# In defense of dominance: PAD usage in computational representations of affect.

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## Abstract

Factor-based models of emotion (affect) are often used in the field of emotion modeling and emotion measurement, in particular the three factor model commonly known as Pleasure Arousal and Dominance (PAD). This article addresses computational use and usefulness of the third factor, i.e., Dominance. The claim made in this article is that Dominance should be seriously considered when modeling or measuring affect. More concretely, it presents an easy to understand conceptual description of Dominance, followed by cases in which Dominance was instrumental in modeling synthetic affect, as well as cases in which Dominance was instrumental in measuring user affect. Finally, it relates the PAD factor model to appraisal dimensions.

## Introduction

This article addresses the use of the dominance factor in computational representations of affect. For an introduction on the terminology of affect, emotion, mood and attitude in relation to computing, see e.g. (Hudlicka, 2003; Picard, 1997). Dominance in this article refers to the third factor of the modern factor-based affect representation commonly known as Pleasure-Arousal-Dominance (PAD) (Bradley & Lang, 1994; Mehrabian, 1980; Osgood, 1966; Russell & Mehrabian, 1977). This article is not meant as a theoretical account for, or against the existence of dominance as a psychological construct in emotion and affect. Further it is not intended to give a historical account of factor-based approaches towards representing emotion (such as Wundt's). I focus on practical PAD usage in a computational setting, and present evidence that dominance is a useful and sometimes necessary dimension, both for human affect measurement and synthetic affect representation. Further I propose that PAD factors are a useful intermediate representational format for emotion and affect in computational systems by comparing PAD with Scherer's stimulus checks. But first, I will explain in plain terms what dominance represents.

## What is dominance?

Dominance as a factor in the Pleasure (Valence/Evaluation) Arousal (Activity), Dominance (Potency) factor view of affect represents the amount of influence you feel (an aspect of) the environment has upon you and vice versa (Osgood, 1966). Its inverse is called submissiveness. More specific, dominance refers to whether you feel in control or not, whether you feel powerful or not, and whether you feel overwhelmed or not (Bradley & Lang, 1994; Mehrabian, 1980; Mehrabian & Russell, 1974). If you feel dominant, this means you feel in control and/or powerful and/or not overwhelmed. If you feel submissive, you feel overwhelmed and/or not powerful and/or not in control. If you feel dominant, you feel able to influence your environment. If you feel submissive it is the other way around. Please notice the "and/or" referring to the fact that dominance relates to all three aspects (and certainly many more aspects related to influence). Dominance is not coupled to a relationship between persons per se, but coupled to a relationship between a person and its environment (including persons, events, objects, etc…). You can be overwhelmed by events but also by persons, crowds, relationships and even ideas. You can feel in control of a person but also in

control of a situation or in control of a device. You can feel powerful because of, for example, money, hierarchy, and physical strength.

Just like valence and arousal, dominance is nothing more than the result of a principal component analysis (PCA) showing that there is this "component" that strongly relates to power, control, being overwhelmed, etc.…It might seem as if valence is more pure or more grounded but this is just a matter of personal interpretation of these factors. Valence, just like Arousal, also fell out a PCA showing that there is a "component" that strongly relates to other things such as goodness, warmth, pleasant, happy, etc. It is just that the grounding of these factors is different. Valence is grounded in what is sometimes called the hedonic state (positiveness/negativeness of the experience of the individual relating to reward and punishment as well as dopamine levels). For example, some stimuli simply are pleasant (sugar, soft touch) while others are not (bitter, pain). Arousal is grounded in stimulus intensity, detecting change, and directing attention. Some stimuli simply trigger attention by nature, such as a quickly approaching big object. The grounding of dominance is understood easiest as being grounded in a relation between the environment and the individual. Note that even the most primitive behavior related to dominance, i.e., approach versus avoidance, is per definition relational. One always approaches or avoids *something*. More complex relations include social hierarchy and power relations in general. For example, a CEO might feel submissive towards shareholders but dominant towards employees, resulting in fear and apologies towards annoying shareholders but anger and short-tempered reactions towards annoying employees. Nothing changed, apart from the feeling of dominance, i.e., the interpretation of the relation in terms of power and controllability. This relational grounding complicates matters a little, and is probably a major cause of confusion and misunderstanding and hence reason for not using dominance as a factor in computational or measurement approaches. However, as we will see later, this complication in no way prevents using dominance as a factor to represent an artificial emotion. It only makes measuring dominance from human individuals a task that involves care with respect to framing the rating question in the right way.

I will now give a couple of examples of relations that involve high or low dominance. Each time the perspective is the individual, i.e., the individual feels dominant or submissive about *x*.

- First an easy one. A huge angry crowd is nearing me quickly. This situation will provoke submissive feelings. The crowd has higher power and I have low control potential over a crowd, it is perceptually very present and hence an overwhelming stimulus.
- I feel anger towards someone who just recklessly drove his car onto the road from his car park forcing me into an emergency brake. This is a situation in which I feel dominant. Anger relates to higher dominance because it is associated with actively controlling the environment, and is associated with approach behavior.
- Now the inverse, I feel guilty because I just drove my car onto the road not paying attention forcing a stranger to execute an emergency brake. Now I feel submissive. Guilt and shame involve a situation that I cannot change anymore, and hence lack of control.
- A friend of mine gave me a winning lottery ticket, and I feel both surprised and grateful. Now I feel submissive. Winning the lottery is completely out of your control, and receiving a gift is something that is in control of another (someone else does something to you).
- You just gave an invited lecture on your favorite topic, and afterwards people tell you they thought it was excellent. You feel dominant (although some might feel submissive). You are

the expert and you were invited, both aspects that related to being on control. The fact that you get compliments usually provokes feelings of pride, although introvert people can feel awkward when receiving compliments. So on average this situation will provoke feelings of dominance, but for some the situation in fact has the inverse effect.

Finally, there are many stimuli (words, images, situation descriptions and sounds) with specific dominance attribution (Bradley & Lang, 1994, 2007; Mehrabian, 1980; Mehrabian & Russell, 1974). For example (Mehrabian, 1980), fearful (D=-0.43), distressed (D=-0.36) and protected (D=-0.41) have moderately negative dominance values, while angry (D=0.25), alert (D=0.45), and happy (D=0.46) have moderately positive dominance attribution. Strongly dominant are terms like controlling, masterful, powerful, mighty, influential and proud (all between D=0.66 and D=0.75), while strongly submissive terms include helpless, crushed, timid and feeble (ranging between D=-0.51 and D=-0.46). What is clear from especially these strongly positive or negative terms is that there is a relation involved. One always feels masterful about a skill or activity, powerful with respect to others, but also helpless with respect to a problem and timid with respect to others. In all of these terms, an appraisal of the relation with something else is present, not just the appraisal of that something else. In the CEO example given earlier, this is explicit because it is a social setting: the CEO has more power and is in control of the employees but not the shareholders. In the other examples it is less explicit because they are about relations between situations and persons. This observation points towards the key difference between pleasure, arousal and dominance with respect to "aboutness". One feels pleasant about *x*, but one feels dominant about the relation with *x*. Alternatively, one could say that my dominance is always *relative* to something else in addition to being *about* something else: if I feel something or someone else to be more dominant than me, I feel submissive.

**Dominance in synthetic emotion representation**

Previous examples hopefully give some intuitive meaning to what the dominance dimension represents. In the remainder of this article I will show why it is useful and sometimes necessary for computational modeling of emotion as well as measurement of affect. I will do so by discussing several studies (own and of others) that involved the use of dominance. First I would like to discuss synthetic emotion representation. I focus on representing the affective state, not on the process of emotion elicitation. A well known system that uses Pleasure Arousal and Dominance to represent its affective state is Kismet the social robot (Breazeal, 2003; Breazeal & Scassellati, 1999; Breazeal & Scassellati, 2000). Even though Dominance is referred to as Stance, the interpretation is approximately the same, i.e., an open stance is characterized by approach-like behavior of Kismet (expression of interest, anger), while a closed stance is characterized by avoidance-like behavior (expression of fear, sadness). Approach behavior is typically associated with influencing the environment and for avoidance behavior vice versa. The addition of stance as a factor to represent the affective state of Kismet enabled the representation of the difference between fear (high arousal, low pleasure, low dominance – closed stance) and anger (high arousal, low pleasure, high dominance – open stance). Without stance (dominance) the differentiation between these two classes of affective states is not possible to represent. It is argued that to differentiate fear from anger, something else (read: appraisal) is needed in addition to the dimensions pleasure and arousal (Ellsworth & Scherer, 2003), and this might be true to understand emotion elicitation. But, for the representation of an emotion in a computational system, the availability of a dominance dimension is sufficient. In two strongly related approaches (Becker, Kopp, & Wachsmuth, 2004; Broekens &

DeGroot, 2004; DeGroot & Broekens, 2003), the PAD model is used to dynamically represent the emotional state. In both approaches a mechanism is proposed to incorporate emotional states with moods and or personality traits by enabling the state to gradually change (or pull) the mood state. Both approaches use slightly different mechanisms, but the essence for the current discussion is that also here the dominance dimension plays a major role, i.e., to differentiate between anger-like, and fear-like emotions and associated behaviors, but also to be able to integrate the affective consequences of events that would be appraised as increasing or decreasing control (coping potential) (Broekens & DeGroot, 2004).

**The relation between Pleasure, Arousal, Dominance and appraisal dimensions**

The issue of emotion representation leads us to a second important reason to include dominance in a representation of synthetic emotion, namely, the fact that coping potential, control and power are important appraisal dimensions (Ellsworth & Scherer, 2003; Scherer, 2001; Scherer, Schorr, & Johnstone, 2001). The Dominance dimension strongly relates to this class of appraisal processes. When an event is interpreted, according to appraisal theory, this is the result of a process that identifies to what extent the event is beneficial to ones goals, to what extent this was expected or not, whether there is a responsible agent, and whether something can be done about it. The resulting emotion and associated behavior depends on how these appraisals activate. For example, a sudden, pleasant event makes me happy and surprised. Or, anger can be triggered as a reaction to an action of a responsible actor that is negative for my goals when I have high coping potential available (controllable situation and power to control it). If the PAD factors are used to integrate the result of event appraisal (such as in the previously cited systems), then removing Dominance will severely limit the type of appraisals that can be integrated. Obviously one could argue that as factor- and component-based theories of emotion have a different goal, and history, it is already flawed from a theoretical point of view to want to integrate the result of appraisals in a factor based model. Two things can be said here. First, Pleasure, Arousal and Dominance could be argued to be the common denominators for appraisal processes related to goal/need conduciveness, expectedness and coping. Pleasure relates to the evaluation of valence of events, just like appraisal processes related to goal/need conduciveness and intrinsic pleasantness (Ortony, Clore, & Collins, 1988; Scherer, 2001). Arousal relates to increased attentional resources, preparation of the body for action, heart beat and physiological arousal, just like appraisal processes related to novelty such as suddenness and familiarity (Scherer, 2001). Dominance relates to coping potential, in particular power and control, with power related to available energy, physical strength, money, etc. (i.e. the ability to change a situation), and control related to the possibility of changing a situation (i.e., a characteristic of the situation). Second, from a computational perspective this argument is less important. PAD space affect representation enables two important things: dynamical integration of event appraisal based on appraisal theory, and a useful mapping to categorical emotions (at least category classes) by means of the PAD values for the emotion words for these categorical emotions so that sensible expressions for the robot or agent can be chosen. As such PAD space, provided that Dominance is used, is a useful interface representation from a computational point of view. And, from a theoretical point of view this makes sense. PAD factors are supposed to be the common denominators of affect, so, if anything should be able to interface between appraisal results and categories, it should be these PAD factors. Given the fact that these factors can be used to affectively label a broad set of

stimuli, feelings, emotion words, and even music and environments (see, e.g, the work of Mehrabian, and the extensive work by Bradley and Lang, but see also the next section on affect measurement studies), it makes sense to assume that if one has to choose an intermediate level of representation for emotion, PAD is a good candidate, provided, of course, that Dominance is used. Removing Dominance also removes the differentiation between approach/avoidance behavior, affective states related to high or low coping potential, and emotions such as fear versus anger, thankful versus content, and happy versus impressed. A drawback of using *only* PAD as basis for a representation of affect is that one loses some emotional specificity.

| Valence (evaluation) | Arousal (activation) | Dominance (coping) |
|---|---|---|
| Intrinsic pleasantness | Suddenness | Power |
| Goal/need conduciveness | Familiarity | Control |
| | Predictability | |

*Table 1. Example relations between core affective factors, Scherer's appraisal processes (Scherer, 2001).*

**Dominance in affect measurement**

Not using dominance for measuring human affect also involves losing important information. I will argue for this point by showing two studies in which dominance played a major role. First, though, we discuss several instruments for measuring affect in three dimensions. A well-known instrument, the Self-Assessment Manikins (SAM) (Bradley & Lang, 1994), is based on the three affective dimensions Valence, Arousal and Dominance. It presents the scales graphically, by showing small iconic figures (see figure 1). Subjects indicate on a 9 point scale to what extent they feel positive/negative, arousing, and dominant. A detailed explanation should be given when using the SAM instrument, including an explanation in specific wording about the three affective dimensions. We have recently developed a measurement tool that enables to measure PAD, but using a smaller and dynamic interface component, called the AffectButton (Broekens & Brinkman, 2009). The AffectButton presents a dynamical changing iconic facial expression that enables users to self-report affect by clicking on the expression that best matches their affective state, affective attitude or emotion. A related instrument is the one developed by (Sánchez, Hernández, Penagos, & Ostróvskaya, 2008). Here the user is presented with small icons that together span the PAD space. Users first select the PA quadrant after which they can detail the feedback including the selection of variation of affective states that are due to the dominance (see e.g. the example in figure 1, in which both fear and anger are present in the same PA quadrant).
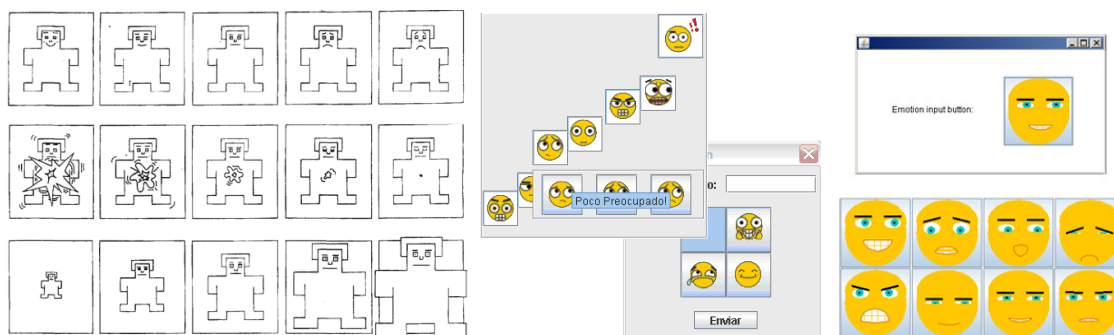


*Figure 1. Self-assessment Manikins (SAM) (Bradley & Lang, 1994), the Instrument by (Sánchez, et al., 2008) showing the unfolded (−P, −A) quadrant, and the AffectButton with example extreme states (Broekens & Brinkman, 2009).*

The point of this overview is to show that many instruments (well-established, and novel ones) use the dominance dimension and thus enable the collection of dominance-related feedback. Unfortunately, dominance feedback is rarely used or collected, and one can often see only the *P* and

*A* scales of SAM being used, or the Positive-Negative affect questionnaire which is also based on Valence and Arousal (PANAS; (Watson, Clark, & Tellegen, 1988)). I argue that dominance should be used because it gives meaningful information about the user or stimulus being rated. We recently performed a statistical analysis on Bradley and Lang's stimuli (ANET, ANEW, IAPS, IADS), Mehrabian's word list describe in (Mehrabian, 1980) and our own measurements of subjects moods and induced stress versus relaxed states. We found all three factors to significantly correlate. We controlled for the number of stimuli in each set by taking 60 pooled measurements from each dataset, resulting 7x60 = 480 cases. We found *P* and *A* to correlate with $r$=-0.31, *P* and *D* to correlate with $r$=0.71, and A and D to correlate with $r$=-0.26. Correlations between *P*, *A* and *D* in the individual datasets were consistent with these overall correlations[1]. This analysis confirms that although *P* and *A* are correlated with *D*, they are by no means the same. Further, a scatter plot of the Dominance – Pleasure distribution in these datasets (see the P-D plot in Figure 2) shows that dominance can vary independently of *P* and *D*, even though some P-D areas are definitely emptier than others (consistent with the correlation). It also shows that these dimensions are simply not orthogonal (a finding consistent with literature). However, and this is the point of the discussion of the next two studies; absence of orthogonality does not mean absence of meaning. As will be discussed in the concluding remarks, stimulus selection bias influences the basis (i.e., the data set) of a principle component analysis aimed at extracting affective factors and can thus play a major role in deciding upon factor importance. In the two following studies we show two types of stimuli for which dominance is important. This is obviously biased, but it does show that there are settings in which it is important to measure stimulus dominance. In the first study, the music rating study, this came as a surprise. In the second it was part of the experimental setup to measure dominance. We used the AffectButton to measure affect self-report (please note that AffectButton has been validated before (Broekens & Brinkman, 2009)).



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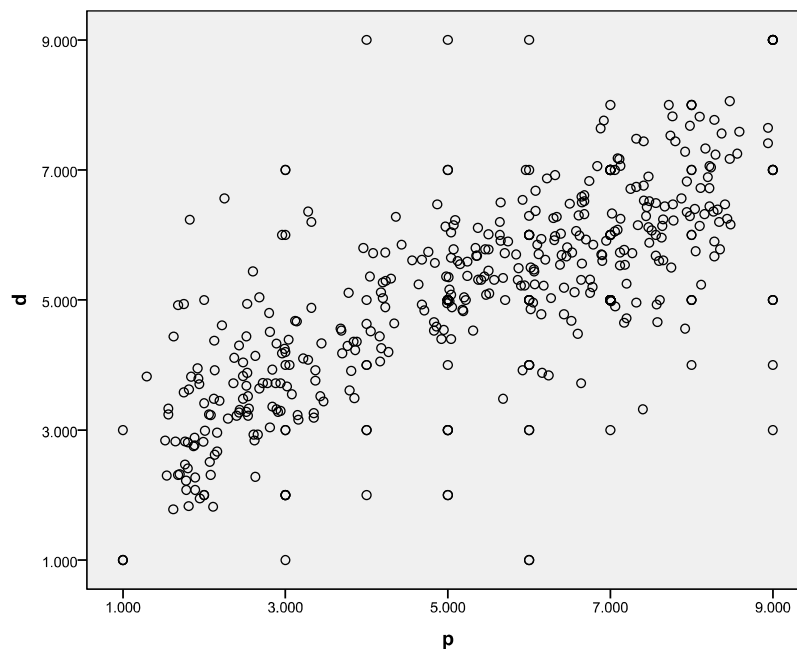
[1] except the word list by Mehrabian, which showed a positive correlation between P and A of $r$(148)=0.28, and *P* and *D* of $r$(148)=0.45. This could be explained by a different factor rotation for Mehrabian's PAD scales and Bradley and Langs PAD scales.

*Figure 2. P-D plot of polled dataset (See text).*

In the first study we asked high school students (n=21) to rate film music from the movie Pirates of Caribbean. Three songs were selected (Broekens, Pronker, & Neuteboom, 2010). When plotting the aggregated data for each song, we were able to visually follow the affect trace of the music (Fig. 3). The aggregation consisted simply of binning all ratings of all subjects and then ordering the ratings according to time to be able to generate a running average over the last 20 rating. The interesting finding was that the dominance trace played an important role in characterizing the music independent of pleasure and arousal, and that this was consistent with a qualitative analysis of the music. As can be seen, there is a dissociation between the *P* and *D* factor, most notably between $t$=16 and $t$=28 where *P* goes up and *D* goes down, and between $t$=105 and $t$=115 where P goes down and D goes up, indicating that both factors can vary independently of each other. Dominance differentiates between "light" and "heavy" pieces of music (Broekens, et al., 2010). Light and heavy in this case refer to the overwhelmingness of the music. This means that if we would not have measured dominance in the first place, we would not have been able to measure this important characteristic of the music.
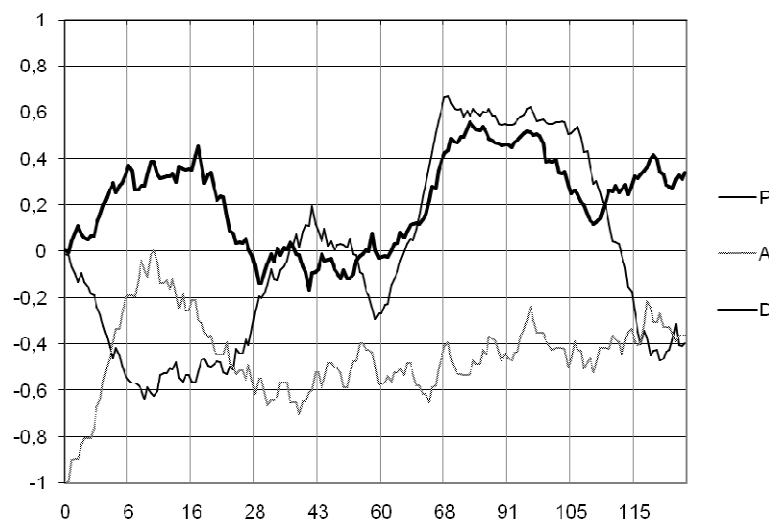


*Figure 3. Affect trace of the song Walk the Plank. For a detailed qualitative analysis see (Broekens, et al., 2010).*

In a second study (Ham & Broekens, 2011), we asked students to rate their affective association with the described role of an intelligent virtual agent (IVA) against whom they had to play a negotiation. For the research hypothesis, we needed to manipulate perceived dominance (Ham & Broekens, 2011). There were two conditions. The first described the IVA as being the employer, having a lot of options for hiring new personnel. The second condition described the IVA as being the potential employee, really in need of job. We used to AffectButton to measure how the IVA would feel according to the subject in terms of PAD values. A statistic analysis of our data showed that only the AffectButton's ratings on the dominance scale varied significantly (higher dominance for the employer, lower for the employee). This shows again that dominance can be selectively manipulated and thus is different from pleasure and arousal from a measurement point of view.

Finally, the fact that in two of our studies we were able to interpret the affective feedback only because we explicitly included dominance in the measurements and analyses clearly indicates that dominance is meaningful.

**Concluding remarks**

To conclude my argument, I have presented an intuitive description of dominance by giving a (simplified) definition, its grounding in a relation between an agent and its environment, and examples of situations that involve dominance or submissiveness. I have further shown that dominance is useful in computational models that want to represent a synthetic emotion using a factor-based system as basis, at least useful to those systems that need to represent social emotions, approach-avoidance reactions, or integrate coping-related appraisal results. Finally, I have shown that affect measurement can benefit from including dominance, and that dominance cannot be discarded as a redundant factor.

To put my argument in perspective, it is focused on computational use of the PAD model, not on the psychological validity of dominance as a construct. It could well be the case that dominance is too much a "rest" factor to be able to account for something real. That is, if dominance is about approach versus avoidance, coping, control, power, influence, etc., then what does it really represent? This is the sort of argument that can be seen in the work on core affect (Russell, 2003). It is argued that only valence and arousal are the most consistent and most important factors across different studies and can be grounded in physiology and motivational behaviors. However, depending on the selected stimuli as basis for the dimensional clustering, different factors come out as more or less important (Gehm & Scherer, 1988). For example, (Gehm & Scherer, 1988) found valence and dominance to be more important than arousal, while (Fontaine, Scherer, Roesch, & Ellsworth, 2007) argue for the inclusion of a fourth dimension (splitting off unpredictability from arousal) based on an analysis of emotion terms and emotion features in three different languages. This means that stimulus selection bias can play a major role in determining factor importance. In any case, dominance is useful in computational representations of affect. If the reason for not using dominance in measurement is, for example, the difficulty of explaining to subjects the dominance scale, then perhaps we should focus on the development of a measurement tool that is more user-friendly, but still valid and reliable. If one does not include dominance as a factor in a computational model of synthetic affect, than the reason should be that power, control, approach vs. avoidance and coping potential are less important for that particular agent.

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