Judgments of Time in Traffic Related Decision-Making Situations

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Abstract

Judgments of time can have a crucial role for the choices drivers take while in traffic. At the same time drivers' value of time is often predicted as being the core benefit from new road development schemes (Mackie, Jara-Días, Fowkes, 2001; Beesley, 1965). This paper uses the theoretical perspective of Kahneman & Tversky's (1979) Prospect Theory to investigate how time is judged in traffic situations. In particular, it is examined how the *framing* of time-prospects, influence the drivers' judgments. To investigate this a questionnaire was distributed on the internet. 213 participants were presented with 6 different situations related to time in traffic and asked to choose between two different time-prospects in each of the 6 situations. The 6 different choice situations were each framed in both a positive and a negative formulation. The individual participant was presented with only one of the two formulations in each choice situation.
The results from the experiment indicate that the framing of the specific choice situation play a role in drivers' judgments of time in traffic related situations, as Prospect Theory predicts. Also, the results show that special consideration must be given to judgments of time as compared to choices involving judgments of objects or money, as the perception of time differs from the perception of objects or money.

Introduction

In general terms human information processing can be divided into three systems: automatic, intuitive and controlled (Kahneman, 2002). Traditionally, traffic psychology has been concerned with automatic and controlled processes and the relationship between these two (e.g. Groeger, 2000). All non-automatic choices have therefore been treated as outcomes of controlled processes (for an example, see Bötticher & van der Molen, 1988). In opposition to this, recent studies have shown that intuitive processes play the main role in a large part of the choices people encounter (Kahneman & Tversky, 2000). It is therefore time to take a new perspective in the investigation of the processes behind decision-making in traffic situations.

Apart from influencing the decisions made while in traffic, judgments of traffic related time also play a major role in analyses of the costs and benefits of different types of transportation (Mackie et al., 2001; Beesley, 1965). In economics the predictions of how drivers judge and value time spent in traffic has primarily been based on utility theories that assume decision-makers to be rational, and thereby have been focusing on controlled decision-making processes under no influence of the intuitive system.

The understanding of how time prospects are judged in traffic situations is, as indicated above, a grossly neglected research area, both within transport psychology and economics. This paper aims to introduce the topic of intuitive judgments and the resulting choice pattern, to the field of judgments of time in traffic.

Theoretical background

Decision-making is a complex and multifaceted topic with relations to philosophy, economics and psychology. Theories of 'Rational Choice' and 'Expected Utility' have long dominated the field of human decision-making in economics. These theories are used as a basis for economical modeling, allegedly revealing and predicting the consumers' preferences (McFadden, 2006; Fehr & Tyran, 2005), and as such play an important role in planning and guidance of political decisions (Mackie et al., 2001).

During the 20th century it has become clear through extensive empirical work that the traditional economic utility theories do not comply with observed decision-making behavior. This acknowledgement has lead to a shift of perspective in a large part of the ongoing research into decision-making, from a focus on logical and normative rationality to decision-making theories that take human information processing into consideration.

As early as in the 1950's psychologists have been concerned with the discrepancies between economical decision-making theories and the neuropsychological knowledge of the limited capacity of the human information processing system (Simon, 1956, 1964). It puts an enormous strain on the information processing system to be perfectly rational, even when only in respect to the individual's own subjective preferences. The rationality assumption as described by the two main contributors behind neoclassical utility theory, Neumann & Morgenstern (1944/2004), implies that the individual is fully informed of all the existing prospects and their possible outcomes, and is unaffected by economically irrelevant differences in the description of the prospects. Simon's extensive research showed that Neumann & Morgenstern's axioms are neither plausible nor necessary to make good decisions. In the decades after Simon's critique several paradoxes (Allais, 1979; Ellsberg, 1961), where actual behavior is in opposition to the predictions made by utility theories, has further questioned the validity of the rationality assumption and the extension of controlled processes in general decision-making.

Kahneman & Tversky's Prospect Theory offers a solution to the mentioned discrepancies by using actual observed behavior to form a theoretical understanding of human decision-making (Miljkovich, 2005). Of main interest for the current paper is the theory's introduction of how the intuitive information processing system plays a role in most decision-making. Even though a choice is explicitly considered and consciously available to the decision-maker, the processes can be irrational (in the traditional economical sense) and dependent on automatic judgments inferred from the individuals' current reference situation (Kahneman & Tversky, 1979).

Judgment processes in the intuitive system follow a well specified pattern. The subjective utility shows marginally falling sensitivity, as also the traditional utility theories proposes, but in Prospect Theory prospects are not evaluated by their absolute values, instead the subjective utility is dependent on the individual's current situation or expectations, referred to as 'the reference point'. The subjective value of a given prospect therefore depends on the reference point, and by changing the reference point, it is possible to manipulate the individual's judgment of a given prospect. The effect of changing the reference point is accentuated by the fact that the subjective weighting of negative prospects generally is twice as large as the weighting of positive prospects (Kahneman & Tversky, 1979). The subjective utility function in Prospect Theory is named 'the value function' and takes the shape shown in figure 1.

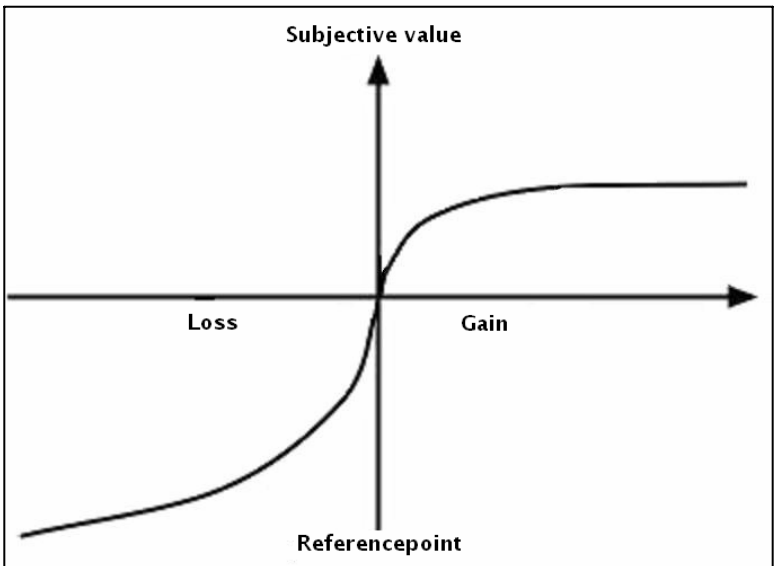

Fig. 1: Graphic depicturing of the subjective weighting of the outcomes of prospects as according to Prospect Theory. Adapted from Kahneman & Tversky, 1979, p. 279

The shape of the value function is confirmed by a large body of empirical research. The results of which show that participants generally decline gambles of the following type and instead prefer the status quo situation which represent a certainty of neither winning nor loosing anything:

> **Problem 2** "Would you accept this gamble? 50% chance to win $150, and 50% chance to lose $100" (Kahneman, 2002, p. 461).

On the other hand it is seen that participants accept the same gamble if $100 is subtracted from the prospects including the status quo situation. Here the choice is between a gamble and a sure loss instead of between a gamble and status quo. In this type of situation the participants prefer the gamble:

> **Problem 3** "Which would you choose? Lose $100 with certainty or 50% chance to win $50, and 50% chance to lose $200" (Kahneman, 2002, p. 461).

The two 'Problems' demonstrate that people are not unaffected by irrelevant changes in the choice situation (e.g. subtracting $ 100 from the involved prospects) and that people show inconsistent preferences.
Even more problematic for the rationality assumption is the inconsistent preferences seen in the following to choice situations:

> **Problem 11** "In addition to whatever you own, you have been given 1,000. You are now asked to choose between A: (1,000, .50) and B: (500)" (Kahneman & Tversky, 1979, p. 273.).
>
> **Problem 12** "In addition to whatever you own, you have been given 2,000. You are now asked to choose between C: (-1,000, .50) and D: (-500)" (Kahneman & Tversky, 1979, p. 273.).

The choice between the same absolute values has been framed in two different ways in 'Problem 11' and 'Problem 12'. In 'Problem 11' participants generally prefer B, whereas the exact same prospects in regard to absolute values produce the opposite preferences in 'Problem 12' (that is, participants generally prefer A), due to the change in reference point.

The above mentioned choice patterns has been tested thoroughly in a wide number of different situations involving judgments of for example cars, ice cream, ball point pens, chocolate, and more abstract things such as insurances, health plans, and working hours (see Kahneman & Tversky, 2000). It is therefore of great interest to take a closer look at, how this "irrational" choice pattern stemming from intuitive processes influences the judgment of time in traffic situations, and the choices resulting from these judgments.
In the current study Kahneman & Tversky's experimental paradigm was used to examine how drivers choose between different time prospects in traffic related situations. Apart from putting a new perspective on how judgments of time can influence decisions made in traffic, this approach also provides a basis for understanding whether judgments of time follow the pattern described by the value function.

Method

Participants

All participants corresponded with the following sampling criteria: were between 25 and 65 years, possessed a valid driver's license, drove on a regular basis[1], and were randomly chosen from WEBPOL's internet panel. 213 participants corresponded with these criteria and answered the questionnaire. The mean age of the participants was 43.66 years.
In spite of the small sample size, the participants correlated fairly well with the general characteristics of the Danish population (see table 1). There are minor underrepresentations of women and of persons with a low personal income, most likely an effect of the sampling criteria.

Procedure

The questionnaire was distributed by the internet survey company WEBPOL. 610 persons were randomly sampled from WEBPOL's internet panel consisting of approximately 20.000 voluntary panel members stratified from the Danish population. The 610 randomly sampled panel members received an email invitation to complete the questionnaire. In the email the panel members were presented with a link that led them to the internet site where the questionnaire was placed.

[1] More than 100 km a week.

Beforehand it was agreed with WEBPOL that the survey would close after the completion of approximately 200 questionnaires. The survey was closed after 213 persons had answered the questionnaire. These persons will henceforth be referred to as the participants.
The questionnaire comprised of 6 dilemma pairs, each dilemma pair representing a choice situation described in both a positive and a negative frame. (The dilemma pairs are described more thoroughly in the next section of this paper.) Each participant was only required to answer one of the two dilemmas in each dilemma pair. Which of the two dilemmas in each dilemma pair the individual participant was presented with was randomly extracted for each dilemma pair. The sequence of the dilemma pairs were on the other hand fixed in order to avoid presenting two very similar dilemmas immediately after each other.
The questionnaire was presented in Danish in correspondence with the sample population's first language.

Table 1 The distribution in percent of the participants on selected background variables compared to the distribution in percent of the general Danish population. * Statistics supplied from "Statistics Denmark" (http://www.dst.dk/Statistik/ags/Statiskaarbog.asp)

VARIABEL		PARTICIPANTS	THE DANISH POPULATION IN GENERAL*
Sex	Male	60,1	49,5
	Female	39,9	50,5
Age	25-29	8,4	11,2
	30-39	24,5	26,4
	40-49	27,7	26,3
	50-59	26,4	24,7
	60-65	13,0	11,5
Personal yearly income	- 99.999 kr.	1,0	8,7
	100.000 kr. – 199.999 kr.	10,8	24,7
	200.000 kr. – 299.999 kr.	27,2	19,8
	300.000 kr. – 399.999 kr.	30,8	12,8
	400.000 kr. – 499.999 kr.	11,8	9,9
	500.000 kr. – 599.999 kr.	6,7	9,1
	600.000 kr. – 699.999 kr.	3,6	6,1
	700.000 kr. – 799.999 kr.	2,6	3,5
	800.000 kr. – 899.999 kr.	2,1	2,0
	900.000 kr. – 999.999 kr.	0,5	1,2
	1.000.000 kr. –	3,1	2,5
	Missing:Won't answer/don't know	n = 18	
Zip code area	Capital counties	28,5	22,3
	Other counties in Sjælland	14,6	22,7
	Fyn	7,2	8,8
	Jylland	49,7	46,1

Table 2: English translation of the dilemmas of which each participant was presented with one dilemma from every dilemma pair on the internet questionnaire.

	Version .1	Version .2
Dilemma pair no 1 *and 6*	You're on your way to the ferry and still have 100 km left on the highway left. The ferry runs once every hour. You now have the choice between A or B. **A**) Keep driving according to the speed limit. If you choose this option you have 50 % chance of catching the ferry at 2 p.m. and 50 % chance of having to wait for the next ferry at 3 p.m. **B)** Exceed the speed limit by 10 km/h. *(20 km/h)* If you choose this option you have 75 % chance of catching the ferry at 2 p.m. and 25 % chance of having to wait for the next ferry at 3 p.m..	You're on your way to the ferry and still have 100 km left on the highway left. You have been delayed by construction work earlier on your trip. The ferry runs once every hour. You now have the choice between A or B. **A)** Keep driving according to the speed limit. If you choose this option you have 50 % chance of catching the ferry at 2 p.m. and 50 % chance of having to wait for the next ferry at 3 p.m. **B)** Exceed the speed limit by 10 km/h *(20 km/h)*. If you choose this option you have 75 % chance of catching the ferry at 2 p.m. and 25 % chance of having to wait for the next ferry at 3 p.m..
Dilemma pair no 2	You're on your way home, driving. Usually it's a 55 min. drive, but today you have to choose between two different routes, A or B. **Route A)** You will be home 20 min. later than the usual time with certainty. **Route B)** You have 50 % chance of being at home 10 min. faster than the usual time and 50 % chance of being at home 30 min. later.	You're on your way home, driving. Usually it's a 90 min. drive, but today you have to choose between two different routes, A or B. **Route A)** You will be home 15 min. faster than the usual time with certainty. **Route B)** You have 50 % chance of being at home 45 min. faster than the usual time and 50 % chance of being at home 5 min. faster.
Dilemma pair no 3	You're on your way to a concert and have been delayed due to construction work earlier on your trip. The doors close when the concert begins. You have approximately 30 min. drive left on the highway. Which do you prefer? **A)** Driving according to the speed limits, and thereby having 50 % chance of getting to the concert before it begins and 50 % chance of getting there too late. **B**) Exceeding the speed limit with up to 20 km/h, and thereby having 75 % chance of getting to the concert before it begins and 25 % chance of getting there too late.	You're on your way to a concert. The doors close when the concert begins. You have approximately 30 min. drive left on the highway. Which do you prefer? **A)** Driving according to the speed limits, and thereby having 50 % chance of getting to the concert before it begins and 50 % chance of getting there too late. **B)** Exceeding the speed limit with up to 20 km/h, and thereby having 75 % chance of getting to the concert before it begins and 25 % chance of getting there too late.
Dilemma pair no 4	You're on your way home, driving. Which would you choose? **A)** 50 % chance of being at home 30 min. sooner than expected and 50 % chance of being at home 20 min. later. **B**) Be at home at the expected time with certainty	You're on your way home, driving. Which would you choose? **A)** 50 % chance of being at home 10 min. sooner than expected and 50 % chance of being at home 40 min. later. **B)** Be at home 20 min. later than expected with certainty
Dilemma pair no 5	You're on your way home, driving. You can choose between routes A or B. Usually you go by route B which has a speed limit of 100 km/h, but last time you went by route B it was under construction. Which route do you prefer today? **Route A)** The speed limit here is 70 km/h. **Route B)** There is 50 % chance of the construction work being finished and the speed limit therefore being 100 km/t and 50 % chance of the construction work still being in progress and the speed limit being 50 km/h.	You're on your way home, driving. You can choose between routes A or B. Usually you go by route A which has a speed limit of 70 km/h. Route B has just been rebuild, but you don't know whether the construction work has finished yet. Which route do you prefer today? **Route A)** The speed limit here is 70 km/h. **Route B)** There is 50 % chance of the construction work being finished and the speed limit therefore being 100 km/h and 50 % chance of the construction work still being in progress and the speed limit being 50 km/h.

Materials

The 6 dilemma pairs in the questionnaire were modelled from Kahneman & Tversky's experimental paradigm as presented in e.g. their 1979 article. Three of the dilemma pairs in this experiment (dilemma pairs 2, 4, and 5) used the same form as the two original problem pairs presented earlier in this paper (see the section 'Theoretical Background'), to establish whether the subjective value of time follow the pattern of the value function. The three remaining dilemma pairs (dilemma pairs 1, 3, and 6) explored the subjective value of time under different conditions by examining three similar choice situations in varying context conditions. An English translation of the questionnaire is presented in table 2.

Results

In each of the 12 single dilemmas the distribution of the participants' preferences (A or B) was checked for statistical significance. Differences in the preferences across the two dilemmas within each dilemma pair were analyzed to see whether the different framings of the prospects elicited variations in the distribution of preferences.
The statistical analyses were performed in SPSS 15.0. Chi^2 tests were chosen due to the nominal data. The results of the statistical analysis can be seen in table 3 and 4.

In 10 of the 12 dilemmas the participants had a statistical significant preference for one of the two time-prospects over the other. In dilemma no. 2.2 and 6.2 the participants showed no general preference between the presented time-prospects in these dilemmas.
In dilemma pair no. 4 there was a statistical significant change in the preferred choice from the gain framing (4.1) of the dilemma pair to the loss framing (4.2).No difference in preferences between the two formulations of the same choice situation was seen in any of the other dilemma pairs.
Dilemma pairs 1, 3, and 6 were checked for differences across the three dilemma pairs (see table 4). The participants' preferences change significantly both from dilemma pair 1 to 6, and from dilemma pair 6 to 3.

Table 4: Distributions of preferred choice compared across dilemma pairs 1, 3 and 6. Both p-values and chi^2-værdier are round off. All p-values represent two sided analysis. * $p < 0,05$.

VERSION	DELAYED DUE TO CONSTRUCTIONWORK			NEUTRAL		
DILEMMA NO	1.1 FÆRGE10 N=112	6.1 FÆRGE20 N=117	3.2 KONCERT20 N=106	1.2 FÆRGE10 N=101	6.2 FÆRGE20 N=96	3.1 KONCERT20 N=107
A: KEEP WITHIN THE SPEED LIMITS	33,9 % (38)	55,6 % (65)	38,7 % (41)	35,6 % (36)	56,3 % (54)	30,8 % (33)
B: EXCEED THE SPEED LIMITS	66,1 % (74)	44,4 % (52)	61,3 % (65)	64,4 % (65)	43,7 % (42)	69,2 % (74)
CHI^2 TEST DIFFERENT SPEEDS	$Chi^2 = 10,8$, p=0,001*			$Chi^2 = 8,4$, p = 0,004*		
CHI^2 TEST DIFF. ACTIVITIES		$Chi^2 = 6,3$, p = 0,012*			$Chi^2 = 13,3$, p = 0,000*	

Table 3: Distributions of preferred choice analyzed for statistical significance within each dilemma and between the two dilemmas in each dilemma pair. Both p-values and chi²-værdier are round off. All p-values represent two sided analysis. * p < 0,05.

DILEMMA PAIR	RISIK SEEKING FERRY10		REFERENCE DEPENDENT TIME		RISIK SEEKING CONCERT20		VALUEFUNCTION		REFERENCE DEPENDENT SPEEDCHOICE		RISIK SEEKING FERRY20	
DILEMMA NO	1.1 Neutral N=112	1.2 Delayed N=101	2.1 Gain N=116	2.2 Loss N=97	3.1 Delayed N=107	3.2 Neutral N=106	4.1 Gain N=108	4.2 Loss N=105	5.1 Loss N=104	5.2 Gain N=109	6.1 Neutral N=117	6.2 Delayed N=96
OPTION A	33,9 % (38)	35,6 % (36)	62,1 % (72)	56,7 % (55)	30,8 % (33)	28,7 % (41)	10,2 % (11)	28,6 % (30)	62,5 % (65)	63,3 % (69)	55,6 % (65)	56,3 % (54)
OPTION B	66,1 % (74)	64,4 % (65)	37,9 % (44)	43,3 % (42)	69,2 % (74)	61,3 % (65)	89,8 % (97)	71,4 % (75)	37,5 % (39)	26,7 % (40)	44,4 % (52)	43,7 % (42)
CHI² TEST DILEMMA	p=0,001* chi²=11,6	p=0,004* chi²=8,3	p=0,009* chi²=6,8	p=0,187 chi²=1,7	p=0,000* chi²=15,7	p=0,020 chi²=5,4	p=0,000* chi²=68,5	p=0,000* chi²=19,3	p=0,011* chi²=6,5	p=0,005* chi²=7,7	p=0,229 chi²=1,4	p=0,221 chi²=1,5
CHI² TEST DILEMMA PAIR	p=0,791 chi²=0,1		p=0,427 chi²=0,6		p=0,230 chi²=1,4		p=0,001* chi²=11,6		p=0,904 chi²=0,0		p=0,919 chi²=0,0	

Discussion

Framing effects

The participants' preferences in dilemma pair no 4 in this experiment indicates that the framing effect mentioned in Prospect Theory plays a role when drivers evaluate time-prospects in traffic related situations. The change of frame produced by subtracting 20 min. from all the possible outcomes in the gain situation in dilemma 4.1 making 4.2 represent a loss situation, results in a statistically significant change in the distribution of the preferences in the expected direction. That is, the participants are more willing to accept the gamble in the loss frame than they are in the gain frame.

Even though the results from dilemma pair no 4 are clear and statistically significant it must be recognized that the size of the change in preferences in the current study is considerably lower than in Kahneman & Tversky's original experiments. On top of this, against expectations no framing effects were found in dilemma pair 2 and 5, which like dilemma pair no 4 is modelled over some of the classical 'Problems'. These results indicate that the complex situation of judging time-prospects in traffic related situations involve special processes, not represented in the classical 'Problems'.

Uncertain time

In the current experiment the 4th dilemma pair is the only one where framing effects are manifested. Dilemmas 2.1, 2.2, 4.1, 4.2, 5.1, and 5.2 all represent choices between a certain outcome and a 50/50 gamble. In all 6 dilemmas the 50/50 gamble represents the mathematically superior choice. In spite of this the participants prefer the certain option in all 6 dilemmas even when the certain option is a sure loss! These results indicate that the participants find it particularly aversive to be uncertain about the time of their arrival. An aversion that makes them prefer the sure loss of time rather than facing the uncertainty of a potential gain.

From a psychological point of view this aversion is not very surprising. Perception of time differs from perception of other physical entities in that it is dependent on the activities by which the time is consumed (Fraisse, 1984). This close relationship between time and the content of time is also manifested in the fact that knowledge about the present and immediate time perspectives are essential for the individual to be able to schedule and control the near future. A loss of this knowledge essentially leads to a small loss of control, which is extremely aversive to the individual (se e.g. Seligman 1975) and therefore might explain the observed aversion of uncertain time in this experiment.

Time and the content of time

Dilemma pairs 1, 3, and 6 all involved the same type of situation: driving with the purpose of arriving on time for a specified activity, the choice standing between driving according to the speed limits and exceeding them. The three dilemma pairs were varied in regard to the specified activity and the amount of km/h the participants would exceed the speed limits if they chose this option. Not surprisingly the amount of km/h the speeding option represented had a significant effect on whether the participants chose to speed or not. Of more interest is that the nature of the specific activity at the destination of the drive had a statistically significant effect on the participants' preferences. In dilemma pair 6 where the goal was reaching the next ferry less than half the participants preferred to speed. While in 3rd dilemma pair where the goal was reaching a concert more than 60% of the participants chose to speed. These results indicate, that the content of the time lost and not the specific amount of time saved by speeding, was a determining factor for the participants' preferences. This gives

further support for the argumentation that judgments of time prospects differ in crucial ways from judgments of objects and money.

Final remarks

The results from this experiment show that the decision-making processes in the intuitive system identified by Kahneman & Tversky (1979) play a role in judgments of time-prospects in traffic related situations. It is clear though that these processes alone can not fully describe the complex task these kinds of decisions represent. Especially it seems that the correlation between time, the content of time, and perceived control plays a role in this type of decision-making. Further research on judgment of time under different conditions is needed before any conclusions about which consequences the judgment processes have for traffic behavior can be reached.

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