CAAT - A Discrete Approach to Emotion Assessment

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Abstract
In this work we present a new way of assessing affective states through direct selection of emotion words from a discrete set. The proposed tool, the Circumplex Affect Assessment Tool (CAAT), is built upon Robert Plutchik's circumplex model of emotions and, as far as our preliminary tests have shown, is a pleasant and reliable way to assess user's affective states, with significant correlations with Self Assessment Manikin ratings.

Keywords
Emotion; Assessment; Psychoevolutionary Theory.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI), Miscellaneous.

Introduction
Emotions, or affects, are inherent to our condition as human beings and scientific evidence strongly suggests that emotions influence most aspects of our behavior [7]. It naturally follows that the assessment of emotional states is a very important issue for the understanding of human behavior and many approaches can be found on scientific disciplines traditionally dedicated to it – Psychology being the first. Also, some technological disciplines with intrinsic interest on human factors, like HCI, have also been

proposing a number of interesting approaches, attempting to avoid the unwieldiness of traditional questionnaire-based approaches [3, 5, 7, 8].

The subject of emotions and their nature, however, is not a settled matter. Indeed, many theorists advocate the existence of biologically determined categories of affects, independent from each other, that are similarly experienced and recognized by all individuals, like “anger” or “fear” [4]. This postulate is the main premise of the Discrete Emotions Theory, one of the first perspectives to have been proposed on the subject of emotions. However, this theory has been disputed by more recent perspectives, like Barrett’s Conceptual Act Model [1]. In her work, the author states an emotion paradox, highlighting that “to date, there is no clear, unambiguous criterion for indicating the presence of anger or sadness or fear”. The solution proposed is the conceptualization of emotions as products of the moment that arise to conscience from the interplay of two deeper constructs: “core affect” and a process of cognitive categorization that allocates common names to the experienced emotional state. Core affect is defined as an individual’s neurophysiological relation to an environment in a point of time and may be evaluated along two dimensions: valence (hedonic pleasure vs. displeasure) and physiological arousal (high arousal vs. low arousal). It is widely accepted that these two dimensions are essential components of the emotional experiencing, although a third one also figures recurrently in the literature: dominance (being in control vs. being controlled) [2].

A number of methods have already been developed to perform direct mappings of emotional experiences to multidimensional space representations. A charismatic and widely used example is Bradley and Lang’s Self Assessment Manikin (SAM) [2]. The SAM is a single item measure of affect, presenting users with three strips of progressively changing drawings of a simplistic manikin. Each strip represents variations along a single affective dimension - valence, arousal and dominance - and the number of figures varies in accordance with the desired result range. In order to use SAM, subjects are required to select the three figures (one per strip) that they judge to best represent their overall emotional state. However, they are also required to have more than a superficial understanding of the dimensional concepts involved and this is reflected on SAM’s detailed, lengthy instructions.

On the other side, we can find several methods of mapping emotional experiences to discrete representations, like facial expression recognition [4] or keyboard typing patterns [5]. However, the assumptions that only a discrete number of emotions exist and that people can, to some extent, recognize their own affective states, suggest that the selection of one or more emotions from a list may suffice to perform emotional assessments. This approach has the advantage of having a foothold on common, colloquial emotion expression, although it also suffers from some evident drawbacks. For instance, the selection of which emotions should compose the list is not trivial. In fact, over the centuries philosophers and psychologists have proposed distinct sets, containing anywhere from 3 to 11 basic emotions [10]; and even if we settle for a particular set of emotions, there is always the possibility of ambiguous word interpretation.

To overcome these issues, we developed the Circumplex Affect Assessment Tool (CAAT), based on Robert Plutchik’s Psychoevolutionary Theory and Circumplex Model, that (1) is pleasant to use,

(2) allows users to express a wide spectrum of affective experiences and (3) is reliable, having significant correlations with SAM scores.

The Psychoevolutionary Theory of Emotion

The Psychoevolutionary Theory proposes the existence of eight basic emotion dimensions, each having three intensity variants and arranged in four pairs [9]. To illustrate this conceptualization, Robert Plutchik designed a visual representation, his circumplex model, establishing a parallelism between his eight "primary emotions" and a color wheel (Figure 1). Plutchik argued that, "in English, there are a few hundred emotion words, and they tend to fall into families based on similarity". Therefore, he placed "similar emotions close together and opposites 180 degrees apart, like complementary colors". To account for the vast number of emotions that do not figure explicitly on the circumplex model, the author conceptualized other emotions as being mixtures of primary ones, "just as some colors are primary and others made by mixing the primary colors" [10]. From the center of the model to its periphery we can find each primary emotion's intensity variants, decreasingly ordered by intensity - the more intense, the closer to the model's center.

The Design of CAAT

We designed CAAT as an alternative to discrete item selection controls (e.g., *drop-down lists* or *list boxes*), dedicated to the choice of emotions. Therefore, the prototype was implemented with two states: a closed state, with CAAT occupying as little space as possible and showing the current selection (Figure 2.a), and an open state (Figure 2.b) prompting users to make their selection. Some exemplificative use cases for such an implementation would be the assessment of users' emotional responses to media (e.g., articles, news or

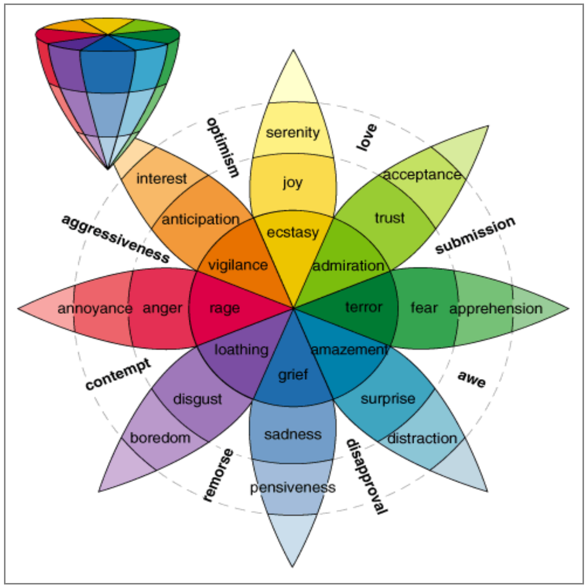

Figure 1. Robert Plutchik's circumplex model.

music) as they browse contents on the Web, media tagging activities or the collection of data as part of remote surveys. All of these usage examples clearly benefit from an HCI emotion assessment tool over a pen-and-paper approach.

At this point, it's important to highlight that Plutchik's circumplex model is, before all, a classification system with pedagogical and illustrative purposes and it was not originally intended to serve as an assessment tool. That being said, we now hypothesize that the model's layout and analogy to a color wheel positively contribute to render it both visually engaging and naturally ordered. Besides, we also argue that the emotion word ambiguity problem is alleviated since each emotion appears aligned with its variants, thus

Emotion	V	A	D	S_1	S_2
Terror	1	7	1	1	7
Fear	2	6	2	2	6
Apprehension	3	5	3	3	5
Annoyance	3	5	5	3.7	5
Anger	2	6	6	3.3	6
Rage	1	7	7	3	7
Admiration	7	5	5	6.3	5
Trust	6	4	5	5.7	4
Acceptance	5	4	4	4.7	4
Boredom	3	3	5	3.7	3
Disgust	2	5	3	2.3	5
Loathing	1	6	2	1.3	6
Ecstasy	7	7	7	7	7
Joy	6	6	6	6	6
Serenity	5	3	5	5	3
Pensiveness	3	3	3	3	3
Sadness	2	2	2	2	2
Grief	1	1	1	1	1
Vigilance	4	7	7	5	7
Anticipation	4	6	6	4.7	6
Interest	4	5	6	4.7	5
Distraction	4	3	3	3.7	3
Surprise	4	6	2	3.3	6
Amazement	4	7	1	3	7

Table 1. The proposed scoring system for the primary emotions. The columns correspond to valence (V), arousal (A) and dominance (D). S_1 and S_2 are the effective scoring system for CAAT emotions (see section *Scoring system*).

potentially allowing some disambiguation in the likely case where the user recognizes an associated emotion.

As a preliminary usability test, we used the circumplex model's image as-is, and conducted a small scale user test with six participants, where they were asked to perform a number of quick tasks with the model, like locating a number of randomly selected emotions. As a result, some important observations were made. First, aside from the axes' background color that fades as the respective emotion's intensity decreases, the need for some additional visual cues was expressed. Next, even though Plutchik's model includes the notion of emotional intensity, presumably fading into a common "no emotion" periphery (Figure 1), it does not feature any objective representation for a "no emotion" state. From these suggestions resulted that the CAAT's axes were reversed, a "no emotion" central node was added and the size of the selectable nodes varies in proportion to their respective emotion's intensity (Figure 2).

Scoring system

Another important decision relates to the CAAT's scoring system. Although the user's selection of emotion words is a valid and useful product of CAAT, it is mostly interesting in cases where only categorical emotion expressions are required. Given the possibility of mapping emotion words to dimensional spaces [7], another small scale study was conducted, in which 12 users were asked to rate each of the CAAT emotions, in terms of valence, arousal and dominance, using a nine-point SAM. The ratings were then averaged and binned into seven equally spaced "containers" (as much as the emotions on each opposing pair of axes, plus the central "nothing"). Afterwards, we used the container index (1 to 7) as the score for each emotion's valence,

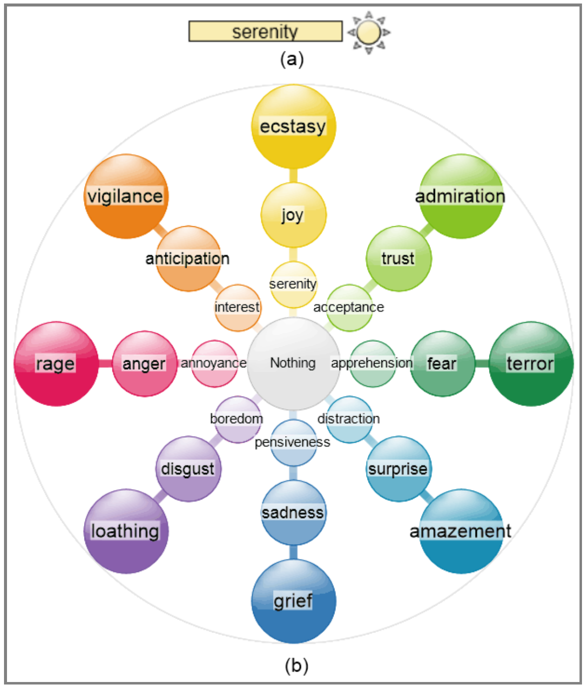

Figure 2. The CAAT tool in (a) closed state and (b) open stated, featuring reversed intensity ordering on the axes.

arousal and dominance dimensions (Table 1, V, A and D columns, respectively). Finally, since valence and arousal are the prevalent dimensions in most of the literature and valence is the one that accounts for most of the variance, both valence and dominance scores have been merged into a single S_1 score. S_2 is simply the arousal score.

$$S_1 = \frac{2V+D}{3} \; ; \; S_2 = A$$

To account for multiple emotion selection (the prototype allows for the maximum choice of two

	CAAT		OEL	
	S_1	S_2	S_1	S_2
V	0.857		0.828	
A		0.543		0.434
D	0.695		0.649	

Table 2. Correlations between SAM valence (V), arousal (A) and dominance (D) and CAAT/OEL S_1 and S_2 scores.

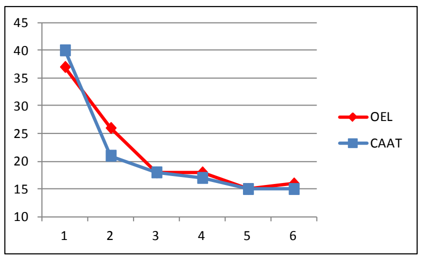

Figure 3. Averages of the automatically measured response times, at each of the six times the tools were used.

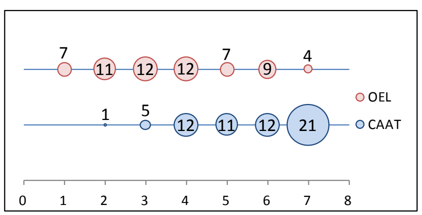

Figure 4. Item 4 answers, "How would you describe this tool", 1 (Slow) – 7 (Fast).

emotions) the final S_1 and S_2 scores are the average of each of the selected emotions' S_1 and S_2 scores.

Testing CAAT

We have decided to validate and compare the results of CAAT against those of two other assessment methods: the SAM and an alphabetically ordered list featuring the same emotion words as CAAT[1] (OEL). SAM is a widely used and validated psychological tool so it is naturally important to validate CAAT against it. On the other hand, OEL is merely the set of CAAT's emotion words on a traditional display – a list –, under a traditional ordering scheme - alphabetical; therefore, a validation against it allows us to conclude about the adequacy of CAAT's design.

A user study was conducted on a quiet classroom at our University, in which participants were asked to provide information about their emotional reactions to stimuli – six photos taken from Lang's International Affective Picture System (IAPS) collection [6]. The IAPS consists of a large collection of photos that have been validated to evoke emotional responses on viewers. Therefore, after a stimulus was presented to each user (for a minimum of 7 seconds), he/she was required to express about his/her emotional reactions on CAAT, OEL and SAM (across participants, the tools and stimuli order was random). The tests were implemented as a computer application and the results and response times were automatically recorded on a database.

In addition to the aforementioned test, the participants were also requested to answer a short questionnaire containing usability satisfaction and user experience items.

The tests were performed by 62 participants (47 male). Ages ranged from 18 to 58 years, averaging 24.6. The majority reported being fluent English speakers. The objectives of the study were explained to the participants and they were also instructed on how to use SAM.

Results and discussion

The most significant results of the data analysis are, perhaps, the Pearson's correlation coefficients between CAAT/OEL and SAM. Since S_1 is an average of valence and dominance, it was only correlated to these two SAM scores (Table 2). On a comparison between the correlations of OEL and CAAT with SAM, it can easily be noticed that CAAT scores have systematically higher coefficients, even though the same emotions were featured on both tools. This suggests that the principles that Plutchik used to layout his model positively contribute to increase CAAT correlation with SAM's.

It should also be noted that S_1 has a significantly higher correlation with both SAM valence and dominance than does S_2 with SAM arousal. This suggests that CAAT results are mainly driven by valence and, to a lesser extent, by dominance.

On their own, CAAT S_1 score is highly correlated with SAM's valence and dominance scores (0.86 and 0.70 respectively) and CAAT S_2 score correlates moderately with SAM's Arousal (0.54). All correlations had their p-values below 0.001.

As previously stated, the response times were recorded automatically. Since both tools were presented six times to each user, the averages of the time lengths

[1] Since OEL features the same emotions as CAAT, we've used the same scoring system, S1 and S2, for its selected emotions.

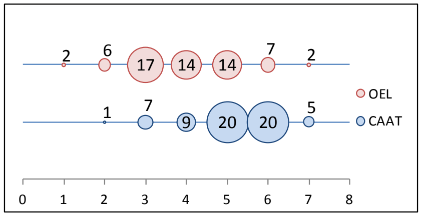

Figure 5. Item 1 answers, "This tool enables me to accurately express my emotions". 1 (Totally disagree) – 7 (Totally agree).

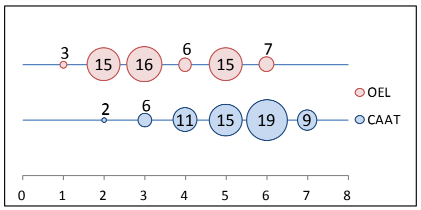

Figure 6. Item 2 answers, "It is easy to find the emotions I'm looking for". 1 (Totally disagree) – 7 (Totally agree).

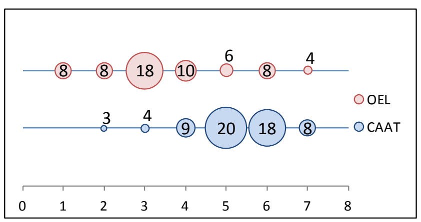

Figure 7. Item 3 answers, **"**The emotions on this tool were ordered". 1 (Totally disagree) – 7 (Totally agree).

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taken at each of these contacts reveal the response time evolution, as the participants were getting familiar with both tools (Figure 3). The results favor CAAT, except for the first contact, when OEL had inferior response times. However, when users were asked to rate the response times of both tools, the differences were more obvious (Figure 4).

The user experience questionnaire allows us to confirm that the users perceived CAAT as allowing them to better express their emotions than OEL, even though both tools contained the same emotions (Figure 5). Furthermore, the users reported that it is easier to find the emotions on CAAT than on OEL (Figure 6) and, in accordance, they did not judged alphabetical ordering as adequate when dealing with discrete sets of emotions (Figure 7).

Conclusions and Future Work

Our tool proved to be, in laboratory settings, a reliable and quick way to assess affective states. Besides being an effective discrete emotion selection tool, its S_1 score manifested strong correlations with SAM valence and dominance and its S_2 score correlated moderately with SAM arousal. Additionally, since the user experience questionnaire results also clearly favor CAAT over OEL, we conclude that, when dealing with discrete emotion word sets, the layout and design principles of CAAT are more adequate than those of ordered lists.

Next, we will research the possibility of allowing for the selection of more than two emotions and what, if any, benefits come from it. Also, a field experiment is being designed in order to understand if CAAT is fit for the assessment of daily life affective experiences.

As a final remark, we believe the presented results prove that CAAT may become a valuable tool for assessing user's affective reactions to stimulus.

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