**Supplementary material for**

Schlegel, K., Grandjean, D., & Scherer, K. Unidimensional ability or a set of modality- and emotion-specific skills?

The supplementary material is structured as follows:

* Using the unbiased hit rate when calculating correlations between emotion categories
* Development of the Geneva Emotion Recognition Test
* Tables 1-9: Mean unbiased hit rates, confusion tables, and correlation matrices for study 1.
* Tables 10-12: Mean unbiased hit rates, confusion table, and correlation matrix for study 2.
* Figure 1: Rasch model with three items.
* Figures 2-3: Path diagrams of the measurement models in study 2.

# Using the unbiased hit rate when calculating correlations between emotion categories

In most ERA studies, recognition accuracy is calculated as the percentage of correctly identified stimuli. However, the percentage-correct score does not consider potential response biases towards certain emotions. For example, a participant who chooses “anger” for all 30 portrayals in the MERT audio modality will get the same perfect anger recognition score as another participant who chooses “anger” correctly only for the three anger portrayals.

Wagner (1993) proposed an alternative score, the “unbiased hit rate” (Hu), designed to account for such response biases. Hu for each participant is calculated as the squared frequency of correct responses for a target emotion divided by the product of the number of stimuli representing this emotion and the overall frequency of this emotion category being chosen. Hu has a range of zero to one, one indicating that all stimuli of an emotion have been correctly identified and the respective emotion has never been falsely chosen for a different emotion. Thus, for the example mentioned above, Hu\_anger for the first participant is 32/(3\*30)=0.1, accounting for the “overuse” of the anger category, whereas the second participant has an Hu\_anger of 32/(3\*3)=1. We propose that using the unbiased hit rate (Hu, Wagner, 1993) instead of percentage-correct scores leads to a more appropriate correlation matrix of the recognition accuracies, because it accounts for frequently occurring confusion patterns. Consider the example of anxiety and fear which are frequently confused with each other in the audio modality (see Table 6 in the supplementary material). Participants choosing anxiety in stimuli of both fear and anxiety (“overusers”) will generally have a lower percentage-correct score for fear than participants who use anxiety correctly (“correct users”), while both groups will have a high score for anxiety. In contrast, Hu distinguishes “overusers” from “correct users” in that “overusers” will have a lower Hu for anxiety. As a consequence, one would expect the correlation between fear and anxiety Hu‘s to be higher than the correlation between the percentage-correct scores. In our dataset, described in study 1, the correlation between the Hu’s was indeed higher than the correlation between the percentage-correct scores (.219 versus 0.002) for fear and anxiety in the audio modality.

# Development of the Geneva Emotion Recognition Test

***Background***

The ability to recognize the type and intensity of others’ emotional states from their nonverbal expressions (i.e., emotion recognition ability, ERA) is crucial to effective social functioning (Hall, Andrzejewski, & Yopchick, 2009) and is considered a basic component in the popular construct of emotional intelligence (Mayer & Salovey, 1997). However, to date no comprehensive and psychometrically sound test to measure ERA exists. Previous tests have been criticized for focusing on a single modality (mostly the face), for neglecting the dynamic nature of emotional expressions, and for including only a small number of basic emotions (Bänziger, Grandjean, & Scherer, 2009). With the development of the Geneva Emotion Recognition Test (GERT; Schlegel, Grandjean, & Scherer, in preparation), we aim to account for these shortcomings by a) including a high number of emotions, b) using dynamic and multimodal stimuli, and c) applying modern psychometric methods.

***Selection of the initial item set***

The stimuli used for the development of the Geneva Emotion Recognition Test (GERT; Schlegel, Grandjean, & Scherer, in preparation) were taken from the Geneva Multimodal Emotion Portrayals (GEMEP, Bänziger, Mortillaro, & Scherer, in press) corpus. This corpus contains 1260 short audio-video clips of 18 emotions displayed by a total of 10 actors (5 female). For our test we chose the 12 core emotions of the corpus that were portrayed by all actors: Joy, amusement, pride, pleasure, relief, interest, anger, fear, despair, irritation, anxiety, and sadness. Further, we added surprise and disgust as these emotions are frequently included in other ERA tests. For all emotions, portrayals with three different verbal contents (two pseudolinguistic “sentences” and a sustained vowel, “aaa”) are available in GEMEP. For the purpose of the test, we chose the sentence portrayals, as we considered them to be particularly ecologically valid.

The selection of the portrayals was based on ratings obtained from 28 psychology students. For each portrayal, the students were asked to rate its believability and to select one or two emotion words which described best the emotional expression of the actor. The recognition accuracy computed for each portrayal and the believability ratings formed the basis of the item selection which was guided by three principles: First, we aimed at choosing portrayals that are sufficiently believable and authentic displays of the respective emotion. Second, we selected stimuli covering a wide range of item difficulties in order to avoid a ceiling effect of recognition accuracy. Third, we wanted to balance actor gender and the two verbal expressions (sentences). To this end, we created an emotion (N=14) \* actor gender (male/ female) \* verbal content (sentence 1 vs. 2) matrix which we filled with up to five portrayals that met the following criteria: a) The target emotion, i.e., the emotion that was supposed to be expressed, had to be the most frequent response category. b) The recognition accuracy and believability had to be above the 30th percentile of all portrayals in a given emotion category. This criterion was chosen to ensure the sufficient quality of the emotion expressions while maintaining a wide range of difficulty. Following this strategy, between six and nine portrayals per emotion were selected, which led to a total of 108 items.

***Scale development***

*Item Response Theory and the Rasch model*

For the development of the 14 emotion scales used in this study we used Item Response Theory (IRT, Embretson & Reise, 2000), a class of measurement models that has been developed for binary and categorical items. In contrast, standard procedures in Classical Test Theory, such as calculation of reliability or item-total correlations, are primarily applicable to continuous data and yield biased results when used with binary data. The basic assumption of IRT is that the probability with which a person solves an item is determined by: a) the expression of a person on an underlying latent trait dimension θ, and b) characteristics of the item, such as item difficulty or item discrimination (Embretson & Reise, 2000). In our case, the latent trait or ability dimension can be labeled “emotion recognition ability”. The higher the ERA of one person, the higher is the probability of solving an item, or correctly recognizing the emotion displayed by an actor in a certain portrayal. The logistic function describing this relationship is called Item Characteristic Curve (ICC). We illustrate the interpretation of ICCs with the help of the simplest IRT model, called the Rasch model (Rasch, 1980). As can be seen in Figure 1, the ICCs for the three items in this model differ in their position on the latent trait dimension. The more an item is located on the right side of θ, the more difficult it is to solve and only subjects with a comparatively high ability have a high probability of getting it right. The ICC slope determines the discrimination of an item- the steeper the slope, the better the item discriminates between subjects in this range of θ. In the Rasch model, the slopes of all items are assumed to be equal, i.e., the ICCs do not cross. As a consequence, if the Rasch model fits the data, the simple sum or mean score of correctly solved items can be used as a sufficient statistic or estimate of a person’s ability (for details, see Embretson & Reise, 2000). Because of this practically useful property, we used the Rasch model to develop our 14 emotion subscales.

*Data analysis*

The item selection procedure for each subscale can be summarized as follows:

1. As the Rasch model is based on the assumption of a unidimensional latent trait or θ, we first tested each subset of items (between six and nine items per emotion) with a one-factor CFA in Mplus. Model fit was assessed with the CFI, RMSEA, and RMSR fit statistics as described in the methods section of study 1. In case of insufficient fit, items with negative or very low factor loadings were eliminated.
2. In the next step, we fitted the Rasch model to each of the unidimensional item subsets using the ConQuest software (Wu, Adams, & Wilson, 1998). Then, we checked to what extent each single item fit the Rasch model with the weighted-fit or “Infit” index. The Infit statistic indicates how much the slope of an item differs from the slope that is estimated by the Rasch model. Values between .80 and 1.20 are usually considered as an “indication of useful fit” (Wright & Linacre, 1994), with 1.00 representing perfect fit. Items outside this Infit range were eliminated.
3. In the last step, our aim was to establish scales with six items each and an equal number of portrayals by male and female actors where possible. Therefore, we inspected the item difficulties and removed very easy items in scales where more than six items were left after step 2.

*Results*

Of the initial 108 items, 13 items (12%) were eliminated in the course of the first two steps. For all emotions except despair, between six and eight items were found to fit the Rasch model. In the case of despair, only five of the items (two male and three female actor portrayals) met the unidimensionality assumption and were further analyzed. For amusement and anger, after the Rasch analysis only two portrayals by female actors were left. Consequently, we included four male actor portrayals for these emotions in the final item set. Table 10 shows the composition and mean scores of the 14 final scales.

Tables 1 to 9 refer to study 1, tables 10 to 12 refer to study 2.

*Mean unbiased hit rates and standard deviations in study 1*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| modality/ | audio | | video | | still picture | | audio-video | | all modalities combined | |
| emotion | mean Hu | SD | mean Hu | SD | mean Hu | SD | mean Hu | SD | mean Hu | SD |
| anxiety | .26 | .21 | .21 | .22 | .19 | .19 | .23 | .20 | .22 | .12 |
| disgust | .08 | .15 | .51 | .28 | .59 | .29 | .49 | .27 | .42 | .17 |
| happiness | .40 | .27 | .70 | .28 | .44 | .25 | .76 | .25 | .57 | .17 |
| anger | .80 | .26 | .71 | .27 | .52 | .30 | .79 | .24 | .70 | .19 |
| irritation | .31 | .23 | .25 | .21 | .17 | .21 | .36 | .26 | .27 | .14 |
| fear | .19 | .18 | .23 | .20 | .23 | .21 | .22 | .19 | .22 | .12 |
| sadness | .36 | .27 | .55 | .29 | .22 | .20 | .57 | .28 | .42 | .17 |
| elated joy | .25 | .24 | .74 | .24 | .56 | .20 | .76 | .23 | .58 | .16 |
| contempt | .28 | .23 | .38 | .21 | .38 | .26 | .46 | .24 | .37 | .15 |
| despair | .18 | .17 | .24 | .22 | .22 | .22 | .27 | .21 | .23 | .14 |

Table 2

*Correlation matrix of the arcsine transformed unbiased hit rates in the audio modality in study 1*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | anxiety | disgust | happi-ness | anger | irritation | fear | sadness | joy | contempt |
| anxiety | 1 |  |  |  |  |  |  |  |  |
| disgust | .114 | 1 |  |  |  |  |  |  |  |
| happiness | .250 | .047 | 1 |  |  |  |  |  |  |
| anger | .175 | .064 | .191 | 1 |  |  |  |  |  |
| irritation | .251 | -.005 | .149 | .330 | 1 |  |  |  |  |
| fear | .169 | .021 | .038 | .059 | .126 | 1 |  |  |  |
| sadness | .229 | .119 | .337 | .161 | .090 | -.053 | 1 |  |  |
| elated joy | .182 | .090 | .297 | .071 | .109 | .156 | .184 | 1 |  |
| contempt | .222 | .066 | .198 | .169 | .288 | .179 | .128 | .182 | 1 |
| despair | .125 | -.004 | .141 | .122 | .134 | .068 | .206 | .032 | .060 |

Table 3

*Correlation matrix of the arcsine transformed unbiased hit rates in the video modality in study 1*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | anxiety | disgust | happi-ness | anger | irritation | fear | sadness | joy | contempt |
| anxiety | 1 |  |  |  |  |  |  |  |  |
| disgust | .108 | 1 |  |  |  |  |  |  |  |
| happiness | .152 | .116 | 1 |  |  |  |  |  |  |
| anger | .222 | .191 | .315 | 1 |  |  |  |  |  |
| irritation | .221 | .127 | .202 | .371 | 1 |  |  |  |  |
| fear | .305 | .122 | .092 | .143 | .106 | 1 |  |  |  |
| sadness | .046 | .254 | .075 | .152 | .158 | .055 | 1 |  |  |
| elated joy | .125 | .066 | .586 | .229 | .150 | .040 | .052 | 1 |  |
| contempt | .061 | .351 | .188 | .276 | .226 | .106 | .143 | .093 | 1 |
| despair | .050 | .063 | .056 | .092 | .222 | .249 | .284 | .114 | .059 |

Table 4

*Correlation matrix of the arcsine transformed unbiased hit rates in the still picture modality in study 1*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | anxiety | disgust | happi-ness | anger | irritation | fear | sadness | joy | contempt |
| anxiety | 1 |  |  |  |  |  |  |  |  |
| disgust | .182 | 1 |  |  |  |  |  |  |  |
| happiness | -.016 | .022 | 1 |  |  |  |  |  |  |
| anger | .167 | .187 | .197 | 1 |  |  |  |  |  |
| irritation | .065 | .031 | .023 | .205 | 1 |  |  |  |  |
| fear | .221 | -.061 | .165 | .246 | -.014 | 1 |  |  |  |
| sadness | .067 | .100 | .144 | .183 | .110 | -.037 | 1 |  |  |
| elated joy | .055 | .156 | .539 | .258 | .005 | .145 | .051 | 1 |  |
| contempt | .110 | .382 | .097 | .213 | .201 | -.058 | .098 | .120 | 1 |
| despair | .039 | .159 | .125 | .212 | .114 | .090 | .230 | .144 | .065 |

Table 5

*Correlation matrix of the arcsine transformed unbiased hit rates in the audio-video modality in study 1*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | anxiety | disgust | happi-ness | anger | irritation | fear | sadness | joy | contempt |
| anxiety | 1 |  |  |  |  |  |  |  |  |
| disgust | .049 | 1 |  |  |  |  |  |  |  |
| happiness | .139 | .066 | 1 |  |  |  |  |  |  |
| anger | .044 | .051 | .139 | 1 |  |  |  |  |  |
| irritation | .126 | .150 | .155 | .478 | 1 |  |  |  |  |
| fear | .154 | .100 | .100 | -.028 | .011 | 1 |  |  |  |
| sadness | .206 | .003 | -.018 | .070 | .033 | -.005 | 1 |  |  |
| elated joy | .134 | .142 | .487 | .118 | .090 | .221 | .034 | 1 |  |
| contempt | .086 | .366 | .168 | .186 | .332 | .021 | .091 | .146 | 1 |
| despair | .095 | .102 | .117 | .161 | .046 | .120 | .343 | .206 | .092 |

Table 6

*Confusion matrix for the audio modality in study 1*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **judgment category** | | | | | | | | | | |
| **target emotion** | anger | anxiety | con-tempt | despair | disgust | fear | happi-ness | irritation | joy | sadness | total |
| anger | 803 | 1 | 20 | 9 | 3 | 7 | 2 | 66 | 4 | 0 | 915 |
| anxiety | 3 | 500 | 14 | 99 | 7 | 179 | 19 | 27 | 6 | 61 | 915 |
| contempt | 4 | 21 | 413 | 53 | 82 | 3 | 89 | 118 | 3 | 129 | 915 |
| despair | 41 | 111 | 6 | 404 | 12 | 214 | 7 | 11 | 11 | 98 | 915 |
| disgust | 7 | 143 | 152 | 114 | 91 | 15 | 92 | 153 | 0 | 148 | 915 |
| fear | 14 | 294 | 5 | 192 | 6 | 327 | 9 | 31 | 19 | 18 | 915 |
| happiness | 1 | 64 | 59 | 41 | 30 | 8 | 558 | 42 | 3 | 109 | 915 |
| irritation | 38 | 31 | 166 | 30 | 33 | 7 | 128 | 455 | 7 | 20 | 915 |
| joy | 12 | 142 | 9 | 228 | 9 | 72 | 98 | 20 | 243 | 82 | 915 |
| sadness | 2 | 32 | 29 | 230 | 18 | 11 | 15 | 15 | 2 | 561 | 915 |
| total | 925 | 1339 | 873 | 1400 | 291 | 843 | 1017 | 938 | 298 | 1226 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |

*Note.* Numbers are frequencies.

Table 7

*Confusion matrix for the video modality in study 1*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **judgment category** | | | | | | | | | | |
| **target emotion** | anger | anxiety | con-tempt | despair | disgust | fear | happi-ness | irritation | joy | sadness | total |
| anger | 776 | 4 | 27 | 7 | 4 | 1 | 1 | 86 | 3 | 6 | 915 |
| anxiety | 48 | 327 | 49 | 137 | 10 | 91 | 3 | 201 | 2 | 47 | 915 |
| contempt | 25 | 3 | 647 | 25 | 62 | 0 | 23 | 102 | 2 | 26 | 915 |
| despair | 51 | 78 | 10 | 410 | 7 | 285 | 2 | 15 | 6 | 51 | 915 |
| disgust | 6 | 20 | 237 | 36 | 526 | 3 | 6 | 47 | 1 | 33 | 915 |
| fear | 41 | 286 | 20 | 149 | 9 | 359 | 3 | 28 | 5 | 15 | 915 |
| happiness | 4 | 13 | 30 | 7 | 1 | 3 | 694 | 7 | 150 | 6 | 915 |
| irritation | 62 | 13 | 336 | 14 | 33 | 0 | 21 | 402 | 4 | 30 | 915 |
| joy | 5 | 22 | 3 | 44 | 1 | 25 | 27 | 1 | 781 | 6 | 915 |
| sadness | 2 | 59 | 7 | 177 | 12 | 10 | 11 | 19 | 3 | 615 | 915 |
| total | 1020 | 825 | 1366 | 1006 | 665 | 777 | 791 | 908 | 957 | 835 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |

*Note.* Numbers are frequencies.

Table 8

*Confusion matrix for the still picture modality in study 1*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **judgment category** | | | | | | | | | | |
| **target emotion** | anger | anxiety | con-tempt | despair | disgust | fear | happi-ness | irritation | joy | sadness | total |
| anger | 587 | 32 | 60 | 13 | 40 | 53 | 6 | 113 | 8 | 3 | 915 |
| anxiety | 23 | 363 | 26 | 88 | 22 | 243 | 17 | 93 | 4 | 36 | 915 |
| contempt | 22 | 18 | 557 | 37 | 135 | 2 | 9 | 63 | 3 | 69 | 915 |
| despair | 39 | 116 | 12 | 344 | 16 | 269 | 6 | 20 | 4 | 89 | 915 |
| disgust | 41 | 9 | 105 | 7 | 703 | 5 | 4 | 34 | 3 | 4 | 915 |
| fear | 55 | 244 | 2 | 99 | 20 | 432 | 7 | 14 | 6 | 36 | 915 |
| happiness | 1 | 4 | 8 | 0 | 1 | 1 | 461 | 3 | 435 | 1 | 915 |
| irritation | 34 | 53 | 222 | 76 | 67 | 7 | 43 | 247 | 1 | 165 | 915 |
| joy | 5 | 15 | 4 | 17 | 16 | 47 | 26 | 1 | 781 | 3 | 915 |
| sadness | 2 | 175 | 76 | 172 | 28 | 51 | 20 | 64 | 4 | 323 | 915 |
| total | 809 | 1029 | 1072 | 853 | 1048 | 1110 | 599 | 652 | 1249 | 729 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |

*Note.* Numbers are frequencies.

Table 9

*Confusion matrix for the audio-video modality in study 1*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **judgment category** | | | | | | | | | | |
| **target emotion** | anger | anxiety | con-tempt | despair | disgust | fear | happi-ness | irritation | joy | sadness | total |
| anger | 803 | 1 | 19 | 4 | 0 | 4 | 1 | 81 | 2 | 0 | 915 |
| anxiety | 5 | 379 | 23 | 142 | 13 | 231 | 4 | 38 | 5 | 75 | 915 |
| contempt | 14 | 3 | 704 | 14 | 68 | 1 | 21 | 71 | 2 | 17 | 915 |
| despair | 15 | 100 | 2 | 467 | 7 | 249 | 1 | 13 | 5 | 56 | 915 |
| disgust | 8 | 48 | 194 | 53 | 503 | 1 | 7 | 43 | 3 | 55 | 915 |
| fear | 10 | 326 | 9 | 149 | 6 | 384 | 1 | 13 | 2 | 15 | 915 |
| happiness | 3 | 13 | 38 | 7 | 4 | 1 | 766 | 10 | 68 | 5 | 915 |
| irritation | 75 | 10 | 318 | 9 | 25 | 1 | 26 | 440 | 3 | 8 | 915 |
| joy | 3 | 35 | 6 | 43 | 0 | 18 | 62 | 3 | 740 | 5 | 915 |
| sadness | 1 | 14 | 5 | 235 | 6 | 8 | 5 | 3 | 1 | 637 | 915 |
| total | 937 | 929 | 1318 | 1123 | 632 | 898 | 894 | 715 | 831 | 873 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |

*Note.* Numbers are frequencies.

Table 10

*Composition, mean unbiased hit rates and standard deviations for the 14 emotion recognition scales used in study 2*

|  |  |  |  |
| --- | --- | --- | --- |
| emotion | number of items | mean Hu | SD |
| anxiety | 6(3/3) | .36 | .18 |
| disgust | 6(3/3) | .49 | .23 |
| pleasure | 6(3/3) | .66 | .23 |
| anger | 6(4/2) | .47 | .28 |
| irritation | 6(3/3) | .35 | .20 |
| fear | 6(3/3) | .44 | .25 |
| sadness | 6(3/3) | .63 | .22 |
| joy | 6(3/3) | .53 | .22 |
| despair | 5(2/3) | .43 | .20 |
| pride | 6(3/3) | .48 | .24 |
| surprise | 6(3/3) | .30 | .20 |
| amusement | 6(4/2) | .74 | .22 |
| relief | 6(3/3) | .73 | .22 |
| interest | 6(3/3) | .43 | .19 |

*Note.* Numbers in brackets show the number of male and female actor portrayals.

Table 11

*Correlation matrix for study 2*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1 | anxiety | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 | disgust | .346 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| 3 | pleasure | .172 | .180 | 1 |  |  |  |  |  |  |  |  |  |  |
| 4 | anger | .325 | .158 | .072 | 1 |  |  |  |  |  |  |  |  |  |
| 5 | irritation | .403 | .357 | .140 | .575 | 1 |  |  |  |  |  |  |  |  |
| 6 | fear | .329 | .236 | .007 | .298 | .269 | 1 |  |  |  |  |  |  |  |
| 7 | sadness | .276 | .211 | .201 | .116 | .092 | .081 | 1 |  |  |  |  |  |  |
| 8 | joy | .140 | .168 | .232 | .234 | .315 | .178 | .132 | 1 |  |  |  |  |  |
| 9 | despair | .349 | .235 | .176 | .242 | .224 | .318 | .467 | .189 | 1 |  |  |  |  |
| 10 | pride | .207 | .233 | .288 | .200 | .319 | .144 | .144 | .380 | .219 | 1 |  |  |  |
| 11 | surprise | .209 | .198 | .099 | .077 | .162 | .171 | .030 | .194 | .163 | .089 | 1 |  |  |
| 12 | amusement | .187 | .229 | .169 | .134 | .270 | .202 | .151 | .359 | .154 | .311 | .178 | 1 |  |
| 13 | relief | .273 | .243 | .451 | .179 | .300 | .168 | .238 | .356 | .238 | .224 | .109 | .331 | 1 |
| 14 | interest | .301 | .233 | .252 | .215 | .363 | .153 | .106 | .176 | .172 | .232 | .119 | .280 | .301 |

Table 12

*Confusion matrix for study 2*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **judgment category** | | | | | | | | | | | | | | |
|  | **target emotion** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | total |
| 1 | irritation | 1230 | 21 | 9 | 150 | 44 | 0 | 8 | 11 | 5 | 0 | 42 | 0 | 16 | 208 | 1744 |
| 2 | surprise | 87 | 735 | 5 | 516 | 3 | 2 | 42 | 19 | 74 | 1 | 2 | 1 | 8 | 233 | 1728 |
| 3 | disgust | 268 | 16 | 881 | 222 | 17 | 7 | 161 | 139 | 3 | 0 | 0 | 0 | 18 | 12 | 1744 |
| 4 | anxiety | 21 | 128 | 1 | 1241 | 0 | 32 | 67 | 72 | 0 | 0 | 3 | 0 | 16 | 156 | 1737 |
| 5 | anger | 740 | 1 | 0 | 11 | 962 | 0 | 1 | 27 | 0 | 0 | 1 | 0 | 1 | 5 | 1749 |
| 6 | fear | 79 | 14 | 1 | 252 | 121 | 813 | 5 | 457 | 0 | 1 | 0 | 0 | 1 | 0 | 1744 |
| 7 | sadness | 37 | 1 | 5 | 88 | 1 | 1 | 1390 | 152 | 1 | 1 | 10 | 1 | 19 | 22 | 1729 |
| 8 | despair | 39 | 3 | 1 | 126 | 30 | 22 | 173 | 1036 | 1 | 0 | 2 | 0 | 2 | 3 | 1438 |
| 9 | amusement | 1 | 14 | 0 | 5 | 0 | 0 | 1 | 2 | 1467 | 192 | 6 | 5 | 22 | 1 | 1716 |
| 10 | joy | 2 | 91 | 0 | 5 | 1 | 1 | 1 | 8 | 55 | 1291 | 164 | 2 | 80 | 11 | 1712 |
| 11 | pride | 84 | 11 | 0 | 6 | 10 | 0 | 0 | 2 | 113 | 248 | 1075 | 32 | 39 | 87 | 1707 |
| 12 | pleasure | 5 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 35 | 132 | 168 | 1226 | 84 | 44 | 1700 |
| 13 | relief | 16 | 28 | 0 | 9 | 1 | 0 | 1 | 2 | 3 | 28 | 44 | 94 | 1454 | 16 | 1696 |
| 14 | interest | 121 | 128 | 3 | 158 | 5 | 0 | 32 | 14 | 6 | 42 | 26 | 10 | 33 | 1130 | 1708 |
|  | total | 2730 | 1196 | 906 | 2790 | 1195 | 878 | 1882 | 1941 | 1763 | 1936 | 1543 | 1371 | 1793 | 1928 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

*Note.* Values are frequencies. The unequal total frequencies of the judgments per target emotion result from missing values: 40 participants did not complete the study and had between one and 11 missings.

**References**

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List of figures and captions:

Figure 1: Rasch model with three items.

*Note.* δ = item difficulty, *θ*=latent trait dimension.

Figure 2: Path diagram of the moderate unidimensional model in study 2.

*Note.* pri=pride, amu=amusement, ple=pleasure, rel=relief, int=interest, sur=surprise, anx=anxiety, fea=fear, des=despair, sad=sadness, dis=disgust, irr=irritation, ang=anger, ERA=emotion recognition ability.

Figure 3: Path diagram of the final two-factor model with residual correlations in study 2.

*Note.* pri=pride, amu=amusement, ple=pleasure, rel=relief, int=interest, sur=surprise, anx=anxiety, fea=fear, des=despair, sad=sadness, dis=disgust, irr=irritation, ang=anger, POS=positive emotion recognition, NEG=negative emotion recognition.