between younger, middle-aged, and older adults. Thus, a detailed FACS analysis could also reveal if older individuals, comparing to their younger counterparts, use less masking of negative emotions with smiles (Magai et al., 1992, 2006). As happiness is the easiest emotion to be decoded on a human face (Ekman & Friesen, 2015), consequently such results would shed more light on the origins of the existing stereotypes that women are more expressive than men and older people are less expressive than younger ones.

IMPLICATIONS

When individuals are asked to make judgements based on ambiguous information, such as facial expressions of mixed emotions, their judgements conform to gender-emotion stereotype (Plant et al., 2000). And even if perceivers are free to seek information about a target person, they preferentially seek stereotype–confirming information (e.g., Johnston, 1996; Johnston & Macrae, 1994; Leyens et al., 1998; Leyens & Yzerbyt, 1992; Trope & Thompson, 1997). Such stereotypes are highly enduring and are even present in mental health professionals (Heesacker et at., 1999). In such circumstances, it is important to search for methodological approaches which can measure actual differences in facial expression of emotion and not gather data which by the nature of their approach only strengthen the existing stereotypes. Our data revealed that the reality of emotion expression is more nuanced than what is found by self-report studies. From the three components of emotions (subjective, behavioural, and physiological) it is the emotion-expressive behaviour that may be of greatest significance in shaping social interaction (Gross et al., 1997). Understanding of differences between groups of people and the origins of those differences helps us to understand social interactions, cultural differences, and internal psychological states.

Also, our study clearly demonstrated the need to take baseline facial appearance into account when evaluating facial expressions of emotions. For sex differences, facial appearance may function as a stepping stone for gender stereotypic socialisation pattern for emotion expression. For a correlation with age, our data showed that a facial appearance changes as adults age and that such changes interfere with the intensity of expressed emotions in a manner that makes the emotional signal from the face more mixed. Our results are highly relevant considering the results by Todorov (2008) who concludes that facial features in neutral faces can resemble emotion expression and that this resemblance drives personality judgements.

CONCLUSION

This paper aimed to extend work on sex and age differences in facial expressions of each basic emotion under one paradigm on a large scale. Existing sex and age stereotypes (expressivity decreases with age and women are more emotionally expressive) were not confirmed in our sample of White Europeans in the context of everyday life stimuli showing different patterns in frequency and intensity of emotional expressions. We found that women are not more expressive across all emotions however that the facial expression depend on the discrete emotional state. Our data partially support the emotion-specific stereotype that women express more affiliate emotions and men express more dominant emotions except for sadness. There were found correlations of emotion expression with age, however intensity and frequency did not follow the same pattern. With increasing age, people express less frequently anger and happiness and less intensively sadness and surprise. On the other hand, positive correlation with disgust was identified.

Because of its interconnected nature we decided to conclude data about baseline facial appearance as a whole. First, our results on intensity of facially expressed emotions and age shows that when baseline facial appearance is not eliminated, new correlations appeared, specifically a positive correlation with anger, fear, and happiness emerged. These emotions cannot be characterized based on previous categorizations – among these emotions are both pleasant and unpleasant emotions, dominant as well as affiliate emotions. And of course, all three emotion communicate a different signal: anger is a signal that a barrier is to be eliminated, fear for danger and help, and happiness for affiliation and safety (Ekman, 2003). Thus, we conclude that changes that appear on a human face with increasing age pose a challenge to read facial signals of emotions.

Not eliminating the differences between men and women in the baseline facial appearance resulted in men expressing more intensive dominant emotions (anger and disgust), and women expressing more affiliative emotions (happiness, fear, and surprise). Sadness expression stands as an exception in such pattern. Based on this we conclude that facial appearance can be one of the origins of the existing gender stereotypic socialisation stereotype. Our

data support the notion that emotions need to be analysed as distinct categories not trying to simplify them on the dimensions of valence or affiliation/dominance.

The importance of conducing this study lied in testing sex and age differences in facial expressions of at frequency as well as intensity of all six basic emotions at once and using an automated facial expression analysis. We challenged existing age and sex stereotypes that women are more expressive than men (e.g. Timmers et al., 2003) and that expressivity decreases with age (e.g. Gross et al., 1997). In addition, this was the first complex study testing if the same results appear when facial appearance either is or is not taken into account.

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