Yesterday's expectation of tomorrow determines what you do today: The role of reference-dependent utility from expectations

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Abstract

The paper introduces the concept of *adjustment utility*, that is, reference-dependent utility from expectations. It offers an explanation for observed preferences that cannot be explained with existing models, and yields new predictions for individual decision making. The model gives a simple explanation for, e.g., why people are reluctant to change their plans even when these turn out to be unexpectedly costly; people's aversion towards positive but false information, which cannot be explained with previous models; and the increasing acceptance of risks when people get used to them.

JEL classification: D11, D81, D84, C99

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1 Introduction

Consider the following two situations. In the first situation, you learn on Friday that you will receive a wage increase two months hence, which you did not expect. However, the following Monday you learn that the payroll department made a mistake and you will not receive this wage increase. In the second situation, you are not told anything about a wage increase. In which situation are you happier on Monday?[1]

According to the existing concepts of utility, i.e., expected utility theory, prospect theory and anticipatory utility, you are equally happy in both situations. The reason is that your current outcomes and expected future outcomes are the same. And the time until the realization of future outcomes is long enough such that the reference state for your wage two months hence can adjust to your expectations. However, most people expect to be happier on Monday if they are never told about the wage increase. One of the surveys described in this paper shows that more than 90% of the participants expected to be happier in the second situation. This means that past expectations have an influence on current utility from expectations, i.e., preferences are path-dependent with respect to expectations. The state of your expectations over the weekend influences the utility you derive from your expectations on Monday.

I account for such preferences by introducing a novel component of individual utility: *adjustment utility*, that is, reference-dependent utility from expected future outcomes. This component complements existing concepts of utility in the following way. Von Neuman and Morgenstern (1944) established $u(x)$ as the absolute (i.e., reference-independent) utility we derive from experiencing the realization of outcomes x, e.g., from spending our wage. Kahneman and Tversky (1979) added $v(x|r)$ as the relative (i.e., reference-dependent) utility we derive from experiencing the realization of outcomes, given a reference state r we compare these realized outcomes to. For example, the utility we derive from spending our wage depends on whether we compare it to spending more or less than our current wage. Finally, Caplin and Leahy (2001) introduced anticipatory utility, that is, absolute utility from expecting future outcomes. They showed that people derive utility from the expectation to spend their wage. This paper adds the fourth component: it applies reference dependence to the utility from expectations. It shows that the utility from expecting a certain outcome depends on what expected outcome we compare it to, i.e., on our reference expectation. For example, the utility that our expectation of tomorrow's wage induces in us today depends on the expectation of tomorrow's wage we had yesterday. Since this component of utility is caused by the adjustment of expectations, I use the term adjustment utility (see table 1 for an overview of the components of individual utility). It explains preferences like those observed in the surveys that are described in this paper. That changes in expectations can affect utility is an experience most people make frequently, and in this sense is not new at all. It has also recently been described non-formally by, e.g., Kimball and Willis (2006). Given this general knowledge, this paper makes two contributions. First,

[1] Assume that you do not undertake consumption during the weekend which you would not have done without the news about the wage increase.

	Utility from realized outcomes	**Utility from expectations**
Absolute utility (reference-independent)	Expected Utility Theory (vNeumann/Morgenstern, 1944)	Anticipatory Utility (Caplin/Leahy, 2001)
Relative utility (reference-dependent)	Prospect Theory (Kahneman/Tversky, 1979)	*Adjustment Utility* (this paper)

Table 1: Components of individual utility

it offers survey-evidence on the existence of adjustment utility, and identifies two factors that influence the reference expectation. Second, it provides a formal treatment of adjustment utility, which is based on earlier work by Matthey (2005, 2006). This formalization allows for an analysis of the implications of adjustment utility on decision making and expected overall utility. Complementing this analysis, Koszegi and Rabin (2006) have more recently developed a model where they study optimal consumption plans when adjustment utility is accounted for.

The important difference between adjustment utility and prospect theory (Kahneman and Tversky, 1979) should be noted from the beginning: while prospect theory considers utility derived from realized outcomes, adjustment utility is derived from expectations. Accordingly, the reference *expectation* of adjustment utility is conceptually different from the reference *outcome* of prospect theory, although the latter may also be stochastic (as, e.g., in Sugden, 2003; Kőszegi and Rabin, 2006). This difference may seem subtle at first, but the paper shows that it implies differences in utility, and in individual decision making.

In addition to explaining the preferences expressed in the surveys, adjustment utility offers explanations for observed behavior. For example, it can explain why people are often reluctant to abandon their plans, even when they learn that following them may induce unexpectedly high costs. It does so without relying on more subtle concepts like, e.g., cognitive dissonance (which may also play a role). Further, it shows that people may get used to risks, and thus offers a plausible explanation for anecdotal evidence on how people deal with the risk of an HIV infection. Finally, it can explain why most people do not like false information, even if it is positive and corrected in time.

Consider these three situations in turn. First, many people are familiar with situations where they have made plans for the future, and feel reluctant to change them even if they turn out to induce higher costs than expected. Anecdotal evidence of this phenomenon is provided by Carroll (2006), who finds that most people are reluctant to change their vacation plans if the cost structure changes. Similarly, Croll and Moses (2005) find that most British school children stick with the education decision they made at age 11-12, even if their perspectives change. To clarify the role of adjustment utility, consider an individual who plans to get a prestigious and well-paid job. At some point, she realizes that getting such a job requires very long working hours. If she sticks to her plan, she will have little spare time and may incur adverse health effects. But even if the absolute utility from a life with more leisure and better health exceeds the absolute utility from a prestigious position in 10 years time, she may not abandon her ambitious plan, or at least feel disappointed if she does. The reason is that adjusting the expectation of a future top-level job down to expecting a medium-level job causes feelings of loss at present, i.e., negative adjustment utility. Sticking to one's plan, even if it turns out to be costly, avoids this loss. Note that the effect can neither be explained by time-inconsistent individual preferences (see, e.g., Laibson, 1997), nor by prospect theory. Time-inconsistent individuals that attach higher value to the present than to the future would work *less* at present at the cost of lower wages in the future (self-control problem). Prospect theory with stochastic reference states implies that individuals maximize absolute utility: Since the individual has sufficient time for her reference state to adjust to the new situation, that is, to the less prestigious position in 10 years time, she does not expect a feeling of loss or gain in the future. Accordingly, her utility is unaffected by a change in expectations, since her reference state will adjust to any new expectation. This means that according to the existing concepts of utility changing plans at an early stage does not induce costs, and hence does not affect people's decision on how much to work.

Second, consider the behavior towards the risk of an HIV infection. Data on new infections with HIV in Germany and on people's attitude towards protective measures in the years 1997 to 2004 showed an alarming trend: People were at least as well informed about the risk of an infection and the protective effect of condoms as before. However, the use of condoms decreased slightly but significantly between 1997 and 2004 (RKI, 2005 and BzGA, 2005). This means that the acceptance of the risk of an HIV infection increased. As the data shows (see table 1 in appendix A), lack of care due to the availability of new therapies can not explain this effect. In fact, the people that were aware of the new therapies increased their use of condoms.
Adjustment utility offers a plausible explanation, though probably not the only one. Over the years, some people have accepted the risk of an infection occasionally or have learnt of others accepting the risk, e.g., through the media. The expectation of a possible infection has become slightly more normal, i.e., it was to a small extend included in some people's expectation of their own and relevant others' possible future state. Since the expectation of an infection induces negative utility, it reduces the reference expectation if it becomes part of it. This reduction of the reference expectation slightly increases the utility from accepting the risk of an infection. With less negative utility from the risk, lower (non-monetary) costs are accepted in order to avoid the risk. This may have led to the decrease in the use of condoms.

Consider finally the release of positive but false information. Think again of the situation in the wage example from the beginning. But now consider the overall utility of the information release, rather than only the utility at the time of the correction. Initially you think that your wage two months hence will be as low as today's. Then the payroll department makes you believe that your wage will increase, only to destroy this illusion a few days later. According to expected utility theory and prospect theory, this false information does not affect utility, since realized outcomes do not change. According to anticipatory utility, the effect is unambiguously positive: for a few days, you derive higher utility from anticipating your higher future wage. When the information is corrected, utility moves back to its previous level. In contrast, accounting for adjustment utility shows that the release and subsequent correction of positive information may lead to negative net utility. This is the case if the initial delight after the release of the information (the joy of expecting a higher wage) is overcompensated by the disappointment caused by the correction. The more loss averse individuals are, the more likely is a negative net effect. This explains why in most cases people do not like false information, even if it is positive and corrected long before outcomes are realized.

The paper is organized as follows. Section 2 describes the surveys and shows that previous concepts of individual utility cannot explain the results. Section 3 introduces and formally defines adjustment utility, and analyzes equilibrium behavior. The impact of adjustment utility on economic decision making is considered in section 4. The value of information is derived in section 5, while section 6 shows the exogeneity of the reference expectation. A brief conclusion is given in section 7. Proofs are in appendix B.

2 Surveys

I conducted two classroom surveys. In the first survey (*own*), I asked subjects to compare two situations (see a translated copy of the questionnaire in appendix C). In the first situation, the individual is told on Friday, February 3, that she will receive a 5% wage increase from April 1. She did not expect this wage increase. On Monday, February 6, she is told that the payroll department made a mistake and that she will not receive the wage increase. In the second situation, the individual does not receive any information about a wage increase. I then asked the students in which situation they thought the individual would be happier.

The aim of this first survey was to vary the individual's expectation of her *own* wage. Over the weekend, the individual holds different expectations in the two situations, while on Monday the expectation in the first situation is adjusted to equal the one in the second situation. This is the moment that is of interest here, when neither expectations nor realized outcomes differ between the compared situations, but the path of expectations does. Then, the relevance of this path can be assessed.

In the second survey (*others*), I again asked subjects to evaluate two situations (see appendix C). In the first situation, the individual knows already in August that she will earn 50.000 EUR next year. She expects her colleagues in similar positions to earn 40.000 EUR on average. On October 1, she learns that her colleagues will also earn 50.000 EUR on average next year. In the second situation, in August she expects her colleagues to earn 60.000 EUR on average, but on October 1 also learns that they will earn 50.000 EUR.[2] I then asked the subjects to evaluate the individual's utility on October 1.

[2]It cannot be determined for either survey whether the students interpreted the individual to believe in the information or her expectation to 100% or less. This does not, however, affect the results.

The aim of this second survey was to vary the individual's expectation of the wages of relevant *others*. Similarly to the first design, expectations in August differed between the two situations, while in October they were adjusted to be the same. Note again that in both surveys current wages were the same throughout, and utility was assessed at the time when expectations had adjusted to being equal in both situations.

Note that the subjects expressed hypothetical rather than real preferences. This had to be accepted since for an incentivized choice (or WTP/WTA analysis), subjects would have to be informed about the later change in expectations. This would have changed the character of the situations such that adjustment utility could not have been tested anymore. Given the clear results of the surveys, which are in line with most people's intuition, the general message of the surveys seems to be reliable nevertheless.

Surveys took place in January and May 2006 at the Technical University Berlin. The first survey was conducted with 47 students of a Master's course in Game Theory. The second survey was conducted with 78 students of a Master Course in Industrial Economics. Most of the participants in both courses studied industrial engineering. No subject participated in both surveys.

According to expected utility theory, prospect theory or anticipatory utility, there is no difference in the individual's utility between the two respective situations in either survey. To see this, consider the different concepts separately. Expected utility theory (v. Neumann and Morgenstern, 1944) refers to the absolute utility people derive from realized outcomes. Prospect theory (Kahneman and Tversky, 1979) refers to the relative utility people derive from realized outcomes. Since the outcomes (wages) realized on February 6 and October 1, respectively, are the same in both situations, these concepts cannot explain differences in utility. Note that this result is unaffected by recent developments in prospect theory, which specify the reference state as expectations or uncertain outcomes in general (e.g., Sugden, 2003, Kőszegi and Rabin, 2006). Since this literature refers to *realized* outcomes only, and the outcomes that were realized at the time that the subjects considered were the same, it predicts that utility is also the same in both situations.

Anticipatory utility (Caplin and Leahy, 2001), in contrast, is derived from expected future utility. This future utility consists of absolute and relative utility from realized outcomes. Consider first expected absolute utility $u(x)$. In both surveys the individual expects the same future outcomes in the two respective situations. Hence, she expects the same absolute utility and, accordingly, derives the same anticipatory utility from this component. It cannot explain differences in utility. Now consider expected relative utility $v(x|r)$. Assume as in the models above that if there is plenty of time between the formation of expectations and the realization of outcomes the reference state for the outcomes adjusts to expectations (Kőszegi and Rabin, 2006). This is the case in both surveys. In the first survey, the individual forms expectations in early February, and receives her wage in April. In the second, she forms expectations in early October and she and her colleagues receive their wages in January. This means that in both situations she expects a relative utility of zero when she (and her colleagues) finally receive their wage, since her reference state has adjusted to her expectations by the time outcomes are realized. Accordingly, in both surveys she experiences the same anticipatory utility in the two situations. Differences in utility can again not be explained.

However, a large majority of the participants in the surveys expects the individual to experience different utility in the two situations. The results are summarized in table 2.

	happier in Sit. 1	happier in Sit. 2	No difference
Exp 1 (*own*)	1 (≈ 2%)	44 (≈ 94%)	2 (≈ 4%)
Exp 2 (*others*)	4 (≈ 5%)	61 (≈ 78%)	13 (≈ 17%)

Table 2: Number and share of participants who thought the individual would be happier/more satisfied in the respective situation. The hypothesis that the observations for "happier in situation 1" and "happier in situation 2" are uniformly distributed noise can be rejected at $p = 0.000$ in a binomial test.

These results can be explained with adjustment utility: Past expectations influence current utility from expectations, which means that preferences are path-dependent with respect to expectations. Put differently, current expectations are compared to a reference expectation, and both influence experienced utility. In the surveys, the state of the individual's expectations over the weekend influences the utility she derives from her expectations on Monday. Similarly, her expectations in August and September influence her utility on October 1. Adjustment utility will be formally defined in section 3.1.

The survey also allows for inferences about the formation of the reference expectation. First, it suggests that the reference expectation depends positively on the individual's past expectations regarding her own future state. In the first survey (*own*), the individual expected a higher wage over the weekend. This reduced her utility on Monday. Since relative utility depends negatively on the reference expectation, one can infer that the higher expectation increased the reference expectation. Hence, there exists a positive relationship between expected own future state and the reference expectation. Second, the reference expectation depends positively on the individual's past expectations regarding the future state of other members of her reference group.[3] This relation can be derived from the second survey (*others*). Expecting first a higher and then a lower wage of her colleagues induces higher utility in the individual than if she first expected a lower and then a higher wage of her colleagues. This means that the reduction of her colleagues' wages leads to a reduction of the reference expectation. This shows the positive relationship. The reference expectation for adjustment utility will be defined in section 3.2.

[3] I define the reference group of an individual endogenously as the group of people who's utility is affected by the choices of this individual, and who's choices affect the utility of the individual.

3 Model

3.1 Adjustment utility

In this section I develop the basic setup of the model, and formally define the concept of adjustment utility. The model includes all previous concepts of utility in order to identify the effects that are caused by adjustment utility.

Consider an individual who in period t chooses an action which influences her outcomes at time $T > t$. Let X be the set of possible outcomes in T, with x_i, $i = 1, .., n$ as elements of X. Let P denote the set of finite probability distributions over the set of outcomes. Each action the individual chooses in t results in a probability distribution $p^c \in P$ over X to be realized in T, assigning probability p_i^c to outcome x_i, with $c \in [y, z]$. The sequence of events is shown in figure 1.

For simplicity, in what follows I consider only two possible actions of the individual, y and z. For example, she can choose whether to work hard or not, buy shoes or not, eat genetically modified food or not. The model could, however, be extended to a larger action space. If she chooses action y, the resulting distribution over X in T is p^y. If she chooses action z, the resulting distribution is p^z.

There exists a preference relation $\succeq$ over outcomes x_i, with strict preferences denoted by $\succ$ and indifference by $\sim$. The preference relation is assumed to be complete and transitive. This means that a representing function U exists such that $x_i \succeq x_j \Leftrightarrow U(x_i) \geq U(x_j)$. $U(x)$ is called utility and may consist of several parts, as is described below. I abstract from problems of probability weighting, which means that the preference relation extends to distributions over X: $p^y \succeq p^z \Leftrightarrow \sum_i p_i^y U(x_i) \geq \sum_i p_i^z U(x_i)$. To shorten notation, and since the set of outcomes is the same, in this case I will write $U(p^y) \geq U(p^z)$.

There are two interpretations for the sequence of events. First, the individual may choose in t to take a certain action in T, and this action then causes immediate outcomes when taken in T. Second, she may take a certain action in t, but this action causes outcomes only in T.
Deciding in winter to buy shoes in spring is an example for the first interpretation. Working hard and later possibly getting a prestigious job, or eating genetically modified food and later possibly developing an allergy are examples for the second. In the latter case, the immediate effects from the action in t, e.g., the utility from working hard or from eating is normalized to zero, since it is not the focus of this paper. In both scenarios, the individual in t chooses between distribution p^y and distribution p^z over outcomes in T.

In period T, the individual experiences utility from realized outcomes as established in the literature. First, she experiences classic von Neumann and Morgenstern (1944) absolute utility $u^o(x)$, where x denotes the element of X that is realized in T. Second, she experiences relative utility $v^o(x|r)$ according to prospect theory (Kahneman and Tversky, 1979). I will term these two components *outcome* utility (superscript o), since they are derived from the realization of outcomes. r denotes the reference state for outcome utility. There exists both experimental and empirical evidence for relative outcome utility $v^o(x|r)$. It shows that the majority of people evaluates outcomes relative to a reference state in many dimensions of utility, e.g., for consumption levels and wages (see, e.g., Kahneman, Knetsch and Thaler, 1991, for experiments on the endowment effect, or Benartzi and Thaler, 1995, for an explanation of the *equity premium puzzle* for loss averse investors). For simplicity, and since the formation of r is not the focus of this paper, I will assume throughout that r is formed by the expectation the individual has for her outcomes in T, provided that expectations are formed long before T. This is the specification that, e.g., Kőszegi and Rabin (2006) and Sugden (2003) choose in their models.[4] The assumption that expectations are formed a considerable time before T is necessary, since experimental evidence shows that reference states do not adjust quickly to new expectations (Matthey and Dwenger, 2007).

In addition to outcome utility $u^o(x) + v^o(x|r)$, in all periods prior to the realization of outcomes the individual experiences anticipatory utility, $u^a(p^c)$. It denotes the absolute utility the individual experiences from expecting outcomes in T to be distributed according to p^c. Although anticipatory utility is less established than the two components considered above, there is convincing evidence for its existence. Loewenstein (1987) analyzed the utility people derive from anxiety and pleasant anticipation. In an economic context, utility from expectations has been considered by, e.g., Caplin and Leahy (2001), Kőszegi (2005) and Brunnermeier and Parker (2005).

As shown in the previous section, these three components of utility do not suffice to explain the preferences that are expressed in the surveys, since neither realized outcomes nor expected future outcomes differ between situations. In order to explain them, I introduce *adjustment utility* as the relative utility the individual experiences from expecting future outcomes.

In analogy to Kahneman and Tversky's (1979) value function for realized outcomes, the adjustment utility derived from p^c depends on p^c and on the individual's reference distribution p^r over X. Similar to the reference state for outcomes, r, the reference distribution p^r denotes the distribution of outcomes in T that serves as the individual's comparison distribution when evaluating distributions over X. Accordingly, adjustment utility is to be interpreted as a measure of the utility of anticipating p^c relative to anticipating the reference distribution p^r, when both are compared to anticipating the reference distribution p^r. If the individual prefers outcomes in T to be distributed according to p^c over them to be distributed according to p^r, i.e., $p^c \succ p^r$, anticipating p^c is experienced as a gain relative to anticipating p^r. Similarly, if $p^r \succ p^c$, anticipating p^c is experienced as a loss relative to anticipating p^r.

Definition 1 *Let X denote the set of possible outcomes in T. The* adjustment utility *that an individual derives in all periods between $t+1$ and $T-1$ from anticipating the*

[4] It does not matter for the purpose of this paper whether the reference "state" is a reference expected outcome (an event) or a reference distribution. The term *state* is chosen throughout as the most general option.

distribution p^c on X given her reference distribution p^r on X is defined as $v^a(p^c|p^r)$, where v^a denotes a finitely valued function $v^a : P \times P \rightarrow \mathbb{R}$ and

A1: *$v^a(p^c|p^c) = 0$ for all p^c.*

A2: *$v^a(p^y|p^r) \geq v^a(p^z|p^r)$ for all $p^y \succeq p^z$ given p^r.*

A3: *$v^a(p^c|p^r) \geq v^a(p^c|p^{r\prime})$ for all $p^{r\prime} \succeq p^r$.*

Adjustment utility captures the observation that the pleasure or pain people derive from anticipating future outcomes depends on what they compare them to, not only on their absolute parameters. If an individual expected to become CEO of her firm in 5 years time and then realizes that she will only make it to middle management, she will initially derive different utility from expecting this position (namely disappointment) than if she had always expected to stay at this level.

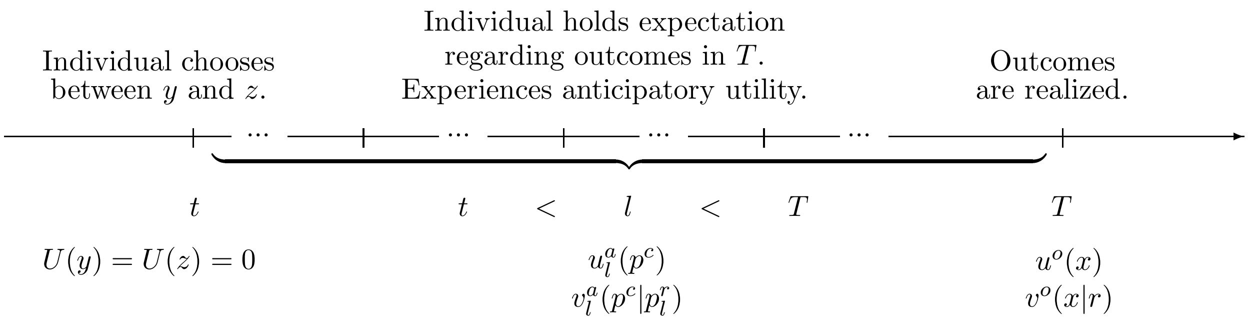

Figure 1: Sequence of events between the individual's choice and the realization of outcomes

Combining previous concepts of utility with adjustment utility, the individual's overall utility from choosing action y in t can then be written as

$$U(y) = \sum_{l=t}^{T-1} [u^a_l(p^y) + v^a_l(p^y|p^r_l)] + u^o(x) + v^o(x|r). \tag{1}$$

where $\sum_{l=t}^{T-1} [u^a_l(p^y) + v^a_l(p^y|p^r_l)]$ denotes the anticipatory utility $u^a_l(p^y)$ and adjustment utility $v^a_l(p^y|p^r_l)$ in all periods between the choice of action y in t and the realization of outcomes in T. The reference distribution p^r_l has a time index because if expectations change between t and T, so may the reference distribution. This adjustment process of the reference distribution is discussed in detail in the next section. Further, $u^o(x)$ and $v^o(x|r)$ denote the absolute and relative outcome utility the individual derives when outcomes are experienced in T.

Note that equation (1) contains previous concepts of utility as special cases. If the anticipated distribution is equal to the reference distribution, that is, there is no change in beliefs, adjustment utility is zero. The individual then experiences only outcome utility $u^o + v^o$ and anticipatory utility u^a. Further, if the individual does not anticipate her future state (she is surprised when outcomes from X are realized), she derives only outcome utility $u^o + v^o$. Finally, if her reference state for realized outcomes is equal to her realized outcome, she is left with classic expected utility u^o.

What, then, is the crucial difference between r, the reference state for outcome utility, and p^r, the reference distribution for adjustment utility? The reference state r is an individual's reference for the outcomes she experiences in T, i.e., a reference *outcome*. For example, the reference state for her wage in T may be Y. If in T she finds an amount lower than Y on her pay slip, she experiences a loss. If she finds an amount above Y, she experiences a gain. Although r may be uncertain, e.g., an expectation (as in Kőszegi and Rabin, 2006, or Sugden, 2003) it is the reference state for *realized* outcomes, i.e., it influences the utility induced by outcomes.
The reference distribution p^r, in contrast, is the reference for the *expectations* an individual holds in all periods up to $T-1$ for outcomes to be realized in T. It is a reference *expectation*, and as such influences the utility induced by expectations.
In the example, she may expect to get wage Y in T. If in period t she makes a decision which makes her believe that her wage in T will be higher than Y, this information induces a feeling of gain, although she did not receive the wage yet. Similarly, the news that she will receive less than Y induces a feeling of loss, although she did not yet receive the lower amount. The effect on utility is the same if the change in expectations is not the result of a certain decision, but due to new information becoming available.

It should be noted that the utility in (1) is a simplification. It assumes, for both anticipatory utility u^a and adjustment utility v^a, that the individual only holds expectations regarding her outcomes in T. She may, however, in period t also have expectations regarding the anticipatory and adjustment utility she will experience in the periods between t and $T-1$, which in turn affects her anticipatory and adjustment utility in all periods before $T-1$. Including this explicitly in the model, however, would compromise readability and not add significant new insight.

3.2 Reference expectation

To characterize adjustment utility, one has to characterize the reference distribution p^r it refers to. As shown in section 2, the surveys point to two factors that influence p^r: the individual's past expectation of her own future state and her past expectation of relevant others' future states.
This parallels the findings for outcome utility. There the reference state has been found to be influenced by the individual's own past consumption level, wage, investment return etc. (e.g., Kahneman, Knetsch, Thaler, 1990; Campbell and Cochrane, 1999) and by relevant others' consumption levels, wages etc. (e.g., Abel, 1990; Constantinides, 1990).

Denote with $p_{i,s}$ the distribution on X that individual i anticipates in period $s < t$ regarding her own outcome in T. The set of distributions $\mathbf{p}_{-i,s}$ on X denotes the expectations she has in s regarding the outcomes in T of the members of her reference group. Note that the exact composition of the reference group is not of relevance here. For the behavior of one individual to influence a larger group of people it suffices if the individual's reference group is linked with other reference groups through at least one common individual. For example, if an individual is only a valid reference for her colleagues, but some of these colleagues are valid references for people outside the firm, the behavior of this individual can potentially influence people outside the firm (see section 4 for the influence of an individual's behavior on others).

In addition, it is sensible to assume a mental discount factor, denoted β. This factor takes account of the fact that events further in the past are less salient in people's minds than the same events in more recent periods. Accordingly, past expectations are less relevant for the formation of the reference expectation than recent expectations. They receive a "mental discount", which may differ across dimensions and individuals: $0 \leq \beta \leq 1$. The reference expectation can then be defined as follows:

Definition 2 *The reference distribution p^r for the adjustment utility of individual i in any period t is defined as*

$$p^r_{i,t} := p^r_{i,t}\left(p_{i,s}; \mathbf{p}_{-i,s}; \beta\right)_{s<t} \tag{2}$$

and

$$\text{If} \quad p^r_{i,s} = p^r_{i,t} \quad \text{and} \quad p_{i,s} \succeq p_{i,t} \quad \Rightarrow \quad p^r_{i,s+1} \succeq p^r_{i,t+1}. \tag{3}$$

$$\text{If} \quad p^r_{i,s} = p^r_{i,t} \quad \text{and} \quad \mathbf{p}_{-i,s} \succeq \mathbf{p}_{-i,t} \quad \Rightarrow \quad p^r_{i,s+1} \succeq p^r_{i,t+1}. \tag{4}$$

$$\begin{aligned} \text{If} \quad \hat{p}_i \succ \bar{p}_i \quad \Rightarrow \quad & p^r_{i,t}\left((\bar{p}_{i,s}, .., \bar{p}_{i,m}, \hat{p}_{i,m+1}, \bar{p}_{i,m+2}, .., \bar{p}_{i,t-1}); \mathbf{p}_{-i,s}; \beta\right)_{s<t} \\ & \succ p^r_{i,t}\left((\bar{p}_{i,s}, .., \bar{p}_{i,m-1}, \hat{p}_{i,m}, \bar{p}_{i,m+1}, .., \bar{p}_{i,t-1}); \mathbf{p}_{-i,s}; \beta\right)_{s<t} \end{aligned} \tag{5}$$

Expression (2) along with (3) and (4) take account of the observation that the reference expectation of an individual increases if she expects a better outcome for herself and/or for the members of her reference group. Relation (5) states that if expectations in all but one previous period were constant, and the expectation in the deviating period is preferred over the expectation in the other periods, then the reference distribution is preferred if the deviation in expectations occurred more recently. This relation captures the mental discounting, namely that expectations further in the past have less impact on the reference expectation than more recent periods.

Considering a sequence of past expectations and weighting each expectation according to its time distance (β) smoothes the reference formation process. It reflects the observation that reference formation in most cases can be expected to be a gradual process (for experimental evidence, see Matthey and Dwenger, 2007). After a change in expectations, the reference distribution takes some time to adjust to the new situation. In contrast, considering only last period's expectations would lead to jumps in the reference formation process. A change in expectations would then lead to an abrupt change of the reference expectation, which seems unrealistic in most cases. In addition, through adjusting β properly, the process does not depend on the definition of the length of a period.

3.3 Expectation Personal Equilibrium

In this section, I apply the concept of Kőszegi and Rabin's (2006) *personal equilibrium* (PE) to adjustment utility and consider the predictions this yields. I show in which cases a PE with adjustment utility yields predictions different from those of a PE without adjustment utility. Since it considers only utility from outcomes, I will denote the latter as "outcome personal equilibrium" (OPE), while the former will be called "expectation personal equilibrium" (EPE).

Consider an individual who has rational expectations and is aware of her reference formation process. At any time t, she forms expectations regarding the outcomes in T given her choice in t. As before, she predicts her reference state r for realized outcomes in T to be equal to these expectations.

In the context of the above model, Kőszegi and Rabin's (2006) (preferred) personal equilibrium would then be defined as follows:

Definition 3 *Let $r(y)$ denote the reference state for outcome utility that results from choosing action y. A choice y inducing distribution p^y forms an* outcome personal equilibrium *if for all possible distributions $p^z \in P$*

$$\sum_X p^y u^o(x) + \sum_X p^y v^o(x|r(y)) \geq \sum_X p^z u^o(x) + \sum_X p^z v^o(x|r(y)).$$

It forms a preferred outcome personal equilibrium *if it forms an outcome personal equilibrium and for all $p^z \in P$*

$$\sum_X p^y u^o(x) + \sum_X p^y v^o(x|r(y)) \geq \sum_X p^z u^o(x) + \sum_X p^z v^o(x|r(z)).$$

In outcome personal equilibrium, an individual chooses the strategy that yields optimal expected utility in T, given the reference state r that results from making this choice. In a preferred OPE, she chooses an OPE strategy that yields weakly higher expected utility than all other OPE strategies.

In addition to r, u^o and v^o, when making a choice the individual can predict her reference expectations p_l^r for all periods $t < l < T$ according to (2).[5] Knowing her reference expectations she derives utility from anticipation, u^a and v^a. The individual then makes her optimal choice in t, considering all four components of utility as given in (1) .

[5] I omit the indices i and l where no confusion can arise.

Definition 4 *Let $p^r(y)$ and $r(y)$ denote the reference expectation for adjustment utility and the reference state for outcome utility, respectively, that result from choosing action y. A choice y inducing distribution p^y forms an* expectation personal equilibrium *if for all possible distributions $p^z \in P$*

$$\sum_{l=t}^{T-1}[u_l^a(p^y) + v_l^a(p^y|p_l^r(y))] + \sum_X p^y u^o(x) + \sum_X p^y v^o(x|r(y)) \geq$$
$$\sum_{l=t}^{T-1}[u_l^a(p^z) + v_l^a(p^z|p_l^r(z))] + \sum_X p^z u^o(x) + \sum_X p^z v^o(x|r(z))$$

In words, an individual's choice forms an expectation personal equilibrium if, given her reference expectation p^r and reference state r given this choice, she derives utility from this choice which is at least as high as that derived from any other possible choice, given the reference expectation and reference state that result from this other choice. Put differently, in EPE the individual chooses the action that yields the highest utility from expectations and realized outcomes, given the reference formation processes that result from the respective action.

Compare now the predictions of the preferred OPE with those of the EPE, in order to see where EPE is necessary to correctly predict individual decisions. For ease of comparison, consider the example of a shoe purchase as in Kőszegi and Rabin (2006). Assume that an individual is used to buying new shoes in spring. Some time during winter, she receives the catalog for shoes that will be available in spring. But this year she realizes from studying the catalog that shoe prices have increased and new shoes may be beyond her means. Assume that if the individual considers only outcome utility, it is her preferred OPE strategy not to buy the shoes in spring. She makes this decision predicting that her reference state for the purchase will adjust to her expectation of not buying the shoes until spring actually comes, such that not buying shoes is not felt as a loss then. If the absolute outcome utility she derives from the shoes does not warrant their price, then it is optimal for her not to buy the shoes.

Now add the utility from expectations. First, taking into account anticipatory utility makes the purchase of the shoes more attractive, since the individual can look forward to the purchase and derive utility from that. Second, and more important here, including adjustment utility makes the purchase of the shoes even more attractive. Planning to buy the shoes avoids the disappointment the individual would experience from adjusting her expectations towards expecting not to buy the shoes since she initially expected - without detailed knowledge of the market - to buy shoes as every year. Her reference expectation in winter, which included the expectation to buy shoes in spring, makes the expectation of not buying the shoes be felt as a loss. This is different from the utility in spring, for which the individual has time to get used to the idea of not buying the shoes and may not feel disappointed. In summary, if the reference expectation in winter is to buy the shoes, adjustment utility increases the utility from buying the shoes. This means that there exist cases where it is the individual's strategy in Kőszegi and Rabin's preferred OPE not to purchase the shoes, but her strategy in EPE is to purchase the shoes.

Corollary 1 *Consider an individual who has the choice between actions y and z. Then, if*

$$\sum_{l=t}^{T-1}[v^a(p^y|p_l^r(y)) - v^a(p^z|p_l^r(z))] <$$
$$\sum_{l=t}^{T-1}[u^a(p^z) - u^a(p^y)] + \sum_X p^z(u^o(x) + v^o(x|r(z)) - \sum_X p^y(u^o(x) + v^o(x|r(y))$$

the individual's EPE strategy is z, while her preferred OPE strategy is y.

Corollary 1 results directly from the definitions for OPE and EPE. It shows that adjustment utility can change equilibrium behavior.

In a context more general than shoe purchases, this result can explain why the expectation to get a prestigious job in the future may induce us to work hard even if we learn the costs of long working hours well before getting the desired job: abandoning the expectation of a top-level job would induce a feeling of loss, which we try to avoid. Similarly, if we expected to drive a big car in the future, learning about its price well in advance of the actual purchase may not keep us from planning to buy it. In both cases, we are reluctant to adjust our pleasant expectation when receiving negative information about the (monetary or non-monetary) costs of following our plans. Accordingly, in equilibrium we may stick to our plans.

4 Effects of adjustment utility on optimal choice

4.1 Repeated choice

So far I have analyzed the individual's utility from an action y in one particular period. For example, the individual may consider buying shoes in a situation where she had expected to buy shoes vs. in a situation where she did not. In this section, I analyze the impact of adjustment utility on the net utility from choosing y if the choice is considered repeatedly. This yields implications, e.g., for the impact of habituation on the utility from working towards a top-level job, or from consuming products inducing health risks.

The net utility of a choice is the difference between the utility of taking action y and the utility of abstaining from y and doing nothing. If the net utility of choosing y increases, it becomes more likely that the individual takes action y. Similarly, if net utility decreases, repeated choice leads to a lower probability of the individual choosing y.

Consider the example of an individual who repeatedly decides whether to consume food which induces future health risks. As an example I will use genetically-modified (gm) food, since for such food the long run health implications are uncertain. If the individual decides to eat gm-food, she expects possible adverse health effects in the future. This expectation then becomes her reference expectation. I analyze utility starting in period t, where t is the period such that before period t neither the individual herself nor a member of her reference group has ever chosen the action, but in t the individual chooses it.[6] Comparing the utility of taking action y in t and $t+1$, respectively, to abstaining from y in t and $t+1$, yields the following proposition:

Proposition 1 *Consider a loss averse individual that in period t first chooses action y. Then, the net utility that this individual and the other members of her reference group derive from choosing action y is higher in $t+1$ than in t.*

The proof is in the appendix.[7] The argument is the following: If action y is taken in t, the expectation of p^y enters the reference expectation which the individual holds in $t+1$. Consider the case where $p^y \prec 0$. Then, the reference expectation worsens due to the inclusion of p^y, $p^r_{t+1}(y) \prec p^r_t$. This makes the expectation of p^y being felt as a smaller loss. In contrast, an outcome of zero as the consequence of not taking y is now felt as a (higher) gain. For loss averse individuals, losses are experienced more strongly than gains, which means that the reduction of the loss outweighs the increase of the gain, leading to an increase in the net utility of choosing y. In the case when $p^y \succ 0$, including p^y improves the reference expectation in $t+1$: $p^r_{t+1}(y) \succ p^r_t$. Expecting p^y is then experienced as a smaller gain, but expecting an outcome of zero as the consequence of not taking y is experienced as a larger loss. Again, for loss averse individuals, the net effect is an increase in the utility of taking y relative to not taking it.

For an illustration of proposition 1, consider figure 2. In analogy to the value function for realized outcomes (Kahneman and Tversky, 1979), assume that the adjustment utility function is continuous in p^c and p^r. In period t, the individual's reference expectation is $p^r_t \sim 0$. She can choose action y, which induces the distribution $p^y \prec 0$ in T. If she abstains from y, this induces the distribution $p^z \sim 0$ in T. Assume that she chooses y. She then experiences adjustment utility $v^a_t(p^y|p^r_t) < 0$ in t. In $t+1$ she considers choosing y again. Due to her decision in t, her reference expectation has now moved from p^r_t to $p^r_{t+1}(y)$. $p^r_{t+1}(y) \prec p^r_t$ since it is influenced by $p^y \prec 0 \sim p^r_t$. This lower reference expectation implies a shift of the adjustment utility function towards the left. The adjustment utility of the distribution p^z that results from abstaining from y increases from $v^a(p^z|p^r_t) = 0$ to $v^a(p^z|p^r_{t+1}(y)) > 0$. The adjustment utility of expecting the distribution p^y induced by the individual choosing y increases from $v^a(p^y|p^r_t)$ to $v^a(p^y|p^r_{t+1}(y))$. Accordingly, the change in net utility of choosing y is

[6] The analysis applies to all situations where p^r has not yet fully converged to the state that reflects permanent choice of the action by all members of the reference group.

[7] Note that this result is derived assuming loss averse individuals. For previous results the existence of adjustment utility is sufficient.

$v^a(p^y|p^r_{t+1}(y)) - v^a(p^z|p^r_{t+1}(y)) - [v^a(p^y|p^r_t) - v^a(p^z|p^r_t)]$. This is positive for loss averse individuals, since v^a is steeper for losses than for gains.

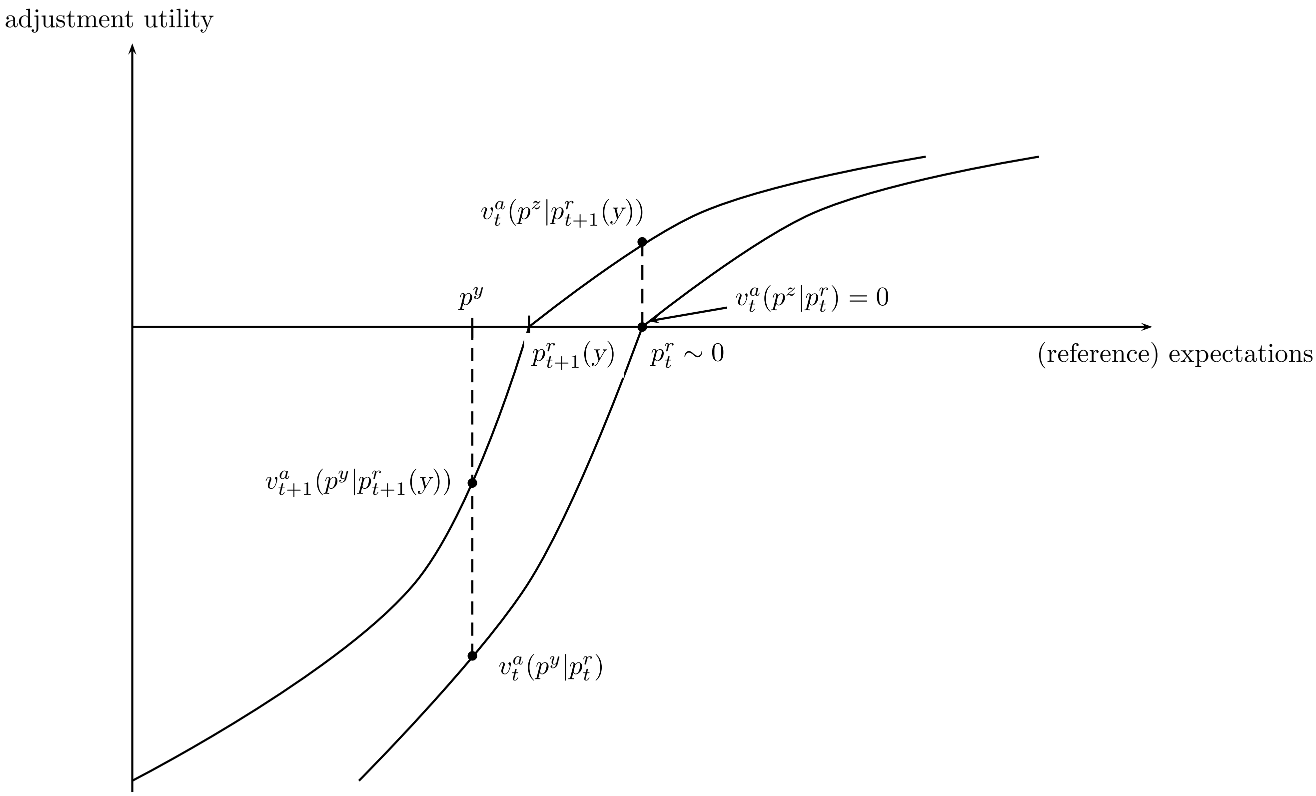

Figure 2: Effect of a change in the reference expectation for $p^y \prec 0$
Distributions on the x-axis are ordered according to the individual's preference, with preferred distributions towards the right.

Proposition 1 shows that when the individual gets used to the expectation induced by a certain action, this increases the utility of choosing this action compared to not choosing it. This means, for example, that even if people consider certain foods to induce health risks (e.g., gm-food) the utility they derive from consuming these foods relative to consuming alternative foods considered as safe (e.g., organic food) increases if they consume them repeatedly. Similarly, the net utility from expecting a prestigious job relative to an ordinary one, or a big car relative to a small one, increases if people get used to these high expectations: the longer they hold them, the more they are reflected in the reference expectation, and the higher is the loss they experience if they abandon them.

4.2 Consumption decision

As the final step of the analysis I now add prices, and take into consideration the individual's reference formation regarding her overall consumption. This accounts for the fact that different actions may also have different prices, and may therefore affect overall consumption differently. For example, products inducing health risks may be cheaper than safe products, and working towards a medium level job may induce lower costs (e.g., shorter working hours) than working towards a top level job. If the individual takes an action which makes her pay less than expected in one dimension of consumption she can spend more than expected in other dimensions of consumption. This induces feelings of gain there. Similarly, accepting a lower job expectation, working less and saving time for other activities will result in a feeling of gain from these activities.
Considering differences in prices, and reference effects in dimensions of consumption other than the one that is directly affected by action y, allows me to derive the net effect of adjustment utility on economic decision making in the context of individual consumption optimization.

I compare the individual's utility from choosing action y to her utility from choosing the alternative action z. Action z is taken to mean "not choosing y", and assumed to induce the same outcome at present but no additional outcome in the future. For ease of exposition, I restrict the analysis to actions y which yield negative expected outcomes, $p^y \prec 0$. In addition, I focus on actions that induce non-monetary outcomes like health effects. This allows me to simplify the analysis by separating monetary and non-monetary utility.

In period t, the individual receives monetary income Y and can choose between actions y and z. As before, I normalize present outcomes of both actions to zero.[8] The price for action z is normalized to $B_z := 0$. The risky action has a discount π, such that $B_y = -\pi$. To fix ideas, think of an individual who has the choice between consuming gm-food and organic food. Organic food is safe but more expensive, and I heroically assume that both taste the same (equal outcomes at present).

$p^r(y)$ as before denotes the reference expectation that results if action y is chosen, while $p^r(z)$ denotes the reference expectation that results if action z is chosen. In addition to this choice, individuals can invest into monetary consumption c_t. Utility from monetary consumption is denoted with U^c. To keep the model simple, I abstract from savings, which means that monetary consumption in periods $l > t$ has no influence on the optimization.[9]

Let the parameter ξ denote the decision, where $\xi = 1$ if the action y is chosen and $\xi = 0$

[8]Since present outcomes are the same, reference state effects for those outcomes are also the same and can be ignored in a relative analysis.

[9]This simplification does not affect the main results of the model, since I assume utility from monetary and non-monetary assets to be separable. This is common in the literature and seems at least a good approximation(see, e.g., Feldman and Dowd, 1991, who assume separability between medical care consumption and non-medical care consumption).

if action z is chosen. The individual's optimization problem is then given as

$$\begin{aligned} max_{\xi} \quad U^c(c_t) \quad &+ \quad \xi \left[\sum_{l=t}^{T-1} (u_l^a(p^y) + v_l^a(p^y|p_l^r(y))) + \sum_X p^y(u(x) + v(x|r(y))) \right] \\ &+ \quad (1-\xi) \sum_{l=t}^{T-1} [u_l^a(p^z) + v_l^a(p^z|p_l^r(z))] \\ \text{s.t.} \quad c_t \quad &= \quad Y + \xi\pi \quad . \end{aligned}$$

The risky action y is preferred over the safe action z if the utility increase due to the lower price of the risky action exceeds the utility decrease due to the lower utility from expectations and realized outcomes caused by a possible negative outcome in T. Considering reference formation regarding expectations (future health effects) *and* realized outcomes (current consumption), it can then be shown that the trade-off between monetary and non-monetary utility changes in favor of action y if the expectation induced by y becomes part of the individual's reference expectation:

Proposition 2 *Consider an individual who has the choice between action z, which induces no future outcomes, and the cheaper action y, which induces expected negative outcomes in the future. Then, if the individual chooses y at time t,*

$$EU_{t+1}(y) - EU_{t+1}(z) > EU_t(y) - EU_t(z) \tag{6}$$

The proof is in the appendix. In words, the net effect of the reference formation process regarding both the utility from expectations and the utility from realized outcomes is an increase in the expected utility from choosing action y relative to the expected utility from choosing action z.

If the utility from taking action y increases, the probability that the individual chooses action y also weakly increases. For example, if an individual has already consumed food inducing possible negative health effects, her probability of consuming such food again is higher than if she had never consumed it. In addition, the individual's behavior affects others in her reference group. According to the definition of the reference expectation in (2), the reference expectations of the members of the individual's reference group decrease if she takes an action which induces negative expected future outcomes. With a lower reference expectation, expecting p^y leads to higher utility, and hence taking action y also becomes more likely for the members of the reference group.

This result can explain the trend in the use of condoms in Germany in the years 1997 to 2004 (see table 7 in appendix A), which was mentioned in the introduction. Although the risk of an infection did not decrease during these years, and people were at least as well informed about the risk as before, the use of condoms decreased slightly but significantly between 1997 and 2004 (RKI, 2005, BzGA, 2005). The data shows that this cannot be explained by people having become careless due to the availability of new therapies, an explanation that is often mentioned and may indeed apply to later years. People getting used to the risk of an infection offers one plausible explanation: with some members of the population having accepted the risk in the past, it has to a small degree become part of people's reference expectations: At least some people have gotten somewhat used to the risk of an infection. Accordingly, the adjustment utility from expecting a possible infection has become slightly less negative for these people, such that they accept only lower costs in order to avoid the risk.[10] As the result, the use of condoms decreases. Although this is not the only possible explanation for the observed behavior, it is a plausible one consistent with the data, and may be responsible for part of the effect.

5 Aversion to positive but false information

In this section I analyze the effect of false information on individual utility. Consider situations where information is first released and later corrected, and the correction takes place considerable time before outcomes are realized. If the information is positive, previous concepts of utility predict either no effect or a positive effect on utility. In contrast, adjustment utility can explain why we may not like to receive false information even if it is positive and corrected in time.

Consider again an individual who in t expects a distribution p^y on outcomes in T. At time $l > t$ she receives new information and updates her expectation to the distribution p^w on outcomes in T. At time m with $l < m < T$ the information is corrected and expectations are adjusted back to p^y. In T, outcomes are realized as expected.

Compared to the case where no information is obtained between l and T, i.e., expectations are constant at p^y, the net effect of the false information in period m is

$$\Delta U = \underbrace{\sum_{\tau=l}^{m-1} [u^a(p^w) - u^a(p^y)]}_{I} + \underbrace{\sum_{\tau=l}^{m-1} v^a(p^w|p^r_\tau)}_{II} + \underbrace{\sum_{\tau=m}^{T-1} v^a(p^y|p^r_\tau)}_{III} + \underbrace{v^o_T(x|r_T)}_{IV}$$

Term I denotes the aggregated effect on anticipatory utility for all periods between the announcement and the correction of information. Term II denotes the aggregated adjustment utility that is experienced after the initial announcement of the information but before the correction, while term III denotes the aggregated adjustment utility after the correction of the information but before outcomes are realized. Finally, term IV denotes the effect on reference-dependent outcome utility in case the reference state has not adjusted to the corrected expectations until T.

Consider the case when positive information is released in period l, $p^w \succ p^y$. Then,

$$\begin{aligned} \Delta U > 0 \quad &\text{if} \quad I + II > |III + IV| \quad \text{while} \\ \Delta U < 0 \quad &\text{if} \quad I + II < |III + IV|. \end{aligned} \tag{7}$$

[10]The costs of using condoms, although primarily non-monetary, may be significant for some people.

After the initial announcement of the information anticipatory utility increases, and adjustment utility is experienced as a gain, i.e., terms I and II are positive. After the correction, adjustment utility and reference-dependent outcome utility are experienced as losses, i.e., terms III and IV are negative. Consider as before the case when the information is corrected soon enough such that the reference state r_T in T has fully adjusted to expectations, i.e., term IV is zero. Accounting only for anticipatory utility (term I) would then imply an unambiguously positive effect. Including adjustment utility (terms II and III), however, shows that positive false information, if believed by the individual, is no "free lunch". Rather, if the disutility from the disappointment after the correction of the information is large relative to the initial elation, the overall effect may be negative. Whether the positive or negative effect prevails depends on the functional forms of u^a, and v^a given p^r, as well as on the formation process of p^r.[11] The more loss averse individuals are, the more likely is a negative effect on utility.

If negative information is released, assuming that losses are no less important than gains, one finds that $\Delta U < 0$ in all cases. Here, adjustment utility predicts the same effects as the existing concepts of utility.

In summary, (7) shows that in contrast to the implications of anticipatory utility and reference-dependent outcome utility, spreading good news that later prove to be false may have a negative overall effect on utility, even if it is corrected in time for r to adjust to the individual's expectations until outcomes are realized. This can explain why people do not like to receive wrong information, even if it improves their expectation of the future and is corrected in time to avoid disappointment when outcomes are actually realized.

6 Exogeneity of the reference expectation

An important theoretical implication of adjustment utility is that, in general, the reference expectation cannot be derived endogenously. This means that it is still an open question which factors influence the reference formation process in which way. For example, we do not know in which situations the individual component (one's own expected state) influences the reference expectation stronger than the social component (others' expected state). Or what determines the speed with which references adjust to changes in the determining factors. In addition, there are more candidate factors of influence that have been suggested in the literature, e.g., aspirations levels. Their importance relative to and interaction with the two factors considered here also requires future research.

Why is the reference expectation exogenous? In short, the exogeneity is due to the *gradual* process of reference adjustment and the *continuous* experience of utility. To see this, consider again the framework developed in section 3. For simplicity, timing there is discrete. However, in reality people experience pleasure and pain in any moment in

[11] If r has not fully adjusted to p^y until T, it also depends on the functional form of v^o given r and the formation process of r.

time. This means that both utility and references are experienced continuously. Hence, the time Δ between two periods in the model should be thought of as very short. With $\Delta \to 0$, it is sensible to assume that the reference expectation adjusts to changes in the determining factors over several periods rather than from one period to the next, i.e., that reference formation is a smooth process without jumps. This assumption is supported by recent experimental research, which suggests that reference states do not quickly adjust to expectations (Matthey and Dwenger, 2007).
Consider a period when information arrives that induces a change in expectations. The new expectation is then gradually included in the reference expectation p^r. But until the adjustment of the reference expectation is complete, the reference expectation is also partly determined by the former state of expectations. These former expectations are exogenous to the new adjustment process. Only in the periods when the reference expectation has fully adjusted to expectations and no new information arrives is the reference expectation determined endogenously.
One may argue that if there is never a change in expectations, the reference expectation is endogenous. However, for any action that is relevant for utility, an individual's initial unawareness of the possibility of this action has to be overcome in order for her to analyze the action's utility. She only becomes aware of the action if the necessary information is supplied, which then affects her expectations. Hence, at least when leaving initial unawareness, the reference expectation is exogenous (at zero).

Note that the exogeneity of the reference expectation differs from the assumption of Kőszegi and Rabin (2006) for the reference state for realized outcomes. In their model, the individual's expectation before T over her consumption decision in T is interpreted as the reference state for outcomes in T. Since the adjustment of the reference state to new expectations is completed *before* the reference state affects utility, the reference state in T is fully determined by expectations, and therefore endogenous. The argument above, however, shows that the reference formation process in general is not completely endogenous.

7 Conclusion

The surveys described in this paper suggest that there exists a component of utility which has so far not been formally considered in the literature: reference-dependent utility from expectations, or *adjustment utility*. This component accounts for the fact that the utility people derive from holding certain expectations is path dependent. In particular, the results suggest that it depends on the expectations an individual held in the past regarding her own and relevant others' future outcomes. Adjustment utility is shown to affect individual utility and economic decision making through changing equilibrium choice and altering preferences over consumption decisions.

The results can explain preferences like those observed in the surveys that cannot be explained with existing models of individual utility. In addition, they offer an explanation, e.g., for people's reluctance to change their plans even if following them induces unexpectedly high costs, for the increasing acceptance of risks if they are faced repeatedly, and for people being averse to positive but false information, even if it is corrected in time.

The model also has implications for the behavior of firms. If a firm wants to introduce a product into the market that is perceived as being risky, e.g., genetically modified food, it will focus on increasing the number of individuals that consume the product. This decreases consumers' reference expectation regarding the risk induced by this product, which increases their utility from consuming it and their willingness to buy it. Accordingly, selling a product initially at below-cost prices is profitable in the long run if market penetration is high enough to substantially decrease people's reference expectations regarding the involved risks. At a later stage, the firm would then raise prices to profitable levels without a marked reduction in sales volume, since reference expectations continue to decrease until the product's risk is fully included in consumers' reference expectations. The market introduction of gm-products may offer a good possibility to empirically test for such pricing strategies.

Further, the findings have implications for regulatory policy. Habituation is shown to imply a tendency of increasing risk acceptance. Accordingly, when regulating activities that induce health or environmental risks, one has to account for this increasing trend.

Finally, some limitations of the paper should be mentioned. First, the experimental evidence is based on hypothetical situations. Although the results seem to be strongly supported by intuition, more research is needed to substantiate the conclusions. Second, empirically the predictions have so far only been confirmed by anecdotal evidence from HIV data, rather than by profound analysis of micro data, e.g., on consumption behavior. Empirical tests of the model's predictions should be the subject of future research.

Appendix A

Indicator	1996	1997	1998	1999	2000	2001	2002	2003	2004
Number of new infections with HIV in Germany	1871	2070	1923	1752	1690	1425	1635	1827	2058
People who know that HIV is transmitted through unsafe sex (%)	98	98	98	99	99	99	100	99	100
People who believe that condoms reduce the risk of an HIV infection (%)	-	-	-	-	86	85	88	87	89
People who intend to use condoms (%)	91	90	93	92	92	93	94	91	93
People who possess condoms (%)	64	62	62	61	64	65	64	67	67
People who actually use condoms (%)	72	73	72	72	70	70	69	71	69
People who actually use condoms (new relationships, %)	72	70	73	72	78	77	75	73	70
People who actually use condoms (more than one sexual partner, %)	81	80	78	80	79	83	82	78	77
People who are informed about new therapies and use condoms (%)	-	74	-	-	-	-	-	74	78
People who are not informed about new therapies and use condoms (%)	-	75	-	-	-	-	-	77	72

Table 3: HIV and the use of condoms in Germany, 1996-2004.
Source: line 1: RKI (2005); lines 2-10: BZgA (2005).
The data in line 2-10 regards singles below the age of 45 with sexual relations in the last year. The decrease in the use of condoms between 1997 and 2004 (line 7) is statistically significant (BzGA, 2005).

Appendix B

Proof of Proposition 1

Assume that individuals are loss averse for both realized and expected outcomes:

$$\begin{aligned} |v^o(x|r)| &> v^o(r|x) \quad \text{for} \quad x < r \quad \text{and} \\ |v^a(p^y|p^r)| &> v^a(p^r|p^y) \quad \text{for} \quad p^y \prec p^r \quad . \end{aligned}$$

I first compare the individual's utility from choosing action y for the first time in period t to choosing it the second time in period $t+1$. If action y is taken in t it induces outcomes in T, while if taken in $t+1$, it induces outcomes in $T+1$. No new information regarding the outcomes of action y becomes available in $t+1$, i.e., p^y does not change. This means that $u^a_l(p^y)$, $u^o(x)$ and $v^o(x|r)$ are constant in all periods until $T+1$.

The reference expectations of individual i in t and $t+1$ are:

$$p^r_{i,t} = p^r_{i,t}\left(p_{i,s}; \mathbf{p}_{-i,s}; \beta\right)_{s<t} \quad \text{and} \quad p^r_{i,t+1} = p^r_{i,t+1}\left(p_{i,s}; \mathbf{p}_{-i,s}; \beta\right)_{s<t+1} \quad .$$

Consider the individual in isolation first, i.e., ignore the effects of social comparison. The index i is dropped for simplicity. Utility is assumed to be additive over time. The difference in expected utility between choosing y in t and choosing it in $t+1$ is then given as

$$\begin{aligned} EU_{t+1}(y) - EU_t(y) &= \sum_{l=t+1}^{T} [u^a_l(p^y) + v^a_l(p^y|p^r_l)] + \sum_X p^y [u^o_{T+1}(x) + v^o_{T+1}(x|r)] \\ &- \sum_{l=t}^{T-1} [u^a_l(p^y) + v^a_l(p^y|p^r_l)] - \sum_X p^y [u^o_T(x) + v^o_T(x|r)] \quad . \end{aligned}$$

Since $r_T = p^y$ per assumption, $\sum_X p^y u^o_T(x) = \sum_X p^y u^o_{T+1}(x)$ and $\sum_X p^y v^o_T(x|r) = \sum_X p^y v^o_{T+1}(x|r)$. Hence, $\sum_X p^y [u^o_T + v^o_T]$ and $\sum_X p^y [u^o_{T+1} + v^o_{T+1}]$ offset each other, such that

$$U_{t+1}(y) - U_t(y) = \sum_{l=t+1}^{T} [u^a_l(p^y) + v^a_l(p^y|p^r_l)] - \sum_{l=t}^{T-1} [u^a_l(p^y) + v^a_l(p^y|p^r_l)] \quad .$$

Both terms above contain $(T-t-1)$ terms $u^a_l(p^y)$, which, given that $u^a_l(p^y)$ is constant in all periods, is the same such that

$$U_{t+1}(y) - U_t(y) = \sum_{l=t+1}^{T} v^a_l(p^y|p^r_l) - \sum_{l=t}^{T-1} v^a_l(p^y|p^r_l) \quad .$$

Since p^r_l is relevant for all $v^a_l(p^y|p^r_l)$, $\sum_{l=t+1}^{T-1} v^a_l(p^y|p^r_l)$ drop out, yielding that

$$U_{t+1}(y) - U_t(y) = v^a_T(p^y|p^r_T) - v^a_t(p^y|p^r_t) \quad .$$

The individual's reference expectation is $p^r_{i,s} \sim 0$ for $s \leq t$. After choosing y in t, she expects p^y in T, and $p^r_{l>t}$ adjusts towards p^y according to (2). The longer $l - t$, the larger the difference between p^r_t and p^r_l, since for $\beta < 1$ the weight of $p_{s<t} \sim 0$ decreases while the weight of $p^y_{l \geq t} \nsim 0$ increases.

Hence, if the individual chooses action y repeatedly, $p^r_t \succ p^r_{t+1}$ if $p^y \prec 0$ and $p^r_t \prec p^r_{t+1}$ if $p^y \succ 0$. This means that:

$$\begin{array}{rcll} U_{t+1}(y) & > & U_t(y) & \text{if } p^y \prec 0 \\ U_{t+1}(u) & < & U_t(y) & \text{if } p^y \succ 0 \end{array} \quad ,$$

with $p^r_t \sim 0$. In general, $U_{t+1}(y) > U_t(y)$ if $p^y \prec p^r$ and $U_{t+1}(y) < U_t(y)$ if $p^y \succ p^r$.

Consider now the process for individuals with social comparison preferences. As before, $p^r_t \sim 0$ at time t for all individuals in the reference group, and at least one individual chooses y in t. This leads to $p^r_{t+1} \prec p^r_t$ if $p^y \prec 0$ and $p^r_{t+1} \succ p^r_t$ if $p^y \succ 0$ for all individuals in the group. Since for all individuals $\mathbf{p}_{-j} \nsim 0$ in all periods t to $T-1$, $p^r_T \nsim p^r_t \sim 0$, i.e. $p^r_T \prec p^r_t$ if $\mathbf{p}_{-j} \prec 0$ and $p^r_T \succ p^r_t$ if $\mathbf{p}_{-j} \succ 0$, for all individuals in the reference group.[12] Then, if an individual considers choosing y in $t+1$, independently of the predicted future behavior of herself and relevant others, it results the same effect as above:

$$\begin{array}{rcll} U_{t+1}(y) & > & U_t(y) & \text{if } p^y \prec 0 \\ U_{t+1}(y) & < & U_t(y) & \text{if } p^y \succ 0 \end{array}$$

for all individuals in the reference group. This completes the analysis for the utility from choosing action y.

Next, consider the utility of not choosing action y, denoted action z, which induces $p^z \sim 0$. In general, this utility is affected by p^r in the same way as is the utility of choosing y.

Consider first an action y with $p^y \prec 0$. Then, if y is chosen in t, $p^r_t \succ p^r_T$ and hence $v^a_T(p^z|p^r_T) > v^a_t(p^z|p^r_t)$. Accordingly, $U_t(z) < U_{t+1}(z)$. Starting from $p^r_t \sim 0$, a marginal change to $p^r_{t+1} \prec 0$ leads to $v^a_{t+1}(p^z|p^r_{t+1}) > v^a_t(p^z|p^r_t) = 0$ and $0 > v^a_{t+1}(p^y|p^r_{t+1}) > v^a_t(p^y|p^r_t)$.

Over the entire reference formation process, for loss averse individuals a change in the reference expectation from $p^r \sim 0$ to $p^r = p^y \prec 0$ leads to $v^a(p^y|p^y) - v^a(p^y|p^r_t) > v^a(p^z|p^y) - v^a(p^z|p^r_t)$. Hence, as the net effect, the action becomes more attractive.[13]

For actions where $p^y \succ 0$, $U_{t+1}(z) < U_t(z)$ since $p^r_t \prec p^r_{t+1}$ if y is chosen in t. Since not choosing y is now felt as a loss, for loss averse individuals $U(z)$ decreases faster initially

[12] If only one individual chooses y, for this individual the change in R results from individual reference formation, rather than from social comparison.

[13] Note that if y causes large losses, the initial increase in utility of not choosing the action may exceed the increase for choosing it. This is the case if v^a at $0 \succ p^r$ is steeper than at $p^y \prec p^r$. Then, for a certain part of the reference formation process, the action becomes relatively less attractive after a decrease in p^r.

than $U(y)$. Accordingly, the net utility from choosing y compared to not choosing y increases. Hence, even though the analysis above showed that the utility from action y decreases, choosing the action nevertheless becomes *more attractive* relative to not choosing it.[14]

$\sqcap$

Proof of Proposition 2

Let r_t^c denote the reference state for the relative outcome utility $v_t^c(c|r_t^c)$ from the consumption of monetary goods c in t. Since action y is not taken before t, and hence the price premium π was not available until t, assume $r_t^c = Y$. Further, $r_{t+1}^c > r_t^c$ if $c_t > r_c$, as is usually assumed in models of habit formation (e.g., Campbell and Cochrane, 1999). The expected utility from taking action y is

$$EU(y) = u^c(Y+\pi) + v^c(Y+\pi|r^c) + \sum_{l=t}^{T-1}[u_l^a(p^y) + v_l^a(p^y|p_l^r(y))] + \sum_X p^y[u^o(x) - v^o(x|r)]$$

while the expected utility from taking z is

$$EU_(z) = u^c(Y) + v^c(Y|r^c) + \sum_{l=t}^{T-1} v_l^a(p^z|p_l^r(z))$$

given that $u^a(p^z \sim 0) = 0$.

The terms $\sum_X p^y[u^o(x) - v^o(x|r)]$, $u^c(Y+\pi)$, $u^c(Y)$ and $\sum_{l=t}^{T-1} u_l^a(p^y)$ do not depend on either r^c or p^r, i.e., they are unaffected by action y being chosen repeatedly, such that

$$EU_{t+1}(y) - EU_t(y) =$$

$$v_{t+1}^c(Y+\pi|r_{t+1}^c) - v_t^c(Y+\pi|r_t^c) + \sum_{l=t+1}^{T}[v_l^a(p^y|p_l^r(y))] - \sum_{l=t}^{T-1}[v_l^a(p^y|p_l^r(y))]$$

and

$$EU_{t+1}(z) - EU_t(z) = v_{t+1}^c(Y|r_{t+1}^c) - v_{t+1}^c(Y|r_{t+1}^c) + \sum_{l=t+1}^{T} v_l^a(p^z|p_l^r(z)) - \sum_{l=t}^{T-1} v_l^a(p^z|p_l^r(z)) \quad .$$

For the relative utility from monetary consumption,

$$v_{t+1}^c(Y+\pi|r_{t+1}^c) - v_t^c(Y+\pi|r_t^c) < 0$$
$$v_{t+1}^c(Y|r_{t+1}^c) - v_t^c(Y|r_t^c) < 0$$

[14] Only if the final loss that is derived from an expectation of zero, given a reference expectation $p^r = p^y \succ 0$, is large, the utility from choosing the action may temporally decrease faster for an increase in the reference expectation than that from not choosing the action.

since $r^c_{t+1} > r^c_t$ for $\xi = 1$ and $Y + \pi > r^c_t$. However, for $v^c(y)$ the repeated choice of y induces the reduction of a gain, while for $v^c(z)$ it induces the occurrence of a loss. Accordingly, for loss averse individuals

$$v^c_{t+1}(Y + \pi | r^c_{t+1}) - v^c_t(Y + \pi | r^c_t) > v^c_{t+1}(Y | r^c_{t+1}) - v^c_t(Y | r^c_t) \tag{8}$$

Proposition 1 has shown that

$$\sum_{l=t+1}^{T} [v^a_l(p^y | p^r_l(y))] - \sum_{l=t}^{T-1} [v^a_l(p^y | p^r_l(y))] > \sum_{l=t+1}^{T} v^a_l(p^z | p^r_l(z)) - \sum_{l=t}^{T-1} v^a_l(p^z | p^r_l(z)) \tag{9}$$

Combining (8) and (9) shows that $EU_{t+1}(y) - EU_t(y) > EU_{t+1}(z) - EU_t(z)$ and hence that

$$EU_{t+1}(y) - EU_{t+1}(z) > EU_t(y) - EU_t(z)$$

$\sqcap$

Appendix C

Questionnaire 1

This questionnaire is part of a research project of the chair of Microeconomics, Prof. Dr. Dorothea Kübler. Please answer the questions and return the questionnaire to the lecturer. Thank you for your participation!

Consider the following situations:

Situation 1

Ms. Schulz is told on Friday, February 3, that she will receive a 5% wage increase from April 1. Ms. Schulz did not expect this wage increase. On Monday, February 6, in the morning, she is told that the payroll department made a mistake and that she will not receive the wage increase.
On April 1 she receives her usual wage.

Situation 2
Ms. Schulz does not receive any information about a wage increase. On April 1 she receives her usual wage.

Question (Please tick the situation in which you think Ms. Schulz is happier.):

In which situation is Ms. Schulz happier on February 6 at noon?

Situation 1 o Situation 2 o Equally happy in both situations o

Thank you for your participation!

Questionnaire 2

This questionnaire is part of a research project of the chair of Microeconomics, Prof. Dr. Dorothea Kübler. Please answer the questions and return the questionnaire to the lecturer. Thank you for your participation!

Consider the following situations:

Situation 1

Mr. Meier is department manager at his company. He knows already in August 2006 that he will receive a salary of EUR 50,000 in 2007. He does not know the salaries of the other department managers at his company, and the other managers do not know his salary. However, Mr. Meier believes that the other managers will receive an average salary of EUR 40,000 in 2007. On October 1, 2006, Mr. Meier learns by coincidence that the other department managers will also earn EUR 50,000 on average in 2007. The other managers do not get to know his salary. Assume that the average salary of the other managers does not have an impact on Mr. Meier's future salaries or career perspectives.

Situation 2

Mr. Meier is department manager at his company. He knows already in August 2006 that he will receive a salary of EUR 50,000 in 2007. He does not know the salaries of the other department managers at his company, and the other managers do not know his salary. However, Mr. Meier believes that the other managers will receive an average salary of EUR 60,000 in 2007. On October 1, 2006, Mr. Meier learns by coincidence that the other department managers will also earn EUR 50,000 on average in 2007. The other managers do not get to know his salary. Assume again that the average salary of the other managers does not have an impact on Mr. Meier's future salaries or career perspectives.

Question (Please tick the situation in which you think Mr. Meier is happier.):

In which situation is Mr. Meier happier on October 1?
Situation 1 o Situation 2 o Equally happy in both situations o

Thank you for your participation!

References

Abel, A., 1990: Asset Prices under Habit Formation and Catching up with the Joneses, The American Economic Review, Vol. 80, No. 2, Papers and Proceedings of the Hundred and Second Annual Meeting of the American Economic Association. (May, 1990), p. 38-42.

Benartzi, S. and Thaler, R., 1995: Myopic Loss Aversion and the Equity Premium Puzzle, Quarterly Journal of Economics, Vol. 110, No. 1, p. 73-92.

Brunnermeier, M. and Parker, J., 2005: Optimal Expectations, American Economic Review, Vol. 95, No. 4, p. 1092-1118.

BzGA, 2005: Aids im öffentlichen Bewusstsein der Bundesrepublik Deutschland 2004, Bundesanstalt für gesundheitliche Aufklärung (BzGA), Endbericht, Juni 2005.

Campbell, J. and Cochrane, J., 1999: By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior, Journal of Political Economy, Vol. 107, No. 2, April 1999.

Caplin, A. and Leahy, J., 2001: Psychological Expected Utility and Anticipatory Feelings, Quarterly Journal of Economics, Vol. 116, No. 1, p. 5580.

Carroll, J., 2006: Few Plan to Change Vacation Plans Because of Gas Prices, GALLUP News Service, 2 June 2006.

Constantinides, G., 1990: Habit Formation: A Resolution of the EEP, Journal of Political Economy 98, p. 519-543.

Croll, P and Moses, D., 2005: The Formation and Transmission of Educational Values and Orientations, Economic and Social Research Council, study R000239963.

Feldman, R. and Dowd, B., 1991: A New Estimate of the Welfare Loss of Excess Health-Insurance, American Economic Review, Vol. 81, No. 1, p. 297-301.

Kahneman, D., Tversky, A., 1979: Prospect Theory: An Analysis of Decision under risk, Econometrica, Vol. 47, No. 2, p. 263-292.

Kahneman, D., Knetsch, J. and Thaler, R., 1990: Experimental Tests of the Endowment Effect, Journal of Political Economy, Vol. 98, p. 1325-1348.

Kahneman, D., Knetsch, J. and Thaler, R., 1991: The Endowment Effect, Loss Aversion and Status Quo Bias, Journal of Economic Perspectives, Vol. 5, p. 193-206.

Kőszegi, B., 2005: Utility from Anticipation and Personal Equilibrium, Working Paper, University of California, Berkeley.

Kőszegi, B., Rabin, M., 2006: A Model of Reference-dependent Preferences, Quarterly Journal of Economics, Vol. 121, Iss. 4, p. 1133-1165.

Kőszegi, B., Rabin, M., 2007: Reference-dependent consumption plans, Working Paper.

Laibson, D., 1997: Golden Eggs and Hyperbolic Discounting, Quarterly Journal of Economics, Vol. 112, Iss. 2, p. 443-477.

Loewenstein, G., 1987: Anticipation and the Valuation of Delayed Consumption, Economic Journal, Vol. 97, p. 666-684.

Matthey, A., and Dwenger, N., 2007: Don't aim too high: the potential costs of high aspirations, Jena Economic Research Papers No. 2007-097.

Matthey, A., 2005: Getting Used to Risks: Reference Dependence and Risk Inclusion, SFB 649 Discussion Paper 2005-036.

Matthey, A., 2006: Getting Used to Expectations, Paper presented at the International Workshop on Behavioral Game Theory and Experiments, Capua, Italy, May 12/13, 2006.

Neumann, J.v. and Morgenstern, O., 1944: Theory of Games and Economic Behavior, Princeton University Press.

RKI, 2005: HIV Infektionen und Aids-Erkrankungen in Deutschland, Epidemiologisches Bulletin, Sonderausgabe A/2005, Robert-Koch-Institut (RKI) Berlin.

Sugden, R., 2003: Reference-dependent subjective expected utility, Journal of Economic Theory, Vol. 111, p. 172-191.

Thaler, R., 1980: Toward a Positive Theory of Consumer Choice, Journal of Economic Behavior and Organization, Vol. 1, p. 39-60.