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Jekyll and Hyde

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Abstract

Jekyll and Hyde were in fact two people inside the same person – an obviously dynamically-inconsistent person. In the book and in the movie, the dynamic inconsistency was resolved in a rather dramatic way. We investigate its resolution in the laboratory.

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1. Introduction

Jekyll & Hyde were two different people inside the same person. Dynamically inconsistent people are the same. We are interested in how such people cope with this inconsistency. Do they realise that they are inconsistent, and, if so, how do they behave in the light of it? Are they naïve, sophisticated or resolute? A naïve person simply ignores his or her dynamic inconsistency; a sophisticated person takes his or her future behaviour into account when deciding in the present; and a resolute person just imposes his first period preferences on all future decisions. For references to these terms, and a discussion of them, see Machina (1989) and McClennen (1990). Such considerations are important in two contexts: dynamic decision making under risk when people do not have Expected Utility preference functionals; dynamic decision making through time when people do not discount the future exponentially. The literature on the latter theme, particularly that relating to people with quasi-hyperbolic discounting (see, for example, Harris and Laibson 2002), typically assumes that such dynamically inconsistent people resolve their inconsistency sophisticatedly. Whether they do or not is clearly of importance.

In the context of a simple life-cycle consumption model, we first develop the theoretical implications of these three types of responses, and then we explore experimentally which of these types is nearest to actual behaviour. As it is impossible to induce dynamically inconsistent preferences in the laboratory, we explain how we implemented an experimental investigation in the laboratory with two people – one playing the role of Jekyll, and the other the role of Hyde.

2. The Theory

We start with the following discrete period life-cycle story applied to a dynamically consistent individual. The individual receives an income *M* in every period. He or she has to decide how much to consume C each period. Savings earn interest at the constant rate of return r. The probability of the problem continuing is ρ every period[4]. The per-period utility function is

$$u(C) = C^{1/2}$$

and the individual wants to maximise expected (discounted) lifetime utility, given as in period t by

$$u(C_t) + \rho u(C_{t+1}) + \rho^2 u(C_{t+2}) + \rho^3 u(C_{t+3}) + ... \tag{1}$$

The optimal solution takes the form[5]:

$$C = A[W + M/(r-1)] \text{ where } A = (1-\rho^2 r) \tag{2}$$

where W denotes the stock of wealth at any time. Thus the optimal strategy is to consume a constant fraction of 'lifetime wealth', namely $W+M/(r-1)$, each period.

Now consider the same problem for a 'Jekyll & Hyde' individual. Such an individual alternates in that he or she has one objective function one period and a different objective function the next. We can implement this by assuming that the objective function in odd periods is given by equation (1) with $\rho = \rho_1$ and that the objective function in even periods is given by equation (1) with $\rho = \rho_2$ [6]. We assume the same per-period utility function $u(C) = C^{1/2}$. If the individual is naïve, and therefore does not realise his or her dynamic inconsistency, then he or she uses equation (2) with $\rho = \rho_1$ in odd periods and uses equation (2) with $\rho = \rho_2$ in even periods. If he or she is resolute, then he or she uses equation (2) with $\rho = \rho_1$ throughout – with individual 1 somehow[7] imposing his or her preferences throughout the lifetime. The interesting case is a sophisticated person – who is aware of his dynamic inconsistency and takes his future behaviour into account when deciding on his present behaviour. In this context, each individual takes into account the future decisions of the other individual when deciding what to do in the present. The solution[8] to this problem takes the form

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[4] Alternatively it can be considered an infinite horizon problem with discount factor ρ

[5] A proof can be found in a Technical Appendix, available on request.

[6] Alternatively, uses a different discount rate in odd periods from that in the even periods.

[7] We do not inquire into how this resolute behaviour may be implemented.

[8] A proof can be found in a Technical Appendix, available on request.

$$C_i = A_i[W + M/(r-1)] \text{ where } A_i = 1/\alpha_i \text{ for } i = 1,2 \tag{3}$$

The values of α_1 and α_2 depend on all the parameters of the problem – specifically ρ_1, ρ_2 and r – and can be shown to the solutions of the equations

$$\alpha_1 = (1+\rho_1^2\beta_1^2 r)^{1/2} \qquad \alpha_2 = (1+\rho_2^2\beta_2^2 r)^{1/2}$$
$$\beta_1 = \frac{1+\rho_1\rho_2\alpha_1\beta_2 r}{(1+\rho_2^2\beta_2^2 r)^{1/2}} \qquad \beta_2 = \frac{1+\rho_2\rho_1\alpha_2\beta_1 r}{(1+\rho_1^2\beta_1^2 r)^{1/2}} \tag{4}$$

We note that the form of the optimal solution (equation (3)) is the same as the form in the individual case – equation (2) – but the average propensity to consume out of lifetime wealth is different. Note that even if $\rho_1 = \rho$ it is not the case that $A_1 = A$ (if $\rho_2 \neq \rho$). The sophisticated player takes into account his or her other self when taking decisions. We give some specific numbers in the next section.

3. The experimental Implementation

The difficulty with investigating this theory in the laboratory is that it seems to be impossible to appropriately incentivate a subject to be dynamically inconsistent. Normally one simply incentivates the subject by paying him or her the realised value of his or her objective function. However, a dynamically inconsistent individual effectively has two objective functions. It is clearly impossible to give one subject two different objective functions[9]. We get round this problem by having two subjects who play together, one taking the decision in the odd periods and the other in even periods. As in the theory, they get an income of M (units of experimental money) each period, and have to decide how much to consume/convert into real money each period. If they

[9] This is so even if one uses deception: one tells the subject in the first period that his or her objective function is one function and then in the second period one tells the subject "now you have a different function", as it is crucial that a dynamically inconsistent person has two functions, and, in the case of sophisticated and resolute subjects, that they know that this is so. Nor can one tell the subjects that, in odd periods the continuing probability is ρ_1 while in even periods it is ρ_2 because by so doing one induces on them the preference function

$u(c_1) + \rho_1 u(c_2) + \rho_1 \rho_2 u(c_3) + \rho_1^2 \rho_2 u(c_4) + \rho_1^2 \rho_2^2 u(c_5) + \ldots$

which is not the preference function of a dynamically inconsistent person.

convert C in any period, they *each* get paid $C^{1/2}$ in real money for that period. The odd player stays in the pair with probability ρ_1 and the even player with probability ρ_2. The only problem now is what happens when one player leaves the pair. Obviously this cannot stop the problem for the other player (for that would make the continuing probabilities the same) so we get round this problem by having in the laboratory *2n* subjects divided into *n projects* each of the form of the above. When a subject leaves one project then he or she joins some other project – when a space becomes available. Then, to have an end point to the experimental session as a whole, we implement an 'earthquake' which occurs with a given small probability at the end of each period[10]. When the earthquake happens all projects terminate. We have therefore reproduced the Jekyll & Hyde problem *n* times in the laboratory. We note that this is in a sense a 'game' between the two subjects in a project – but they do not have a conflict of interest (they both get the money converted whether by themselves or the other player) – rather they have a conflict of objectives. This is precisely the problem of a dynamically inconsistent person.

We implemented 4 different treatments, with different pairs for the continuing probabilities. The values, and the implied values of the average propensities to consume out of lifetime wealth, are given in Table 1. Note that Treatment 1 is not a case of dynamic inconsistency as the continuing probabilities are the same for both subjects in any project. We had the following numbers of subjects, projects and periods[11]: Treatment 1: 26 subjects, 13 projects, 35 periods; Treatment 2: 28 subjects, 14 projects, 28 periods; Treatment 3: 28 subjects, 14 projects, 27 periods; Treatment 4: 24 subjects, 12 projects, 25 periods; giving us a total of 106 subjects and 53 projects.

4. Results

We carry out an examination of the question with which we started – are the subjects naïve, sophisticated or resolute? We can answer this question by comparing the mean absolute deviations

[10] Obviously the continuing probabilities have to take into account the earthquake.
[11] The latter determined by the computer.

of actual conversion/consumption from the optimal conversion/consumption depending upon whether the subject was naïve, resolute or sophisticated. There is a slight problem here in that there are two possible scenarios that we can consider: *Scenario 1*: the optimal consumption throughout the life of the project; *Scenario 2*: the consumption that would be optimal given the wealth actually in the project at the time of the decision. We note that these differ because of suboptimal decisions made in the past. Table 2 reports these mean absolute deviations. Obviously there are no differences between the different types for Treatment 1 as this is not a case of dynamic inconsistency.

The notable features of this table are that the mean deviations are large and there is very little to distinguish the various types. On the whole, Sophisticated fits marginally better in Treatment 2, Resolute in Treatment 3 and Naïve and Sophisticated in Treatment 4. However, the differences are minor and clearly not significant. More importantly, since it is clear that these deviations are significantly different from 0, we can conclude that none of the three models represents the behaviour of our subjects.

One problem is the noisiness of the data. Figure 1, which is not a-typical, shows a particular project in Treatment 2. The thick jagged line is the actual path of the *apc* (average propensity to consume out of lifetime wealth) while the thin lower jagged line is the optimal *apc* for sophisticated subjects. It will be noted that the actual behaviour is much variable than the sophisticated optimal.

This figure does, however, show one important property: that generally, but not always, the subject who is playing Hyde (who has a lower continuing probability) converts/consumes more than the subject who is playing Jekyll (who has a higher continuing probability). If one looks at overall averages of the *apc* (the average propensity to consume out of lifetime wealth), one gets Table 3, which combines the actual data with the theoretical predictions from Table 1. We note that, except in Treatment 3, Hyde has a higher *apc* than Jekyll, as should be the case according to the theory whether the subjects are naïve or sophisticated.

It is also clear that average propensities to consume are much larger than they should be. In Treatment 1, the *apc*s of Jekyll and Hyde are close to each other and around twice the theoretical value. In Treatment 2, the *apc* of Hyde is greater than that of Jekyll – as the theory predicts – as is also the case in Treatment 4, though in Treatment 3 the reverse is true. Thus there is limited support for the hypothesis that the continuing probabilities affected behaviour in the manner predicted by the theory, though in all cases the magnitude is considerably higher than the theoretical predictions. This could have resulted from risk-aversion on the part of the subjects.

5. Conclusions

This paper tries to answer the question: " what do dynamically inconsistent people do about their inconsistency?". Do they ignore it? – thus acting naively; do they impose their first period preferences? – thus acting resolutely; or do they take their future inconsistency into account when deciding in the present? – thus acting sophisticatedly. We have investigated these issues in the laboratory, in the context of a simple life-cycle model of saving, using a design in which two separate subjects play the two selves of a dynamically inconsistent person. Our results show little support for any of these three possible descriptions of behaviour, though there is evidence that subjects do take into account their circumstances when taking decisions. However, there is little evidence to suggest that they take into account the circumstances of their other selves. This may be because our design necessarily involved transforming a game between the two selves in a dual personality into a game between two different people. Thus, in addition to having to consider the *circumstances* of the other, they have to take into account the *behaviour* of the other. It seems to have been the case that many subjects were consuming more than they should have been because they were worried about the behaviour of their other self – and possibly exaggerating the likelihood of the end of the experiment. It is not clear how one can get round these two problems: perhaps the first by getting human subjects to play with computerised 'other selves'; and perhaps the second by having an experiment with a finite number of periods. However, there remain residual problems: if one uses the computer to play the other self, one has to decide what to tell the human subjects as to how the computer is programmed[12]; and in a finite horizon problem, the optimal strategy changes from period to period. However, the bottom line of our experiment seems to be that the decision problem posed to the subjects is too complicated for them even to begin to consider whether they should act naively, resolutely or sophisticatedly.

6. References

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[12] And, indeed, whether they are told whether the computer is playing naively, resolutely or sophisticatedly – which may, in itself, change the behaviour of the human subjects.

Table 1: Average propensities to consume out of lifetime wealth

Treatment	continuing probabilities[13]		naïve		sophisticated		resolute
	ρ_1	ρ_2	odd periods (Hyde)	even periods (Jekyll)	odd periods (Hyde)	even periods (Jekyll)	all periods
1	0.85	0.85	0.097	0.097	0.097	0.097	0.097
2	0.82	0.85	0.159	0.097	0.163	0.101	0.159
3	0.85	0.88	0.097	0.032	0.104	0.040	0.097
4	0.82	0.88	0.159	0.032	0.178	0.053	0.159

Table 2: Mean absolute deviations from optimal consumption/conversion

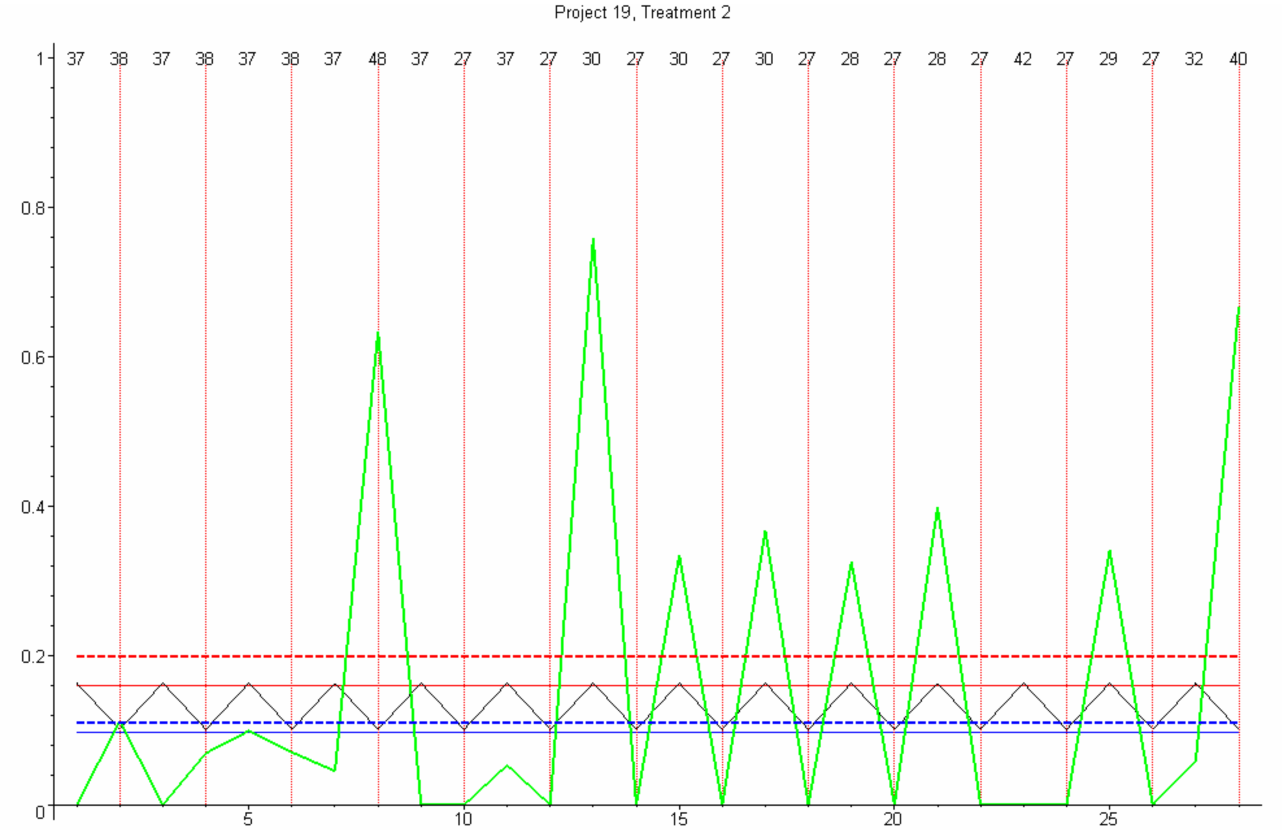
Treatment	Naïve		Sophisticated		Resolute	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	157	162	157	162	157	162
2	165	167	164	167	165	168
3	171	174	168	171	157	160
4	159	157	159	157	163	163

Table 3: Average *apc*s by treatment and type of subject

Treatment	Actual		Theoretical				
			naïve		sophisticated		resolute
	Hyde	Jekyll	Hyde	Jekyll	Hyde	Jekyll	both
1	0.184	0.178	0.097	0.097	0.097	0.097	0.097
2	0.177	0.157	0.159	0.097	0.163	0.101	0.159
3	0.157	0.173	0.097	0.032	0.104	0.040	0.097
4	0.182	0.146	0.159	0.032	0.178	0.053	0.159

[13] These probabilities take into account the earthquake probability.

Figure 1: Consumption/Conversion in Project 19



Notes:
The thick (green) jagged line is the actual average propensity to consume out of lifetime wealth (*apc*)
The thin (black) jagged line is optimal sophisticated *apc*.
Working from the top the horizontal lines are the following:
the first (dashed thick) is the actual average *apc* of the subject with the lower continuing probability
the second (solid thin) is the optimal *apc* of the subject with the lower continuing probability if playing naively
the third (dashed thick) is the actual average *apc* of the subject with the higher continuing probability
the fourth (solid thin) is the optimal *apc* of the subject with the higher continuing probability if playing naively