University of Heidelberg

Department of Economics

Discussion Paper Series | No. 508

Aging and decision making: How aging affects decisions under uncertainty

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December 2010

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Abstract:
In an aging society, it becomes more and more important to understand how aging affects decision making. Older adults have to face many situations that require consequential financial decisions. In the present study, we examined the effects of aging on decisions in two domains of uncertainty: risk and ambiguity. For this purpose, a group of young and older adults played a card game which was composed of risky and ambiguous conditions. In the risk condition, participants knew the probabilities to win or loose the game (i.e. full information), whereas in the ambiguous condition, these probabilities were unknown (thus, there was lack of information). When confronted with risky decisions, the behaviour of older and young adults (measured by the number of times participants chose a gamble instead of a sure amount of money) did not differ. In contrast, under ambiguity, there were significant age-effects in decision making: older people were less ambiguity-averse than young subjects. We conclude that there exist differences in uncertainty-processing between young and older adults, and discuss possible explanations of these differences.

Keywords: Age differences, experiment, risk and uncertainty

J14, C91

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Introduction:

The aging population

Though it is widely recognized that all western societies are facing an aging population, most of the research on individual decision making relies on student populations (Henrich et al., 2010). While this reliance on student populations certainly reflects some effect of subject availability, it possibly is also a consequence of the common belief that decision-making abilities may decline with age (Peters et al., 2000).

Older adults have to make many consequential decisions. Choices in the domain of health care or financial decisions are only two examples of older people's everyday life situations in which they need to decide carefully. Should they undergo a surgery with a certain risk but possibly high benefits, or rather not take the risk (or avoid making a decision (Mather, 2006))? Should they rather sell their house and move to an assisted living facility, or shouldn't they? These and similar decisions not only have an immediate outcome, but possibly can also affect the individual's future well-being.

The primary objective in this study was to elucidate the relationship between aging and decision making under financial uncertainty. Effectively, understanding how older adults make financial decisions is of great importance for social policy (Filer, Kenny, & Morton, 1993; Neugarten, 1974). Wealth tends to accumulate over the life course (Davies & Shorrocks, 2000; Jappelli & Pistaferri, 2000), and thus older adults have generally much more spending power than young adults do. At the same time, in countries devoid of compulsory voting, older individuals are more likely to vote than young people are, and thus they may have high political influence (Glenn & Grimes, 1968; Strate, Parrish, Elder, & Ford, 1989). Due to shifts in the demographic structure of western countries, including long-term trends like increased longevity and shortterm trends with long-term outcomes (cf. the baby-boom of the 1960's), the proportion of older and retired people increases, and the concern to understand the differences between young and older adults increases. This is why we investigate the behavioural differences in financial decision making in the two age-groups.

Uncertainty

In rational-choice theories of financial decision making under uncertainty used in economics, the only factors that should influence uncertain choices are the judged probabilities of possible outcomes and the evaluation of those outcomes. But as by now largely proven, humans are not fully rational decision makers (Kahneman & Tversky, 1979; Krajbich, Armel, & Rangel, 2010), and confidence in estimated probabilities varies. In some choices, such as gambling in blackjack games, probabilities can be computed easily recurring to relative frequencies (by counting the number of played cards and similar strategies). On the other side, for situations like the outbreak of an epidemic, probabilities are based on conflicting or absent information and thus are difficult to compute. The first type of events is called risky in decision theory; the second type is called ambiguous. In subjective expected utility theory, only probabilities of outcomes should influence choice; confidence about probabilities in contrast, should not. But there is large experimental (and common knowledge) evidence that people are less willing to bet on ambiguous outcomes than on risky ones (Camerer & Weber, 1992).

The difference between risk and ambiguity is well illustrated by the Ellsberg paradox (Ellsberg, 1961). Imagine an urn filled with 60 balls, half of the balls are red, and the other half are green. This is a risky treatment. Another urn also has 60 balls, but the distribution of red and green balls is not known to the player. This is the ambiguous treatment. A bet on a colour pays a fixed sum if the chosen colour matches the drawn colour, and nothing otherwise. In situations of such choices, it seems quite intuitive for many people to bet on a green (or red) ball from a risky urn rather than to bet on a green (or red) ball from an ambiguous urn (Becker & Brownson, 1964; MacCrimmon, 1968). If betting preferences were only determined by judged probabilities and their payoffs, this pattern wouldn't happen. Following the theory, preferring the green draw from the risky urn implies that its subjective probability is higher $P_{risk}(green) > P_{ambiguity}(green)$. The same should be true for the red draw $P_{risk}(red) > P_{ambiguity}(red)$. But, and that's the paradox, these inequalities and the problem that the probabilities of green and red must sum to 1 for each urn, imply:

$$\underbrace{P_{risk}(green + red)}_{=1} > \underbrace{P_{ambiguity}(green + red)}_{=1},$$

a logically impossible assumption. Thus, choices can depend on the availability of relevant (and irrelevant) information (Frisch & Baron, 1988; for irrelevant information: Gaeth & Shanteau, 1984; Rabbitt, 1965) – and the paradox can be solved by allowing choices to depend not on objective, but on subjective probabilities of an event (Gilboa & Schmeidler, 1989; Schmeidler, 1989).

Decision making and uncertainty in older adults

As already mentioned, the aim of our experiment was to investigate the difference of uncertainty behaviour between young and older adults as currently no real consensus about the effects of aging on decision-making behaviour in an uncertainty-context exists. The few existing studies looking at decision making in older adults are inconclusive: some state that decision making abilities decline with age, while others disagree with this statement.

In the deficit-perspective, e.g. Deakin et al. (Deakin, Aitken, Robbins, & Sahakian, 2004) show that risk taking decreases with age and, more generally, that age is related to poorer decision making (which can arise via multiple routes (Clark et al., 2008)). Other authors (Chaubey, 1974; Dohmen et al., 2005; Hallahan, Faff, & McKenzie, 2004) agree with Deakin et al.'s first statement that the willingness to take risk is negatively related to age. The groups of Denburg et al. and Fein et al. provide supplementary evidence for Deakin et al.'s second statement (Denburg, Tranel, Bechara, & Damasio, 2001; Fein, McGillivray, & Finn, 2007). Following them, normal aging may compromise the ability to decide advantageously.

In contrast to these studies, e.g. Dror et al. (Dror, Katona, & Mungur, 2000) refute Deakin et al's first finding, and claim that older participants make risky decisions equivalent to those of young adults. Kovalchik et al.'s work (Kovalchik, Camerer, Grether, Plott, & Allman, 2005) disagrees with the second finding of Deakin et al.: for these authors, older adults' overall decision making is similar to that of young adults.

For the moment, there are two strongly related perspectives trying to explain these contradictory findings: a psychophysiological perspective, and a perspective focusing on cognitive, emotional and information-processing changes related to aging.

From a psychophysiological perspective, one important fact is that the effects of ageing on the brain and, more generally, cognition are widespread and have multiple aetiologies (Cabeza et al., 2005). They have various effects on the physiological, molecular, morphological, and functional level. The cognitive effect that most often comes to mind associated with the ageing brain is memory decline (Small, Stern, Tang, & Mayeux, 1999), but as we'll see, other cognitive abilities are affected as well. The main psychophysiological explanation of the contradictory findings seen above is heterogeneity in brain aging: according to Denburg et al. (Denburg, Recknor, Bechara, & Tranel, 2006), good decision making abilities among older adults may be a function of well-functioning somatic markers, whereas poor decision making abilities may arise from an abnormal somatic response generated in anticipation of a future event. This effect is caused by interindividual differences in the aging process of a brain region of crucial importance to decision making, the frontal lobes (for an explanation of the link between decision making and the somatic marker hypothesis, see e.g. Tranel, Bechara, & Damasio, 2000). There is also evidence of ageing effects in other brain regions implicated in decision making: following Hampton and O'Doherty (2007), there is a specific network of brain regions implicated in encoding information relevant to decision making, and these regions can be affected by the aging process of the brain. Older adults counteract age-related decline of brain functioning through a reorganization of brain networks (Cabeza, 2002; Park & Reuter-Lorenz, 2009), but there are large interindividual variations in the extent of this reorganization.

The other explanatory approach is the cognitive / emotional / information processing perspective, following which aging affects cognitive processes, emotion- and information processing. This perspective starts form the premission that a large part of older adults are still high functioning, with an active and intellectually challenging lifestyle. At the same time, even if older individuals are facing declines in cognitive and decision making abilities, this decline happens in general slowly and with a high inter-individual variance (M. Baltes & Montada, 1996; P. Baltes, Lindenberger, & Staudinger, 1995). According to Mata et al. (Mata, Schooler, & Rieskamp, 2007) older adults look up less information, take longer to process it and use simpler, less cognitively demanding strategies; but in general, young and older adults seem to be equally adapted decision makers. There are some additional possible explanations of these findings in the literature on aging, but none of them has been systematically investigated in the context of decision making under financial uncertainty. For example, it is possible that older adults simply pursue different goals than young adults do: the association between time left in life and chronological age ensures age-related differences in goals and sense of future time plays an essential role in human motivation (Carstensen, 2006; Carstensen, Isaacowitz, & Charles, 1999). Decisions are strongly influenced by emotions (Coricelli, Dolan, & Sirigu, 2007) and like affective consequences can induce specific mechanisms of cognitive control of the choice processes (involving reinforcement or avoidance of the experienced behaviour), the emotional state of the decision maker, which in older adults tends to be more positive (Borges & Dutton, 1976), can influence his decision making abilities. Related to this is personality. As aging influences personality in some individuals, and as there are some personality traits – e.g. sensation seeking, cautiousness – influencing economic decision making (Borghans et al., 2008), heterogeneous changes in personality could also account for the contradictory statements.

Hypotheses

Based on the large – but to some extent disputed – scientific evidence that risk-taking decreases with age (see above), we (1) hypothesize that older adults are less willing to take financial risks than young adults are. Also, we (2) hypothesize that differences in decision making under ambiguity between young and older adults exist. Lastly, we (3) hypothesize that young and older subjects gamble less in ambiguity conditions than in risk conditions, as decision-theory predicts.

Methods

Participants

A total of 75 adults (51 young adults, 24 older adults) participated in the experiment. All of the young adults where students at the Universities of Mannheim or Heidelberg and were on average 25 years old (SD = 3.5). The older adults were healthy with an average age of 68 years (SD = 7.3, minimum age: 58 years). The majority of the older adults held a college or university degree and were retired. We recruited them by word of mouth advertisement at an adult education centre. Thereby we wanted to generate a group of participants with a similar level of education and a cognitively active lifestyle and, as our task was computer-based, to ensure that the older adults were familiar with the use of a computer mouse.

Participants		
	Young	Older
Number	51	24
Male	20	12
Female	31	12
Age (SD)	25 (3.5)	68 (7.3)
Years of education* (SD)	12.64 (1.32)	12.22 (1.38)

*until graduation from school

Procedures

The experiment took place at the Collaborative Research Center 504 Lab (SFB-504) of the University of Mannheim (young participants) and at the Alfred Weber Institute Lab (AWI-Lab) of Heidelberg University (young and older participants).

Participants were seated in computer-equipped cubicles devoid of visual access to other participants. An experimenter explained the modus operandi of the study. All participants received the same instructions. Participants first had to fill in a general questionnaire asking questions on their educational level, health status, and related questions. Subsequently, the experimental task by which we examined behaviour under uncertainty started. The task consisted of a card game similar to the card-deck treatment used by Hsu et al. (2005). In this task, subjects had to make continuous choices between a gamble and sure amount of money. In half of the trials, participants were faced with risky decisions (i.e. the probabilities of winning were known), and in half of the trials, they were faced with ambiguous decisions (i.e. the probabilities of winning the gamble were unknown). Risky and ambiguous gambles alternated. In total, subjects had to make 48 decisions (24 risky and 24 ambiguous), in which card distribution (respectively the total number of cards) and outcome varied. We used the same probability distribution as Hsu et al. (2005). The total number of cards in the game ranged between 5 and 40, and outcome between 6 and 20 ECU.

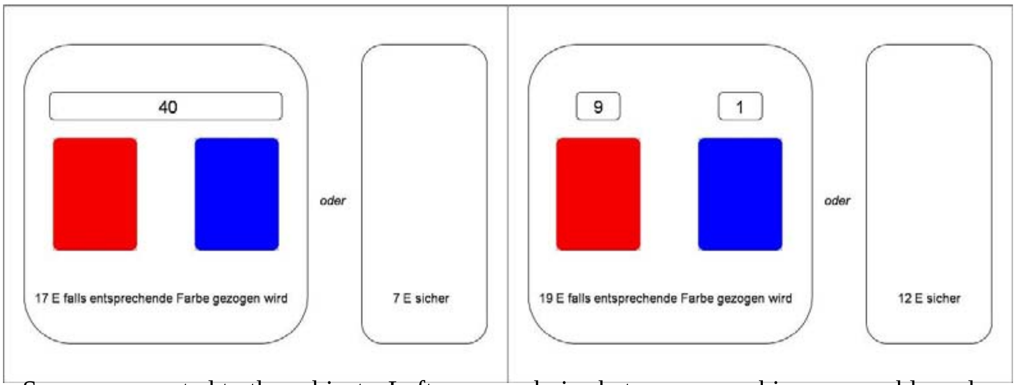
We used two different graphical user interfaces (GUI) to present the game to the participants. First, the game was programmed in ZTree and used with the student population (n = 35). In a subsequent pretest with older adults, we observed massive difficulties using the game (due to factors like button size and menu alignment). This is the reason why we decided to change the GUI to C# instead of ZTree and to slightly adapt the appearance of the game to ensure that it was as easy as possible to manipulate, even for subjects not that familiar with the use of a computer interface. An additional student group (n = 16) played the C#-game to test the comparability of the student group with the elderly group. As there was no significant difference in behaviour between students playing the ZTree-game and playing the C#-game (2-sided t-test for independent groups; risk: $t_{(49)} = .37$, $p = .74$; ambiguity: $t_{(49)} = -1.731$, $p = .09$), we pooled both groups for data analysis.[a]

The aim of the game was to observe player's behaviour under both types of uncertainty. Subjects were allowed as much time as they needed to make their choices. Responses were made by pressing on the corresponding option on the screen. Subjects had the possibility to decide between three options: the sure payoff that paid a certain positive amount of money or a bet on either side of a binary choice gamble that carried some uncertainty of paying either a positive sum or zero.

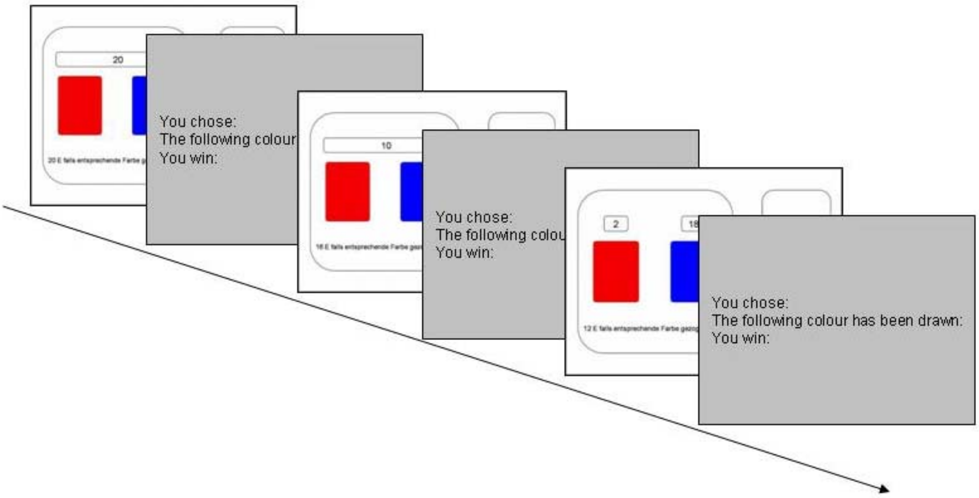
Overall, the task lasted for 15 minutes, and young and old adults took the same time to perform the task. Participants received a show-up fee of € 3. In addition, they were

[a] As the p-value for ambiguity could be considered as marginally significant, we tested whether the results still hold if we only use the students that played with the C# interface. We find that our results still hold.

paid depending on their choices. On average, their total gain in the experimental session was € 7.80 (SD = 0.50).



Screens presented to the subjects. Left screen: choice between an ambiguous gamble and a sure amount of money. Right screen: choice between a risky gamble and a sure amount of money.



Timeline of the game.

Results

Statistical methods

Risk behaviour was measured by the quantity of gambles subjects took instead of a sure amount of money, and was considered as a metric variable ranging from 0 (no gamble chosen at all) to 24 (always chosen the gamble instead of the sure payoff). Ambiguity behaviour was measured, mutatis mutandis, the same way. A search for outliers revealed no results. To test for age effects in risk behaviour (hypothesis 1), we used a one-tailed t-test, because we expected behaviour to tend in the direction of more risky choices in young adults. Hypothesis 2, the existence of age effects in ambiguity behaviour, was not directed, and we used a two-tailed t-test. To investigate our third hypothesis, that subjects are less prone to play ambiguous gambles than risky gambles, we used again one-tailed t-tests.

Analysis

T-tests for independent groups showed that there is no significant difference in decision-making under risk in the two age groups (one-tailed t-test: $t_{(73)} = 0.18$, $p = 0.43$). Young and older adults play the same amount of risky gambles in the game (average number of risky gambles taken by older participants: 16.0, SD = 5.7; by young participants: 15.7, SD = 5.6). In contrast, there is a significant difference in decision-making under ambiguity between older and young people (two-tailed t-test: $t_{(73)} = 2.19$, $p = 0.03$). Older adults are more prone to play ambiguous gambles than young adults are (average number of ambiguous gambles taken by older participants: 17.6, SD = 5.5; by young participants: 14.2, SD = 6.6).

Results 1

Gamble	*Age-group*	*Mean*	*SD*	*t-test*	*t-value (73)*	*p*
Risk	Young	15.7	5.6	one-tailed	0.18	0.43
	Older	16.0	5.7			
Ambiguity	Young	14.2	6.6	two-tailed	2.19	0.03
	Older	17.6	5.5			

T-tests for paired groups showed that young participants play significantly more risky than ambiguous gambles (one-tailed t-test; $t_{(50)} = 1.75$, $p = 0.04$). This is not the case in older participants: older adults play more ambiguous than risky gambles, but with only marginal significance (one-tailed t-test; $t_{(23)} = 1.30$, $p = 0.10$).

Results 2						
Age-group	*Gamble*	*Mean*	*SD*	*t-test*	*t-value (df)*	*p*
Young	Risk	15.7	5.6	one-tailed	1.75 (50)	0.04
	Ambiguity	14.2	6.6			
Older	Risk	16.0	5.7	one-tailed	1.30 (23)	0.10
	Ambiguity	17.6	5.5			

Discussion

The aim of our study was to investigate the effects of aging on decision making under financial uncertainty. We hypothesized that (1) older adults are less willing to take financial risks than young adults are, (2) ambiguity behaviour changes with age, (3) young and older subjects gamble less in ambiguity conditions than in risk conditions. The study only partially confirms our hypotheses, as older adults seem to be equally willing to take risks as young adults are (refuting hypothesis 1), ambiguity behaviour effectively differs with age (confirming hypothesis 2), and young subjects do gamble less in ambiguous conditions than in risky conditions, but older adults show no significant difference between risk and ambiguity behaviour (partially confirming hypothesis 3).

Following our first hypothesis, older adults should have a higher risk aversion than young adults in the risky condition. This is however not the case. Although we didn’t expect that there is no difference in risk behaviour, this result is not surprising. We were aware that the hypothesis of a higher risk aversion in older adults is to some extend debated, as shown by Dror et al. (2000). Effectively, we used a subject pool quite similar to the one of Dror et al., as all our older participants were healthy and highly active. Overall, older adults are very heterogeneous in their cognitive abilities, and activity might preserve cognitive ability with aging. This could explain why we did not find any differences in risky decisions between young and older adults. We have to take into account that our results might apply only to a specific, cognitively active group of older adults, and not to the entire group of older people.

Concerning ambiguity, the study showed that older adults gamble more than young adults in ambiguous conditions. This result seemed prima facie counterintuitive to us; however there are some factors that can explain this behaviour.

The first factor that could explain our result is the positivity effect (Mather & Carstensen, 2005), following which older adults are more optimistic than young adults (Borges & Dutton, 1976; Lennings, 2000). Older adults focus more on regulating emotion than young adults do, and this improves their overall emotional experience. Some authors suggest that in the aging process, an increased focus on emotion regulation influences attention and memory (e.g. Mather, 2004). In tasks focusing on attention, older adults respond faster if the task is associated with positive emotions than when it is associated with negative emotions (Mather and Carstensen, 2003). While brain activation related to emotion salience is the same for positive and negative emotions in young adults, it is higher for positive than for negative emotions in older adults (Mather et al., 2004). This positivity effect of emotions is also salient when it comes to memory: older adults are likely to show a memory distortion that prefers chosen options over rejected options (Mather and Johnson, 2000). This implies that older adults sometimes are more likely to repeatedly choose the same options because their memories are biased in favour of positive outcomes of their past choices. The tendency to focus on positive emotions leads to changes in decision making abilities. It is well known that emotions have effects on economic decision making (Lerner, Small, & Loewenstein, 2004), and in particular positive affect can improve decision making (Isen, 2001). In our case, this positivity effect can influence decision behaviour under ambiguity in two different ways. First, it signifies that older adults' memories of gains are more prominent than those of losses, and decisions based on the memory of gains in ambiguity decisions can lead to a lower level of ambiguity aversion. The other way the positivity effect can influence ambiguous decisions is by the overall emotional state of the individual; mood influences loss aversion (Camerer, 2005), which is strongly related to ambiguity aversion.

A second explanation for the age difference in behaviour is given by Mata et al. (2007). In their study, they found a difference in strategies used by young and older adults to make a decision: older adults look up less information and take more time to process it, but overall decision making of older and young adults seems to be equivalent. If we apply this to the fact that ambiguity is a condition with less information available than risk, one could think that ambiguous decisions are more suitable to older adults.

Another factor that can play a role in our findings simply is experience. In fact, older adults had a lifetime to decide and develop strategies for decisions under ambiguity. They can retrieve information from a memory that young adults are just beginning to develop. One survey of bank managers for example revealed that older managers' business decisions were more aggressive than the decisions of younger managers (Brouthers, Brouthers, and Werner, 2000), and different studies found that risky investments increased until a certain moment in life (Riley and Chow, 1992; Schooley and Worden, 1999, Jianakoplos and Bernasek, 1998).

Lastly, one could argue that older adults pursue different goals than young adults. Effectively, older adults are more interested in social goals (Mather, 2006) and monetary rewards are less of an incentive to them. We have to take into account the fact that winning an amount of around 8€ does not represent a large sum for someone who has earned money all his life and gets a monthly retirement annuity. The case is different for students who mostly haven't had the opportunity to accumulate much wealth during their life course so far and therefore have a different reference point. But, many studies (e.g. Camerer & Thaler, 1995; Cameron, 1999; Hoffman, McCabe, & Smith, 1996) show that as long as participants can earn money in an experiment, the height of the stakes does not (or only little) influence behaviour.

The third hypothesis stated that young and older subjects gamble less in ambiguity conditions than in risk conditions. Our results confirmed this hypothesis for young, but not for older adults: young adults behave as theory predicts, whereas older adults do not show a statistically significant difference between risk and ambiguity decisions. One possible explanation for this finding could be the positivity effect mentioned above. Following the positivity effect, older adults have a memory distortion in favour of previous choices. This leads them to choose coherently with previous decisions, leading to fewer switches in strategies. This low level of strategy changes – in a game in which the ambiguous and risky conditions alternated – could also explain the absence of significant behavioural differences in older adults.

In conclusion, we can say that older adult's decision-making behaviour effectively differs from that of younger adults. In risky situations, they behave such as young adults would behave, and in ambiguous situations, they are less ambiguity averse. We have shown that there are different possible explanations for our results, and further work will be needed to understand the causes of our findings.

On a more practical level, our findings can have implications for older adults' everyday life. In our societies, older adults represent a growing part of the population, and a part of the population that will work until a higher age, thus making financial decisions at a higher age. Employers, as well as financial institutions and politicians should be aware that older adult's decision making behaviour changes, and should adapt to this situation. At the same time, when older adults are aware that their decision making changes, it can help them to cope with decision situations that are designed from and for younger adults. Thus, understanding age differences in decision-making behaviour can help older people to stay adapted decision makers, and thereby improve their overall wellbeing. It can also help employers to decide which tasks are well suited for older employees and which are not.

Bibliography:

Baltes, M., & Montada, L. (1996). *Produktives Leben im Alter*. Frankfurt/Main, New York: Campus-Verlag.

Baltes, P., Lindenberger, U., & Staudinger, U. (1995). Die zwei Gesichter der Intelligenz im Alter. *Spektrum der Wissenschaft, 10*, 52-61.

Becker, S. W., & Brownson, F. O. (1964). What price ambiguity? Or the role of ambiguity in decision-making. *The Journal of Political Economy*, *72*(1) 62-73.

Borges, M. A., & Dutton, L. J. (1976). Attitudes Toward Aging Increasing Optimism Found with Age. *The Gerontologist, 16*(3), 220-224.

Borghans, L., Duckworth, A., Heckman, J., Ter Weel, B (2008). The economics and psychology of personality traits*. IZA Discussion Paper* No. 3333.

Brouthers, K., Brouthers, L., & Werner, S. (2000). Influences on strategic decision-making in the Dutch financial services industry. *Journal of Management, 26*(5), 863-883.

Cabeza, R. (2002). Hemispheric asymmetry reduction in older adults: the HAROLD model. *Psychology and aging, 17*(1), 85-100.

Cabeza, R., Nyberg, L., & Park, D. C. (2005). Cognitive neuroscience of aging: Linking cognitive and cerebral aging. Oxford University Press, New York.

Camerer, C. (2005). Three cheers—psychological, theoretical, empirical—for loss aversion. *Journal of Marketing Research, 42*(2), 129-133.

Camerer, C., & Thaler, R. H. (1995). Anomalies: Ultimatums, Dictators and Manners. *The Journal of Economic Perspectives, 9*(2), 209-219.

Camerer, C., & Weber, M. (1992). Recent developments in modelling preferences: Uncertainty and ambiguity. *Journal of Risk and Uncertainty, 5*(4), 325-370.

Cameron, L. A. (1999). Raising the stakes in the ultimatum game : experimental evidence from Indonesia. *Economic Inquiry, 37*(1), 47-59.

Carstensen, L. (2006). The influence of a sense of time on human development. *Science, 312*(5782), 1913-1915.

Carstensen, L., Isaacowitz, D., & Charles, S. (1999). Taking time seriously: A theory of socioemotional selectivity. *American Psychologist, 54*(3), 165-181.

Chaubey, N. P. (1974). Effect of age on expectancy of success and on risk-taking behavior. *Journal of personality and social psychology, 29*(6), 774-778.

Clark, L., Bechara, A., Damasio, H., Aitken, M., Sahakian, B., & Robbins, T. (2008). Differential effects of insular and ventromedial prefrontal cortex lesions on risky decision-making. *Brain, 131*(5), 1311.

Coricelli, G., Dolan, R. J., & Sirigu, A. (2007). Brain, emotion and decision making: the paradigmatic example of regret. *Trends in Cognitive Sciences, 11*(6), 258-265.

Davies, J. B., & Shorrocks, A. F. (2000). The distribution of wealth. In B. A. Anthony & B. François (Eds.), *Handbook of Income Distribution* (Vol. 1, pp. 605-675): Elsevier.

Deakin, J., Aitken, M., Robbins, T., & Sahakian, B. (2004). Risk taking during decision-making in normal volunteers changes with age. *Journal of the International Neuropsychological Society, 10*(04), 590-598.

Denburg, N., Recknor, E., Bechara, A., & Tranel, D. (2006). Psychophysiological anticipation of positive outcomes promotes advantageous decision-making in normal older persons. *International Journal of Psychophysiology, 61*(1), 19-25.

Denburg, N., Tranel, D., Bechara, A., & Damasio, A. (2001). Normal aging may compromise the ability to decide advantageously. *Brain and Cognition, 47*, 156–159.

Dohmen, T., Falk, A., Huffman, D., Schupp, J., Sunde, U., & Wagner, G. (2005). Individual risk attitudes: New evidence from a large, representative, experimentally-validated survey. *IZA Discussion Paper* No. 1730.

Dror, I., Katona, M., & Mungur, K. (2000). Age differences in decision making: to take a risk or not? *Gerontology, 44*(2), 67-71.

Ellsberg, D. (1961). Risk, ambiguity, and the Savage axioms. *The Quarterly Journal of Economics*, *75*(4), 643-669.

Fein, G., McGillivray, S., & Finn, P. (2007). Older adults make less advantageous decisions than younger adults: Cognitive and psychological correlates. *Journal of the International Neuropsychological Society, 13*(03), 480-489.

Filer, J., Kenny, L., & Morton, R. (1993). Redistribution, income, and voting. *American Journal of Political Science, 37*(1), 63-87.

Frisch, D., & Baron, J. (1988). Ambiguity and rationality. *Journal of Behavioral Decision Making, 1*(3), 149-157.

Gaeth, G. J., & Shanteau, J. (1984). Reducing the influence of irrelevant information on experienced decision makers. *Organizational Behavior and Human Performance*, *33*(2), 263-282.

Gilboa, I., & Schmeidler, D. (1989). Maxmin expected utility with non-unique prior. *Journal of Mathematical Economics, 18*(2), 141-153.

Glenn, N. D., & Grimes, M. (1968). Aging, Voting, and Political Interest. *American Sociological Review, 33*(4), 563-575.

Hallahan, T., Faff, R., & McKenzie, M. (2004). An empirical investigation of personal financial risk tolerance. *Financial Services Review, 13*(1), 57-78.

Hampton, A., & O'Doherty, J. (2007). Decoding the neural substrates of reward-related decision making with functional MRI. *Proceedings of the National Academy of Sciences, 104*(4), 1377-1382.

Henrich, J., Heine, S., & Norenzayan, A. (2010). The weirdest people in the world? *RatSWD Working Paper* No. 139.

Hoffman, E., McCabe, K., & Smith, V. (1996). On expectations and the monetary stakes in ultimatum games. *International Journal of Game Theory, 25*(3), 289-301.

Hsu, M., Bhatt, M., Adolphs, R., Tranel, D., & Camerer, C. (2005). Neural systems responding to degrees of uncertainty in human decision-making. *Science, 310*(5754), 1680-1683.

Isen, A. (2001). An influence of positive affect on decision making in complex situations: Theoretical issues with practical implications. *Journal of Consumer Psychology*, *11*(2), 75-85.

Jappelli, T., & Pistaferri, L. (2000). The dynamics of household wealth accumulation in Italy. *Fiscal Studies, 21*(2), 269-295.

Jianakoplos, N., & Bernasek, A. (1998). Are women more risk averse? *Economic Inquiry, 36*(4), 620-630.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica: Journal of the Econometric Society, 47*(2), 263-291.

Kovalchik, S., Camerer, C., Grether, D., Plott, C., & Allman, J. (2005). Aging and decision making: A comparison between neurologically healthy elderly and young individuals. *Journal of Economic Behavior & Organization, 58*(1), 79-94.

Krajbich, I., Armel, C., & Rangel, A. (2010). Visual fixations and the computation and comparison of value in simple choice. *Nature Neuroscience, 13*(10), 1292-1298.

Lennings, C. J. (2000). Optimism, satisfaction and time perspective in the elderly. *The International Journal of Aging and Human Development, 51*(3), 167-181.

Lerner, J., Small, D., & Loewenstein, G. (2004). Heart Strings and Purse Strings. *Psychological Science, 15*(5), 337.

MacCrimmon, K. R. *(*1968*). '*Descriptive and normative implications of decision theory postulates'. In Borch, K. and Mossin, J. (Eds.), *Risk and Uncertainty*. New York : Macmillan.

Mata, R., Schooler, L., & Rieskamp, J. (2007). The aging decision maker: Cognitive aging and the adaptive selection of decision strategies. *Psychology and aging, 22*(4), 796-810.

Mather, M. (2004). Aging and emotional memory. In: Reisberg, D. and Hertel, P. (Eds.), *Memory and emotion*, 272–307, Oxford / New York : Oxford University Press.

Mather, M. (2006). A Review of Decision-Making Processes: Weighing the Risks and Benefits of Aging. In: Carstensen, L.L. and Hartel, C.R. (Eds.), *When I'm 64*. *Committee on Aging Frontiers in Social Psychology, Personality, and Adult Developmental Psychology,* Washington, DC: The National Academies Press, 145-173.

Mather, M., Canli, T., English, T., Whitfield, S., Wais, P., Ochsner, K., et al. (2004). Amygdala responses to emotionally valenced stimuli in older and younger adults. *Psychological Science, 15*(4), 259-263.

Mather, M., & Carstensen, L. (2003). Aging and attentional biases for emotional faces. *Psychological Science, 14*(5), 409-415.

Mather, M., & Carstensen, L. (2005). Aging and motivated cognition: The positivity effect in attention and memory. *Trends in Cognitive Sciences, 9*(10), 496-502.

Mather, M., & Johnson, M. (2000). Choice-supportive source monitoring: Do our decisions seem better to us as we age? *Psychology and aging, 15*(4), 596-606.

Neugarten, B. L. (1974). Age Groups in American Society and the Rise of the Young-Old. *The ANNALS of the American Academy of Political and Social Science, 415*(1), 187-198.

Park, D., & Reuter-Lorenz, P. (2009). The adaptive brain: aging and neurocognitive scaffolding. *Annual review of psychology, 60*, 173-196.

Peters, E., Finucane, M. L., MacGregor, D. G., & Slovic, P. (2000). The bearable lightness of aging: Judgment and decision processes in older adults. In: Stern, P.C. and Carstensen, L.L. (Eds.): *The aging mind: Opportunities in cognitive research*, 144-165.

Rabbitt, P. (1965). An age-decrement in the ability to ignore irrelevant information. *The Journal of Gerontology, 20*(2), 233-238.

Riley Jr, W., & Chow, K. (1992). Asset allocation and individual risk aversion. *Financial Analysts Journal, 48*(6), 32-37.

Schmeidler, D. (1989). Subjective probability and expected utility without additivity. *Econometrica: Journal of the Econometric Society*, *57*(3), 571-587.

Schooley, D., & Worden, D. (1999). Investors' asset allocations versus life-cycle funds. *Financial Analysts Journal, 55*(5), 37-43.

Small, S. A., Stern, Y., Tang, M., & Mayeux, R. (1999). Selective decline in memory function among healthy elderly. *Neurology, 52*(7), 1392.

Strate, J. M., Parrish, C. J., Elder, C. D., & Ford, C. (1989). Life Span Civic Development and Voting Participation. *The American Political Science Review, 83*(2), 443-464.

Tranel, D., Bechara, A., & Damasio, A. R. (2000). Decision making and the somatic marker hypothesis. In: Gazzaniga, M.S. (Ed), *The New Cognitive Neurosciences,* 1047-1061.