Time discounting (δ) and pain anticipation: Experimental evidence[1]

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Abstract

This paper deals with pain anticipation experienced before medical procedures. Our experimental results show that individuals with lower discount factors are more prone to suffer pain in advance. We provide a framework to rationalize the connection between pain anticipation and impatience. In this set up, more impatient subjects, who only value very near events, take into account mainly the negative effects of medical procedures (just the costs) whereas more patient individuals have a net positive valuation of medical events (given that they value both the cost incurred now and all the benefits accrued in the future).

I MOTIVATION

This paper shows an example of how experimental economics (time discounting behavior) might shed some light in the analysis of a medical problem, pain anticipation experienced before medical procedures. Time preferences reflect subjects' tastes toward the present versus the future and determine intertemporal choices which involve a tradeoff between costs and benefits that occur over time (see Laibson, 1997). We will use an experimental time discounting test to check whether personal attitudes towards the future are correlated with pain anticipation.

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Recent studies suggest that there are psychological and neuronal mechanisms that determine intertemporal choice (Wittman & Paulus, 2009). Time preferences are related to impulsive or impatient behavior and it is argued that people who maintain unhealthy lifestyles (that is, smoke, eat junk foods, are sport-averse, etc.) seldom place a high premium on the future quality of their lives and typify an impatient personality. In other words, they prefer good lives now to a higher quality of their lives later (Cutler & Glaeser 2005, Budría et al. 2010).

Recent medical research on nocebo response –the subject's negative expectation of pain worsening- shows the crucial role of anxiety on pain perception (and reporting). It has been found that anxiety triggers the activation of cholecystokinin that, in turn, facilitates pain transmission (see Colloca & Benedetti 2007). Additionally, nocebo response is associated to the functioning and efficiency of the reward system (Enck *et al*., 2008). These negative expectations increase their level of anxiety and consequently they trigger an activation which generates pain transmission.

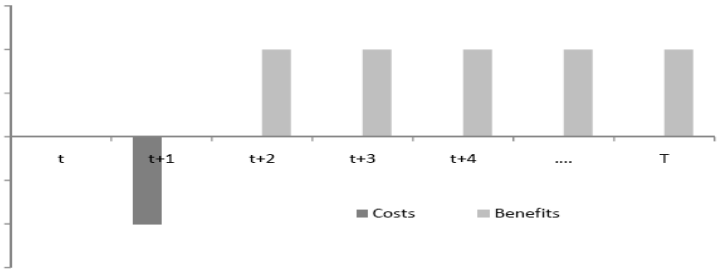
Our experimental results show that *present oriented individuals (impatient people) are more prone to suffer pain in advance.* This suggests that time preferences may be a complementary explanation to anxiety before medical procedures (Colloca & Benedetti 2007). We provide a framework to rationalize the connection between pain anticipation and impatience. In this set up, more impatient subjects, who only value very near events, take into account mainly the negative effects of medical interventions (just the costs) whereas more patient individuals have a net positive valuation of medical events (given that they consider both the cost incurred now and all the benefits accrued in the future). Our results are consistent with the idea of a subjective perception of time as the basis for temporal discounting (see Brañas-Garza *et al*. 2010, Wittmann & Paulus 2008).

II THEORETICAL BACKGROUND

In this section we present the theoretical relationship between time discounting and pain anticipation. To do so, let us consider the case of an individual that at moment t (today) values the potential benefits of going through a medical

procedure -surgery, dentist, etc.- tomorrow, say *t+1*. This subject will compute today both the cost of the medical procedure (in terms of wellbeing reduction due to pain) and the future benefits in wellbeing at *t+2, t+3, ..., T* (see Golub et al. 2009). Figure 1 illustrates this idea.

Fig. 1: Temporal Prospect



In our approach, the key issue is how subjects value this temporal prospect of length *T-t*. We use Laibson (1997) approximation, where the utility of each subject, at moment *t*, depends on the wellbeing (utility of consumption) of tomorrow *t+1* and subsequent periods $t+\tau$ ($\tau = 1 \ldots T-t$) discounted by δ^{τ} and where parameter $\beta \in [0,1]$ captures the preference for immediate rewards:

$$U_t = E_t\left[u(c_t) + \beta \sum_{\tau=1}^{T-t} \delta^{\tau} u(c_{t+\tau})\right] \tag{1}$$

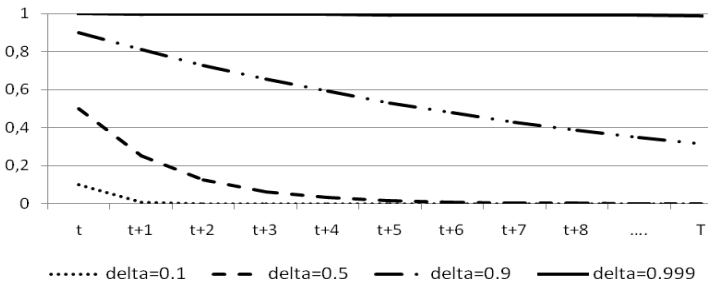
$$= E_t\left[u(c_t) + \beta\delta u(c_{t+1}) + \beta \sum_{\tau=2}^{T-t} \delta^{\tau} u(c_{t+\tau})\right] \tag{2}$$

Equation (1) is the original expression and (2) separates the day of the intervention (*t+1*) from the rest (*t+2, t+3, ..., T*), to account for the fact that costs are incurred in *t+1* and benefits accrue in *t+2, t+3, ..., T*. Note that both costs and benefits are not immediate so that both are affected by β; an individual concerned only by immediate rewards ($\beta=0$) would not anticipate pain in *t*. Pain anticipation in *t* is related to discount (δ). Figure 2 illustrates the effect of discounting (δ) on the valuation of future prospects.

In Figure 2 we compare the evaluation of future events $\beta\delta^{\tau}$ for different values of δ, ranging from hardly impatient subjects ($\delta=0.1$) to highly patient individuals ($\delta=0.999$), for $\beta=1$. It is easy to check that patient subjects value even very distant

outcomes whereas impatient individuals give very low (or no) value to relatively close events.

Fig. 2: Temporal valuation



In words, a myopic subject ($\delta = 0.1$) will value "only" the cost of the surgery at *t+1* (and will put very little weight on any future benefit at periods $t+\tau$) whereas a future-oriented individual will value both the cost at *t+1* and all the subsequent benefits at $t+\tau$. In sum, a future minded individual could value positively a medical intervention (given that it is already prescribed by a physician) whereas a present oriented subject could compute only the pain.

III VARIABLES & EXPERIMENTAL PROCEDURES

Our first core variable –discounting- is usually obtained through a simple experimental mechanism (see Viscusi et al., 2008): the individual is asked to choose between a given amount of money at moment t, m_t, versus a larger amount $M_T = m_t + b$ at moment T ($T > t$; $b \geq 0$). The tradeoff for the subject is that he can get more money in exchange for a longer wait. Obviously, the decision of waiting $(T-t)$ periods depends on the discount factor δ and on the value of b. When $b \to \infty$ only irrational people will not wait; on the other hand, for $b \to 0$, nobody will wait.

In our study, to elicit subjects' time preferences we asked them the value of *b* that would make them indifferent between receiving an amount of money *M* in one month and the amount *M-b* tomorrow. Subjects were confronted to this task:

> *We offer you 100 euros that you will get after 30 days. How much money are you ready to pay in order to get that money tomorrow? That is, how much of the 100 euros you would sacrifice to get the money in advance?*

From the 100 euros I would pay _____ euros.

To create the proper incentives, in each of the three session one (out of 40) subjects was randomly selected to get paid with real money.

Our second core variable –pain anticipation to medical events- is obtained using a self-reported questionnaire. We asked subjects:

> *When you know you are going to suffer a painful experience, do you start feeling pain even before the experience actually takes place?*

Observe that, this question does not mention any specific pain. The individual is asked about his life experience in general, that is, we are not framing to any particular event. The question does not refer to general anxiety or fear of pain but to anticipation of an event that will be painful for sure ("when you know you're going to..."). Hence, this measure should provide us a *lower-bound*: those subjects who give an affirmative answer are, in fact, pain anticipators.

Brañas-Garza et al. (2010) shows that this binary variable correlates significantly with pain *sensitivity* (the period of time that elapses before a person experiences pain after an injury) but it is uncorrelated to pain *endurance* (the period of time that elapses before a person experiencing pain will seek relief from their symptoms).

The experiment was conducted in three sessions at the University of Granada (Spain) in September and December 2009. All the sessions were run by the first co-author. Questionnaire data were collected from 130 university students (55% women, average age=24.4 years), who voluntarily participated in the experiment. The subjects were Economics and Business students (graduate students and undergraduates in the last two years of their degree). The average health status is high (mean=2.81; from very bad (0) to excellent (4); no subject reported the minimum level of health (very bad)).

IV RESULTS

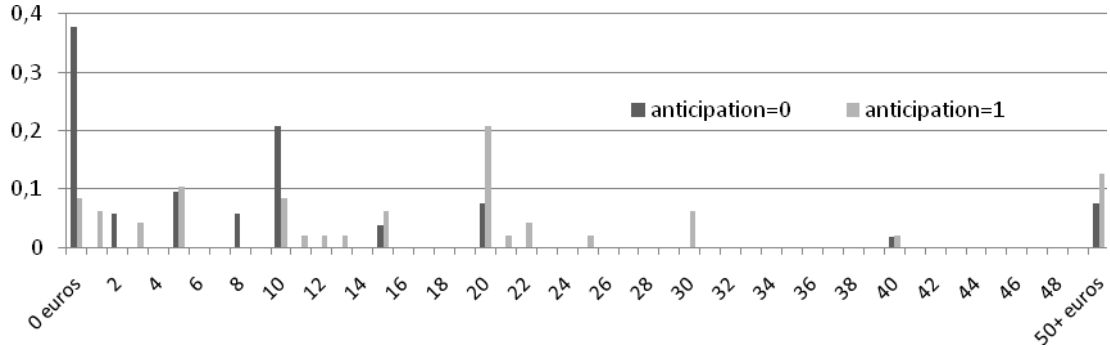
Before showing the results, we should mention that 21 (out of 130, 16%) subjects were unable to fill the discounting task properly.[5] They wrote sentences like "I do prefer money for sure (in advance) rather than future money" (instead of fixing an amount), or "*nothing*" or just left the space empty.

101 subjects completed both the pain anticipation and the time preference questions. In the first question 44% of the subjects reported pain anticipation. The amount of money they were willing to sacrifice in order to speed the time to get it varies substantially across subjects (mean =14.65; st.dev =17.91; min =0; max =80).

Figure 3 shows the histograms of the willingness to pay for two groups of subjects, those who did not anticipate pain (=0) and those who did (=1).

We observe that the group of subjects who did not anticipate pain (dark grey bar) showed lower values (higher δ's) than their colleagues who did anticipate pain (light grey bar). In fact, the number of subjects who were willing to pay 0 in order to get the payment in advance is much higher for those who did not anticipate pain (37%) than for those who did (8%).

Fig. 3: Histograms of Impatience by pain anticipation



These results illustrate how pain anticipation and impatience are positively correlated. The Kolmogorov-Smirnov test reports the same result (*Z=0.41*; p−value =0.00). In sum, subjects belonging to both categories do not behave similarly, that is, they are not drawn from the same population.

[5] Payment cards (an alternative elicitation device where subjects face a sequence of scenarios) usually produce a similar rate of inconsistencies (around 20%).

Therefore, we may conclude that *present oriented individuals are more prone to suffer pain in advance.*

V DISCUSSION

This paper shows that anticipatory pain is related to time discounting. In the medical literature pain anticipation is attributed to anxiety (Colloca & Benedetti, 2007). We rationalize pain anticipation considering that subjects value not only their present wellbeing but also their future health status. Since subjects differ in their time preferences, we find that some individuals weight mainly the prospect of pain associated to a medical procedure and discount heavily the future benefits, while others have a higher discount factor (δ) and weight highly the future benefits. In this framework anxiety could be the consequence of time preferences which assign a high value to a painful event which is close in time.

An interesting avenue for further research is suggested by recent work in Neuroeconomics (Fehr, 2002; McClure et al., 2004, 2007). When an intertemporal choice includes an immediate reward, limbic reward-related areas show greater activity than when the alternatives include only delayed rewards. In contrast, the lateral prefrontal and parietal cortex (areas commonly associated with deliberative cognitive processes, including future planning) do not exhibit sensitivity to immediacy although they react to intertemporal choices in general. People with greater activation in the limbic rewards region are more present oriented (Hariri et al., 2006).

This literature has also dealt with negative rewards (Knutson and Peterson, 2005), relevant to our research on pain anticipation. It has been suggested that the expectation of losses does not activate the same areas of the brain that the expectation of gains. Kuhnen and Knutson (2005) showed that the prospect of a $5 gain activated the nucleus accumbens, while the anticipation of a $5 loss did not. The possibility of a negative reward generates greater overall brain activity and slower response times than in the case of a positive reward (Camerer, 2003; Smith, et al., 2002).

Intertemporal decisions are important in Economics and individuals show heterogeneity on how they take decisions in this respect. This heterogeneity, which could be due to a different functioning of the relevant areas in the brain, is formalized through differences in the discount factor. Our experimental results suggest a relationship between suffering and anxiety prior to medical procedures and discounting, and we provide a framework to rationalize pain anticipation.

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