Chapter 2
How We Predict Time Usage

2.1 Mental Time Travel

We associate the human memory with the past, because memories are established in the past. While it is true that our memories are about things in the past, their purpose is to help us predict and manage the future. The recollection of a positive experience makes us approach similar events and an unfortunate encounter with a hot cooking plate helps us avoid harm in the future. Thus, we learn from experience and update our memory, consciously and unconsciously, for the sake of the future. The future is, however, seldom or never identical to the past and our brain has developed extreme flexibility in the way it handles memories. We can, for example, use our memories to simulate future outcomes before they have happened. This requires a high degree of flexibility and malleability of memories. We are able to combine, adjust, and manipulate memories to foresee the future. Memory is so flexible that one can make people vividly recall childhood hot air balloon flights that never happened and make them believe the event actually took place [1]. An even more surprising finding is that, through the use of interrogation techniques, innocent people can be convinced that they have carried out a crime they never did [2]. On the positive side, the flexibility of memories gives us the capacity to manipulate elements of the past in a way that enables us to travel into possible futures. This is very much what time prediction is all about: manipulating memories, perhaps together with more objective historical data, to simulate possible future outcomes. While physical time travel is still not possible, mental time travel is not only possible but also something at which we excel.

The ability to use our memory for planning and predictions, including mental time travel (*chronesthesia*), seems to make its first appearance between the age of three and four years [3]. Before that, children typically do not understand or respond meaningfully to questions about the future or to questions about the sequence of previously experienced events. The capacity of mental time travel is not a unique human ability. Great apes, such as the chimpanzees, and a few other animals seem to have this ability as well [4]. It seems, however, to be much more advanced among

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humans [5] and we may turn out to be the only species with the ability to believe in and prepare for more than one potential future.[1]

The importance of mental time travel becomes even clearer when observing those who have lost this ability. This is the case for people with certain memory disorders, such as Korsakoff's syndrome [7]. Without the mental time travel ability, they are unable to create plans and take care of themselves, and also experience loss of self-identity and develop depression. The ability to conduct mental time travel is consequently not only a precondition for good predictions but also essential in defining and experiencing who we are as human beings.

Take home message 1: The main purpose of remembering the past is to enable predictions about the future, including time predictions.

Take home message 2: An advanced ability to forethink an event or mentally travel into the future is one of the defining features of human beings.

2.2 How Did You Make that Prediction?

Predictions are manipulations of memories. They connect our previous experiences with ideas about the future [8]. What do we know about which memories we use and how we connect the past and future when predicting time? What has happened when a person thinks that 30 work hours is a reasonable time usage prediction? How did this person's memories turn into a number of work hours? The simple and honest answer is that we do not know much about these issues.

The main reason for not knowing much about what is going on is that our time prediction processes are largely unconscious. Just as most people do not really know *how* they ride a bicycle (they incorrectly think it is easy to master modified bicycles, where the wheel turns right when the handlebars are turned left and vice versa [9]), people predict time without being able to correctly explain how they do so.[2] The unconscious nature of judgement-based predictions also means that we are largely unable to control how we derive our time predictions. This is clearly demonstrated in studies where people are exposed to misleading or irrelevant information and this occurrence affects their time predictions [10]. Typically, people will not even realize or admit that their time predictions have been affected by the misleading or irrelevant information. Even worse, a warning that misleading information will be present along with instructions not to take the information into account does not help much either [11]. People are often surprised when learning that misleading and irrelevant information has affected their judgement, which suggests that people

[1] In a study with adult apes and human children as participants, a grape could fall from two different locations. The apes and two-year-olds prepared to catch the grape from one of the locations, whereas the three- and four-year-old children prepared for both possibilities. See [6].

[2] This does not rule out that many people *think* they know how they predict time. We are very good at rationalizing, that is, inventing a plausible reason for what we think after we know what we think.

believe they are in control of their judgement-based time predictions when, in reality, they are not.

An important step towards better time predictions is, therefore, to accept that we lack full control of how we think about, recall, and judge future time usage. Accepting this fact makes us, amongst other things, more likely to avoid situations and information that distort our time predictions.

Even if people do not know where their time predictions come from, they sometimes seem to be aware of situations that make overoptimistic judgements likely. When interviewing software professionals, we found that some of them described a gut feeling about how much time is needed as the *starting point* for their time predictions. They used their gut feeling but adjusted it to reflect their previous experience about the typical overoptimism or overpessimism of previous time predictions in similar situations. As one of them stated, 'I feel this will take 40 hours. I have, however, experienced that my initial judgement is typically about 50% too low in situations like this. The time prediction I think is realistic is consequently 60 hours'. An acquaintance who works as a carpenter also said, 'I judge how much time I am sure not to exceed. Then I double this'. These statements gives no information about how the initial prediction is obtained, but they suggest that, even if we are not able to know how the initial, judgement-based time prediction was derived, we may be able to improve it through consciously controlled adjustments based on previous experiences in similar contexts. The accuracy of a time prediction strategy of this type, using the initial time prediction as a starting point and adjusting it for typical bias in similar situations, has not yet been evaluated in research.

Take home message 1: We do not know much about the mental processes leading to judgement-based time predictions. The unconscious mental processes involved are difficult to identify and describe.

Take home message 2: People tend to believe that they are more in control of their time prediction processes and less affected by misleading and irrelevant information than they really are.

Take home message 3: Knowing about one's own time prediction biases, for example, knowledge about situations leading to overoptimism, makes it possible to adjust for them and improve the realism of time predictions.

2.3 Time Predictions Are Everywhere

Many time predictions are trivial and go unnoticed, such as deciding when to leave home to be on time for a meeting, deciding whether one has time to write another email before leaving work, and predicting how much the traffic jam will slow you down. Other time predictions are more critical, such as whether one is able to finish important work on a product before the promised delivery date. We do not know much about the total number of time predictions people typically make every day,

but it is likely to be high, perhaps much higher than most would think. In addition, our brain makes many time usage-related calculations that we may not classify as time predictions. When, for example, you manage to avoid hitting a car moving towards you when overtaking a slower car, this is partly due to successful predictions of the time it takes to return to your lane.[3]

We once asked students to write down two examples of situations involving predictions of time. Most frequently, the students gave time prediction examples related to transportation from one place to another and preparing oneself for activities. Interestingly, the students included time predictions not only of the type *how long will it take to…* but also of the type *how much can I do before….* This second type is not always thought about as a time prediction but it requires very much the same use of memory to assess the correspondence between an amount of work and an amount of time. As we will see later in this book, the second type of time prediction has both advantages and challenges.

Take home message: We make numerous time predictions each day. Many of them, probably most, go unnoticed.

2.4 How Good Are We at Predicting Time?

Are people typically overoptimistic when predicting time? How accurate are we in predicting time? These questions are harder to answer than it first appears. In our review on time prediction studies [13], we systematically searched for studies reporting accuracy and bias. Many studies noted only the level of bias, that is, the average tendency of predicting a too low or a too high time usage. Fewer studies included the level of accuracy, which is the average time prediction error irrespective of whether the prediction is too high or too low.[4] Unbiased time predictions do not mean that the predictions are accurate: One half could be far above the actual times and the other half far below but these inaccurate predictions would result in a zero bias if they balance each other out.

When looking at studies that do report the level of accuracy, we typically find an average time prediction error of 20–30% and great variation in time prediction accuracy, depending on the situation.

How *good* an average time prediction error of 20–30% is depends on the context. How accurate time predictions do we need? How complex is the task we are predicting? How much is possible to know about the task's completion? How much

[3]To be fair, such instances of timing are not necessarily time predictions. For example, it has been shown that baseball players running to catch the ball do not make sophisticated calculations of the path of the ball and the point in time when the ball with reach a certain spot. Instead, they continuously adjust their speed according to the angle of the ball. See [12].

[4]The level of accuracy is based on the unsigned error. If, for example, we have one project with a time prediction that is 10% too high and another with a time prediction that is 10% too low, the average time prediction error is 10%, while the average bias is 0%.

can we affect the actual time usage to fit the prediction? Predicting the required time usage to complete a complex and innovative construction project with many dependencies between tasks, little flexibility in deliveries, and a great deal of uncertainty with an average 20–30% error margin does not seem bad at all. Repeatedly spending 30% more time than predicted when walking the same path to the bus from home, which should be easy to predict, may, on the other hand, suggest poor time prediction skills. Our general observation based on the review of available studies is that, despite numerous horror stories about large cost and time overruns, most professional domains seemed to be, on average, quite accurate when predicting cost and time usage. It is mainly when asked for time predictions in contexts in which we have little prior experience that time predictions errors are high.

How *biased* are people's time predictions? Do people, as many would expect, typically give overoptimistic time usage predictions? As with results for accuracy, our literature review documented large variations in time prediction bias, depending on the situation. For example, when overoptimistic time predictions result in strong negative consequences, such as angry customers waiting for food, people tend to give overpessimistic time predictions. Across all reported tasks and projects, we did not find a general tendency towards either overoptimistic or overpessimistic time predictions. Reports from studies of everyday tasks, conducted in laboratory settings, instead suggested that the time predictions, on average, were unbiased. Even time predictions collected in several professional contexts, such as time predictions for smaller software development tasks, did not show a tendency towards too low time predictions. Does this mean that the common impression that people tend to make overoptimistic time predictions is wrong?

To understand and explain the contrast between the research evidence and the common belief in overoptimistic time predictions, it is useful to take a closer look at the context of the predictions. Tasks conducted as part of empirical experiments in a laboratory setting are frequently predicted with no bias. To be completed in a laboratory setting, however, the tasks are usually relatively short and involve few or no unexpected obstacles. Everyday tasks outside the laboratory setting, on the other hand, are more likely to include challenges unknown before initiation of the task. When assembling a piece of furniture, one could experience the screws not fitting or a friend who came to assist being more of a nuisance than help. Given that unexpected problems are a major contributing factor to overoptimistic time predictions, the laboratory experiment data can hardly be used as evidence of a lack of overoptimistic time predictions in realistic everyday or professional settings.

In addition to the point about the lack of realism in laboratory tasks, there are at least two other reasons for a discrepancy between the belief that people are typically overoptimistic and the research finding of unbiased time predictions. First, the likelihood that people decide to initiate projects and tasks in real life increases with an optimistic view and decreases with a pessimistic view on the required time usage [14]. For example, if your partner suggests a new colour for your kitchen cabinets and you hold realistic or even pessimistic views about the amount of work involved (removing the doors, sanding, priming, three layers of paint, etc.), you may argue that the current finish is fine and the project will never be initiated. If your time prediction

of the same work is highly overoptimistic and you assume the work will be easy and take hardly any time, it is much more likely that the project will be initiated. We can only evaluate the degree of time prediction optimism on completed tasks, which means that we are more likely to become aware of our optimistic rather than our realistic or pessimistic time predictions. In contrast, all participants in psychology experiments complete their assigned tasks, regardless of whether they predict the task to be complex or easy.

A second reason for a discrepancy between research results and the perception that people typically give overoptimistic time predictions is related to the fact that the actual use of time can never be less than zero, while there is, at least in theory, no upper limit to time usage. This results in a so-called right-skewed time prediction error distribution. A task predicted to require two hours can turn out to require six additional hours but not six hours less than predicted. Throughout your life, the total time overrun is consequently likely to exceed your total time underrun. Cases of extreme overruns will also stick in your mind, whereas underruns are typically less impressive and more likely to be quickly forgotten.

Returning to the results of our systematic review of time prediction bias, we did not even find a general tendency towards overoptimistic predictions in the area of software development, a domain notoriously known for cost overruns and delays. Again, however, a closer look at the data gives a more nuanced picture. We found that the median time prediction bias was dominated by a large number of small tasks, with unbiased or even overpessimistic time predictions. When including only projects of at least 100 work hours, we found the expected overoptimism with a median time overrun of about 20%. Larger projects have a higher risk of severe problems and there are more things that can be forgotten when predicting time for such projects, so it is not surprising that the time predictions of larger projects tend to be too low. The pattern also corresponds to experimental results suggesting that people are likely to overestimate the time usage of smaller tasks and underestimate that of larger tasks.

Take home message 1: The average error of time predictions, based on evidence from multiple domains, seems to be around 20–30%.

Take home message 2: Research on time prediction finds just as much overestimation as underestimation of time usage, suggesting unbiased time predictions. For larger projects, however, the time predictions tend to be biased towards being too low, with a median time overrun of about 20%.

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