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## THE MEASUREMENT OF EMOTION INTENSITY: A PSYCHOPHYSICAL APPROACH\*

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### Abstract

*Despite its phenomenal salience, the intensity of emotions remains a neglected issue of emotion research. The very notion has long been shown subtle and elusive, never precisely matched by physiological arousal or, on the subjective side, by the activation dimension so common among emotion space models. This paper argues in favor of reframing the whole matter into a psychophysical measurement approach. An experiment focusing on emotion words related to seven basic discrete emotions is reported, that relies on a cross-modal matching paradigm to check the validity and quantitative properties of the scaling achieved. Considerations that put the method's contribution in perspective are also offered.*

A surprising feature of emotion studies is the enduring neglect of intensity issues. As underlined by Frijda et. al. (1992), the fact is all the more surprising as it contends with the well-acknowledge relevance of felt intensity to the overall experience of emotion. Moreover, it also collides with the central role assigned to an intensity component, on more or less a priori grounds, by several influential theories of emotions (Plutchick, 1982; Reisenzein, 1994). Two severe consequences of this neglect are (1) the risk of a widespread confounding of intensity effects all across the field of emotion studies (see Levenson, 1988, for a description of the problem within the scope of ANS physiological research on emotions) and (2) the constraints imposed by resorting to an unmeasured independent variable, whenever the subject matter turns out to be the impact of emotions on other variables.

The experiment here reported was meant as a first exploratory step towards a quantified approach of emotion intensity. Focusing on emotion words, it asks the following question: Can subjects validly and consistently rate overall intensity of a given expressed emotion? This question serves two functions: (1) it addresses the meaningfulness of the very concept of expressed overall emotional intensity, hereby recasted as a measurement problem, and (2) it embodies the view that the measurement of overall intensity stands as an empirical issue to be addressed on its own right, not to be dismissed by a priori assumptions regarding the «loose» multidimensionality of emotions.

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The method employed is a cross-modal matching paradigm drawing on the extension of direct psychophysics to the scaling of social consensus (Stevens, 1975). Since little doubt remains about the existence of multiple determinants of emotion intensity (Sonnemans, 1991), any general, multi-purpose, quantified approach must come to grips with the problem of their integration, which Steven's framework, being one-dimensional, is unfitted to do. We should be remindful, however, of Stevens's view of judgment as the outcome of a goal directed abstractive process, operating on stimuli never to be considered one-dimensional -- his "goal" calling upon, in a sense, the machinery of "cognitive algebra" from Anderson's psychophysics (Ward, 1992). Three specific aims of the experiment can thus be stated: (1) to psychophysically validate the scaling obtained, (2) to assess the properties of the evaluative continua within the prothetic-metathetic rationale (3) to obtain sensible indications that pave the way for further multidimensional approaches, resorting to distinct methodologies.

### Method

21 college students from the University of S. Paulo, Ribeirão Preto, aged between 18 and 31 years old and all of them naïve regarding the matters under scrutiny, participated in this experiment.

Seven Lexical Scales of Emotion Intensity (LSEI) were used, relating to seven discrete basic emotions. Most of the selected emotion categories stem from the influential framework outlined by P. Ekman (1992): fear, happiness(joy), sadness, anger, disgust, surprise. To this nuclear set love was added, since it has been extensively promoted as a basic emotion within the realm of prototype approaches (Fehr and Russell, 1991). All scales were built on purpose for the experiment, using words collected from two sources: (1) published work on english affective vocabulary (Shaver et al, 1987; Frijda et al., 1992), and 2) a selection of emotional terms from a reference dictionary of portuguese language from Brazil. Each word was rated for familiarity and for the degree to which it represents a given emotion on a seven-point scale by a sample of 37 brasilian subjects. Criteria for keeping words were a median punctuation value above 3,5 on both attributes (a further appreciation of semi-interquartil range was shown to be of no consequence). As a final result, 20 words were kept for Fear, 20 for Joy/Happiness, 12 for Surprise, 17 for Disgust, 20 for Anger, 20 for Sadness and 20 for Love. Besides the lexical scales, other item materials included a metric tape for line length production, instruction sheets and response registration sheets.

Three psychophysical methods were used in the experiment: category estimation on a seven-point scale, numeric magnitude estimation (NE) and cross modal matching to line length responses (LLR). The attribute under evaluation was overall emotion intensity as expressed by words. The ordering of the methods was evenly balanced over subjects. To counter fatigue effects, each subject was asked to scale only three of the seven LEIS, assigned to subjects through a partial counterbalancement procedure. All words were randomly presented, and were entitled to a sole judgment from each subject. No modulus was provided for any of the psychophysical tasks. This choice was intended (1) to enable greater closeness to the daily task of judging emotion expressions (that is, better ecological validity) and (2) to prevent distortions arising from arbitrarily assigned standard stimuli. Judgments were then adjusted according to the procedure presented in Lane, Catania and Stevens (1961), that allows for an even contribution of all judgments to determine a common modulus. Before running the experimental phase, a calibration procedure was undertaken, during which subjects made numerical estimates of six line lengths and also line length matching to six numeric magnitudes, within a balanced design. Exponents have been derived for both methods and used to check performance adequacy and subjects understanding of instructions.

## Results

The first body of results concerns the psychophysical validation of the scaling of emotion intensity. The rationale behind the validation rests on the transitivity properties of cross matching functions. It follows from there that the exponent obtained by matching any two modalities should hold if they are to be indirectly matched through a third one enabling valid ratio scaling of whatever is under judgment. The key empirical issue is thus how close the exponents obtained by indirectly matching NE and LLR through judgments of emotion intensity stand to 1, the characteristic ratio between these two response measures.

Graphic plots of the regression of NE on LLR and of LLR on NE were obtained for each emotion, on log coordinates. A linear model fit was shown highly significant for all the emotion categories except surprise (Sign.F (1,10) = 0,039). The two slopes (exponents) derived were geometrically averaged before comparing to the expected value of 1. The outcomes of these comparisons, undertaken for all emotions, are summarized in Table 1.

Table 1. Comparisons of the geometric mean of the two regression coefficients (for NE on LLR and for LLR on NE) to the theoretical predicted exponent (= 1)

	Fear	Anger	Sadness	Happiness	Love	Disgust	Surprise
G.Mean Slopes	0,912	0,903	0,74	0,862	0,893	0,824	0,60
t	< 1	< 1	2,6478*	< 1	< 1	1,1856	1,57909
Signif t (one-tailed)	Nonsig.	Nonsig.	*Sign. at 0,05	Nonsig.	Nonsig.	Nonsig.	Nonsig.
Power for a 0,05 difference	> 80%	> 80%	>80% (86%)	< 80%	< 80%	< 80%	< 80% (22%)
Power for a 0,10 difference	> 80%	> 80%	> 80%	> 80%	> 80%	> 80%	< 80% (54%)

With few exceptions, all regression coefficients scored below 1, showing evidence for some regression effect, more pronounced for LLR than for NE. This pattern is in good accordance to what had been observed during the calibration phase, with both exponents falling below 1 and NE achieving the highest value (0,871), a suggestion that biases are operating in essentially the same manner on both phases. Care should be taken with the comparison outcome for surprise, obviously due to inadequate power.

A reasonable agreement between the outcomes of the two response methods was also apparent through the analysis of rang covariation of their estimates, with the Kendall's tau b reaching high significance for all emotions but one (Surprise: p = 0,170).

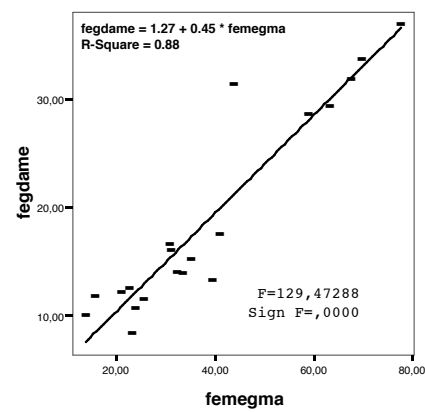
Table 2. Mean Kendall's coefficient (tau b) between NE and LLR for each emotion category

Fear	Anger	Sadness	Happiness	Love	Disgust	Surprise
0,811**	0,755**	0,726**	0,637**	0,632**	0,721**	0,303

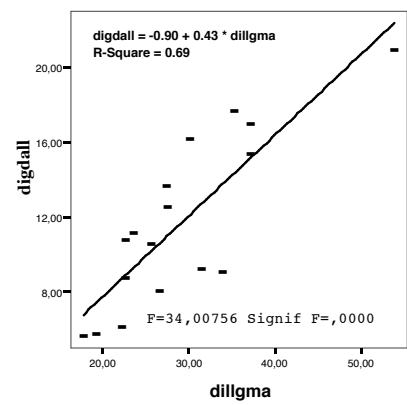
\*\* Correlation is significant at the 0,01 level (2-tailed)

Inquiry over the properties of the continua under study relies on the extension of some functional relations holding for well-known prothetic continua to the realm of nonmetric stimuli. The two relations here considered are Ekman's Law – standing for the linear growth of subjective variability as a function of subjective magnitude – and the curved shaped relation, concave downwards, that typically arises when category estimates are plotted as a

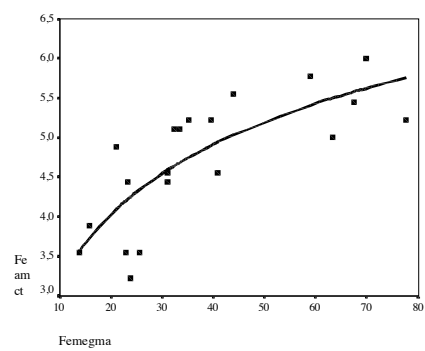
function of magnitude estimates. Figs. 1 and 2 illustrate Ekman’s Law for Fear (NE) and Disgust (LLR) respectively. With the exception of Surprise, where data could no be significantly fitted by a linear model (NE: Sign.F = 0,427; LLR: Sign.F = 0,333) the same pattern occurred for all other emotion categories, both with NE and with LLR responses.



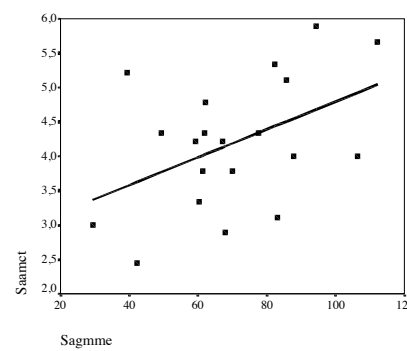
**Figure 1.** Ekman’s Law for Fear (NE)



**Figure 2.** Ekman’s Law for Disgust (LLR)



**Figure 3.** Logarithmic best fit between NE (G.Mean) and category estimates for Fear



**Figure 4.** Linear best fit between NE (G.Mean) and category estimates for Sadness

Fig. 3 shows the plot of the NE response method (geometric means) against the category estimates of conveyed intensity (arithmetic means) for Fear. It exhibits the typical bowed shape concave downward with a logarithmic best fit (Sign.F = 0,000), and could therefore be taken as evidence for prothetic behavior (also obtained with LLR). Fig. 4 presents an

identical plot for Sadness (NE), well adjusted by a linear model ( $\text{Sign.F} = 0,04$ ) and thus suggestive of a methatetic continuum. Most of the scatters obtained for the different emotions were of this last kind, adjustable whether by linear or by slightly exponential curves. Happiness was best adjusted by a power function, either for NE or LLR, with an exponent below 1, therefore showing some tendency for the typical downward bowed shape, however hardly distinguishable from a linear relation.

These results, somehow inconsistent with those stemming from Ekman's law, should be looked upon reservation, given the unusual pattern of variability exhibited by the category estimates. This could suggest that biases are present in the method, eventually arising from range and spacing constraints of the stimuli sets.

### **Final discussion**

Taken altogether, the exponents obtained by the indirect cross matching of numeric estimates and line length responses through judgments of overall emotion intensity gave general support to the internal validity of the scaling achieved. Even if caution is in order, this might point to the advantages of addressing the overarching notion of emotion intensity over focusing on more fragmentary attributes like physiological or subjective activation. Also, the empirical mismatch between these last three constructs could perhaps be reassembled into a coherent scenario by assigning to overall intensity an integrative role over its multiple contributing sources. No pattern of differences arose on the basis of opposite valenced emotions: surprise, sadness and disgust, in that order, had the worst fits to the theoretical exponent, while fear presented the best fit, followed by anger.

As for the properties of the evaluative continua, results were not as neat. Almost every emotion (exception made for surprise) showed to obey Ekman's law on both psychophysical tasks (NE and LLR), thus favoring the idea of a prothetic nature of the continua but, with few exceptions, the plots of the arithmetic means of category estimates as a function of the geometric means of NE and LLR failed to exhibit the curved relation with concavity downward that makes the "signature" for prothetic variables. Meanwhile, the unusual pattern of variability associated with the category estimates suggests that the problem may be springing from biases in the rating method. This is not entirely unexpected, given the susceptibility of category scales to the effects of range and spacing of the stimuli, on the one side, and the little information available on the constraints imposed by the chosen stimuli sets, on the other. Under reservation, then, the compliance to Ekman's principle is to be valued above the inconsistencies found. Another possibility deserving consideration is that the scaling for some emotions be found prothetic within a range and methatetic when falling out of it. As a matter of fact, for sadness and disgust, the relation between magnitude and category scales could be reasonably well approached by cubic functions with a concavity downward along part of its course. Further examination of these issues cannot be sensibly undertaken without a better understanding of the potential heterogeneity present in the stimuli, and of its spacing and range properties.

Among the set of emotions considered, fear has shown a remarkably consistent prothetic profile, with a most definite logarithmic relation between the category and both magnitude scales (NE and LLR). It would of course be more than premature to even think of tracing back this patterned behavior regarding intensity to the privilege accorded to fear as a "natural kind" of emotion, resting on a somehow specific neurological circuitry, and provided with definite evolutionary meaning (Panksepp, 2000). It is nevertheless an occasion to remind that such kind of suggestions have indeed been made, for instance, by Plutchik, who thought of patterned intensity profile as a mandatory criterion for primary emotions. Thought it remains entirely speculative, an exciting prospect would be that intensity measurement scaling might substantively contribute to the intrinsic characterization of basic emotions.

Finally, two obvious shortcomings of the experiment must be noticed: (1) it is limited to words, leaving as an open issue the degree to which these findings generalize to other stimuli materials; (2) most of all, it is exclusively concerned with the scaling of outer sources of emotion expressions, not of felt emotion intensity. This is no doubt the biggest challenge to be faced by future work, offering a severe testing ground for the presumed integrative role of overall intensity, and allowing for the direct manipulation of its contributing sources.

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