Documento de Trabajo/
Working Paper

IESA 01-04

Estimating Time by Counting Hands

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Abstract

We analyse retrospective time judging from a survey of more than fifty thousand reviews. Subjects were told to verbally estimate the time they had been waiting in the lounge until they entered the consulting room. The estimations ranged from 0 to 300 minutes. Our aim is to test whether subjects use round numbers when estimating time. We find that the round number is 5, although for longer intervals of time, the round number increases to 15, 30 and 60 minutes.

Keywords: Retrospective Time Perception, Verbal Estimation, Round Numbers.

“What then is time? If no one asks me, I know what it is. If I wish to explain it, I do not know”. Back to the fourth century, St. Augustine (354-430) quite rightly pointed out the difficulty in tackling the subtle issue of defining what “time” is. But even without having a precise definition, we all do experience the passage of time in everyday life. For example, when attending an economics class, we do notice when the class starts and when the class is over, and then we realise that the “time” of the class is over. Also, from time to time we do eat food and later on, we feel hungry again, realising in this way that we have been some “time” without taking food.

However, the perception of time, and more specifically how we do perceive time, is actually a tricky issue. Again, our everyday life reveals us that there are no sensory receptors for time (i.e. we do not hear time or see time). In fact, if we were prevented from our senses, we could still notice the passage of time for example, through the changing of our thoughts.

All this suggests that we basically realise the passage of time by means of other things which we perceive, much of them through our senses. These experiences of time have been analysed by Pöppel (1978), who isolated a number of elementary time experiences; among these we find (i) duration, (ii) non-simultaneity, (iii) order, (iv) past and present and (v) changes. For an introduction to these elementary time perceptions, see Le Poidevin (2000).

We shall be concerned with one of these fundamental aspects of our experience of time: the duration. In the estimation of the duration of an event or of the time elapsed, our brain needs two pieces of information: the time of the beginning of the event, which is actually in our memory, and the time of the end of the event, which might also be in our memory. Then the brain forms a belief about the duration.

The formation of these beliefs about temporal duration can be analysed from different perspectives. From an physiological point of view, we might be interested on the complex dynamics of the neuronal pathways involved as well as on the neuromuscular system.1 Also, this issue admits a metaphysic point of view. In the philosophy of time there is an ample debate on whether time itself

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1 Specifically, it is known that the prefrontal cortex (in the frontal lobe) plays a fundamental role in temporal processing, as well as the cerebellum.
or some aspects of it (i.e. passage of time) are unreal, without objective counterparts in the real world. Tensed theorists proclaim that the passage of time is an objective fact whereas untensed theorists deny it.²

And of course, Psychology has a prominent say in this issue, which is easily noticed by the large amount of experimental research conducted. In this area, there are two basic paradigms: (i) Prospective: Subjects are explicitly told in advance that they will be required to judge the duration of an interval, usually lasting less than 60 seconds, and (ii) Retrospective: Subjects are not given any prior warning about time judgements. Its focus is on memory and the time interval ranges from 60 seconds to several minutes. For a discussion of the methodology and the terminology involved in the analysis of time judgements, the reader is referred to Bindra and Waksberg (1956). For a modern analysis of both prospective and retrospective methods, see Block and Zakay (1997).

Our contribution is to analyse the phenomenon of the estimation of time from an economic point of view. We all have experienced that time is a relevant variable attached to economic goods: When we step into a restaurant and order our meal, it is needless to say that we want to take it in that precise moment, and we get really annoyed if food is not served quickly. An economic good as simple as “having dinner out” has plenty of dimensions to consider: The comfortableness of the chairs, the atmosphere, the variety of the menu, the quality of the food... and also several dimensions related to time, as the time of standing in a queue for getting seated, the time of being served, the time of getting the check or the bill, etc.

This example makes plain that the way we perceive the passing of time affects the way we perceive the economic goods and the way we assess them. And these assessments of the economic goods will affect our economic choices, under the widely accepted economic paradigm that subjects choices are optimal, in the sense that they are their most preferred alternatives.

Once the perception of time is recognised as having an important economic impact, we can imagining ourselves telling to some friends how much time we were waiting for the food in a particular restaurant. I have to admit that I would hardly say 37 minutes, or 21 minutes. I imagine myself as selecting a rounder number.

In fact, a well known fact in Experimental Economics is that individuals tend to choose round numbers when asked to select a number.³ For example, when subjects are asked to choose which will be the maximum amount of

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² A challenging question for tenseless theory is to explain why, if it is true that time does not pass in reality, it appears to us as passing.
³ See Albers and Albers (1983) and Albers (1997) for a Theory of Prominence in the decimal system for accounting for these observations. Also Selten (1997) for an empirical application of these ideas. Our approach here is in the spirit of these papers although we do not restrict ex ante the set of prominent numbers.
money they will pay for some commodity, or when subjects are asked to say their monetary contribution to a public good, answers tend to be round numbers. But this fact is not specific to economic situations; it has also been observed in non-economic questions, as for example, in answers to the question on how many inhabitants Madrid has. In this situation, it is rarely observed an answer like 3,547,345 individuals.

Our purpose is to analyse whether people also use round numbers in time judgement. To this end, we develop a model based on the use of scales for generating round numbers. A scale is defined by two numbers: the origin and the base. In our case, the origin is taken to be 0 and the base is taken to be any positive integer number. Given the scale and the waiting time, the individual selects the closest multiple of the base to the waiting time. This way, the scale generates numbers which are multiples of the base, i.e. round numbers.

For each possible scale we calculate two indexes: The success index, defined as the percentage of observations which are multiples of the base, and the parsimony index, defined as the percentage of numbers which are multiples of the base. We then define the optimal scale as the scale with the largest difference between the success and the parsimony indexes.

We apply this methodology to a survey of 52,200 personal interviews on waiting times in Primary Medical Public Centres in Andalusia for the period 2000-2002. We do find that for the whole sample of waiting times ranging from 0 to 300 minutes, the optimal scale is based on the number 5. But when attention is restricted to sub-samples starting on different multiples of 5, we do find that the size of the optimal base increases in the sequence 15-30-60. Thus, for intervals of time shorter than 15 minutes, the optimal base is 5, whereas for intervals of time between 15 minutes and one hour, the optimal scale increases to 15 minutes. Larger periods of time reveal a scale of 30 and 60 minutes.

Given that the key economic variable is not the real elapsed time but the perceived time and that people discretize time when judging it, the efforts directed to reducing waiting time may be unperceived by the economic subjects. The discretization of time must be an important phenomenon worthwhile to taking into account when assessing the appropriateness of modifying the time variables attached to economics goods or services aimed at improving their quality.

**The Use of Scales**

Our database comes from the study “Health Service in Andalusia: Improving Patient Satisfaction”. This survey was done by the Andalusian Social Studies Institute (CSIC, Spain) with the financial support from the Andalusian Regional Government. The total sample consists of 52,200 personal interviews. These interviews were done from September 2,000 to January 2,002. Each
questionnaire comprised more than fifty items, referring to a variety of questions related to public provision of health care. Among them, item 40 asked:

*How much time has elapsed since you came to the medical centre until you entered into the consulting room? _______ minutes*

Our sample consists of 46,841 answers to this question, disseminated within the interval 0-300 minutes; in particular 2,496 individuals did not wait and 44,345 did wait. Figure 1 illustrates the absolute frequencies of the variable waiting time up to 60 minutes.

![Waiting Time](image1)

Figure 1: Waiting time (histogram)

A visual inspection of the distribution of waiting time reveals that subjects mainly use numbers which are multiple of 5 (in fact, 42,382 observations (95.57%) are multiple of five). However there are also multiples of 2, 3, 10 and 15, as next figure displays, all of them in a share above the 45% of the numerical answers. For example, 63% of the observations are even numbers.

![Multiples](image2)

Figure 2: Multiples

The way in which we investigate the use of round numbers is the assumption that individuals use scales. A scale is defined by the origin, which in our case is taken to be zero, and the base, i.e. the positive integer used as the basis of the numeration scale. For a given waiting time, the individual will...
select the multiple of the base which is closest to the waiting time. This way, a given base will generate observations which are integer multiples of the base.

For selecting among different scales, we will use one of the basic principles of the scientific method: "A theory is better the more it predicts and the less it assumes." We construct an index for measuring the predictive power ("the more it predicts") and the parsimony ("the less it assumes") of a given scale. The success of a scale is calculated by the percentage of observations which are multiple of the base. The parsimony of the scale is defined as the percentage of numbers which are multiples of the base.

We finally combine these two indexes to yield a unique index. To this end, we use the following reasoning: Assume that we had a collection of numbers which are not generated by a scale but they are generated uniformly in a given interval. Then, for any scale, the success index will be the same as the parsimony index. Hence, the larger the difference between the success and the parsimony indexes, the larger the occurrence of observations which are multiples of the base beyond the randomly uniform model, and therefore the better the scale. This overall index will be named the Ockham's index in honour of the English scholastic William of Ockham (1285-1347) who stated the principle Non sunt multiplicanda entia praeter necessitatem (entities are not to be multiplied beyond necessity).

Next figure displays the Ockham's index for the entire sample. We see that the scale whose base is 5 attains the larger Ockham's index (50.78%), and it is therefore selected as the base used by the subjects in our sample.

We next explore whether the base used by the individuals is related to the size of the time to be estimated. We now compute the Ockham's index for different sub-samples, starting at multiples of the optimal base (5) and always ending at 300 minutes. Some results are displayed in the following table.

<table>
<thead>
<tr>
<th>Base</th>
<th>Success</th>
<th>Parsimony</th>
<th>Ockham</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>75</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>10</td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>15</td>
<td>25</td>
<td>25</td>
<td>50</td>
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<tr>
<td>20</td>
<td>25</td>
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<td>25</td>
<td>50</td>
</tr>
<tr>
<td>45</td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>60</td>
<td>25</td>
<td>25</td>
<td>50</td>
</tr>
</tbody>
</table>

Figure 3. Ockham's Index for the entire sample

We next explore whether the base used by the individuals is related to the size of the time to be estimated. We now compute the Ockham's index for different sub-samples, starting at multiples of the optimal base (5) and always ending at 300 minutes. Some results are displayed in the following table.
<table>
<thead>
<tr>
<th>Sub-Sample</th>
<th>Observations</th>
<th>Optimal Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-300</td>
<td>44,345</td>
<td>5 (50.78%)</td>
</tr>
<tr>
<td>15-300</td>
<td>29,424</td>
<td>15 (54.82%)</td>
</tr>
<tr>
<td>30-300</td>
<td>16,183</td>
<td>15 (67.61%)</td>
</tr>
<tr>
<td>45-300</td>
<td>7,468</td>
<td>15 (70.25%)</td>
</tr>
<tr>
<td>60-300</td>
<td>5,646</td>
<td>30 (73.31%)</td>
</tr>
<tr>
<td>75-300</td>
<td>2,071</td>
<td>30 (61.83%)</td>
</tr>
<tr>
<td>90-300</td>
<td>1,878</td>
<td>30 (67.56%)</td>
</tr>
<tr>
<td>105-300</td>
<td>1,061</td>
<td>60 (66.36%)</td>
</tr>
<tr>
<td>120-300</td>
<td>1,037</td>
<td>60 (64.95%)</td>
</tr>
</tbody>
</table>

Table 1. Number of observations and optimal bases for different sub-samples. Ockham’s Index in parenthesis.

Table 1 shows two salient features. First, the base of the optimal scale is endogenous and depends upon the magnitude of the waiting time: the larger the time, the larger the base. And second, the different optimal bases are related to the system in which our civilisation decided to measure time long time ago, i.e. the sexagesimal system: 15, 30 and 60 minutes.

We can rationalise this pattern of the optimal bases on the following basis: When deciding which number to say, the individual uses the first base, 5. He asks himself whether the waiting time is larger that the first multiple of the base. If the answer is positive, he then goes to the second multiple of the base, and asks himself the same question. If the answer is positive he then goes to the third multiple and asks himself the same question.

Once the subject has used three times the same base, the individual changes it and he uses as the new base the next prominent number in the sexagesimal system in order to speed up the process. The process stops when the individual has found a number that is not larger than the waiting time. And his answer is precisely that number.

Our methodology of optimal scales needs not be restricted to the analysis of the estimation of a waiting time. Other phenomena whose output is a numerical answer can be analysed applying our methodology. We leave this for future research.

References


