Joshua Snell

Bachelor Research Internship

at the Helmholtz Institute of Experimental Psychology

Utrecht University

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Date : 30-08-2012 *(dd-mm-yyyy)*

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Preliminary

This document is the result of my two months internship at the Helmholtz institute of experimental psychology in Utrecht, a project that served as the concluding piece of my bachelor study Liberal Arts & Sciences, with a major in cognitive neuroscience. Under supervision of M. de Jong PhD(c) I worked on some preliminary investigations and tests that were required for experiments that are run as of today. These experiments regard cross-modal attentional cueing and multisensory integration, and are part of a research led by dr. C. Dijkerman, coined *It's Personal: Visuotactile predictive mechanisms of peripersonal space*.

Results of my work are presented in the form of three separate reports: (in order of appearance), *Measurement of a Sense of Trustworthiness in Faces Using a Visual Analogue Scale*; *Gamma Encoding of Images for Various Monitor Displays*; and *Research Proposal EMG Measurement.* Further, I will continue to work at the Helmholtz institute for the duration of the current research.

I want to thank dr. C. Dijkerman for this opportunity, and I especially want to thank Maartje for a very pleasant and effective learning and working experience in experimental psychology during the last two months, and months that may follow.

Joshua Snell
30-08-2012

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Measurement of a Sense of Trustworthiness in Faces Using a Visual Analogue Scale

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Measurement of a sense of trustworthiness in faces using a visual analogue scale

1.Introduction

Participants may have a sense of trustworthiness towards (images of) faces. We used images of actors' faces in either a neutral or fearful expression and measured trustworthiness of the faces by means of a VAS score, (fig. 1a). The expressions of these faces were validated by the MacBrain research network (fig. 1b).

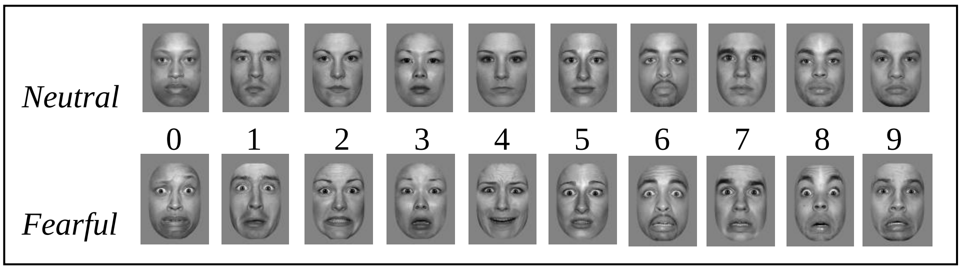

Figure 1a. Images of faces of ten actors, labeled '0' to '9', in both a neutral (upper row) and fearful (lower row) expression.

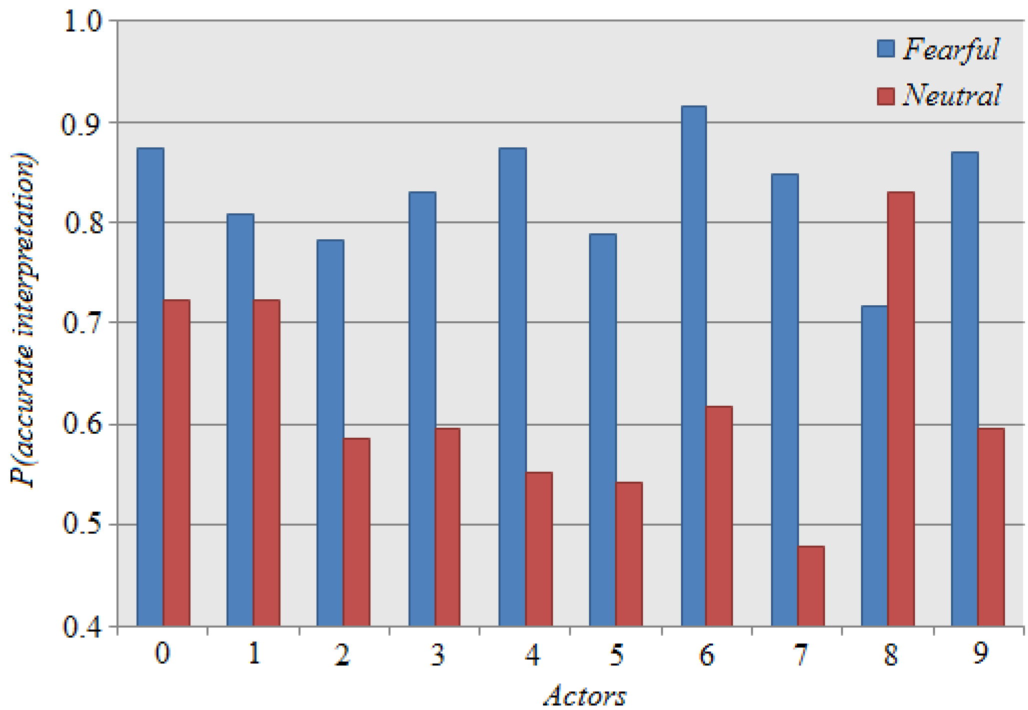

Figure 1b. In order to validate both expressions for each actor, subjects were asked to indicate for every stimulus (fig. 1a) a most appropriate expression out of the eight expressions *neutral, fearful, angry, disgust, sad, happy, calm* and *surprised* (hence a chance level P=0.125). The vertical axis shows chances on a correct interpretation for both expressions of each actor.[1]

[1] Pictures of ten different actors displaying fearful and neutral expressions were taken from the MacBrain Face Stimulus Set. (Development of the MacBrain Face Stimulus Set was overseen by Nim Tottenham and supported by the John D. and Catherine T. MacArthur Foundation Research Network on Early Experience and Brain Development. Please contact Nim Tottenham at tott0006@tc.umn.edu for more information concerning the

We were interested in differences in the measured trustworthiness among the ten actors used, and between the two emotional expressions. The results of this experiment serve as a baseline measurement for a series of experiments regarding cross-modal attentional cueing and multisensory integration. These follow-up experiments will use the same images, and one of the manipulations is planned to be a manipulation of trustworthiness of the actors. Besides providing a baseline condition, tests may reveal interesting findings such as a significant effect of *gender*, or that certain actors are judged to be extremely trustworthy or untrustworthy, and those actors may be excluded from future experiments, (typically, in case of a significant effect, we will aim to exclude one actor, as is motivated in the discussion section of this paper). We will examine these possibilities in section 3.

2. Method

2.1 Subjects

The participants group consisted of 15 subjects, of whom 6 female and 9 male, aged 18-49 years old. None of the participants was subject to any personality- or emotional disorder that may have had severely influenced test outcomes (e.g. autism), based on self-report. No further distinctions among subjects were measured.

2.2 Materials

Each individual stimulus (i.e. a single face image) was printed at dimensions 85mm*115mm on the quarter of a size A4 sheet of paper. Each stimulus was printed in grayscale, in line with figure 1 above. Right below the image, a black line (the VAS, notably) was presented with a length of 54 mm. Its left and right ends were accompanied by the texts "not trustworthy" and "completely trustworthy", respectively. Furthermore, subjects were provided a pen.

2.3 Procedure

Participants were first asked to indicate for each stimulus the extent to which they deemed the actor in his or her *neutral expression* trustworthy, by means of an 'x' or a vertical line somewhere on the VAS. This was done for all upper stimuli as shown by figure 1 in a randomized order. Subsequently, the same was done for stimuli of actors in their *fearful expression*.

The VAS score for each stimulus was determined by measuring the length (in mm) of the portion of the line left from the mark, and fitting this value into a -100 to 100 scale (-100 representing the least trustworthy and 100 the most trustworthy), by using the formula: VAS score = 3,7**length* – 100.

2.4 Analysis

A repeated-measures analysis of variance (ANOVA) with 'actor' and 'emotion' as within-subjects factors was used to test for effects of individual actors and their emotional expressions in ratings by participants. A Greenhouse-Geisser correction was applied to all tests. In case of a significant effect of *actor*, post hoc testing was performed to provide information on (i) the extent to which measured effects are present for either one emotional expression; and (ii) which stimuli are the odd ones out. The latter was done by performing tests of within-subjects contrasts; actors that showed to differ significantly from others were then excluded one by one from an additional ANOVA to see whether any effects measured

stimulus set). Using Adobe Photoshop 7.0.1 software, the faces were matched for size, shape, luminance, and contrast.

before would still hold[2]. Additionally, outlier analyses were performed to check not only for extreme outliers among actors, but also whether their scores were caused by extreme ratings of single participants. Further, we performed a linear correlation between the results for the two emotional expressions per individual actor.

3. Results

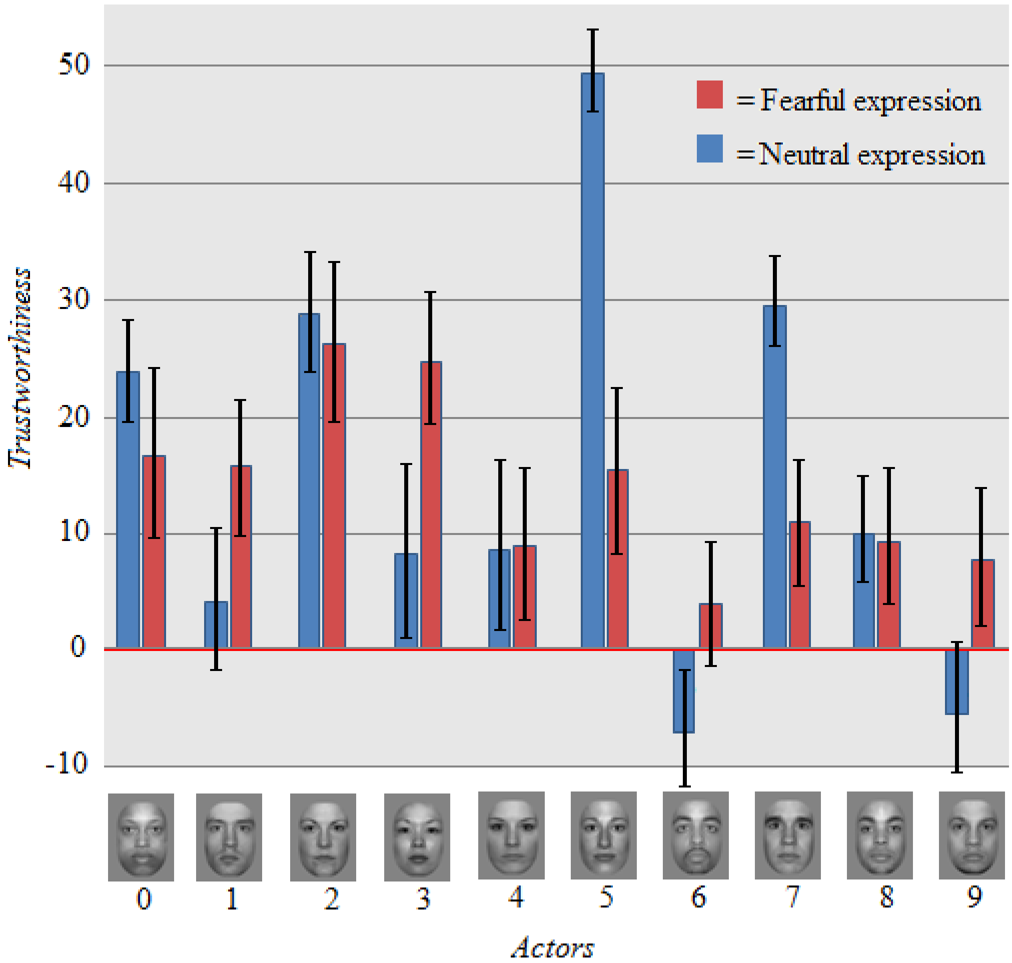

Figure 2. For both expressions and per individual actor, mean scores are shown and accompanied by their respective std. errors. For all conditions, n=15.

Scores among actors are statistically significantly different, at $F(3.767, 41.439)=3.025$, $p=0{,}030$ (See fig. 2). However, the interaction between factors *emotion* and *actor* showed to be marginally significant at $F(4.182, 46.004)=2.152$, $p = 0{,}087$, and *post hoc* testing revealed that the effect mentioned above did not hold for the fearful expression in seclusion. This may be due to several reasons, the foremost of which will be discussed in the next section. There was a correlation between the neutral emotional expression and fearful expression, (fig. 3). In further analyses, however, only the neutral expression was tested.

Aforementioned possibility of an effect of gender was indeed found. When comparing actors in their neutral expression with a factor *gender* included, at $F(1.00, 11.00)=8.029$, there was a significance value of $p=0.016$, indicating that female actors received significantly higher scores than male actors.

[2] If the latter was not the case, the actor of concern would be a strong candidate for exclusion from follow-up experiments.

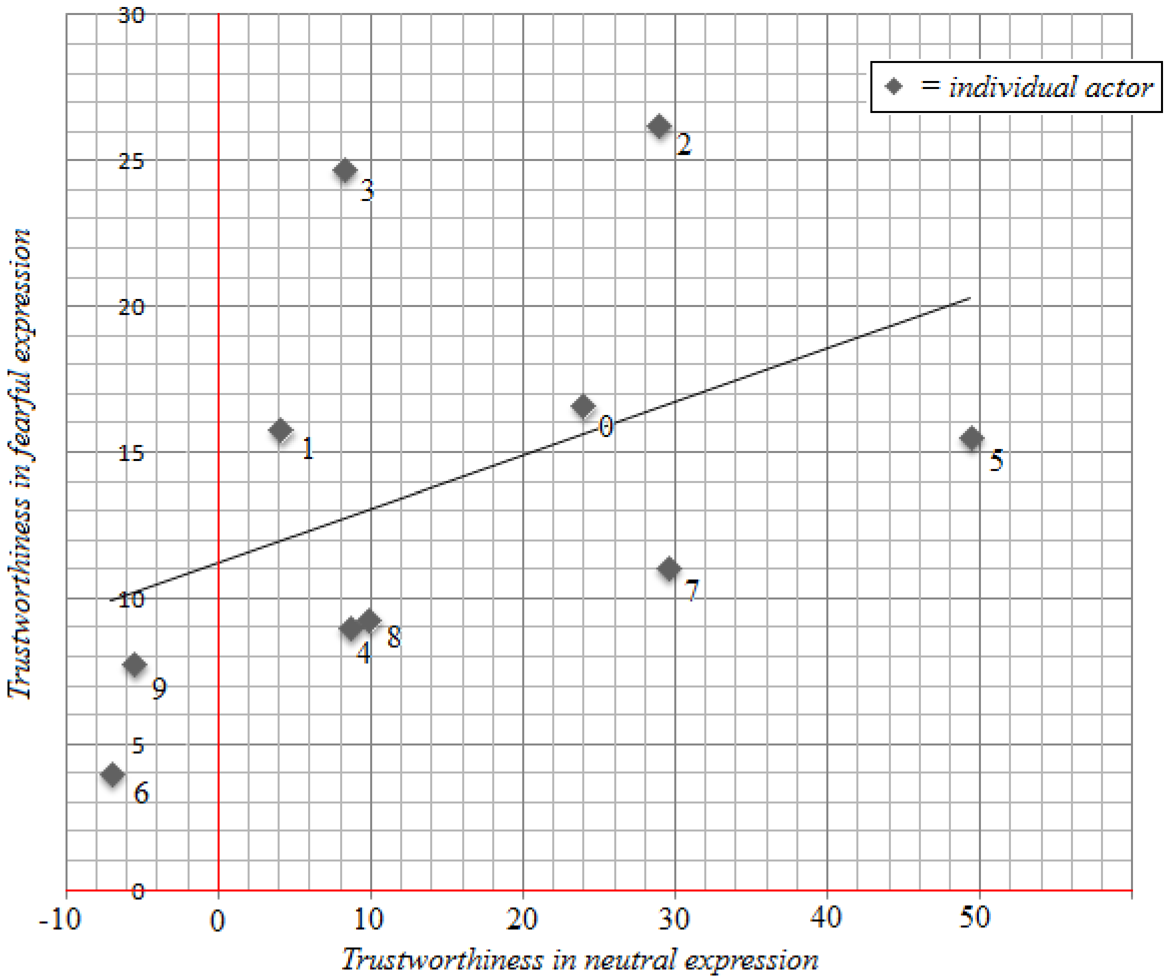

Figure 3. Correlation between scores for both expressions per individual actor, labeled by their number. For all conditions, n=15.

Post hoc tests of within-subjects contrasts showed that *actor 5* deviates significantly from all other actors, except for actors 2 and 7, from whom it deviates marginally significantly at $F(1, 11)=3.381$, p = 0,093 and $F(1, 11)=3,468$, p = 0,089 respectively. Similarly, *actors 6* and *9* deviate significantly from actors 0, 2, 5 and 7.

Running an ANOVA for just the neutral expression, with the exclusion of either one of these actors, revealed that without actors 6 and 9 there were still significant effects at $F(4.381, 48.194)=3.916$, $p = 0.006$ and $F(4.194, 46.132)=3.694$, $p = 0.010$, respectively. When excluding actor 5, however, there was only a marginally significant effect at $F(4.385, 48.233)=2.448$, $p = 0.054$.[3]

For the neutral expression, the actors have an overall mean score of 14.99 with a std. deviation $\sigma = 14.36$. Since $2\sigma = 28.72$, extreme outliers are considered to have a mean score either below -13.73, or above 43.71. Hence, at mean scores of -7.067 and -5.567 respectively, actors 6 and 9 cannot be considered extreme outliers. Actor 5, however, scored well beyond 2σ from the overall mean at a score of 49.367, which suggests, in line with the previous finding, that actor 5 may best be excluded from subsequent experiments.

[3] When running an ANOVA with both emotional expressions, excluding actor 5 led to an absence of the effect measured before: $F(3.721, 40.935)=2.040$, p = 0,111. Meanwhile, when excluding actor 6 or 9 there were still marginally significant effects at $F(3.461, 38.075)=2.380$, $p = 0.077$ and $F(3.476, 38.241)=2.878$, p = 0,042.

To see whether any of the actors' scores may have been caused by extreme ratings of single participants, an additional outlier analysis with box plot was performed. This revealed that none of the participants judged any of the actors beyond 1.5 times that actor's interquartile range, indicating that no extreme ratings have been given (see fig. 4).

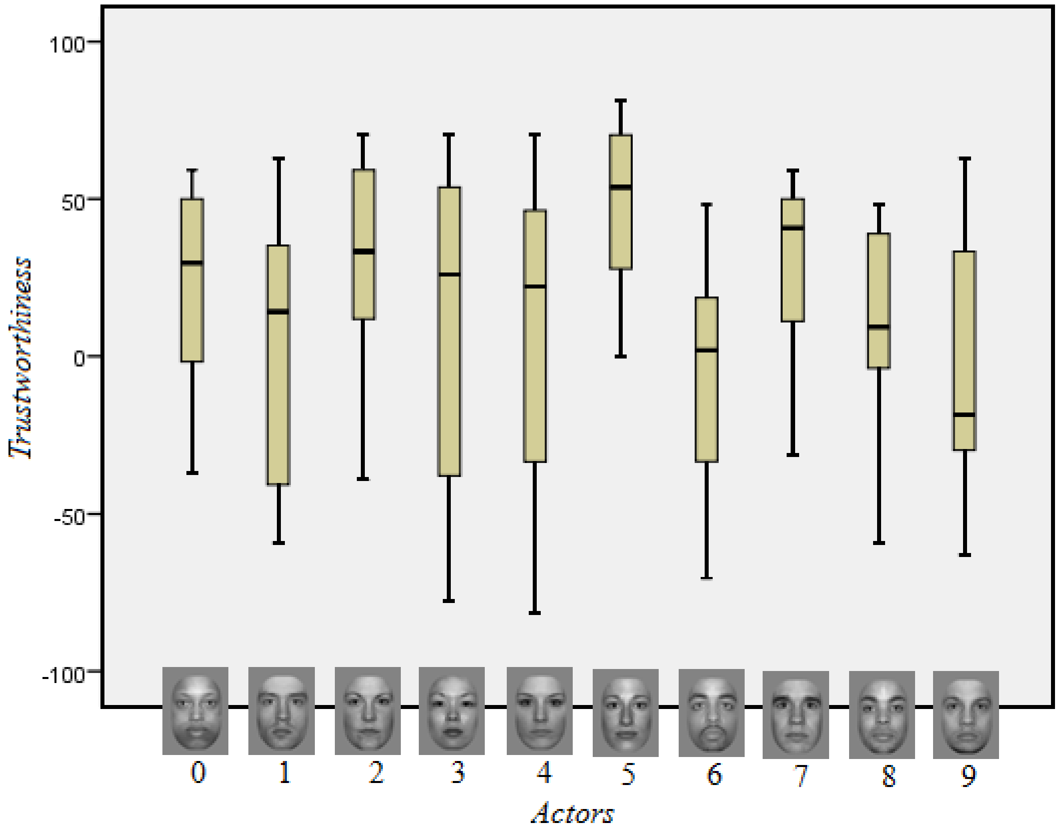

Figure 4. Outlier analysis for every actor in his or her neutral expression. Whereas the horizontal line within the box indicates the median (or second quartile), the upper and lower hinge indicate the third and first quartile respectively. Next, the whiskers (or 'T-lines'), indicate the furthest datum within 1.5 interquartile ranges (the length of the box, typically) from the upper and lower hinge. No dataset points beyond these whiskers are found, implying that no outlying ratings have been given by participants. N = 15 for all actors.

4. Discussion

Test outcomes have shown that actors 6, 9 and, most notably, actor 5, are the odd ones out (fig. 2). In subsequent experiments, we will realize three conditions, where actors are 25%, 50% and 75% trustworthy respectively. Hence, we can appoint three out of ten actors to each condition, leaving one to be excluded. In appointing actors to each condition, then, it seems strategically sound to keep overall mean baseline scores as equal as possible among the three conditions.

This strategy crystallizes in a design where we first have to distinguish three actors of a fairly equal low score (1, 6 and 9); three actors of a fairly equal mediocre score (3, 4 and 8); and three actors of a fairly equal high score (0, 2 and 7). Next, appointing one out of each of these groups to every condition in subsequent experiments, would logically lead to equal mean scores amongst these conditions. This strategy can thus best be achieved by excluding actor 5, and this is further supported by the post hoc tests and outlier analysis elaborated in the previous section.

The fearful expressions did not differ in the VAS scores. There may be several reasons for this. While the neutral expression was coined one of two ‘emotional expressions’, the neutral stimuli do not actually contain implicit emotional information. Thus, in judging an actor’s trustworthiness, participants could not rely on anything other than plain physical appearances. Contrariwise, the fearful stimuli show action and intention *in addition to* just the physical appearances. Thus, fearful stimuli may have more (subjective) elements and variables to them, leading to test outcomes of a different nature. Do note, however, that whilst scores do not deviate significantly for the fearful stimuli, overall mean scores for neutral and fearful stimuli are quite similar at 14.99 and 13.97, respectively.

Gamma Encoding of Images for Various Monitor Displays

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Date : 21-08-2012 *(dd-mm-yyyy)*

1. Introduction

Gamma is a parameter that describes the nonlinear relationship between the color input values for a monitor and the luminance (emitted light) of the actual monitor display. This relationship is represented by the equation: Y = X ^ *gamma*, where Y is the relative luminance normalized to a 0-1 scale; X represents the RGB value, and is adjusted from its typical 0-255 scale into a 0-1 scale as well.[4] Gamma affects middle tones; it has no effect on absolute black and white, or (normalized) pixel levels 0 and 1. When gamma increases, middle tones appear darker; when gamma decreases, middle tones appear lighter (Koren 2012).

Gamma correction is required to linearize the input-output relation of the monitor. According to Poynton (2003), this compensates for certain properties of human vision, to maximize the use of bandwidth in what is usually a 8- or 16-bits spectrum, relative to how humans perceive light. Typically, images that are not gamma encoded may allocate too many bits or bandwidth to parts of high luminance that humans would normally not be able to differentiate, while too few bits are allocated to shadow values that humans are otherwise sensitive to, implying a loss of visual quality.

We were interested in the gamma value of various monitor display settings, in order to safeguard the quality of visual stimuli in future experiments – that is, by means of multiplying X (scaled RGB values of stimuli) to the power of the inverted gamma value; Xnew = Xold^(1/*gamma*). As such, Xnew, or the *new x value*, produces a luminance equal to what the *old x value*, Xold, would produce in case of a *linear relationship* between X and Y. This is the typical procedure of gamma encoding or gamma correction, and we have applied it to three monitor display settings of concern; namely, a NEC® cathode ray tube (abbr. CRT) display that is frequently used in various experiments containing visual stimuli in the academic medical centre of Utrecht, and two settings on a Dell® laptop display that we will use in a follow-up experiment regarding cross-modal attentional cueing and multisensory integration. We were particularly interested in finding out which of the two laptop display settings produced Y values that allowed for a better fit into a gamma equation (see section 2.2), and thus keep stimuli most true to their nature.

2. Method

2.1 Materials

We tested three monitor display settings:

- NEC® CRT display, model JC-2143UMB;
- Dell®: *PP11L* laptop display with a brightness setting of level 4 out of 6 (1=dim, 6=bright);
- Dell®: *PP11L* laptop display with a brightness setting of level 6 out of 6 (1=dim, 6=bright).

Both monitor displays were driven by a ATI® Radeon X300 video card. A script was run in Presentation® (experimental psychology software), to produce screens of various grayscale values (RGB-values where red, blue and green levels are equal) between {0, 0, 0} and {255, 255, 255}. This was done in a darkroom setting. Luminance values of these screens were measured with a Spectrascan® *pr650 photo research* luminance meter. Further, Wolfram Mathematica® was used to produce corresponding gamma values. Matlab® was used to

[4] Note that, in case of a value *gamma* = 1, this relationship is in fact linear.

perform the gamma correction on images of several faces that we will use in our follow-up experiments, (see for example fig.1 and Snell, 2012).

Figure 1. Still of an actor's face that will serve as a visual stimulus in future experiments.

2.2 Procedure

For each monitor display, a script was run to produce screens of grayscale values {0, 0, 0}, {20, 20, 20}, {40, 40, 40}, {60, 60, 60}, {80, 80, 80}, {100, 100, 100}, {115, 115, 115}, {120, 120, 120}, {124, 124, 124}, {127, 127, 127}, {130, 130, 130}, {135, 135, 135}, {140, 140, 140}, {155, 155, 155}, {175, 175, 175}, {195, 195, 195}, {215, 215, 215}, {235, 235, 235} and {255, 255, 255}. Further, screens of the separate colors *red*, *green* and *blue* were run, (for example, {40, 0, 0} produces a dim red screen). With each screen, the lens of the luminance meter was held directly against the centre of the display to avoid inconsistencies among trials. Two separate measurements were averaged for each screen.

The resulting series of data were fed into a designated code in Mathematica® to produce the corresponding gamma value, and this was repeated for each monitor display. The dataset of the two laptop display settings that allowed for the best fit, as suggested before, was taken to perform a gamma correction on aforementioned stimuli, using a designated script in Matlab®.

Results for the grayscale values are presented in the following section. Whereas gamma encoding on images with separate colors may have to be done some time, it is not so much relevant for the grayscale images (fig. 1) we will use in our follow-up experiments, and thus data on separate colors will be provided in the appendix.

3. Results

For the two laptop display settings at brightness levels 4 and 6, maximum luminance levels (that is, at a pixel level of 255) were measured to be 64.7 cd/m² and 136.0 cd/m² respectively.

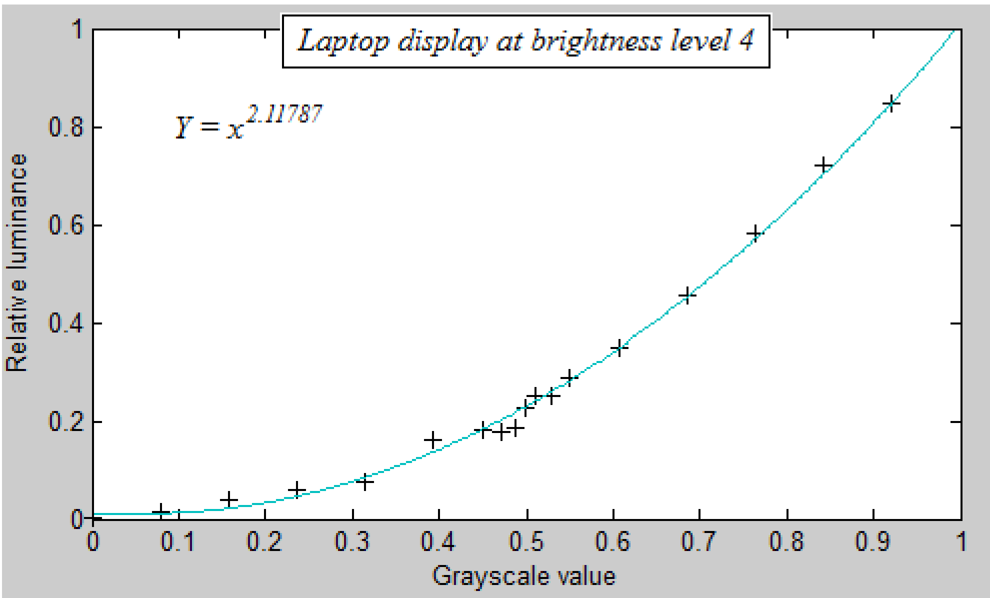

Figure 2 (a). Every '+' marks a dataset point, whereas the blue line represents the fitting equation with a gamma value of 2.11787.

Thus, Y was normalized to 1 by dividing luminance values by 64.7 and 136.0 in the two conditions. Similarly, grayscale values were divided by 255, so to retrieve the corresponding gamma values (see fig. 2a, 2b).

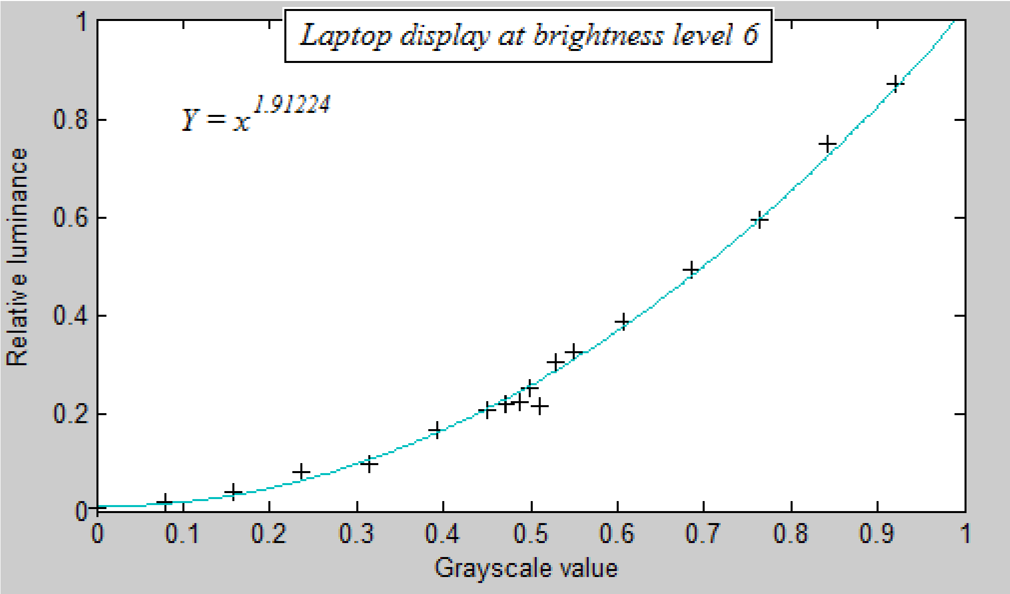

Figure 2 (b). Every '+' marks a dataset point, whereas the blue line represents the fitting equation with a gamma value of 1.91224.

The CRT display showed to emit very little light, as the maximum luminance level was measured at 8.96 cd/m². Dividing luminance values by 8.96 resulted in the graph below.

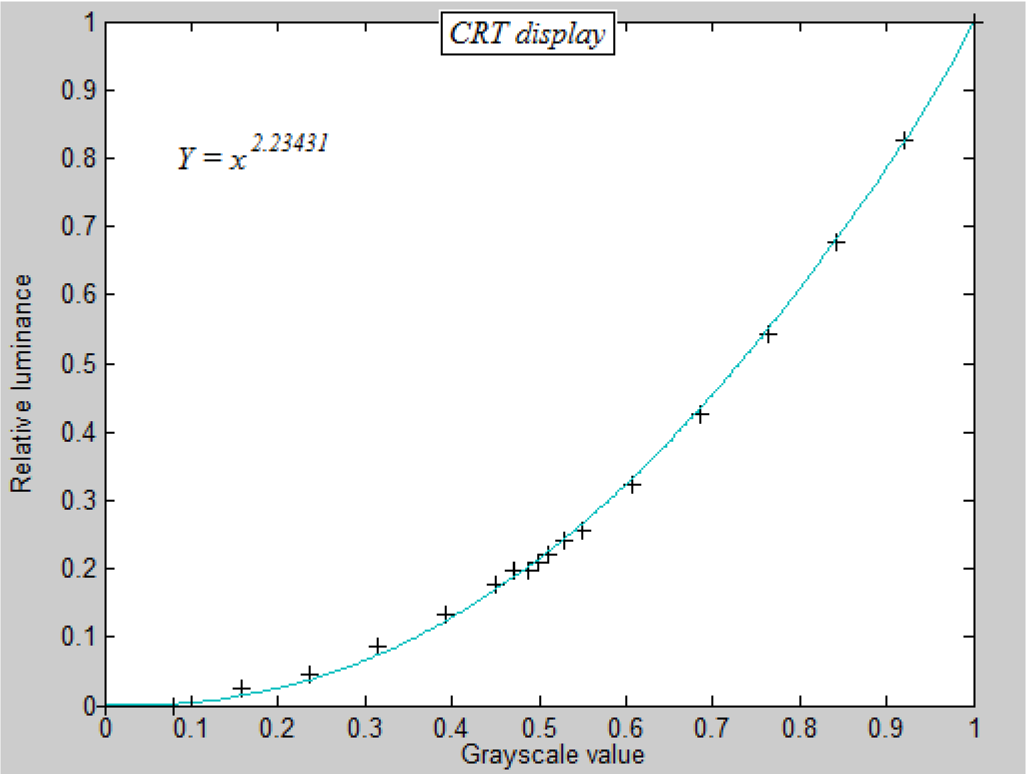

Figure 3. Every '+' marks a dataset point, whereas the blue line represents the fitting equation with a gamma value of 2.23431.

Table 1 below shows for each display the pixel levels (columns ii) that are required to produce luminance levels equal to what was originally meant to be produced by the old pixel levels (columns i). The final luminance levels (not normalized to 1, and true to the nature of the image) for every listed pixel level are shown in columns iii.

Laptop display, *brightness lv. 4*			***Laptop display,*** *brightness lv. 6*			***CRT monitor display***		
i	**ii**	**iii (cd/m²)**	**i**	**ii**	**iii (cd/m²)**	**i**	**ii**	**iii (cd/m²)**
0	0	0	0	0	0	0	0	0
20	76.6564	5.0745	20	67.3623	10.6667	20	81.6116	0.7027
40	106.3376	10.1490	40	96.7921	21.3333	40	111.2968	1.4055
60	128.7752	15.2235	60	119.6537	32.0000	60	133.4428	2.1082
80	147.5111	20.2980	80	139.0793	42.6667	80	151.7795	2.8110
100	163.9016	25.3725	100	156.2936	53.3333	100	167.7208	3.5137
115	175.0826	29.1784	115	168.1446	61.3333	115	178.5472	4.0408
120	178.6365	30.4471	120	171.9289	64.0000	120	181.9808	4.2165
124	181.4238	31.4620	124	174.9024	66.1333	124	184.6712	4.3570
127	183.4832	32.2231	127	177.1027	67.7333	127	186.6577	4.4624
130	185.5171	32.9843	130	179.2782	69.3333	130	188.6184	4.5678
135	188.8527	34.2529	135	182.8517	72.0000	135	191.8314	4.7435
140	192.1236	35.5216	140	186.3625	74.6667	140	194.9794	4.9192
155	201.5823	39.3275	155	196.5507	82.6667	155	204.0670	5.4463
175	213.4710	44.4020	175	209.4292	93.3333	175	215.4578	6.1490
195	224.6619	49.4765	195	221.6226	104.0000	195	226.1499	6.8518
215	235.2618	54.5510	215	233.2324	114.6667	215	236.2516	7.5545
235	245.3529	59.6255	235	244.3375	125.3333	235	245.8465	8.2573
255	255.0000	64.7000	255	255.0000	136.0000	255	255.0000	8.9600

Table 1. For every initial RGB value (columns i), the corrected RGB value is listed (columns ii), so to realize the luminance levels (columns iii) that were originally meant to be produced by the old RGB values.

4. Discussion

In choosing between the two laptop display settings for follow-up experiments, it must be noted that the 100% brightness setting comes with the disadvantage of skyrocketing luminance values at higher pixel levels. Meanwhile, the 67% brightness setting showed to have a stronger exponential form, allowing for a more accurate fit and correction. Hence, this setting was chosen for our follow-up experiments, and the original pixel levels were adjusted as follows: *Xnew* = *Xold* ^ (1 / 2.11787), (for an example, see fig. 4 below).

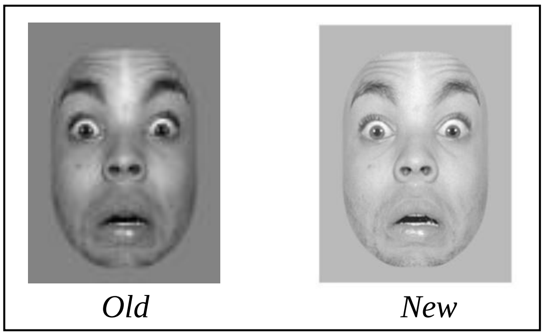

Figure 4. Before and after the gamma correction, at a gamma value of 2.11787. Note that the black regions of the image stay black after the correction; thus, only middle tones change, as opposed to when a mere brightness adjustment would have been performed.

5. References

Koren, N. (2012). *Making fine prints in your digital darkroom: monitor calibration and gamma*. Webpage, consulted at http://www.normankoren.com/makingfineprints1A.html, date 19-08-2012 *(dd-mm-yyyy)*.

Poynton, C.A. (2003). *Digital Video and HDTV: Algorithms and Interfaces*. Morgan Kaufmann. pp. 260, 630.

Snell, J.J. (2012). *Measurement of a Sense of Trustworthiness in Faces Using a Visual Analogue Scale*. (unpublished).

6. Appendix

Laptop, red, *brightness lv. 4*			***Laptop, green,*** *brightness lv. 4*			***Laptop, blue,*** *brightness lv. 4*		
i	**ii**	**iii (cd/m²)**	**i**	**ii**	**iii (cd/m²)**	**i**	**ii**	**iii (cd/m²)**
0	0	0	0	0	0	0	0	0
20	85.0076	1.2863	20	89.0924	3.1137	20	70.0430	0.7576
40	114.6481	2.5725	40	118.6314	6.2275	40	99.5801	1.5153
60	136.5712	3.8588	60	140.2636	9.3412	60	122.3374	2.2729
80	154.6238	5.1451	80	157.9642	12.4549	80	141.5730	3.0306
100	170.2542	6.4314	100	173.2182	15.5686	100	158.5527	3.7882
120	184.1910	7.7176	120	186.7688	18.6824	120	173.9271	4.5459
127	188.7532	8.1678	127	191.1948	19.7722	127	179.0054	4.8111
135	193.7954	8.6824	135	196.0812	21.0176	135	184.6431	5.1141
155	205.7006	9.9686	155	207.5974	24.1314	155	198.0565	5.8718
175	216.7609	11.2549	175	218.2707	27.2451	175	210.6414	6.6294
195	227.1236	12.5412	195	228.2498	30.3588	195	222.5359	7.3871
215	236.8981	13.8275	215	237.6445	33.4725	215	233.8433	8.1447
235	246.1683	15.1137	235	246.5393	36.5863	235	244.6436	8.9024
255	255.0000	16.4000	255	255.0000	39.7000	255	255.0000	9.6600
2.31723			**2.42065**			**1.96999**		

Table i. For every initial color value (columns i), the corrected color value is listed (columns ii), so to realize the luminance levels (columns iii) that were originally meant to be produced by the old color values. The gamma value for each color is listed at the bottom of the table.

Laptop, red, *brightness lv. 6*			***Laptop, green,*** *brightness lv. 6*			***Laptop, blue,*** *brightness lv. 6*		
i	**ii**	**iii (cd/m²)**	**i**	**ii**	**iii (cd/m²)**	**i**	**ii**	**iii (cd/m²)**
0	0	0	0	0	0	0	0	0
20	82.9429	2.6431	20	84.3247	6.4549	20	63.7994	1.5529
40	112.6150	5.2863	40	113.9772	12.9098	40	93.0392	3.1059
60	134.6757	7.9294	60	135.9465	19.3647	60	116.0143	4.6588
80	152.9021	10.5725	80	154.0569	25.8196	80	135.6797	6.2118
100	168.7217	13.2157	100	169.7500	32.2745	100	153.2013	7.7647
120	182.8549	15.8588	120	183.7516	38.7294	120	169.1845	9.3176
127	187.4866	16.7839	127	188.3368	40.9886	127	174.4867	9.8612
135	192.6085	17.8412	135	193.4052	43.5706	135	180.3859	10.4824
155	204.7138	20.4843	155	205.3763	50.0255	155	194.4729	12.0353
175	215.9741	23.1275	175	216.5024	56.4804	175	207.7528	13.5882
195	226.5358	25.7706	195	226.9306	62.9353	195	220.3570	15.1412
215	236.5080	28.4137	215	236.7701	69.3902	215	232.3844	16.6941
235	245.9742	31.0569	235	246.1046	75.8451	235	243.9118	18.2471
255	255.0000	33.7000	255	255.0000	82.3000	255	255.0000	19.8000
2.2665			**2.30034**			**1.83724**		

Table ii. For every initial color value (columns i), the corrected color value is listed (columns ii), so to realize the luminance levels (columns iii) that were originally meant to be produced by the old color values. The gamma value for each color is listed at the bottom of the table.

CRT, red			***CRT, green***			***CRT, blue***		
i	**ii**	**iii (cd/m²)**	**i**	**ii**	**iii (cd/m²)**	**i**	**ii**	**iii (cd/m²)**
0	0	0	0	0	0	0	0	0
20	21.8481	0.0165	20	82.0875	0.3396	20	50.1994	0.0392
40	42.6572	0.0329	40	111.7686	0.6792	40	78.1446	0.0784
60	63.0913	0.0494	60	133.8845	1.0188	60	101.2346	0.1176
80	83.2857	0.0659	80	152.1819	1.3584	80	121.6464	0.1569
100	103.3036	0.0824	100	168.0797	1.6980	100	140.2730	0.1961
120	123.1821	0.0988	120	182.2944	2.0376	120	157.5903	0.2353
127	130.1113	0.1046	127	186.9551	2.1565	127	163.3993	0.2490
135	138.0143	0.1112	135	192.1103	2.2924	135	169.8983	0.2647
155	157.7025	0.1276	155	204.2991	2.6320	155	185.5651	0.3039
175	177.3026	0.1441	175	215.6432	2.9716	175	200.5155	0.3431
195	196.8248	0.1606	195	226.2885	3.3112	195	214.8593	0.3824
215	216.2775	0.1771	215	236.3437	3.6508	215	228.6799	0.4216
235	235.6674	0.1935	235	245.8923	3.9904	235	242.0427	0.4608
255	255.0000	0.2100	255	255.0000	4.3300	255	255.0000	0.5000
1.03597			**2.24577**			**1.56623**		

Table iii. For every initial color value (columns i), the corrected color value is listed (columns ii), so to realize the luminance levels (columns iii) that were originally meant to be produced by the old color values. The gamma value for each color is listed at the bottom of the table.

Research Proposal EMG measurement

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Research Proposal EMG Measurement

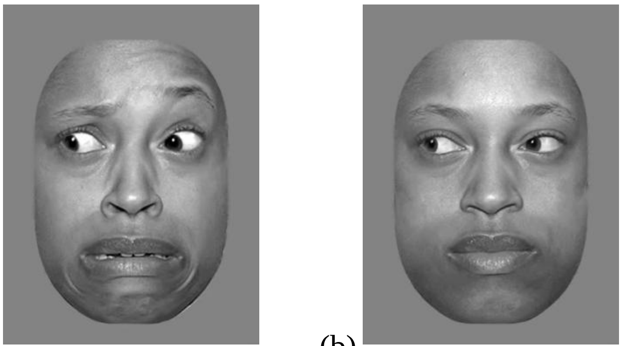
1. Introduction

One aspect of our research involves the effect of visual *emotional* information on multisensory integration and cross-modal attentional cueing. Typically, (visual) perception and recognition of emotions may induce mimicry in the facial musculature of the observer to a certain degree, evidencing the processing of social and emotional information (Hess *et al.* 1999). However, the amount of muscular activity involved tends to be slight, and this mimicry may in fact happen unconsciously most of the time (Dimberg *et al.* 2000).

A way of inquiring this mimicry, therefore, is to measure the slight facial muscular activity in a way reminiscent of how brain activity is measured in electro-encephalography (abbr. EEG) research; the former technique is thus coined *electromyography*. This report outlines some of the considerations that were involved in our setup of this electromyography (abbr. EMG) measurement.

2. Hypotheses

Emotional processing may affect the way persons integrate visual and tactile information. In a setup where cues of these two perceptual modalities are incongruent, emotional involvement with the visual cue may cause a lower response speed for the tactile target detection. A cue that may trigger emotional processing as such can be visualized by a dynamic stimulus of a face that looks in either one direction and that appears fear struck (fig. 1a).



(a) (b)

Figure 1. A stimulus that provides both a directional cue and emotional information (a), compared to a stimulus that provides only a directional cue (b).

Certain task experiments may reveal how much attention is allocated by participants to each of the two modalities of vision and touch, and those results may also be reflected by the extent to which participants convey mimicry of emotions in visual stimuli. On a more basic level, it can be hypothesized that cues with an emotional expression generate different results than cues with a rather neutral expression (fig. 1b); typically, participants that convey more mimicry may show bigger differences between the two conditions (de Jong 2008).

3. EMG research characteristics and setup

EMG activity in the facial musculature has long been linked to emotional processing (Fridlund and Cacioppo 1986); for example, the *lateral frontalis* muscle just above the eyebrow is said to show activity when conveying a fearful expression. However, while specific emotional expressions may be linked to the involvement of specific muscles, it is difficult to link specific muscles and thus specific emotions to the EMG activity that is actually registered.

This problem originates in the fact that the EMG method, like EEG, typically has a low spatial resolution. As a result, Fridlund and Cacioppo have suggested to discern various EMG area's (e.g. forehead-site EMG) rather than specific muscles (e.g. lateral frontalis EMG). They further note that "despite the burgeoning literature using facial EMG to measure mood and emotion, no EMG site 'atlas' has been available for the facial musculature" (1986).

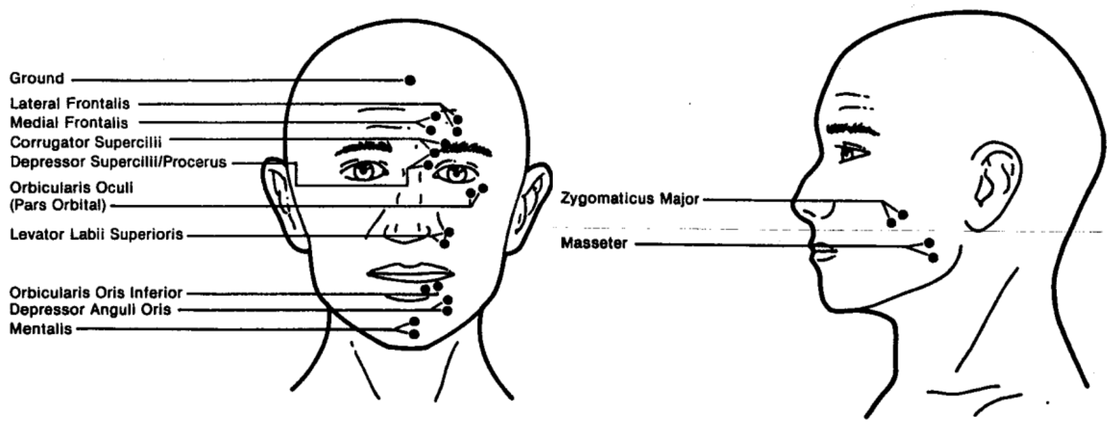


Figure 2. EMG sites that are to this day discerned in EMG research. A *pair* of electrodes is appointed to each of the listed sites (lest the *ground*), and the orientation of each pair is said to be of particular importance. (Derived from Fridlund and Cacioppo, 1986).

There are muscle sites where useful data may be registered, provided that pairs of electrodes are oriented accordingly (fig. 2). However, changes in potential in the lateral frontalis, for example, are not always a guarantee for the emotional characteristics it is traditionally linked to, such as fear, stress and tension (Burish and Horn 1979; Alexander and Smith 1979). A bilateral forehead EMG site is tuned especially to the frontales, but it may also register activity from other areas of the head and the neck. In this light, even a smile of the participant, or an urge to smile, could lead to an incorrect image of fear or anxiety when the registered activity is interpreted in a wrong way. In our experimental setting, such a situation might occur when the stimulus (fig. 1a) happens to amuse a participant rather than to cause a mimicry of the expression.

A possible solution may be to measure the zygomaticus major (fig. 2) in addition to the lateral frontalis, and see how the two sites relate to each other in terms of activity. When activity around the frontalis is accompanied by significant activity around the zygomaticus major (the latter muscle being involved in smiling, notably), activity in the former muscle may perhaps be disregarded as a trace of fearful expression mimicry. Contrariwise, when no significant activity in the zygomaticus major is registered, chances are greater that the activity measured around the frontalis is 'pure', and thus that the participant mimicked a fearful expression.

At the same time, we may find that the lateral frontalis site reveals a positive change in potential during a smile, whereas it shows a negative change in potential in case of (mimicry of) a fearful expression. A similar distinction was made by Sato *et al.* between mimicry of happy and sad faces: whereas the zygomaticus major showed a positive potential change with the former and a negative potential change with the latter, for the *corrugator supercilii* (see fig. 2) it was just the other way around (2008). Such a distinction is yet to be found for the fearful expression relevant in our experiment, however.

In short, we may be able to accurately record the degree of mimicry of participants by measuring both the lateral frontalis and the zygomaticus major and see how these regions relate to each other in terms of activity. We may also find a useful distinction between the causes of positive and negative changes in potential, but this too has to be confirmed by carefully viewing activity in the two muscle sites in relation to each other.

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