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Short-term happiness dynamics as a consequence of an alcohol or caffeine intake

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1 Introduction

There exists a scientific debate about whether happiness is a trait or a state (see [1] for a review). However, some authors go beyond by an inclusive proposal about the happiness nature: it is both a trait and a state [2]. We adopt that approach in this study.

If happiness has a state nature as well as a trait one, we will be able to study its dynamics as both short and long term, even as a result of a unique eliciting stimulus in a single session, as it can be a drug intake. For instance, it has been demonstrated that, after a single dose intake, both alcohol and caffeine can increase happiness and feelings such as euphoria in the short term [3-5]. On the other hand, the existence of individual differences inside the acute effects of both drugs has been proved [6-8]. But its short-term dynamics has not been well described yet.

There exists a mathematical dynamical model to predict and describe how the whole personality changes (The General Factor of Personality or GFP) during a single session in response a single dose of caffeine or alcohol and how the responses vary between individuals [9, 10], but it has not been applied to the study of happiness yet. In this study, we present a dynamical model to predict the evolution of a subject's happiness in response a single dose of alcohol or caffeine.

The model is provided by the following integrodifferential equation:

$$\begin{aligned} \dot{q}\,(t) &= a\,(b - q\,(t)) + \frac{\delta}{M} s(t) q(t) - \frac{\gamma}{M} \int_{t_0}^{t} \exp\left(\frac{r-t}{\tau}\right) s(r) \cdot q(r)\, dr \\ q\,(t_0) &= q_0 \end{aligned} \tag{1}$$

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In Eq. (1), $q(t)$ represents the GFP dynamics; and b and q_0 are respectively its trait level and its initial value. Its dynamics is a balance of three terms, which provide the time derivative of the GFP: the homeostatic control ($a(b - q(t))$), i.e., the cause of the fast recovering of the tonic level b, the excitation effect ($(\delta/M)s(t)q(t)$), which tends to increase the GFP per drug unit, and the inhibitor effect ((γ/M)ů $\int_0^t \exp \frac{r-t}{\tau} s(r)q(r)dr$), which tends to decrease the GFP per drug unit and is the cause of a continuous delayed recovering, being M the amount of drug intake. Parameters α, δ, γ and τ are named respectively the homeostatic control power, the excitation effect power, the inhibitor effect power and the inhibitor effect delay. In addition, $s(t)$ provides the dynamics of the stimulus by the drug kinetics:

$$s\left(t\right) = s_0 \exp(-\beta t) = \begin{cases} \frac{\alpha M}{\beta - \alpha} \left(\exp(-\alpha t) - \exp(-\beta t)\right) & \alpha \neq \beta \\ \alpha M t \exp(-\alpha t) & \alpha = \beta \end{cases} \tag{2}$$

In Eq. (2) α is the drug assimilation rate and β is the drug elimination rate, being again M the amount of drug intake.

The model given by eqs, 1 and 2 has been applied in a study with two participants with a different level of the happiness trait, by using a Trait-State Scale of Happiness previously validated in [11]. This scale was based on the Euphoria Scale [12], and it has been proved that this scale is closely related with the Oxford Happiness Inventory (short version) [13] and how this scale is sensitive to the changes produced by eliciting stimulus [14]. We also use a Smiling Face Scale. Both scales will be described below.

2 Methodology

Two voluntary men participated in this study. A single-case experimental ABC design was used. In phase A the participants received no treatment. At the start of phase B, both participants received 26.51 ml of alcohol and a slight food. In phase C, both participants received 330 mg of caffeine. Two instruments to evaluate happiness were used: 1) The trait-State Scale of Happiness [11] in its trait-format ("*Are you like this in general?*") and its state-format ("*Are you like this at this moment?*" or "do you feel so at this moment?"). It is a 4-item Likert-type response scale with the following self-descriptive adjectives: cheerful, elated, exhilarated, and lively. The scale score goes from 0 (no effect) to 5 (maximum effect); 2) The Smiling Face Scale, that is a 7-item Likert-type response scale, that shows images with very sad to very happy faces, so ranging from negative to neutral to positive values [15, 16]. Both participants filled in the Euphoria Scale in its trait format at the very beginning of this study, and every 5 minutes over a 1,5-hour period, all the three phases long. For the mathematical analysis, the modified response model was applied, whose usefulness has been shown to model the dynamic effect of both drugs. Figures 1 to 4 show the data (Expression) jointly with the predicted by the model response curves (Happiness).

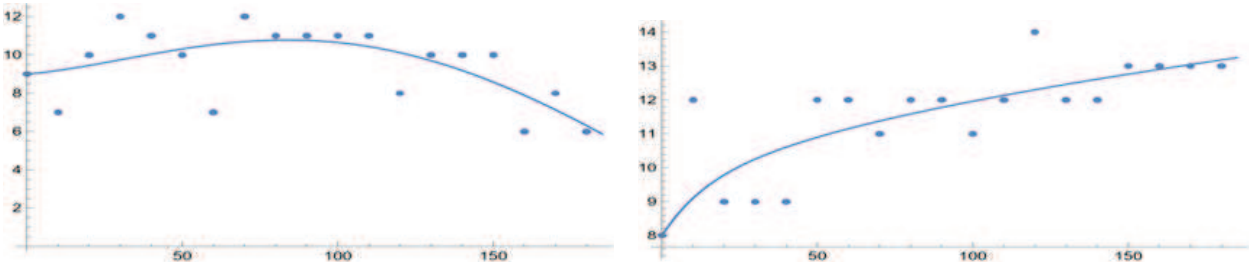

Figure 1: Participant 1: (Left) Happiness response to alcohol dose (R2=.43); (Right) Happiness response to caffeine dose (R2=.45).

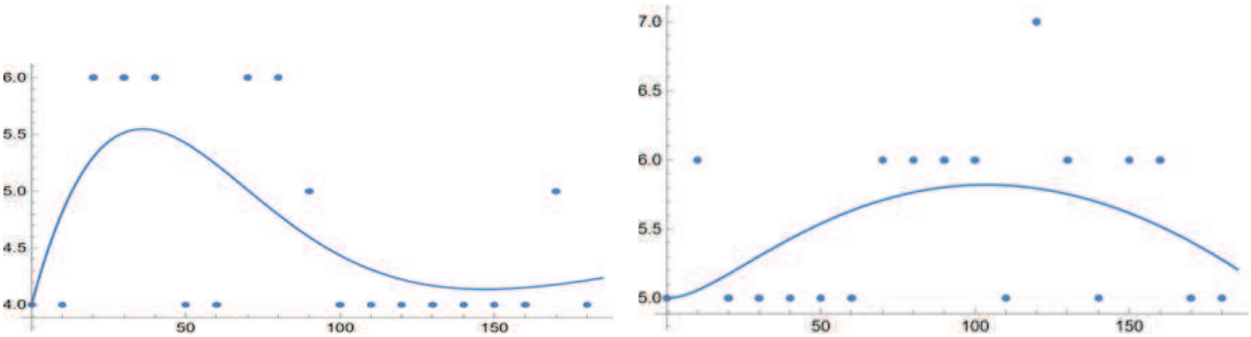

Figure 2: Participant 1: (Left) Expression response to alcohol dose (R2=.36); (Right) Expression response to caffeine dose (R2=.16).

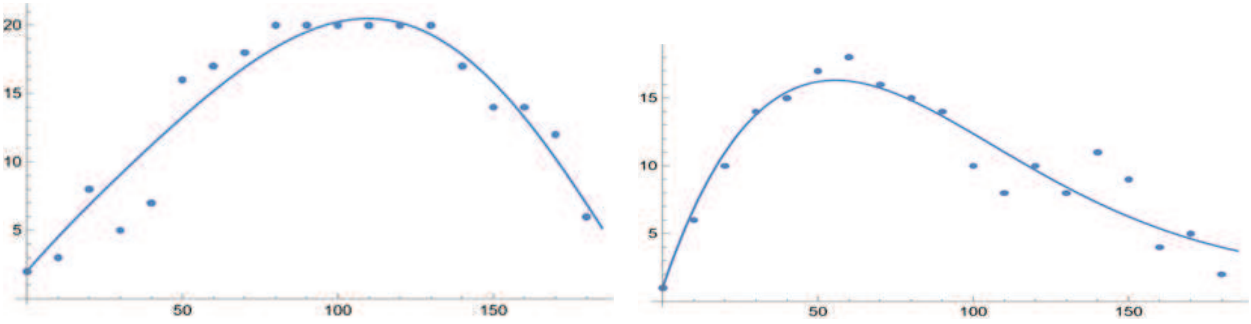

Figure 3: Participant 2 (Left) Happiness response to alcohol dose (R2=.90); (Right) Happiness response to caffeine dose (R2=.87).

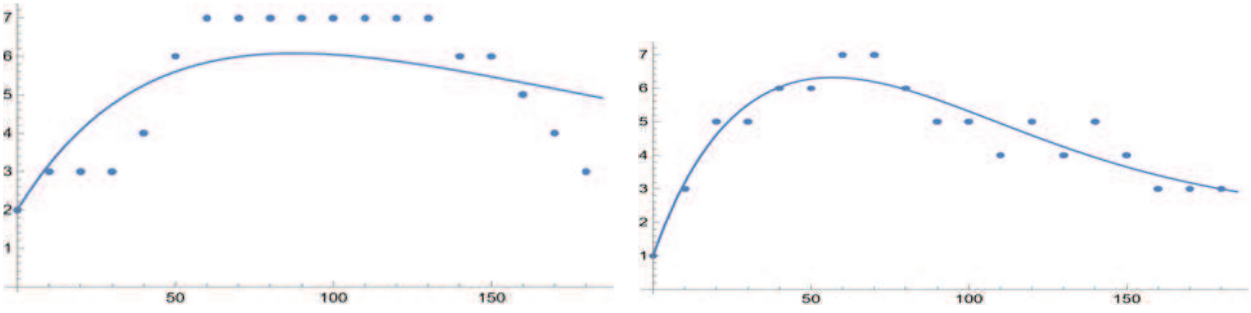

Figure 4: Participant 2: (Left) Expression response to alcohol dose (R2=.74); (Right) Expression response to caffeine dose (R2=.83).

3 Conclusions

The difference between both participants in the experiment is evident: Participant 1 presents more dispersion than Participant 2. In addition, the dynamic model presented here adapts better to Participant 2. However, the results provide random residuals in both cases, and so the model represents the deterministic predictive part of the dynamical responses.

As other studies pointed out [9, 10], a model describe and predict how the GFP changes in response to a single dose of caffeine or alcohol. This mathematical model predicts that the lower the GFP-trait score is the higher the response to both caffeine and alcohol intake will be, and better the corresponding model evolution curve fits the data. That is precisely what happens in the present study, so the participant 2 scores lower in the GFP-trait (17 points) than participant 1 (23 points), and that is because his response is higher, and the model fits the experimental data better. This fact is coherent with the mathematical model prediction [17], and with the fact that GFP and Happiness scores are closely related [11, 14].

Regarding the Happiness scores, the relationship between the trait and the state evolution after a single dose intake of caffeine or alcohol is not the same as regarding the GFP. So, the difference between both participants is not as high as regarding the FGP (10 and 14 points respectively for the Trait Scale of Happiness, and the same score (5) for the Face Scale). So that, this discrepancy should be studied in the future.

Besides, these results are consistent with the ones obtained for the FGP in the sense that the lower the initial score is, the higher level will be achieved during the response to the drug intake. Likewise, the same happens regarding Happiness as this study reveals. So, the initial scores for participant 1 are 9 and 4 for the State Scale of Happiness and for the Face Scale, respectively, while for participant 2 they are 3 for both scales This result is coherent with the model prediction for the personality responses to drug intakes [17].

Note however, that this study is a first approach to the relationship between happiness and drug consumption, taking into account that this subject can provide an upset social discussion due to somebody can understand that this paper suggests consuming drugs to reach short periods of happiness, while its objective is the opposite: preventing consumers that drug consumption must be done rationally. From this result, in a future research, the objective could be to relate happiness with personality dynamics, such as it has been already with the General Factor of Personality dynamics [18].

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