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Homogenization of Classification Functions Measurement (HOCFUN): A Method for Measuring the Salience of Emotional Arousal in Thinking

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The problem of the measurement of emotion is a widely debated one. In this article we propose an instrument, the Homogenization of Classification Functions Measure (HOCFUN), designed for assessing the influence of emotional arousal on a rating task consisting of the evaluation of a sequence of images. The instrument defines an indicator (κ) that measures the degree of homogenization of the ratings given over 2 rating scales (pleasant–unpleasant and relevant–irrelevant). Such a degree of homogenization is interpreted as the effect of emotional arousal on thinking and therefore lends itself to be used as a marker of emotional arousal. A preliminary study of validation was implemented. The association of the κ indicator with 3 additional indicators was analyzed. Consistent with the hypotheses, the κ indicator proved to be associated, even if weakly and nonlinearly, with a marker of the homogenization of classification functions derived from a separate rating task and with 2 indirect indicators of emotional activation: the speed of performance on the HOCFUN task and an indicator of mood intensity. Taken as a whole, such results provide initial evidence supporting the HOCFUN construct validity.

The objective measurement of emotional arousal is an extremely important task. Its importance is twofold because not only could it offer a practical instrument for the evaluation of emotional involvement in situ, which could be useful in various fields, such as marketing (Poels & Dewitte, 2006), nursing (Brotheridge & Grandey, 2002), and even computer science (Ahmad, 2011), but it would also be useful in the development of an empirically grounded theory of emotion. A sign of the difficulty of this task is the variety of theoretical models and of procedures used to accomplish it. These modes differ greatly in *what* is to be measured as well as in *how* to measure it.

The diverse approaches to the measurement of emotional arousal are based on how emotion is conceptualized. An area of the literature focuses on the state of peripheral activation, which can be measured, for example, through electrodermal conductance (Khalfa, Isabelle, Jean-Pierre, & Manon, 2002) or heartbeat frequency or electrocardiography (Agrafioti, Hatzinakos, & Anderson, 2012). Other theories take the activation patterns of the central nervous system as the object of analysis (Buck, 1999; Izard, 1991; Panksepp, 2004), as mapped, for instance, by the electroencephalogram (Bekkedal, Rossi, & Panksepp, 2011) or functional magnetic resonance imaging (Posner et al., 2009).

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However, regardless of their validity (for a critical discussion, see Feldman Barrett, 2006), these methods are usually not easy to apply because they generally require nontrivial instrumental devices, technical skills, and controlled conditions to be carried out. For this reason, several methods have focused on the phenomenological subjective experience, assessed usually using verbal (Crawford & Henry, 2004) or nonverbal (Bradley & Lang, 1994) self-rating questionnaires. However, the validity of self-report methods is jeopardized by people's limited capability in detecting their own inner state in a reliable way (Feldman Barrett, 2006; Nisbett & De Camp Wilson, 1977), as shown by the low level of association between psychophysiological measures and self-reports (Mauss & Robinson, 2009).

Indirect behavioral measures have been developed to overcome the limit of self-reports. Many aspects of overt behavior have been proposed, including vocal characteristics such as fundamental frequency (Protopapas & Lieberman, 1997) or speech rate (Ververidis & Kotropoulos, 2006), facial expressions (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005), and whole-body posture (Coulson, 2004). The methodological assumption of this kind of measure is that emotional arousal triggers the behavioral response, and therefore the latter can act as the marker of (one or more characteristics of) the former.

This article presents a new method for emotion measurement, the Homogenization of Classification Functions Measurement (HOCFUN), based on the assumption presented earlier. By considering the act of expressing evaluations as a behavioral fact, HOCFUN focuses on the evaluation of objects as the indirect behavioral marker of emotional arousal. The evaluation of objects is a procedure widely used in psychology, in many cases for detecting processes considered to be somehow related to emotional arousal. For instance, the evaluations of objects on semantic differential bipolar scales (Osgood, Suci, & Tannenbaum, 1957) are treated and interpreted as the expression of affectively charged connotations. On the other hand, whereas methods of this kind generally focus on the content of the evaluation, HOCFUN focuses on the (intraindividual) structure of the rating responses. Because the participant is not aware and does not intentionally control the structure of ratings, the latter lends itself to be used as an indirect behavioral marker, which means it can be considered as a set of acts that, regardless of the actor's aim, is affected by (and therefore keeps track of) the process to be detected, in this case emotional arousal.

In what follows the HOCFUN theoretical framework is presented, so as to specify which aspect of the structure of ratings we consider as an indirect marker of emotional arousal and why. After that, a description of the HOCFUN device and procedure is provided, together with the results of a first study providing initial evidence supporting its construct validity.

Homogenization of Classification Functions Measurement (HOCFUN)

THEORETICAL FRAMEWORK: THE SYSTEMATIC INVOLVEMENT OF EMOTIONAL PROCESSES IN THINKING.

HOCFUN considers the rating responses as the manifest output of the thinking process that underpins the evaluation of objects. According to the theoretical framework grounding the HOCFUN, the rating responses (more specifically, their structure) trace the extent to which the thinking process of evaluation is affected by emotional arousal. Thus, HOCFUN has been designed as an indirect measure of emotional arousal capable of measuring the latter in terms of the size of the effect that emotional arousal produces on thinking (more specifically on the evaluation of objects).

This view is consistent with the models of emotion that highlight the role emotional processes play in cognition. The Emotional Response Categorisation Theory (ERCT; Niedenthal, Halberstadt, & Innes-Ker, 1999) is an instance of this kind of approach. According to the ERCT, people tend to create categories of objects on the basis of the object's emotional coloring: Things that evoke or have evoked the same emotion are categorized in the same homogeneous category. The homogeneity of the category implies that every item included in a given category is considered to be equivalent to every other item contained in the same category: "Things that have evoked fear, for example, may be categorized together and may be treated as the same kind of thing, even when they are otherwise perceptually, functionally, and theoretically diverse" (Niedenthal et al., 1999, p. 338). In sum, the ERCT shows that emotions play a cognitive role, working as a criterion involved in the definition of the mental categorical relationships between objects.

It is remarkable that several other theories from different fields converge on the idea that the emotional process[1] has a systematic influence on thinking rather than just being an effect of it. Theories moving within the frame of embodied cognition (Ziemke, Zlatev, & Frank, 2007) stress that the body is not the mere container of cognition but is the content as well as the measure of thinking. In other words, on one hand, the symbolic content of cognitive processes consists of the mapping of the ongoing bodily modifications (Damasio, 1999); we *are,* rather than we *have,* representation (Baerveldt & Verheggen, 2012, p. 283). On the other hand, emotional process, together with motor process, provides forms of presemantic categorization, grounding and channeling cognitive processes: "Motor and emotional simulation have therefore proved to be excellent candidates for establishing a basic level of categorization of reality, which presents an adaptive advantage, in that it allows us to establish a functional relation with the world and an empathetic relationship with other individuals" (Garbarini & Adenzato, 2004, p. 105). Several scholars in the field of social representations (Jodelet, 1991; Markova, 1982; Moscovici, 2000; Sammut, Daanen, & Sartawi, 2010) have shown that the emotional valence of representations is a fundamental part of the knowledge system; it plays a central role in regulating the relationship with the object represented. Cultural psychology emphasizes that the human activity of interpreting experience entails the immediate activation of affective generalized meanings, which only later undergo the process of abstraction and discriminative elaboration (Valsiner, 2007). The idea that the emotional process is characteristic of a specific way of mental functioning is widespread in the psychoanalytic field (Bucci, 1997, 2001; Freud, 1900/1953; Matte Blanco, 1975; Salvatore & Freda, 2011), where it is considered in terms of affects (Stein, 1991; Salvatore & Freda, 2011) and recognized as the precipitate of a distinctive way of functioning of the mind (*primary process* in psychoanalytic terminology), different from but no less systematic than rational thought (Brakel, 2004; Brakel & Shevrin, 2003; Vanheule et al., 2011).

Taken together, the theoretical standpoints mentioned earlier outline a view of the emotional process as systematically present and intertwined with the mind's normal everyday functioning. The emotional process is not an obstacle on the road of thinking; rather, it is involved in the mechanics of thought, an ingredient of thinking that contributes to the shaping of its functioning. Consequently, one is led to conclude that the emotional processes may be detected not only in their dimension as an effect but also in their being a causative factor of thinking. According to this perspective, the basic aim of measuring emotional arousal can be extended to include the assessment of the effect of emotional processes on thinking.

HOCFUN RATIONALE.

The HOCFUN rationale starts from the central issue highlighted by the ERCT. When people think, they do not use only conceptual classes, namely classes whose specimens are related by semantic linkages, but asemantic classes as well, namely, the classes defined by emotional linkages between their specimens (e.g., the class of objects evoking fear). These emotional classes are asemantic in the sense that each of them works as a classification function on the basis of which objects are homogenized, that is, treated as equivalent, regardless of their conceptual content.

However, there is phenomenal evidence that leads to an enlargement of such a view. Indeed, the emotional class does not consist solely of a set of objects that are homogenized according to a certain classification function (e.g., objects considered specimens of the class of fearful objects); rather, it consists of the homogenization of an infinite number of classification functions (e.g., "good," "smart," "honest," "emphatic") that are rendered the same as each other and in so doing merged in a single generalized set that could not be justified from the semantic standpoint.

The homogenization of classification functions is already present in Plato, who based part of his philosophy on the assumption that what is beautiful cannot but be good and vice versa. The Greek philosopher himself thus brought together and homogenized two classification functions in a single word, the ancient Greek term *Kalokagathia* ("beautiful and good").

Many signs of the homogenization of classification functions (in the terms described earlier) can be found in everyday life in its association with circumstances of emotional activation. Take the emotional reaction one may have when approached by an unknown man who looks dirty and badly dressed; one is easily led to consider him dishonest and possibly dangerous. He is classified in the category of the "negative" objects, but the classification function itself is generalized and extended to other negative classification functions (CFs): x is CF_1 (badly dressed) and therefore also CF_2 (dishonest), CF_3 (dangerous), and so forth. Not by chance, in fact, several proverbs warn us about the risk of such a mechanism of homogenization (e.g. "clothes don't make the man" or "don't judge a book by its cover" or "the habit does not make the monk") (see Langlois et al., 2000).

Quite often, despite our belief that we are rational beings, we are affected to some degree, generally unawares, by this phenomenon (Dion, Berscheid, & Walster, 1972). Thus, we tend to avoid a can of tomatoes with a tarnished label even when we know perfectly well that the content is in all likelihood identical to that in the other cans, or we tend to consider a clean or powerful car safer. The homogenization of classification functions is particularly apparent in a person in love, to whom the beloved one is, like Descartes' god, the sum of all perfections, each of them to the highest degree. The homogenization of the classification function is a fundamental and well-known phenomenon also in the field of advertising. It can be found, for instance, in the often-suggested connection between good smell, brightness, and cleanliness. In advertisements we often hear statements about a certain cleanser "washing whiter" or giving a "clean smell," explicitly relying on the presumed equivalence of whiteness, fragrance, and cleanliness. In a marketing study about perceived qualities of products that gained some exposure in the media (Plassmann, O'Doherty, Shiv, & Rangel, 2008) it was shown that the same wine, when tagged with a higher price, was perceived by participants as having a better taste. The effect was detectable physically through functional magnetic resonance imaging techniques. In the terms proposed earlier, what happened was a process of homogenization of the classification functions: The classification functions of "high price" and "good taste" were assimilated with each other. In sum, everyday life provides many instances of asemantic processes of homogenization of the classification functions and of the fact that such a process is strictly associated with circumstances of emotional arousal, and moreover it characterizes them.

Before concluding, some aspects of the homogenization of classification functions are worth highlighting. First, a distinction at the conceptual level between the process and the output has to be made. What one sees phenomenally is not the process in itself, namely the homogenizing of the classification functions, but the result of the process, namely the emotional class consisting of the homogenized classification functions. On the other hand, given that it is assumed here that one can infer the process from the output, we use the same term for both here.

Second, although the homogenization involves a potentially infinite number of classification functions, that number is still constrained by the fact that not all classification functions can be merged with each other. The main constraint is provided by the valence (positive vs. negative) of the classification functions: Classification functions to which a positive valence is attributed tend to merge with each other but not with negative classification functions and vice versa. Thus, the person in love considers the beloved as beautiful, smart, and generous but not cruel, dishonest, or violent. Accordingly, the emotional classes resulting from the homogenization of the classification functions are to be considered infinite but incomplete sets, namely sets having an infinite number of specimens but only some of the possible ones (e.g., the set of odd numbers; for a view of the emotional classes as infinite sets, see Matte Blanco, 1975). Incidentally, this aspect makes an important distinction with the emotional class as seen by ERCT. Indeed, according to ERCT, the emotional class corresponds to a discrete emotion (e.g., the class of objects evoking fear, the class of objects evoking joy), whereas according to the definition proposed here the emotional class corresponds to a more generalized set defined by the valence (positive vs. negative) of the classification functions (namely the set of classification functions having positive valence vs. the class of negative classification functions).

Third, the HOCFUN is based on the assumption that there is a direct positive linkage between the intensity of emotional arousal and the degree of homogenization: The greater the former, the greater the latter. On the other hand, this assumption is consistent with the ERCT. In particular, Niedenthal and Dalle (2001) found that high arousal (preexistent or induced) induces participants to be more likely to adopt an emotional modality of categorization, namely to create emotion-based groups of stimuli: "It is during such a state of emotion that individuals are most likely to use emotional response equivalence as grounds for categorization" (Niedenthal & Dalle, 2001, p. 737). Based on this assumption, HOCFUN measures to what extent a performance of rating reflects the active process of homogenization of the classification functions, taking the latter as the marker of the influence emotional arousal exerts on thinking.

The two latter points lead to the conclusion that the homogenized emotional class is a function of the two fundamental characteristics of emotional arousal, valence and intensity (e.g., Feldman Barrett's [2006] definition of core affect), where the valence sets the distinction between what may be part of one homogenized class and what may not, and the intensity defines the degree of generalization of the homogenization.

DESCRIPTION OF HOCFUN.

HOCFUN consists of a rating task. Participants are asked to rate each object of a series of images on two continuous bipolar dimensions. The rating scales represent a corresponding number of classification functions: unpleasant–pleasant (henceforth *pleasantness*) and irrelevant–relevant (henceforth *relevance*). It is worth noting that the classification functions do not lend themselves to be homogenized to the same extent. It can be expected that the more the classification functions are about evaluative, subjective, synthetic judgment, the more they tend to be homogenized; on the contrary, the more they are about descriptive, objective, specific characteristics, the less they are subject to homogenization. Thus, for example, classification functions concerning aesthetic (*beautiful, nice, pretty*), moral (*righteous, correct, honest*), personality (*sympathetic, brilliant*), and conative (*desirable, needed*) aspects lend themselves to be more easily homogenized than classification functions concerning colors, shapes, gender, educational level, and so forth. For this reason, HOCFUN adopts two classification functions that, because they are related to two basic affective, connotative dimensions (Feldman Barrett, 2006; Osgood et al., 1957), are expected to be subject to the homogenizing effect of emotional arousal.

Target objects are pictures of common elements one can meet in daily life (e.g., a newsstand, a train). Objects selected are depicted in an emotionally neutral state, so to make it possible for different people to feel and interpret them in different ways. The objects' emotional neutrality was sought in order to avoid limiting the variability of ratings. To this end, we selected objects that showed the highest interrater variability in preliminary analysis. The current version of the test uses 38 objects.

HOCFUN measures the homogenization of the classification function in terms of the amount of within-subject association of the two bipolar dimensions on which the objects are rated. The association between the two bipolar rating dimensions is measured in terms of the coefficient of determination (R), namely the amount of shared variance between the two rating dimensions. More specifically, for each participant the Pearson's product moment correlation coefficient between pleasantness and relevance scales is performed on the intrasubject ratings matrix, that is, the matrix composed of the ratings of the 38 objects on each of the two bipolar dimensions. Then, Pearson's r is squared so as to calculate the coefficient of determination ($R = r^2$). In so doing, the measure of the association was made independent from the direction of the association. In the context of HOCFUN, to highlight its conceptual meaning, the extent of the homogenization of the classification function is labeled with the Greek letter κ (in accordance with the *Kalokagathia* effect).

HOCFUN is implemented as a fully computer-based test, thanks to an ad hoc computer program developed by the first author in 2009. It starts with a brief presentation of instructions about the task. The participant is informed that there are no right answers and that every rating on the two dimensions is equally acceptable. The participant is also informed that he or she is allowed to change the rating until he or she presses the "Continue" button; after that the rating cannot be changed, and the system shows the next stimulus. The participant is then presented with a preliminary stage, with the specification that it is provided merely to allow him or her to become familiar with the procedure. Three black-and-white pictures of geometric shapes (a line, a square, and a sphere) are presented, always in this sequence. Each picture contains only one object. The participant is asked

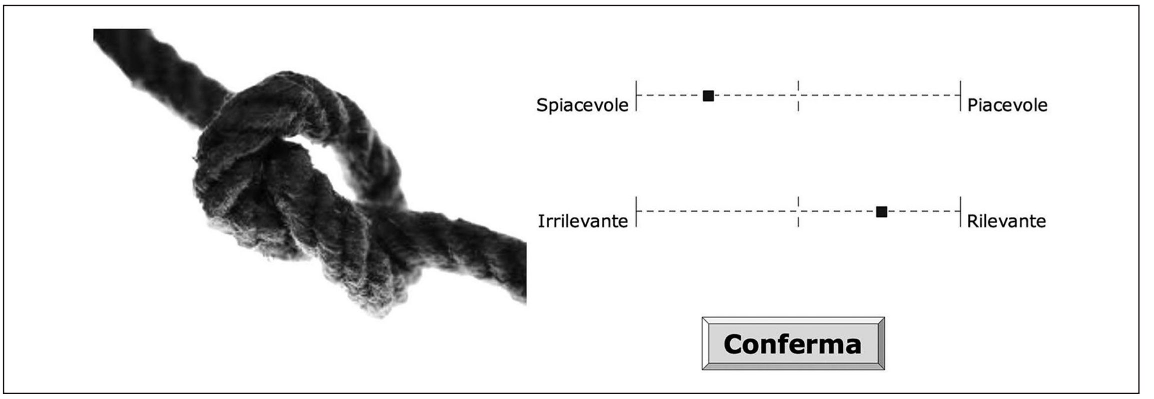

FIGURE 1. A screenshot of the original test in Italian. "Spiacevole–Piacevole" is "Pleasant–Unpleasant," "Irrilevante–Rilevante" is "Irrelevant–Relevant," and "Conferma" is the "Confirm" button

to rate each of them as to how unpleasant–pleasant as well as how irrelevant–relevant it is. Each rating is performed analogically, namely through the selection of a point on the continuous axes representing the bipolar dimension; the position of the point compared to the polarities marking the extremes of the dimension defines the score of the rating. The picture, the two axes representing the bipolar dimension rating, and the "Confirm" button are the only elements displayed on the white background of the screen (Figure 1). Ratings are confirmed only when the "Confirm" button is pressed. Once this is pressed, the screen is reset and the next picture appears.

As soon as the three preliminary trials are completed, a message informs the participant that the actual task is about to start. The task consists of the evaluation of 38 objects—one object at a time—on both bipolar dimensions. Objects are presented in a random order. Randomization of the presentation order is achieved by application of the Fisher–Yates/Durstenfeld–Knuth algorithm (Durstenfeld, 1964; Knuth, 1998). For every object, the system records the participant's ratings and the time (in milliseconds) from the appearance of the image to the click on the "Confirm" button.

The way the object is displayed, the modality of the rating, and the shift to the following object are the same as in the preliminary trials.

Aim and Hypotheses

HOCFUN's construct validity basically concerns interpretation of the κ indicator as a measure of the homogenization of classification functions, in turn seen as the effect of emotional arousal. Accordingly, the present study, being aimed at providing initial evidence supporting HOCFUN's construct validity, pursues the following two purposes. First, it intends to test whether HOCFUN may be considered a tool for measuring homogenization of the classification functions. Second, it intends to perform a preliminary test of the basic assumption that homogenization of the classification function is associated with emotional arousal and therefore can be considered a valid marker of it.

To this end, three analyses were carried out, each focused on the relationship between κ and one behavioral variable that, according to widely accepted interpretations, can be regarded as the marker of, respectively, homogenization of the classification functions (Analysis 1) and emotional arousal (Analyses 2 and 3).

First, the association between κ and the level of homogenization of the classification functions participants showed in a parallel rating task was studied. The parallel task was performed just after HOCFUN. Here it must be emphasized that emotional arousal tends to be spread over the field of stimulation, consequently showing a certain degree of persistence across space and time (Salvatore & Freda, 2011). In other words, once activated by a certain triggering experience (in this case, the experience of participating in the study), emotional arousal tends to associatively spread over other objects that are contiguous in space and time (Matte Blanco, 1975; Niedenthal & Dalle, 2001; Salvatore & Freda, 2011). Because of this characteristic, the level of homogenization of classification functions during the HOCFUN task is expected not to change greatly during the immediately following rating task.

Second, the association between κ and the speed in performing the rating task was analyzed. We consider speed a marker of emotional arousal; indeed, emotional arousal is expected to be associated with a faster way of computing and responding to stimulation (LeDoux, 1998).

Third, the association between κ and the intensity of the mood, regardless of its direction (i.e., positive or negative), is studied. Although the mood may not be considered coincident with the intensity of emotional arousal (the mood being what the participant experiences of the emotion together with its valence; cf. Feldman Barrett, 2006, p. 31), it is strictly associated with it and therefore is useful as a partial marker of emotional arousal.

Based on interpretation of the three indicators proposed earlier, three hypotheses were made. It is expected that κ is positively associated with

- The use of homogenization of classification functions in a further rating task performed just after the HOCFUN task but still in the same experimental setting (Hypothesis 1)
- The speed of performing the HOCFUN task (Hypothesis 2)
- The intensity of mood, regardless of whether it is a positive or negative score (Hypothesis 3)

EXPERIMENT

METHOD

Sample

The experiment involved 71 participants (24 men, 47 women; all Italian), with an average age of 35.3 years (SD = 14.2). Nine of them had a university degree and 62 a high school leaving certificate; 1 was unemployed, 7 were managers, 21 were employees, 1 was an entrepreneur, 6 were professionals, 1 was a soldier, 1 worked in the service industry, and 33 were university students. Exclusion criteria were the presence of psychopathological disorders or cognitive deficit and physical constraints in performing the task. Participants were recruited among the employees of public and private offices and the students of the university course. The experiments took place in similar settings. The first author supervised the experiments. Potential participants were invited on the basis of a generic description of the purpose of the study, presented as analyzing the process of evaluation. Most of the people invited agreed to participate.

Measures

As a parallel rating task (Analysis 1), a semantic differential was submitted to the participants just after HOCFUN. The semantic differential was composed of nine 7-point bipolar Likert scales (active–passive, beautiful–ugly, good–bad, weak–strong, large–narrow, light–heavy, mobile–steady, pleasant–unpleasant, fast–slow, as translated into English from the original in Italian), each of them applied to six target objects: "myself," "immigrants," "future," "place where I live," "Italian people," and "this situation." Content and structure of bipolar scales were defined in accordance with how semantic differential methods are generally applied (Grossman, Wirt, & Davids, 1985; Osgood et al., 1957). The six objects were chosen for their capacity to trigger an emotional modality of evaluation. For each participant, the measure of homogenization of the classification functions in the parallel task was provided by the average level of intrasubjective association between the nine ratings. More specifically, for each participant 36 Pearson's correlation coefficients were calculated, each measuring the intrasubjective association between two bipolar scales (e.g., active–passive vs. beautiful–ugly, active–passive vs. good–bad) over the six objects. Then, the mean of the absolute values of the 36 ($n[n - 1]/2$, with $n = 9$) correlation coefficients were calculated (for each participant) and interpreted as the indicator of the level of homogenization of the classification functions involved in the parallel task (henceforth *SD-HOM*). It is worth pointing out that because the absolute value of every correlation coefficient was used, the average correlation coefficient was made independent from the actual direction of the association; this was consistent with the purpose of the analysis because it was designed to estimate the extent of homogenization of the classification function rather than its direction.

As an indicator of speed (Analysis 2) we adopted the ratio between the time used to perform the HOCFUN task and the hypothesized amount of movement on the computer screen (henceforth *speed*). The adoption of a speed indicator permits control of potential bias due to the spatial configuration of the responses (i.e., responses closer to the middle and to the "Confirm" button take less time to click and confirm; Figure 2). The time was

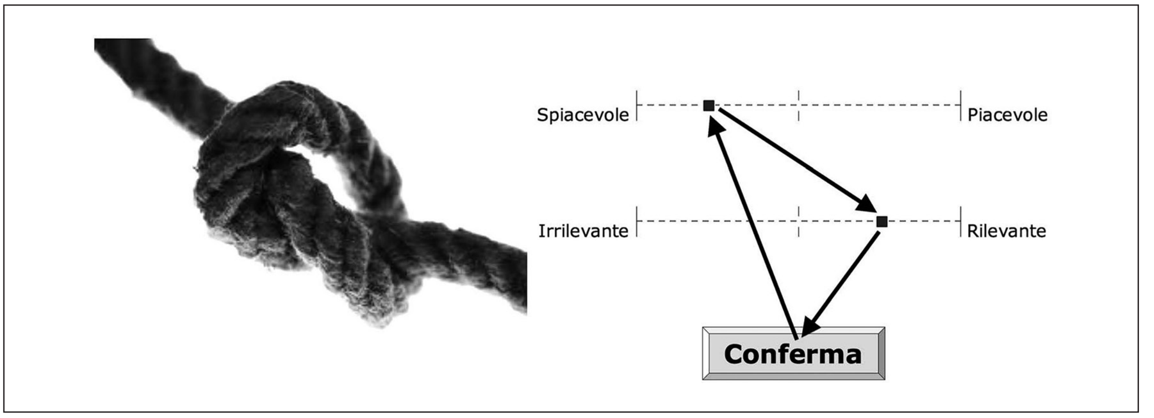

FIGURE 2. Minimal trajectory of the mouse pointer in expressing the evaluations

recorded in milliseconds and spanned from the onset of the stimulus to the clicking of the "Confirm" button; in this way interstitial technical delays were controlled and excluded. The amount of movement was defined in terms of the presumed trajectory the participant followed. More precisely, this trajectory was defined as the triangle that had the two ratings and the center of the "Confirm" button as its vertices (Figure 2). Indeed, at the starting time the pointer is positioned on the button (because the participant had had to click "Confirm" in the previous step), then it is moved onto the first rating, then onto the second rating (the order is not important because the two triangles have the same perimeter), and then back onto the "Confirm" button. Thus, the triangle represents the shortest path to complete every step of the HOCFUN task.

As for Analysis 3, the indicator of mood intensity (henceforth *mood*) was assessed in terms of the polarization of semantic differential ratings the participant gave to the object "myself." More specifically, the ratings of "myself" underwent a principal component analysis to extract the component that, as one can expect given with the majority of studies using semantic differentials, lends itself to be interpreted as the *evaluation* dimension (i.e., negative vs. positive). The evaluation dimension was chosen because of its consistency with the basic bipolar affective organization (i.e., pleasant–unpleasant) of emotional activation (Feldman Barrett, 2006; Isen & Daubman, 1984; Klein, 1969; Osgood et al., 1957; Salvatore & Zittoun, 2011). Moreover, because the study focused on the intensity of mood rather than on its direction, the absolute value of the evaluation dimension—indeed, the polarization of the score over it—was considered.

Procedure

Experimental tasks were presented to each participant in a single experiment, merged in a single presentation displayed on a computer. Thus, the participants had the impression of dealing with a single setting.

The presentation started with a brief introduction, aimed at defining a meaningful frame supporting and uniformly orienting participants' involvement and commitment. However, the presentation was limited to a general indication about the purpose of the study: "the analysis of certain characteristics of the evaluation processes." Additional information or clarification (they were told) would be provided once the task was finished, to avoid conditioning the participants.

The presentation was followed by the preliminary test showing geometric shapes, then the HOCFUN, in turn followed by the semantic differential task. Finally, participants were presented with a brief questionnaire aimed at collecting sociodemographic data (age, gender, education, occupation).

Participants performed the tasks in separate rooms, located in a private space, either on university premises or in public offices. (The location was chosen by the experimenter, and the participants came to the site.) The participants were alone during the task, or at least unable to see each other. The experimenter (the first author) was either not present during the completion or out of sight, depending on the specific situation. He was not in eye contact with the participants in any case.

Data Analysis

To test Hypothesis 1, a regression analysis (least squares method) was performed, with the indicator of homogeneity of the classification functions characterizing performance on the semantic differential task (i.e., SD-HOM) as criterion and κ as predictor. Regression analyses were performed on standardized scores. Because the association between predictor and criterion variables might be nonlinear (e.g., it could show a threshold effect), both a first-order and a second-order regression model were calculated. ANOVA was used for testing the model.

To test Hypothesis 2 a correlation analysis was performed, calculating Pearson's r between κ and speed.

To test Hypothesis 3, a regression analysis (least squares method) was performed, with mood intensity as criterion and κ as predictor. Regression analyses were performed on standardized scores. Also in this case, because the association between predictor and criterion variables might be nonlinear (e.g., it could show a threshold effect), both a first-order and a second-order regression model were calculated. ANOVA was used for testing the model.

RESULTS

Table 1 reports descriptive statistics for the four indicators used in the analyses. Preliminarily, to check the independence of the indicators used in the three analyses, Pearson's correlation coefficients were calculated. No significant correlations resulted: SD-HOM versus speed, $r(68) = .191, p = .113$; SD-HOM versus mood, $r(68) = .105, p = .385$; mood versus speed, $r(69) = .167, p = .163$.

Analysis 1

The average SD-HOM was .48, $SD = .113$, range .34–.84. The regression analysis was performed over 70 cases, because one criterion variable score was missing. First-order regression analysis produced a model unable to fit data, $F(2, 67) = .271928, p = .604$.

TABLE 1. Descriptive Statistics for Indicators Used in the Analysis

Indicators	*M*	*SD*	Range
κ	0.192	.806	0.00–0.98
SD-HOM	0.489	.113	0.34–0.84
Speed (ms)	22.561	.612	8.36–39.48
Mood	0.765	.637	0.01–2.52

The second-order regression model proved able to fit the data, $F(2, 67) = 4.972, p = .010, R^2 = .129$. Both first-order, $\hat{a} = -.361, p = .046$, and second-order parameters, $\hat{a} = -.552, p = .003$, were significant. The model maps a parabola showing that, for lower κ values, the indicator of homogeneity of the classification functions characterizing performance on the semantic differential task (SD-HOM) decreases slightly as κ increases, whereas for values of κ above the mean, the indicator of homogeneity of the evaluations characterizing performance on the semantic differential task increases as κ increases (Figure 3).

To deepen the analysis of the nonlinear relation between SD-HOM and κ, the data were split with κ median as cutoff point and Pearson's r between the two indicators calculated separately for the two subsets of data. In the case of the subset below the κ median, Pearson's r proved not significant, $r(34) = -.209; p = .222$; in the case of the subset above the κ median, Pearson's r between SD-HOM and κ was positive and significant, $r(32) = .436, p = .010$.

Analysis 2

SD-HOM shows $M = .48$, $SD = .113$, range .34–.84. The correlation between speed and κ was $r(69) = .292, p = .014$.

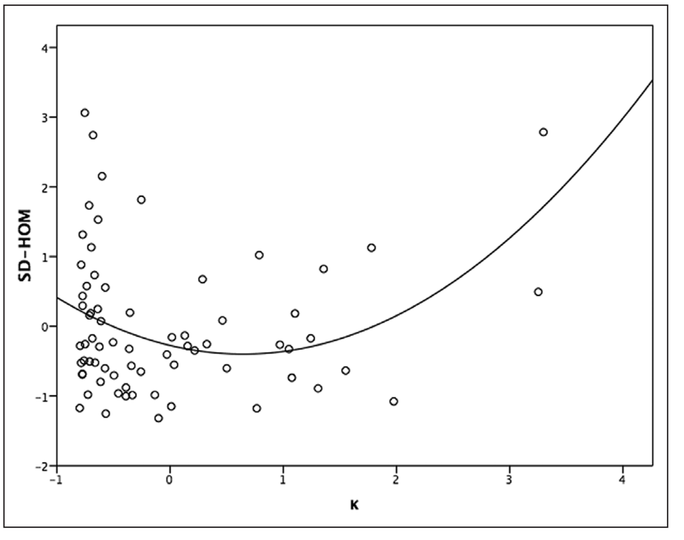

FIGURE 3. Second-order regression model. Criterion variable, *y*-axis: SD-HOM (indicator of the homogeneity of the classification functions characterizing the performance to the semantic differential task, standardized scores). Predictor variable, *x*-axis: κ (standardized scores)

To highlight a possible threshold effect, data were split with κ median as cutoff point and Pearson's r between the two indicators calculated separately for the two subsets of data. In the case of the subset below the κ median, the correlation between speed and κ was not significant, $r(34) = -.100$, $p = .562$; in the case of the subset above the κ median, the correlation between the two was positive and significant, $r(33) = .420$, $p = .012$.

Analysis 3

Table 2 shows the output of the principal component analysis applied to the semantic differential scales concerning the object "myself." The first three factors explain 61.9% of the total variance. The first factor (34.1% of explained variance) is saturated mainly by the scales pleasant–unpleasant (.853), good–bad (.721), and beautiful–ugly (.661). The second factor (15.3% of explained variance) is saturated by the scales active–passive (.806), mobile–steady (.806), and fast–slow (.751). The third factor (12.5% of explained variance) is saturated by the scales light–heavy (.860), weak–strong (–.447), beautiful–ugly (.416), and large–narrow (.386). This is consistent with the majority of studies using semantic differentials, and it enables factors to be interpreted as, respectively, *evaluation*, *activity*, and *potency*. Thus, we used the absolute score on the dimension *evaluation* as the indicator of the intensity of mood.

TABLE 2. Principal Component Analysis Output Factorial Dimensions for the "Myself" Semantic Differentials (Varimax Rotation)

Adjective	Factor 1 Evaluation	Factor 2 Activity	Factor 3 Potency
Active	.422	.806	–.051
Beautiful	.661	–.032	.416
Good	.721	.202	–.022
Weak	.009	–.409	–.447
Large	.322	.104	.386
Light	–.013	.046	.86
Mobile	.363	.806	.039
Pleasant	.853	.14	–.033
Fast	–.139	.751	.294

First-order regression analysis produced a model able to fit data, $F(1, 70) = .4.636$, $p = .035$; $R^2 = .062$. The relation between criterion (mood) and predictor (κ) was positive ($\hat{a} = .249$). The second-order regression model was not significant, $F(2, 69) = 2.297$; $p = .108$.

As in the previous analyses, in order to highlight a possible threshold effect, data were split with κ median as cutoff and Pearson's r between the two indicators calculated separately for the two subsets of data. In the case of the subset below the κ median, the correlation between mood and κ was not significant, $r(34) = -.163$, $p = .343$; in the case of the subset above the κ median the correlation between the two proved positive and significant, $r(33) = .354$, $p = .037$.

DISCUSSION

The results are consistent with all the three hypotheses the study aimed at testing.

First, the distribution of SD-HOM (i.e., the indicator of homogenization of the classification functions in the context of the semantic differential) over the sample shows that participants are highly differentiated from each other as regards this aspect. Furthermore, this is a marker of how homogenization of the classification functions is active within the sample, to a variable extent, between participants. Taken in itself, this datum shows a somewhat counterintuitive picture: Participants tend to use semantic differential rating dimensions (i.e., classification functions) to a more or less large extent independently from their semantic content; that is, they attribute similar scores to objects regardless of the meaning of the nine rating scales (e.g., fast, good, weak).

Second, the findings of Analysis 1 provide evidence supporting interpretation of the κ indicator as the homogenization of classification functions, namely the phenomenon the HOCFUN was designed to measure. Indeed, Analysis 1 allowed the association between κ and SD-HOM to be assessed (i.e., the indicator of homogenization of the classification functions as detected in a parallel, independent task, namely the semantic differential ratings carried out after the HOCFUN). The results of the regression analyses provide support to the hypothesized linkage between the two indicators and therefore to the possibility of considering κ a measure of homogenization of the classification functions.

Third, however, it has to be noted that the association between κ and the parallel indicator of task is low (the regression model explains about 13% of the variance). In part, this has to be considered the consequence of the nonlinearity of the association: Only the second-order regression model was significant, highlighting a threshold effect. The association between κ and SD-HOM becomes high and significant only above a certain level of κ (i.e., above the median). On the other hand, the level of association concerning the values of κ above the threshold is moderate but not high. Therefore, other aspects must have played a role in reducing the strength of the relation between the two indicators. An aspect that can be considered important concerns the differences between the two rating tasks.

Fourth, results of Analysis 2 are consistent with the interpretation of κ as a marker of emotional arousal. As expected, a positive correlation was found between the speed of performance on the HOCFUN task and the κ indicator. This result does not depend on the idiosyncratic structure of the task, because the use of speed as a behavioral variable allowed the control of this potential source of bias. Thus, insofar as the speed of performance is taken as an indicator of emotional activation, it can be concluded that the κ indicator is sensitive to emotional activation: It increases as the emotional activation increases and vice versa. On the other hand, it should be noticed that the correlation is just slightly less than moderate ($r = .292$), even if significant. In part, this low level can be attributed to the nonlinearity of the association. Indeed, also in this case a threshold effect appeared, adopting the median as a cutoff point. Thus, if one focuses on the subsample above the κ median, the association between the latter indicator and speed is quite high ($r = .420$). On the other hand, two accounts can be considered for interpreting this intermediate level of association, not necessarily alternative to each other. First, the measurement of speed adopted in the study did not take into account circumstances increasing the time spent on the task but independent from the level of emotional activation (e.g., a participant's voluntary or involuntary break during the performance; time spent changing a rating). Finally, the low level of correlation might reflect the actual level of association between the two variables. However, the latter interpretation would not be inconsistent with the conceptual definition of the κ indicator. In fact, the κ indicator is not strictly a measure of emotional activation; rather, it is intended to be a marker of the salience of emotional arousal on thinking. Needless to say, such salience must be somehow linked with emotional arousal, but such linkage is not necessarily strong or linear. On the contrary, it is plausible that the linkage may be only partial, especially when the level of emotional activation is not high (as one can expect to be the case of the participants engaged with the HOCFUN task). Accordingly, a conjecture that further studies should test is that when emotional activation is high, the salience of emotion on thinking is high as well, whereas when the emotional activation is low, the salience of emotion on thinking can vary, as a result of the greater role other factors may play (e.g., the evocative content of the stimuli, the participant's interpretation of the task).

Fifth, the results of Analysis 3 are consistent with the interpretation of κ as a marker of emotional arousal. As expected, the first-order regression model showed a positive association between κ as predictor variable and intensity of mood as criterion: The higher the κ scores, the higher the mood intensity. Unlike Analysis 1, however, the second-order regression model proved nonsignificant. However, the threshold effect is present also in this case: The strength of the association does not spread over the whole distribution but is a matter of κ scores being above the median. This result has to be taken with caution. Indeed, it is based on an indirect marker of the intensity of mood, the polarization of the semantic differential evaluative dimension concerning one's own self (the object "myself"). Therefore, this result awaits confirmation by more direct measures of the mood intensity (e.g., physiological markers). On the other hand, the notion that polarization of the evaluative connotation marks the current state of mood is consistent with several psychological observations and models. The phenomenon of affective priming (Fazio, Sanbonmatsu, Powell, & Kardes, 1986; Murphy, Monahan, & Zajonc, 1995) provides an inverse form of evidence supporting this relationship. Indeed, the affective priming effect shows that when a certain state of mood is triggered, it induces consistent connotation of neutral objects. From a psychoanalytic standpoint Stern, 2004 provides brilliant clinical observations showing that feelings sustaining the experience of the present moment affect the way of connoting objects and events that have no functional or semantic relation with such feelings. Finally, an indirect, unconscious linkage between mood (as the product of situated and contingent emotional dynamics) and evaluation of objects is one of the basic assumptions grounding the rationale of projective tests (Bornstein, Bowers, & Bonner, 1996).

Before we conclude, two other considerations are worth discussing. First of all, the findings discussed earlier are based on indicators derived from somehow interconnected sources. Speed was sourced from the same task from which κ is derived. SD-HOM and mood compute different facets of the same semantic differential rating task. Moreover, even if the two tasks (HOCFUN and the semantic differential) are conceptually and functionally independent, participants performed them in the same spatial–temporal unit; consequently, it cannot be ruled out that any response pattern could be generalized implicitly through the tasks (e.g., the tendency to provide polarized rating responses). On the other hand, the absence of association between the three indicators provides empirical support to the view that the results emerging from the analysis reflect the substantial linkages between the process under investigation rather than the redundancy within and between the tasks. Finally, the threshold effect emerged as a systematic characteristic of κ scores. Such an effect could be due to computational reasons, namely to the fact that the HOCFUN tends to be less capable of detecting homogenization of classification functions when the magnitude of emotional arousal is low. Such a case would need to be considered a limit of reliability and as such should be addressed. A different (though not necessarily alternative) interpretation is that the threshold effect could reflect the inherent quality of the association between emotional arousal and homogenization, namely the fact that a certain level of emotional arousal is necessary for it to have the "strength" to influence the process of thinking.

Conclusion

This article presented a method of measuring emotional arousal: the HOCFUN. The conceptual framework and rationale of the method have been discussed, and preliminary evidence supporting its construct validity has been provided.

HOCFUN is based on detection of the salience of emotional arousal on thinking. Accordingly, emotional arousal triggers asemantic forms of categorization that lend themselves to be conceived as the output of the process of homogenization of classification functions. With such an expression, we have indicated the tendency to merge and consider characteristics or attributes of objects identical regardless of their semantic contents. Plato's notion of *Kalokagathia* ("beautiful and good") provides a partial instance of such a mechanism: an object that is beautiful cannot but be good and vice versa. Such an instance is partial because it is limited to just two of the classification functions we commonly homogenize, yet the homogenization can go on: An object that is beautiful and good is also trustworthy, happy, generous, powerful, efficacious, and so forth.

The purpose of HOCFUN is twofold. On one hand, it is a method designed to contribute to the empirical detection of emotional arousal, quite an important transversal task for psychology. On the other hand, it may help shed further light on the intriguing relation between emotion and thinking. In the final analysis, the recognition of the fact that emotional arousal not only motivates or interferes with cognition but also contributes to its organization makes it legitimate to think of the relation between emotion and thinking in a more integrated way, namely as two components of a whole computational dynamic. A perspective such as this would be consistent and support the caution some authors have expressed about the tendency of contemporary psychology to take concepts such as "emotion" as reified entities, taken for granted as such (Feldman Barrett, 2006; Salvatore & Valsiner, 2014).

The HOCFUN κ indicator measures the level of homogenization of the classification functions characterizing the participant's way of rating objects on two semantically independent dimensions: pleasantness and relevance. This indicator is thus conceived as a quantitative detection of the salience of emotion in thinking. To test this conceptual interpretation of the κ indicator, the latter was compared with three other indicators. Consistently with the hypotheses, the κ indicator proved to be associated, even if weakly and nonlinearly, with a marker of homogenization of classification functions derived from a separate rating task. The indicator is associated as well with two indirect indicators of emotional activation: the speed of performance on the HOCFUN task and the intensity of mood (as detected by the tendency to polarize the semantic differential evaluation ratings of "myself").

Taken as a whole, such results provide evidence supporting the HOCFUN construct validity. Needless to say, however, this is just a first step. Several limitations of the study must make us cautious about interpreting and homogenizing conclusions. The current version of HOCFUN calculated the κ indicator on the basis of only two classification functions. Further study will have to explore a more complex measure, based on more classification functions. Moreover, most of the evidence was drawn from comparisons of the κ indicator with indirect indicators of emotional activation (speed, semantic differentials). Interpretations of such indicators are to some extent based on inferences that, even if conceptually grounded, are prone to alternative interpretations. Still, such indicators were measured not fully independently from the HOCFUN; consequently, one cannot exclude the alternative hypothesis that their association with the κ indicator depends on the fact that they are not structurally independent. We therefore consider the findings of this study to be promising and we feel encouraged to proceed in the development of this method, in particular by comparing it with independent sources of validation.

NOTES

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1. We use this generic term to encompass the different views conveyed by the theoretical standpoints mentioned later. Thus, according to the theory in question, *emotional process* denotes emotional arousal, or a certain specific emotion (e.g., fear, joy), in the sense of discrete states characterized by peculiar patterns of psychobiological response pattern.

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