Personality and wellbeing: mining data from behaviour change interventions

Nathaniel CHARLTON [a,1] John KINGSTON [a] and Ben (C) FLETCHER [b]
[a] *University of Brighton, United Kingdom*
[b] *Do Something Different Ltd and University of Hertfordshire, United Kingdom*

Abstract. We study the relationship between personality and wellbeing using questionnaire data from 14,397 people who participated in a digitally delivered Do Something Different (DSD) behaviour change intervention. Our dataset consists of answers to a pre-intervention questionnaire comprising sections addressing behaviour, wellbeing, anxiety and depression, and habits. For 2,863 of these participants, corresponding post-intervention responses are also available.

DSD interventions target various health and wellbeing issues such as stress reduction, weight loss, smoking cessation and diabetes self-management. They are based on the psychological theory of behavioural flexibility, developed in a series of books and papers by Fletcher, Pine and others.

This paper describes how we applied regression models to data from DSD interventions to understand better the role of behaviours and personality in wellbeing, and hence refine the theory of behavioural flexibility. We describe our dataset and present a simple model of how behaviours are related to wellbeing; discover that the 30 behaviours listed in the questionnaire can be classified into 9 "inhibitory" and 21 "facilitatory" behaviours; and identify regressions models that predict wellbeing from behaviours more accurately than the existing behavioural flexibility model.

1. Introduction

In a series of books and papers (e.g. [1,2,3]) psychologists have amassed evidence for the theory that *behavioural flexibility* can help explain the differences in wellbeing experienced by different people. According to this viewpoint, some people have a smaller range of behaviours to call upon to meet the challenges that arise in their lives and thus experience more stress and difficulty than others. Do Something Different Ltd have developed a range of digitally-delivered (e-health) programmes designed to help people increase their behavioural flexibility i.e. to add new behaviours to their available repertoire, and to break harmful habits. We study a sample of over 14,000 people who have taken part in a DSD intervention since 2012, with objectives such as stress reduction, weight loss, smoking cessation and better diabetes self-management, with impressive results (see e.g. [4]). Each DSD intervention consists of a set of personalised recommendations of small activities, called "Dos", that are outside the participant's normal habits (see [2]). Since these "Dos" are designed to help people develop new behaviours, it is vital to understand exactly how, and which, behaviours contribute to wellbeing.

[1] Corresponding Author: Nathaniel Charlton. E-mail: billiejoecharlton@gmail.com. Charlton and Kingston were supported by Innovate UK (KTP 10152). Fletcher was supported by EU Horizon 2020 grant 643735.

Predictor (behaviour)	Opposite	Group	Coeff. mean	Min	Max	Std. dev.
(Intercept)			442.01	440.12	446.31	1.89
Calm/relaxed	Energetic/driven	F	60.49	59.23	62.51	1.03
Energetic/driven	Calm/relaxed	F	40.42	38.57	41.73	1.01
Definite	Flexible	F	33.44	32.24	34.51	0.74
Flexible	Definite	F	23.95	23.11	25.17	0.77
Lively	Not lively / laid back	F	20.75	19.09	22.94	1.06
Extroverted	Introverted	F	17.44	16.57	18.40	0.66
Systematic	Spontaneous	F	15.65	14.13	16.47	0.80
Proactive	Reactive	F	15.43	13.44	17.10	1.21
Group-centred	Individually-centred	F	14.89	13.57	16.63	1.08
Spontaneous	Systematic	F	10.68	8.85	12.44	1.15
Behave as you wish	Beh. as others want	F	8.81	7.88	10.29	0.76
Predictable	Unpredictable	I	6.27	4.64	7.73	0.94
Trusting	Wary of others	F	5.36	3.84	6.68	0.91
Conventional	Unconventional	I	5.21	3.92	6.38	0.81
Gentle	Firm	F	4.43	3.29	5.66	0.74
Open-minded	Single-minded	F	3.86	2.43	4.69	0.80
Risk-taker	Play it safe	F	1.55	0.52	3.34	0.77
Assertive	Unassertive	F	−0.02	−1.74	1.51	1.07
Single-minded	Open-minded	F	−1.11	−2.57	0.58	0.99
Firm	Gentle	F	−1.51	−2.72	−0.61	0.66
Individually-centred	Group-centred	F	−1.78	−2.89	−0.43	0.90
Play it safe	Risk-taker	I	−8.78	−10.26	−7.29	1.02
Unconventional	Conventional	F	−9.34	−10.40	−8.25	0.66
Unassertive	Assertive	I	−17.04	−18.47	−15.78	0.75
Behave as others want	Beh. as you wish	I	−23.42	−24.37	−22.28	0.71
Reactive	Proactive	I	−23.82	−25.06	−22.25	0.96
Introverted	Extroverted	I	−32.00	−33.64	−30.27	0.93
Not lively / laid back	Lively	I	−37.37	−39.67	−34.56	1.54
Wary of others	Trusting	I	−44.09	−45.59	−42.26	1.11
Unpredictable	Predictable	F	−44.49	−46.42	−42.08	1.25

Figure 1. Coefficients for the individual behaviours model, with predictors ordered by coefficient mean. The "Group" column shows whether each behaviour is in the (F)acilitatory or (I)nhibitory group in Section 3.

2. Background

Our dataset consists of pre-intervention questionnaire responses from 14,397 people who participated in a DSD intervention, and post-intervention answers to the same questionnaire for 2,863 of these people. Two sections of the questionnaire are important here:

Behaviour rater (full details in [2]) The participant is shown a 6×5 grid, each cell containing a description of a behaviour, and instructed: "Click on the behaviours below that best describe you. Select as many or as few as you like, so long as they describe how you generally are." The 30 behaviours consist of 15 pairs of opposites (positioned far apart in the grid), as shown in the first two columns of Figure 1.

Wellbeing questions Participants are shown 8 statements and asked, "Thinking about how your life has been in the last month, move each slider to indicate how much you agree with the wellbeing statements." Each person's 8 slider positions are converted to integers from 0 (the "a little" end) to 100 (the "a lot" end) and summed to give a wellbeing score from 0 to 800, higher values indicating better wellbeing. The questionnaire is similar to the Warwick–Edinburgh Mental Wellbeing Scale [5], addressing feeling and functioning aspects of wellbeing, e.g. finding it easy to make decisions or feeling happy.

The psychologists [2] propose a formula for scoring a person's answers to the behaviour rater, called the *behavioural flexibility score*:

$$100\% \times \tfrac{1}{2}\left(\frac{\text{number of behaviours selected}}{30} + \frac{\text{number of opposite pairs with both selected}}{15}\right)$$

This formula is monotonic: adding an extra behaviour always increases the score. Implicit in the formula is the idea that every behaviour is beneficial to have at one's disposal. Let us call this idea *Every Behaviour Is Useful* (EBIU). The formula also awards a boost in score when someone selects both of a pair of opposite behaviours, e.g. "extroverted" and "introverted"; rather than viewing this as contradictory, the model [2] interprets it as evidence of flexibility, in that the person has the capacity to be either extroverted or introverted as each situation demands. Let us call this idea *Opposites Are Special* (OAS).

The following table includes the mean wellbeing score before the intervention (for all participants, and for only those for whom post-intervention data is available), after the intervention, and as a change from pre- to post-intervention. Mean behavioural flexibility scores are also given, and we show the correlation between the two scores in each case.

	Pre-intervention (all participants)	**Pre- (only those with post- data)**	**Post-**	**Change (post- minus pre-)**
Wellbeing score	488.89	511.53	561.20	49.68
Behavioural flexibility score	18.64	20.19	19.46	-0.72
Correlation between the above	0.17	0.15	0.17	0.13

The correlations are all positive, as per the behavioural flexibility theory: the higher someone's behavioural flexibility score, the better their wellbeing on average. We also see that the interventions do have a positive effect on wellbeing, as reported in detail in [4]. However, while wellbeing rises, behavioural flexibility scores appear to fall slightly, which is not in line with what is predicted by a simple EBIU model.

3. Relationships between the behaviours

We used correlation networks (cf. [6]) to understand how the 30 behaviours co-occur. Figure 2 shows one of the correlation networks we constructed, using the ϕ coefficient to measure correlation, with a threshold of 0.175.

The behaviours have separated into two groups, with three connecting "bridge" nodes: "gentle", "calm/relaxed" and "flexible". The behaviours to the left of the "bridge" appear to share a common theme: they generally appear to reflect a narrowing down of a

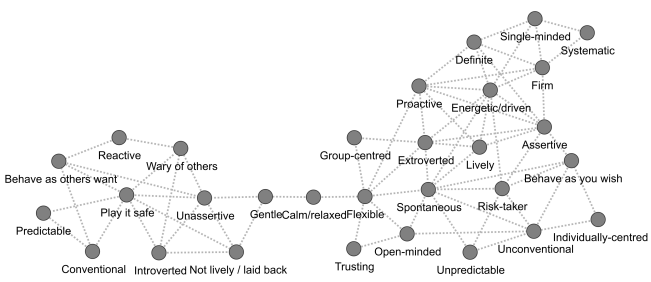

Figure 2. A correlation network depicting the typical co-occurrences of the 30 behaviours.

person's options for action. If a person is wary of others, they are unlikely to take actions that others may disapprove of; while if a person is unassertive, they may be uncomfortable even stating what actions they wish to take. In either case, their possible behavioural options are restricted. We thus term these *inhibitory* behaviours. Conversely, many of the behaviours to the right of the "bridge" appear to be linked to having a broader range of possible actions available in any situation. For example an open-minded person may see more options and an unconventional person may be less restricted by social conventions. We term these *facilitatory* behaviours. The data, therefore, suggest that a higher-order variable connects the 30 behaviours, even though they represent separate traits [2].

4. Regression models linking behaviours and wellbeing

In our research we have experimented with a range of regression models[2] which predict wellbeing scores from behaviours. Some of these models are:

- *Behavioural flexibility model:* a model with a single predictor, the behavioural flexibility score from Section 2.
- *Facilitatory/inhibitory model*: a model with two predictors, the number of facilitatory behaviours selected and the number of inhibitory behaviours selected.
- *Individual behaviours model*: a model with 30 binary predictors, one for each behaviour in the behaviour rater.
- *Individual behaviours and opposites count model*: this is the individual behaviours model, extended with an extra integer-valued predictor, namely the number of opposite pairs of behaviours where both were selected.

Our baseline for comparison is an *intercept-only* model, which simply always predicts the mean wellbeing score in the dataset. Figure 3 reports two measures of model performance, obtained using 10-fold cross-validation: RMSE and correlation coefficients[3]. In terms of predictive power, the behavioural flexibility model is not much better than the intercept-only model. The facilitatory/inhibitory model is significantly better, indicating that our division of behaviours into two groups, from Section 3, does provide a useful tool for understanding behaviours and their effects. The coefficients are as follows[4]:

Predictor	**Coeff. mean**	**Min**	**Max**	**Std. dev.**
(Intercept)	446.15	444.10	449.62	1.85
No. of facilitatory behaviours	13.39	13.00	13.63	0.21
No. of inhibitory behaviours	−22.71	−23.05	−22.31	0.28

The coefficient for the inhibitory behaviours is negative, so that the data does not support EBIU: not every behaviour is associated with an increase in wellbeing. The individual behaviours model is significantly better at predicting wellbeing; Figure 1 gives the fitted coefficients. 13 behaviours have negative mean coefficients, which again does not support EBIU. The inhibitory behaviours appear disproportionately among those with the most

[2]The regression models mentioned here are linear, ordinary least squares models; we tried other kinds too.

[3]The reported RMSE (root mean squared error) values are the means of the RMSEs for each of the 10 folds. The correlations reported are Pearson correlation coefficients obtained using a *pooling* strategy, i.e. we bring together the pairs of actual and predicted scores from the 10 folds, and calculate the correlation on this combined set of points.

[4]We show the mean, minimum, maximum and standard deviation of each coefficient over the 10 folds.

Model	RMSE	Correlation
Individual behaviours and opposites count model	122.40	0.56
Individual behaviours model	122.41	0.56
Facilitatory/inhibitory model	131.18	0.46
Behavioural flexibility model	145.56	0.17
Intercept-only model	147.70	

Figure 3. Performance, with 10-fold cross-validation, of models predicting wellbeing scores from behaviours.

negative coefficients. Adding the number of opposite pairs as an extra predictor did not materially improve model performance; thus a simple OAS hypothesis is not supported. Further experiments with other opposites-related predictors will reveal whether evidence for some modified form of OAS can be found. We performed the same analysis on the post-intervention data, and also using scores from an anxiety and depression diagnostic in place of wellbeing scores, and the pattern of results was essentially the same.

5. Conclusions and future work

By applying regression models to a large dataset of answers to a behaviour and wellbeing questionnaire, we have developed an improved understanding of how behaviours are linked to wellbeing. In particular, some behaviours seem to be beneficial for wellbeing while some are associated with poorer wellbeing. We also observe that, while showing increased wellbeing on average, participants did not increase their behavioural flexibility. Neither observation supports the EBIU hypothesis. Nor did we did find evidence that selecting opposite behaviours confers an added advantage to an individual's wellbeing as would be expected by the OAS model. The third author's research suggests this may be due to lag effects[5] and the interaction of new behaviours with reflective processes [2] which we cannot test with the current dataset. However, the facilitatory/inhibitory model does add significantly to the predictability of wellbeing and we are in the process of putting these findings to work to optimise DSD interventions, ensuring that interventions concentrate on helping people to develop the behaviours that will benefit them most.

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[5] "It takes time to change general or more distal behaviors which are at the core of the person and it is easier to change specific behaviours proximal to a goal." [4]