Supporting online material for

An investigation of a quantum probability model for the constructive effect of affective evaluation

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Appendix A

A cognitive model based on quantum probability theory for the constructive effect of affective evaluation

1. Introduction

The following is adapted from White, Pothos and Busemeyer [1]. It provides more detail regarding how Quantum Probability (QP) has been employed to create a cognitive model for the constructive effect of affective evaluation. An introduction to the basic relevant ideas (e.g., projection) is in White et al. [1].

2. Applying the QP principles to affective evaluation

We proceed by making minimal assumptions regarding representation and dynamics. Specifically, we assume that positive and negative affect are represented by rays in a two-dimensional, real space, in which the state vector represents participants' opinion state, regarding the images. The positive and negative affect rays are orthogonal since certainty that e.g. an image is positive (which means that the state vector aligns with the positive affect ray) implies zero probability that the image is negative (Figure 1A). There is another set of rays, corresponding to having a positive image or a negative image. These rays are positioned close to their respective positive and negative affect rays. Also, the positive and negative image rays are assumed to be orthogonal, because the images in each pair were selected, so that they were unrelated (Figure 1B). Note, we are making fairly strong assumptions in setting the subspaces of all possibilities to be one-dimensional (rays) and coplanar. These assumptions are assessed indirectly in terms of the model's ability to capture the observed empirical results.

We assume that when participants see a positive image the state vector is aligned with the positive image ray (Figure 1C). When they subsequently perceive the negative image, the impact on the state vector is to rotate by a fixed amount towards the negative affect ray. This is an important assumption about dynamics (that they are unitary), but which does not impact on prediction in our case. In more general cases, open system dynamics should be employed [2,3]. Finally, the rating of the second image is assumed to correspond to the length of the projection onto the negative affect ray (Figure 1D). This length squared is the probability of interpreting the second image negatively and, without loss of generality, we can equate this probability to the negativity in the rating. In Figure 1E, we consider the impact of the intermediate rating: as the first image is positive, such a rating is likely to result in a positive impression (aligning the state vector with the positive affect ray). Then, when introducing the negative image, the state vector is rotated to the same extent [4,5], which brings the state vector closer to the negative affect ray. It is clear in Figure 1E that this leads to a longer projection along the negative affect ray. This is how the prediction that the intermediate rating amplifies the negative impression of the subsequent image arises in the QP model, in the PN order. An analogous reasoning predicts that in the NP order an intermediate rating will amplify the positivity of the subsequent rating (Figure 1F).

Further formalization would be warranted if one were to attempt to provide exact quantitative fits to the results, though we stress that this is not our objective here. The way such a formalization would proceed is by noting that, in the PN condition (the situation is exactly analogous in the NP condition), in the single rating condition:

$$Prob(second\ rating\ is\ N) = |P_N U|\psi\rangle|^2$$

where $\mathrm{P_N} = |\mathrm{N}\rangle\langle\mathrm{N}|$ is the projector to the Negative Affect ray and $|\psi\rangle$ is the initial state vector. The matrix U is the unitary matrix quantifying the effect of introducing the negative image. If we consider clockwise rotations as positive, then we can write $|\psi\rangle = \mathrm{R}_{-\theta}|\mathrm{P}\rangle$, where $|\mathrm{P}\rangle$ is the positive affect ray, θ is the angle between $|\psi\rangle$, $|\mathrm{P}\rangle$, and $\mathrm{R}_{-\theta}$ is a rotation (unitary) matrix.

In the double rating condition:

$$Prob(second\ rating\ is\ N) = |P_N U|P\rangle|^2$$

So, the impact of having the intermediate rating can be quantified as:

$$|P_N U|P\rangle|^2 - |P_N U R_{-\theta}|P\rangle|^2$$

Let us further express U as $U = R_\varphi$, where φ is the fixed angle which captures how much the mental state rotates towards the negative affect ray, as a result of introducing the negative image. Then, the expression which determines the extra negativity in the second rating, due to the intermediate rating, is:

$$|P_N R_\varphi|P\rangle|^2 - |P_N R_{\varphi-\theta}|P\rangle|^2$$

noting that $U(x+y)=U(x)U(y)$ (e.g., [6], p.131). We basically see that the intermediate rating is equivalent to rotating the initial mental state further towards the negative affect ray, in relation to the situation where there is no intermediate rating.

As it stands, this expression has two parameters, φ and θ. If computational fits were the primary objective of an investigation, it would have to be the case that at least one of these parameters is determined independently (e.g., through pilot data). As things stand, as noted, in this demonstration we are interested only in the general, qualitative prediction that, introducing the intermediate rating, leads to a more negative rating for the second image (in the PN condition) and, analogously, a more positive rating for the second image (in the NP condition).

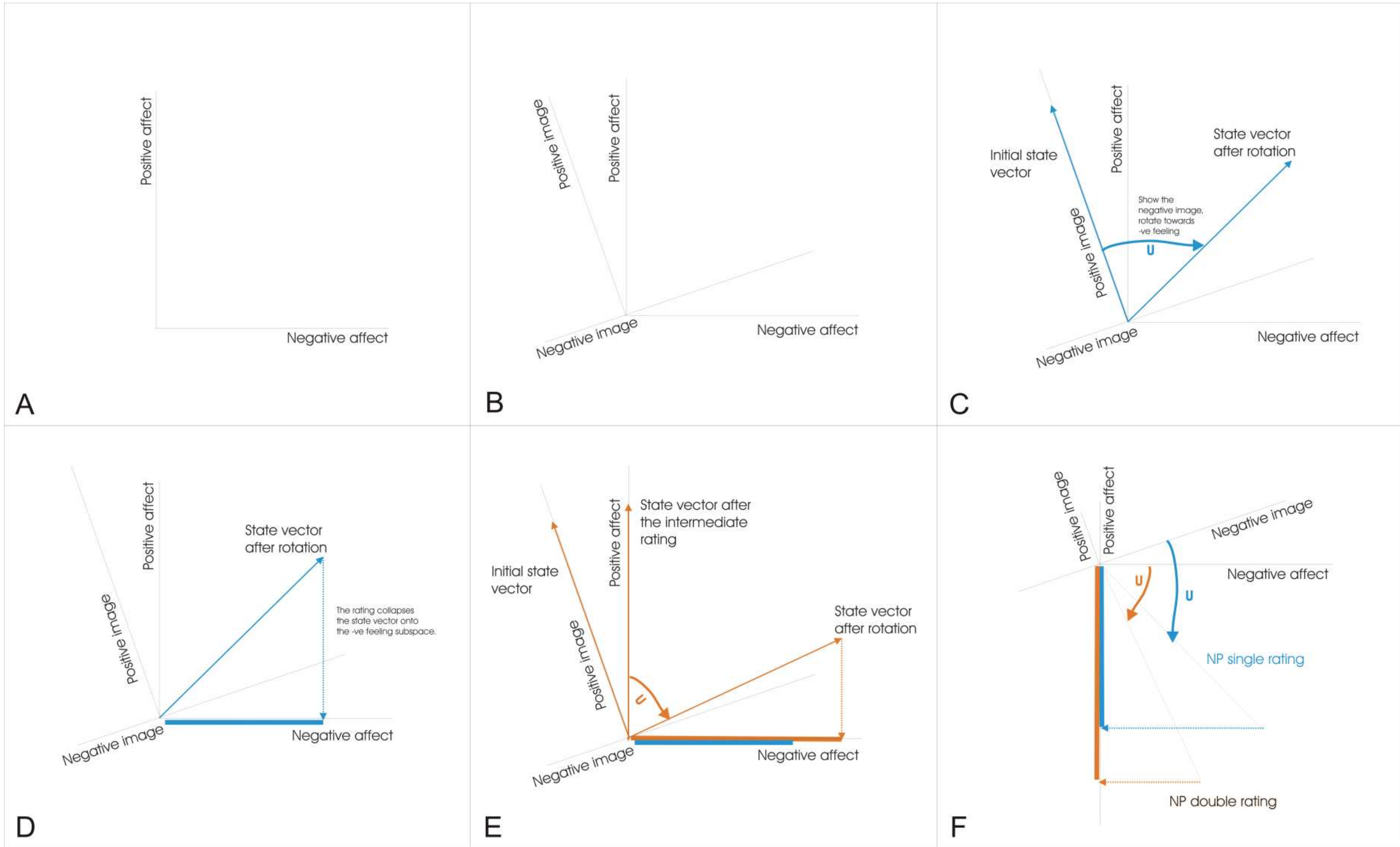

Figure 1. Quantum Probability Model: a QP model for the constructive role of measurement in the present experiments, in the PN condition (2A – 2E) and NP condition (2F). (Source: White et al., (2014). Sometimes it does hurt to ask: the constructive role of articulating impressions. Cognition, 133(1), 48-64. Adapted with permission)

3. References

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Appendix B

Pilot study to select celebrities for Experiment 3

1. Introduction

The stimuli used in Experiment 3 were the images and names of pairs of celebrities drawn from various areas of public life e.g. music, politics and sport. The celebrities were selected on the basis that they were sufficiently related so that one would expect the trustworthiness of one to change our perspective for the trustworthiness of the other and so that one celebrity would be regarded as more trustworthy than the other. The purpose of this pilot study was to validate the trustworthiness of the selected celebrities.

2. Method

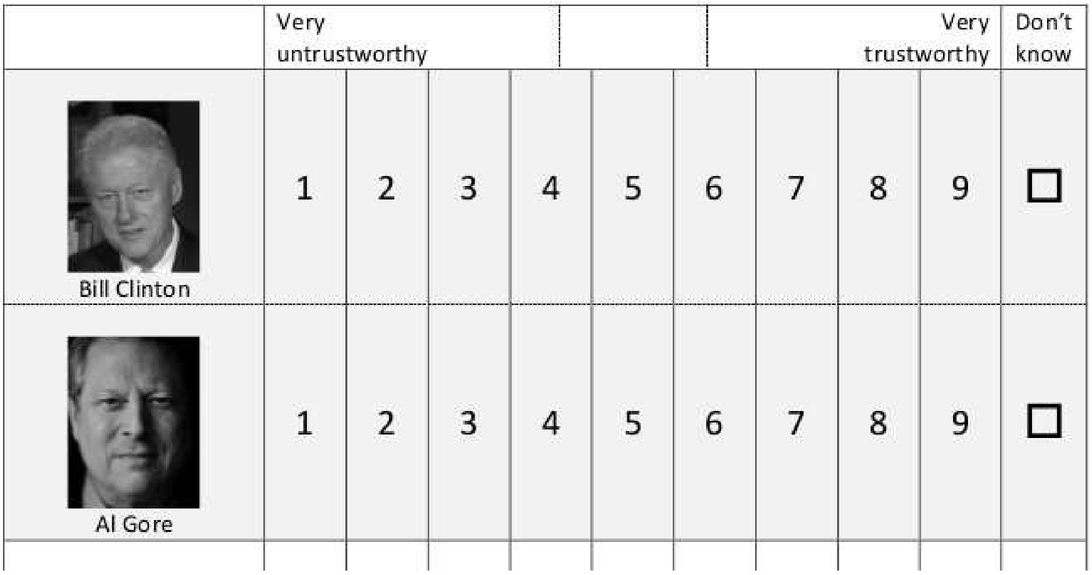
2.1. Participants and Design

Seventeen Swansea University students participated for course credit (16 women, average age 19.7 years).

2.2. Stimuli and procedure

Twenty seven pairs of celebrities were collected from various internet sources as being likely, in the experimenter's estimation, to show differential levels of trustworthiness. Images were selected that showed the celebrity looking directly at the camera and with a neutral, non-emotional expression (e.g., not smiling). The images, as in other experiments [e.g., 1,2], were cropped to the celebrity's head and shoulders, converted to grayscale and scaled to the same size.

Using these images a questionnaire was constructed (see Figure 1), asking people to rate the trustworthiness of each celebrity on a 9 point scale (1 is "Very untrustworthy" and 9 is "Very trustworthy"). Images of celebrities were presented in their intended pairings. There was also an option to say "don't know". Participants completed the questionnaire after taking part in other experiments conducted by the experimenter.



	Very untrustworthy								Very trustworthy	Don't know
Bill Clinton	1	2	3	4	5	6	7	8	9	☐
Al Gore	1	2	3	4	5	6	7	8	9	☐

Figure 1. Sample page from famous faces pilot questionnaire

3. Results and discussion

The mean rating of trustworthiness for each celebrity and the difference in mean ratings for pairs was calculated. We also calculated how well recognised a celebrity was by summing the responses to the “don’t know” question (see Table 1 in main text). The results indicated that five celebrity pairs in particular were not very well-recognised, as compared with the other celebrity pairs, since the corresponding number of don’t knows was over 1 standard deviations above the mean (M=2, SD=3). These pairs (Condolezza Rice & George Bush, Yoko Ono & John Lennon, Ed Balls & Gordon Brown, Bill Clinton & Al Gore, and Ed Milliband & David Milliband) were eliminated. We decided to retain the remainder of celebrity pairs, in spite of the small degree of difference in trustworthiness between some pairs, in order to ensure that we had sufficient numbers of stimuli for the study.

4. References

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