Hedonic capital, adaptation and resilience*

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Abstract

The paper sets out a theory of hedonic adaptation and resilience. By distinguishing between stocks and flows of psychological resources, it suggests a new way to think about the dynamics of happiness. Central to the analysis is the concept of 'hedonic capital' and the idea that the evolutionary function of happiness is as a motivating device. The model successfully replicates the empirical regularity of an approximately stable level of well-being and a tendency to return towards that level, and makes a number of testable empirical predictions.

Keywords: Adaptation; well-being; evolution; happiness; habituation; resilience
JEL codes: D1, I3.

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1 Introduction

Adaptive behaviour is an empirical regularity of the literature on well-being. Individuals recover from bad life events and get used to good ones. This is usually understood as the consequence of an endogenous reference level. Individuals report their well-being by comparing their situation to the reference level, and the reference level itself adjusts slowly towards the actual level[1].

In this paper we propose a new explanation for hedonic adaptation. At the heart of our explanation is the idea that to understand well-being it is valuable to distinguish between stocks and flows. Although it seems natural to view happiness as a flow variable, there is agreement in the literature that some of the important determinants of well-being have the nature of stocks. For example, Carr (2004) writes

> "people with large social support networks and stronger social bonds with members of their networks have better physical and mental health, fewer illnesses and less depression, recover more rapidly from physical illness and psychological problems, and have a lower risk of death."

We formalize this stock concept as "hedonic capital", which we define as the stock of psychological resources available to an individual. While what constitutes hedonic capital is a matter for empirical research, our definition could include social relationships with partners, friends and colleagues; health (some stock aspects of which are discussed by Grossman, 1999); self-esteem; status; and meaningful work. For some people, religious faith may also play a part. These things are stocks in that they rely on past inputs and are carried across time periods.

[1] For an introduction to the empirics of hedonic adaptation and models of endogenous reference levels, see Frederick and Loewenstein (1999). For a review of the more recent literature, see Oswald and Powdthavee (2007).

We use the concept of hedonic capital to write down a parsimonious model of an individual's psychological structure. Given this structure, we adopt an evolutionary approach in the sense that, following Samuelson (1994) and Rayo and Becker (2007), we are interested in what behavioural rules for an individual could emerge as the end-point of an evolutionary process. The role of happiness in this approach is as a motivating device, encouraging individuals to take actions that lead to reproductive success. We show that:

1. The evolutionary process results in individuals who
    a. Exhibit a steady state level of well-being (a 'set-point' in the terminology of Diener et al, 1999)
    b. Display adaptive behaviour in response to life-events ("shocks" in our model)

2. The model predicts that the level of hedonic capital will have implications for an individual's psychological resilience[2]:
    a. High levels of hedonic capital imply high psychological resilience i.e. low volatility of well-being;
    b. After a negative shock to the level of hedonic capital, individuals will substitute towards activities which rebuild their hedonic capital
    c. Income buffers well-being, and will do so more effectively against negative shocks than against positive ones.

Further, our model gives a conceptual framework of a psychological steady state, dependent on a stock variable, and perturbed by different kinds of shock. We discuss how this framework can be used to organize the factors which influence well-being into those which affect an individual's set-point and those which only have short run effects.

The first two implications of our model, 1(a) and 1(b), replicate the "stylised facts" of the empirical well-being literature, and in so doing give a new theoretical explanation of them in terms of hedonic capital. There is already some empirical evidence which supports

[2] Resilience is a concept widely used in the psychology literature, for a review see Masten (2007). Masten defines resilience as "the capacity of dynamic systems to withstand or recover from significant disturbances" and notes that it is closely related to adaptation

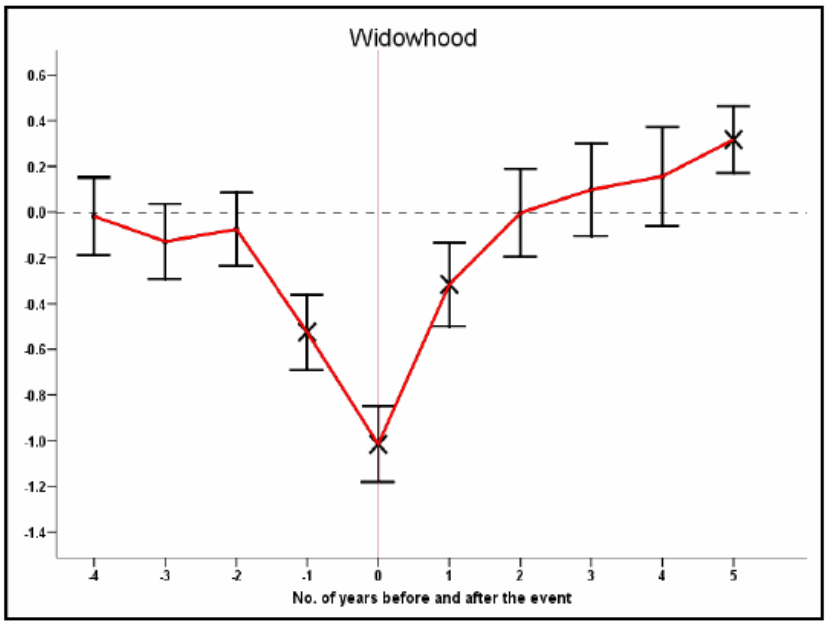
predictions 2(a) and 2(c), and we suggest a number of directions for further empirical studies. The model is extremely parsimonious, keeping the number of free parameters to a minimum, and it should be judged according to how well its empirical predictions fare in future studies, and the usefulness of the conceptual framework it provides.

The remainder of the paper is organised as follows. Section 2 reviews the existing literature relating our modelling approach. In section 3 we write down the model and explain how it is solved. Section 4 discusses the steady state of the model, and section 5 its dynamic behaviour. Section 6 describes the model's empirical predictions and section 7 discusses implications and possible extensions of the model. Section 8 concludes.

2 Existing literature

For a review of the psychological literature on adaptation see Frederick and Loewenstein (1999). Recently economists have applied time-series techniques to look at the path of well-being over time, and the resulting response functions provide an illustration of adaptation. For example Figure 1, taken from Clark et al (2008) shows, using data from the GSOEP, the time path of the well-being of females who were widowed at time 0.

Figure 1: Response of well-being for females who were widowed at time 0



The striking thing is that after 2 years, the well-being of these individuals is statistically indistinguishable from its level before they were widowed. Indeed, Clark et al (2008) find that they cannot reject the hypothesis of complete adaptation for five out of the six life events they consider. The most common theoretical explanation for this uses an endogenous reference level (see Frederick and Loewenstein, 1999 for a more detailed discussion). However, while such models give an account of adaptation, they are silent on which factors affect the steady state level of well-being, and which will influence the speed of an individual's adjustment back towards the steady state.

In contrast, the model we present does allow a discussion of these factors. Three building blocks lie behind the model: the distinction between stocks and flows; the concept of a production function for happiness; and the notion of investment in hedonic capital. Antecedents of all of these can be found in the literature.

Headey and Wearing (1991) point to the difference between stocks and flows -- with stocks arising, in their view, from "stable personality characteristics" and flows from "events". The authors postulate a link between higher levels of a stock and higher levels of a person's well-being. Heading and Wearing also discuss the need for a dynamic equilibrium model in which

> "each person is regarded as having 'normal' equilibrium levels of life events and SWB, predictable on the basis of age and personality. Only when events deviate from their equilibrium levels does SWB change. Unusually favourable events enhance SWB; unusually adverse events depress it."

In this vein, a component of our model is a production function which explains how hedonic capital produces well-being. Ormel et al (1999) describe the mechanism by which well-being is generated. They use a social production function, taking the inputs to be a range of personality characteristics and life events, and the output to be well-being, and suggest, as we later do, that there are diminishing marginal return to the inputs. Ormel et al

also have a concept of emotional investment: they make a distinction between activities that immediately satisfy a goal and those which increase potential for future production.

The final component of our model is the idea that we can analyse the behaviour of an individual which would emerge as the end-point of an evolutionary process. We take this idea from Samuelson (1994), and it was recently used to by Rayo and Becker (2007) to give an evolutionary explanation of an endogenous reference level. Rayo and Becker liken hedonic adaptation to the ability of the eye to adjust -- for reasons of self-preservation -- to changes in the amount of light and show how an evolutionary process would lead to individuals whose well-being adapts.

For Rayo and Becker (2007), happiness is a measuring rod, giving a one-variable indicator of an individual's condition. Adaptation allows the measuring rod to be effective as external conditions change. In contrast, in our model, happiness is a motivating device, encouraging the individual to take actions which lead to reproductive success. We think of our explanation as complementary to Rayo and Becker's in the sense that the "measuring rod" and the "motivation" aspects of happiness are likely to be important; however our model of hedonic capital offers testable predictions about psychological resilience.

3 The model

This section proposes a stylized model of an individual's psychological structure, explains the relation between happiness and hedonic capital, and then considers the behavioural rules for an individual that would emerge as the end-point of an evolutionary process.

3.1 Psychological structure

Assumption 1 *(hedonic capital)*: Individuals have a stock of psychological coping resources which we call hedonic capital which has the following properties:

(a) It depreciates at rate δ

(b) We call changes to its level investment, denoted by i

(c) It is affected by exogenous shocks ω

These properties are summarised in a law of motion for hedonic capital:

$$k_{t+1} = (1-\delta)k_t + i_t + \omega_t \tag{1}$$

Assumption 2 *(hedonic flow)*: Hedonic capital produces a flow of psychological resources.

(a) The relation between this flow and hedonic capital is given by a concave function f and an individual characteristic z which tells us how efficiently a given individual uses their stock of hedonic capital

(b) The flow is affected by exogenous shocks ν

These properties are summarised in the following relation

$$y_t = zf(k_t) + v_t,\ \mathrm{f}' > 0, f'' < 0\,. \tag{2}$$

Assumption 3 *(happiness)*: The flow of psychological resources can be used either directly to produce well-being, h, in the current period, or as investment to increase the stock of hedonic capital

$$y_t = h_t + i_t \tag{3}$$

3.2 Evolution's problem

Given the psychological structure described in the previous section, we are interested in what decision rules for an individual would emerge from an evolutionary process. Following the framework of Samuelson (2004), we focus directly on the limiting outcome of evolution which is described as the solution to a metaphorical principal-agent problem. The principal corresponds to the evolutionary process, which controls the characteristics of the individual, or agent, who serves the purpose of genetic reproduction.

Assumption 4 *(evolution)***:** The evolutionary process selects for behavioural rules that maximize the quality-adjusted number of offspring produced

$$\max \sum_{i=0}^{\infty} \beta^i q_{t+i} n \tag{4}$$

where n is the number of offspring produced in each period (which we normalise to unity) and q is the quality of the offspring. β is a discount factor.

Assumption 5 *(offspring)***:** Happier individuals produce higher quality offspring

$$q_t = g(h_t), g' > 0, g'' < 0 \tag{5}$$

The evolutionary role of happiness is as a motivation device, encouraging individuals to take actions which will enhance the survival and quality of their offspring. If individuals are happy they take actions which encourage successful child-rearing[3]. One important point to bear in mind is that the evolutionary process operated in an environment very different from that of modern societies and so there is the possibility that behaviour that is adaptive in the evolutionary environment is maladaptive today (the obvious example is eating highly calorific food). We return to this in section 7.2.

The outcome of the evolutionary process is a set of decision rules that result from maximizing (4) subject to the constraints imposed by the psychological structure of the individual, described above by (1) to (3). This maximisation problem can be solved by standard methods[4].

In what follows we restrict our attention to the functional forms $f(k) = k^{\alpha}, g(h) = \ln h$ and the limit in which β, the discount factor of the evolutionary process, approaches unity. Our analysis is easily generalised.

4 The steady state

Theorem 1: The non-stochastic steady state of the individual is characterized by

(a) A steady state level of hedonic capital given by $k = \left(\frac{\alpha z}{\delta}\right)^{\frac{1}{1-\alpha}}$

(b) A steady state level of well being given by $h = zk^{a} - \delta k$

Proof: See appendix

[3] In the extreme case, unhappy individuals will take no care of themselves and perish before they reproduce.
[4] The objective (4) combined with the constraints (1) to (3) can be written as a value function and solved iteratively. Alternatively, an approximate solution, valid in the region of the steady state, can be obtained by deriving first-order conditions, linearising them and applying standard methods for the solution of linear difference equations.

This is the first result of our paper. If we think about a steady state in which there are no shocks, the level of hedonic capital is constant, increasing in the parameters α and z, decreasing in δ. This constant level of hedonic capital, k, implies via (2) that the level of well-being is constant. In other words, the model's assumptions lead to the "set-points" commonly described in the psychological literature (e.g., in Diener et al 1999).

The parameter z indexes idiosyncratic characteristics, abstracting from the complex interaction of genetic and developmental factors which produces "happy" individuals (with high z) or unhappy ones (with low z). We do not investigate what determines z. Instead, the paper later examines how individuals' response to emotional shocks can differ with high or low values of z.

The parameter δ is the rate at which hedonic capital depreciates. This combines features of an individual's make-up (perhaps how good they are at sustaining relationships) with features of society. In a society with strong community attachment and low geographical mobility, hedonic capital might depreciate at a lower rate. In a fragmented and highly mobile society, it might be more difficult to maintain attachments and hedonic capital will decay more quickly.

Because hedonic capital depreciates, it will be optimal in this model for the individual to use some of the flow of psychological resources to maintain the stock of hedonic capital. So the steady-state is also characterised by a constant level of investment in hedonic capital -- at a level just enough to keep the level stable and make up for depreciation. These maintenance activities might be viewed as representing the resources put into, say, keeping up friendships and relationships, keeping fit, studying[5].

[5] For simplicity we have assumed that investment in hedonic capital and current period well-being are strictly exclusive uses of the flow of psychological resources. While our model relies on there being some trade-off between current period well-being and investment, it would be straightforward to extend it to allow investment to directly generate well-being.

5 The dynamics of well-being

The preceding section characterised an individual's psychological steady-state in terms of the underlying parameters of the model. We think of this psychological steady-state as being perturbed by shocks. These shocks represent events which affect the emotional state of an individual.

There are two channels, in this model, through which external events influence the individual. The first is a one-off change in the level of a person's hedonic capital, ω in (1). Unemployment, divorce and disability are in this category. The second channel is a temporary event which has no direct effect on the level of hedonic capital but requires some psychic resources, υ in (2). Such events might be a temporary illness of the individual or someone close to them, or some disruption in an individual's work environment.

Real-world events will, of course, often be a combination of these two types, but for clarity we analyse them in isolation. Further, we assume for simplicity that the events are exogenous and random. We discuss this assumption in section 7.2.

5.1 Calibration

Individuals in our model are described by three parameters: δ, the rate at which hedonic capital depreciates; α, the degree of diminishing returns to hedonic capital; and z. Different values of these parameters are to be thought of as describing different types of people. The only effect of z is to change the steady-state levels of the variables. As long as shocks are small relative to the steady-state, z does not affect the model's dynamics.

We choose the two remaining parameters so that the impulse responses produced by our model replicate the known data as closely as possible. Nevertheless, it is useful to bear in mind that current empirical studies do not have enough data points to make such choices completely reliable. Well-being in, say, the time-series plots of Clark et al (2008) appears to have a half-life of approximately one year (i.e. it takes a year for the level of well-being to decay to half of its value on impact). Taking the base time period to be a month, our

model replicates this with α=0.5 and δ=8%. That value for parameter δ means that 8% of an individual's hedonic capital will decay each month. In other words, without investment, roughly two-thirds of the stock of hedonic capital will have been lost after a year. This may seem high, particularly in comparison with physical capital. But it represents an extreme case: a complete lack of investment in hedonic capital would imply an absence both of interaction with other people and of meaningful activity. Solitary confinement in prison would represent such an extreme example.

We assume that the shocks in (2) are random but their effects are persistent, and follow a first-order autoregressive process

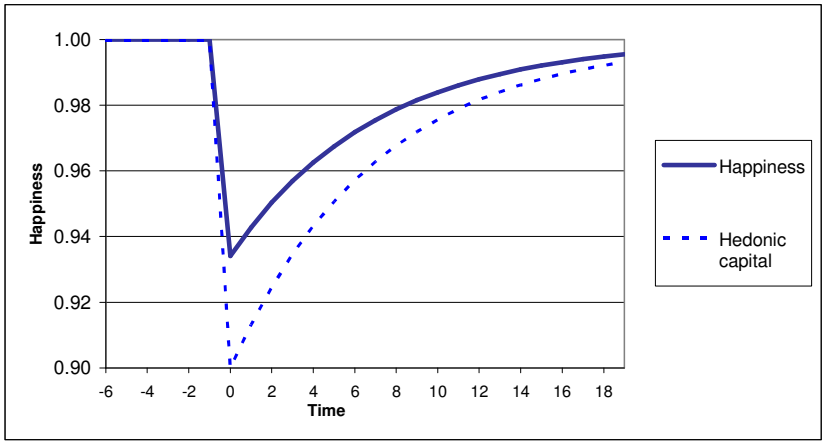
$$\nu_t = \rho \nu_{t-1} + \varepsilon_t \qquad (6)$$

The value of ρ does not affect our qualitative conclusions, so for simplicity we set it to 0.5.

5.2 A shock to the level of hedonic capital

First, we use our model to consider the response of an individual to a life-event which permanently destroys some hedonic capital, in other words a negative innovation to ω in equation (1). Examples of such events are divorce, disability or unemployment. The solid line in Figure 2 shows the path of happiness, first falling and then bouncing back upwards, in response to such a shock. This figure mimics the adaptive pattern often observed in empirical research, an example of which we gave as Figure 1 above.

Figure 2: The response of happiness and hedonic capital to a white noise shock to hedonic capital



The shock is modelled as a one unit fall in the level of hedonic capital at time t = 0. The baseline level of happiness, set to unity for clarity, represents the steady-state. In the figure, there is only one external influence on the individual, everything else is determined by the individual's hard-wired decision rules.

Happiness therefore adapts. It returns asymptotically to its starting point. Step by step, the mechanics are as follows:

1. The reduction in hedonic capital means:
   (a) the marginal return to investing in new hedonic capital increases
   (b) the flow of psychological resources available to the individual decreases.

2. When deciding to allocate the lower flow of psychological resources between well-being and investment, the proportion devoted to investment rises. This is because of the higher marginal return.

3. So well-being falls by proportionally more than it would were investment constant, but hedonic capital increases. Current-period well-being is foregone for future well-being.

4. In the next period, hedonic capital is higher than on impact, but still below the steady-state. Thereafter, steps 1 – 3 repeat themselves, with the marginal return, and hence investment, falling, but still being above the steady-state. This continues in each period until all the variables are back at their steady-state.

While we have treated hedonic capital as an aggregate quantity for simplicity, different types of hedonic capital (health, relationships, meaningful work) are likely to be imperfect substitutes. We discuss this point in more detail in section 7.1, but for the moment note that our model then predicts substitution behaviour after a shock with the individual switching resources to activities which rebuild the stock of hedonic capital. For an example, when an individual becomes disabled they lose some of the health component of their

hedonic capital. Our model predicts that such an individual would put extra resources into building up other types of hedonic capital, maybe relationships or work. Such substitution behaviour is discussed in Ormel et al (1999).

5.3 A shock to the flow of hedonic resources

The previous section examined the effects of a shock which permanently destroyed part of an individual's hedonic capital. Now we use our model to examine the response of an individual to a life-event which temporarily requires some of the individual's psychological resources, but has no long-run effects - a negative innovation to ε in equation (10). An example might be a short-run illness of someone close to the individual.

Figure 3: The response of happiness and hedonic capital to a negative shock to the flow of psychological resources

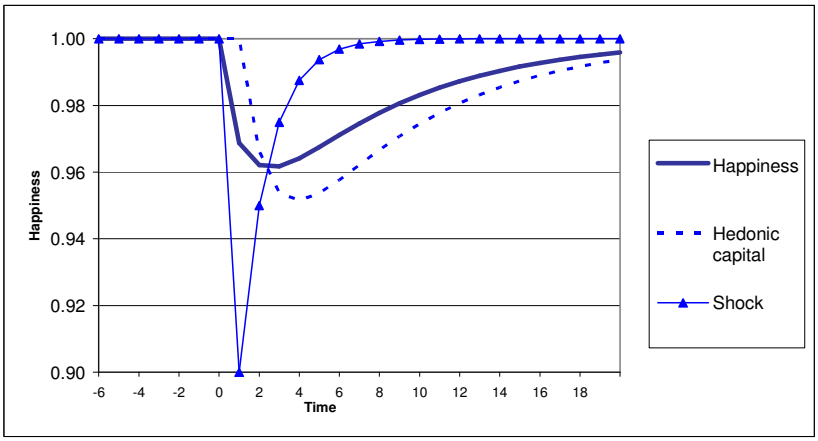


Figure 3 shows the response of happiness and hedonic capital to such a shock, and also depicts the path of the shock itself which has a large initial impact which slowly dies away according to the AR process we specified. If hedonic capital was constant in the face of the shock, the individual's well-being would simply follow the path of the life-event. When people have a stock of hedonic capital, however, the response of well-being is smoothed: it reacts less initially, but more in later periods.

This illustrates an important property of hedonic capital: it is optimally used to smooth the individual's responses to life events. When a bad shock strikes, the individual allows the stock of hedonic capital to fall, so freeing up psychological resources to deal with the event. When the event has died away, the individual rebuilds hedonic capital.

5.4 Psychological resilience

The previous section demonstrated how hedonic capital is used to smooth the impact of shocks. If there were a lower bound on the level of hedonic capital, which might correspond to the concept of depression, below which the individual stops reproducing, this smoothing mechanism could change. For an individual whose psychological make-up means their steady-state level of hedonic capital is well above the lower bound (represented by a high value of z or a low value of δ), and who faces only small shocks, such a lower bound will be irrelevant since only a long sequence of negative shocks would bring the individual's level of hedonic capital near to it.

Instead, consider someone who has a steady-state level of hedonic capital that is not far from the lower bound (represented by a low value of z or a high value of δ). If a negative life event hits this individual, he or she will use hedonic capital to smooth its effect as shown in the previous section - the individual will initially allow their stock of hedonic capital to fall. But this exposes the individual to a risky situation. If in the next period there is another negative shock, the amount of hedonic capital might drop to the lower bound, with grave consequences. So the individual hoards hedonic capital, meaning that the event is not smoothed as much. The same is true of a person subjected to a sequence of negative shocks: if these shocks are large relative to the size of the stock of hedonic capital, the extent to which they can be smoothed will decline with each shock.

So our model has implications for psychological resilience i.e. the extent to which hedonic capital can be used to smooth shocks. First, individuals with higher well-being and higher hedonic capital will be more resilient. People characterized by a high value of z and/or a low value of δ correspond to what Block and Kremen (1996) describe, without using a formal model, as "ego-resilient". Those with low value of z and/or a high value of δ will be "ego-brittle". Second, a series of positive shocks will make an individual better able to absorb the effect of a negative shock. In a cumulative way, positive shocks can buffer a negative one. There is indeed evidence of such buffering in the psychology literature:

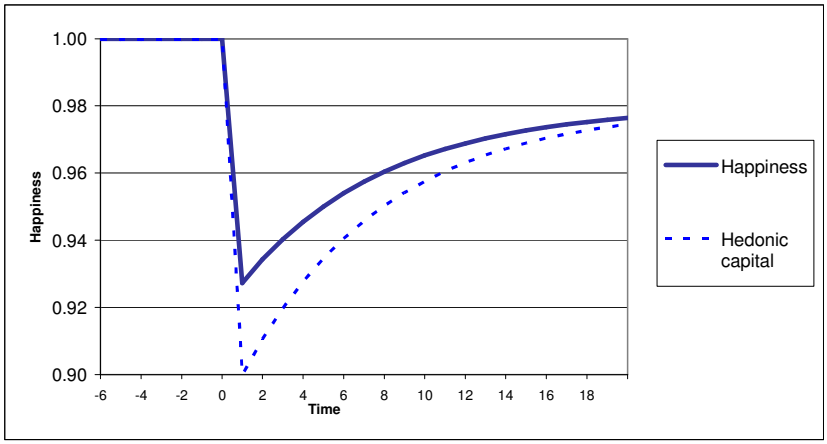
Fredrickson (2001) writes that "individuals who experienced more positive emotions than others became more resilient to adversity over time".

Behaviour away from the steady state is more complicated and an interesting asymmetry emerges. Adjustment back to the steady-state after a positive shock to hedonic capital happens mainly because of depreciation, which is independent of investment opportunities. Yet adjustment from a negative shock requires investment in new types of hedonic capital, hence it will be dependent on the availability opportunities for such investment. This potentially goes some way to explaining the observation that, while income does not have large effects on the mean level of well-being, it can buffer the response of well-being to a negative shock (Smith et al, 2005). Income creates opportunities for investment in hedonic capital. That allows an individual to recover from a negative shock, but income will have no significant effect on the response to a positive shock.

5.5 Permanent changes

The examples we have given above show happiness returning to the initial steady state after a sufficiently long period of time - the extreme 'set point' view. However there is evidence that changes in some specific individual characteristics (for example unemployment, see Clark et al, 2008, or status, see Marmot, 2005) have long-run effects on the level of happiness.

Figure 4: The response of happiness and hedonic capital to a white noise shock to hedonic capital combined with a reduction in z



Our model can generate these effects by assuming a life-event changes both the individual's hedonic capital and the efficiency parameter z. Figure 4 shows the response to a simultaneous drop in the level of both of these variables. An example of such an event might be disability (causing a reduction in hedonic capital) which also leads to job loss and hence reduced status. Although the person recovers much of the initial level of happiness, adjustment is back to a new and permanently lower steady state.

In principle, as Oswald and Powdthavee (2007) and others have pointed out, decision-makers such as judges in legal compensation cases will sometimes need to take a view on whether happiness is fully mean-reverting (that is, returning literally to the value 1.00). Paradoxically, although the issue is conceptually of fundamental importance to this field, and has been the subject of intense debate in the empirical literature (such as in Easterlin 2003), in many practical cases it may not matter whether there is, say, 90% or exactly 100% adaptation. Given data in which there is some measurement error, after a few years it may be impossible statistically to detect reliably the difference between the settings of Figure 2 and Figure 4.

6 Empirical implications

We have shown how modelling hedonic capital can provide a conceptual account of the empirical facts of adaptation, the key empirical regularity of the well-being literature.

However, models of an endogenous reference level also account for adaptation. In this section we describe four empirical predictions which our model makes but about which reference-level models are silent. These are:

a. High levels of hedonic capital imply high well-being;
b. High levels of hedonic capital high psychological resilience i.e. low volatility of well-being;
c. After a negative shock to the level of hedonic capital, individuals substitute towards activities which rebuild their hedonic capital
d. Income buffers well-being, and does so more effectively against negative shocks than against positive ones.

Micro data sets contain questions relating to components of hedonic capital such as length of relationship, contact with friends, health, and self-esteem. A number of studies use such data to investigate questions related to our first prediction. A recent example is Aslam and Corrado (2007) which finds that higher levels of a range of stock-like variables imply a higher level of well-being. There is much less work on our second prediction: Clark and Lelkes (2005) shows that religion can buffer well-being; Graham, Oswald and Powdthavee (2008) use two distinct panel datasets from Germany and Britain to show that high levels of the various components of hedonic capital result in lower volatility of well-being.

Time-use data could be used to examine the third prediction. After a negative shock, do people spend more time on activities which build up their hedonic capital? Do they take up new activities which could provide them with new sources of hedonic capital? These are predictions are testable.

There already exists some evidence to support the framework's fourth prediction (see the results of Smith et al, 2005). This interesting and unusual study, which looks at the buffering effects of income after disability, could be extended in ways suggested by the theory. Richer data set would allow tests for buffering effects in the face of a wider range of shocks. Our model also has implications for how the time-path of well-being after a

shock depends on underlying parameters. Existing data sets are rich enough to allow a start on tests of such predictions.

Another application of our model is as a way of structuring the discussion of life events in well-being research. The model suggests that influences on well-being should be understood either as changes to the parameters of the model (notably δ, the rate at which hedonic capital depreciates and z, the efficiency with which an individual uses their hedonic capital) or as shocks either to the level of hedonic capital or to the flow of psychological resources. The first type of event will have long-run effects on an individual's well-being, the second type only short run effects. Whether a particular type of life event falls into one category or another is a matter for further empirical research, guided by the conceptual framework our model provides.

One example of this would be to throw light on the Easterlin paradox. Some consequences of increasing GDP, such as widely-available health-care, better education and insurance, might lead to the parameter z increasing between different generations of individuals. This would tend to increase the steady-state level of well-being with time. However, if the growth in GDP is accompanied by an increasing rate of depreciation of hedonic capital -- such as higher mobility and the breakdown of traditional communities and roles -- this could offset the increase in z. Then the net movement of well-being would be determined by the relative magnitude of the two effects.

7 Discussion

7.1 Modelling strategy

Our model is very stylised with the individual seen as facing a choice of whether to devote psychological resources to current well-being or to investment in hedonic capital. In reality, of course, choices are not over psychological resources but over goods, or actions, and the choice is complicated by a mass of constraints (time, feasibility, resources) and relative prices of goods and time.

However, our approach has two merits. The first is parsimony. By abstracting away from the details of individual choice we can write down a simple model with a minimum number of free parameters. Whether this simplification is reasonable or not should be judged against the data, by testing the empirical predictions discussed in the previous section.

The second reason is that this high level of abstraction fits with our central idea of the evolutionary process as a "principal" choosing rules for the individual as an "agent". The principal gives the agent very general rules over very general quantities (such as the flow of psychological resources in our model). The agent, with detailed knowledge of its circumstances and the shocks that are hitting it, decides what actions to take to implement these rules.

We treat hedonic capital as an aggregate quantity, or in the terminology of Ormel et al (1999), our social production function contains only a single factor of production. We have alluded to the idea that there are potentially many types of hedonic capital, and that adaptation to life events might involve substituting between types in the way described by Ormel et al (1999). We could easily incorporate this into our model by defining hedonic capital explicitly as an aggregate, for example

$$k_t = \left[\sum_{i=0}^{N} (k_{it})^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \quad (7)$$

where subscript i refers to each type of hedonic capital and σ is an elasticity of substitution between different types.

This is one example of a potential extension. Given the richness of individuals' psychological structure, it is easy to think of many more. However, extending our model in this way would introduce more free parameters, and we doubt the ability of currently available datasets to meaningfully estimate these parameters.

7.2 The evolutionary environment

Rayo and Becker (2007) make the important point that evolution happened in what they refer to as the "ancestral hunter gatherer" environment, but of course many aspects of the evolutionary process are much more ancient, and point out the possibility that individuals are maladapted to the current environment. This idea has a number of implications for our model.

First, the environment that evolution took place in was characterised by a much more restricted set of choices than are available to individuals in modern society. Our model assumes that there are always opportunities to take actions which lead to investment and hedonic capital returning to its steady state. If these opportunities are not available, hedonic capital might not be able to adjust to its steady state[6]. Then when opportunities do become available (because of economic growth, for example) hedonic capital would adjust to the steady state and individuals' well-being would rise. This would suggest that adaptation might be a feature of rich economies with a wide range of possibilities for investment in hedonic capital, and less a feature of poorer economies. There is some evidence that this is the case, for example Graham (2008) argues that an increase in income may have more effect in developing countries than in developed ones.

Second, our assumption that shocks are exogenous seems reasonable in the evolutionary environment when individuals had relatively little control over their circumstances. However, if individuals can to some extent control the arrival of shocks, they may take put resources into producing a continual flow of positive shocks, rather than investing in hedonic capital. This raises their well-being temporarily, but may mean that their hedonic capital falls below the steady state and so is maladaptive in the sense that it does not bring any evolutionary benefit.

[6] If there are no opportunities to do this (as an extreme case, return to the example of a prisoner in solitary confinement), the level of k, and hence h, will fall to the lower bound.

7.3 The role of consumption

Instead of modelling goods, services or actions directly, our model focuses on flows of psychological resources. The steady state of our model would be characterised by a certain amount of psychological resources devoted to investment activities, and the remainder devoted to activities which produce immediate well being. Each of these types of activity would be associated in a richer model with different goods / actions.

Our model gives us a framework to think about the effect of an increase in consumption on well-being. The first question to ask is does additional consumption change the steady state by changing the parameter z, the efficiency with which an individual is able to use their stock of hedonic capital? Some types of consumption could change z; one example might be a mobile phone which allows an individual to maintain relationships better. But if the individual is a long way above a subsistence level, many types of additional consumption, for example, clothes or food would not have an affect on z. Then the role for this extra consumption is as an innovation to the flow of psychological resources, a temporary kick of pleasure from the novelty of having the new goods. This could be maladaptive.

If we had detailed information on the choices taken by individuals, we could in principle use well-being data to determine the extent to which a particular choice constitutes investment in hedonic capital, and combine this with the decision rules that our model predicts to back out the utility function that the evolutionary process would endow the individual with. However, this would require very rich data and a much more complicated model.

8 Conclusion

We have described how a set of decision rules can emerge from an evolutionary process, and shown how such rules imply adaptive behaviour, the key empirical regularity of the well-being literature. We also provide a formal account of the concept of psychological resilience, which has received little attention from economists. Our model makes a number of testable predictions which differentiate it from models of an endogenous reference level.

However, the two approaches are not necessarily exclusive and we would expect them both to be components of an individual's psychological structure. This is particularly relevant given the evidence on adaptation due to peer comparison.

There is a further important difference between the two types of framework. Reference-level models imply that we are "doomed to progress" (Senik, 2006): there is no escape from the Easterlin paradox and economic growth will not increase the well-being of the rich countries. In contrast, our model sets out the determinants of the steady state level of well-being and suggests that policies directed at these determinants could lead to higher steady state levels of hedonic capital, and hence higher well-being.

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Appendix: Proof of Theorem 1

We can exploit the recursive nature of the problem to write the objective (4) as a value function in terms of current period and next period (denoted with a ‘) variables, under the additional assumption that while v can be persistent, ω is white noise

$$V(k,v) = \max_{h} \left[g(h) + \beta V(k',v') \right] \tag{A1}$$

Then substitute for h using the constraints (1) to (3) to obtain a univariate problem in k'

$$V(k,v) = \max_{k'} \left[g\left((1-\delta)k + zf(k) - k' + \omega\right) + \beta V(k',v') \right] \tag{A2}$$

The first-order condition for k' is

$$g_h(h) = \beta V_k(k',v') \tag{A3}$$

Differentiating the value function directly gives

$$V_k(k,v) = g_h(h)\left((1-\delta) + zf_k(k)\right) \tag{A4}$$

and combining these gives an Euler equation

$$g_h(h) = \beta\left((1-\delta) + zf_k(k')\right)g_h(h') \tag{A5}$$

For a steady state to exist in which $h = h'$

$$\beta\left((1-\delta) + zf_k(k')\right) = 1 \tag{A6}$$

and using the functional form of f and rearranging gives

$$k = \left(\frac{1}{z\alpha} \left(\frac{1}{\beta} - (1-\delta) \right) \right)^{\frac{1}{\alpha - 1}} \tag{A7}$$

Taking the limit as $\beta \to 1$ gives part (a) of the theorem. Substituting this in (2) and combining with (3) gives part (b).