# *Medical non-compliance and the competence hypothesis*

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## Abstract

According to Ellsberg (1961), people's preferences in ambiguous choices deviate from what would be expected according to expected utility theory. The competence hypothesis by Heath and Tversky (1991) states that people prefer situations in which they feel competent and knowledgeable, despite the option being vague without known probabilities. This study tests the competence hypothesis applied to medical non-compliance. A survey with 108 participants is used to answer the research question *'Does competence in an ambiguous situation affect compliance to medical treatment?'* The main finding of this research is that competence has no significant effect on compliance to medical treatment. An interesting finding is that experience with medication and previous compliant behaviour has a positive effect on willingness to comply and feelings of competence regarding compliance decisions. Although the gained insights shed more light onto the phenomenon, the findings also emphasize the urge for more research on the competence hypothesis and ambiguous choices in the health domain.

# Introduction

The quality of healthcare has increased over the past decades, resulting in a healthier and longer-living generation than ever before (Sifferlin, 2013). Diseases that used to be fatal are now classified as chronic, as scientific research has greatly improved the efficacy of medication. For these breakthroughs to have an effect on society's health, patients should take their medication according to the recommended treatment. This is currently not the case, as a large percentage of the patients are not complying with their medical treatment.

### Medical compliance

Medical compliance refers to the extent to which a patient's behaviour corresponds with agreed recommendations from a healthcare provider. Not complying with medical treatment is a large, worldwide problem: in developed countries the compliance with long-term therapies is as low as 50%, a percentage that is even lower in less developed countries (WHO, 2003). Consequences of medical non-compliance are severe: patients' state of health is worsened, while costs for society increase and estimates on the efficacy of medication become misjudged (Ho et al., 2001; Roebuck et al., 2011; Health Prize, 2014). Some argue that improving compliance is of larger influence on society's health than the optimisation of medical treatment (Haynes et al., 2001). Yet despite intense research and over 4000 English articles published each 5 years on this problem, scientists still have not found a satisfying answer to the question why patients do not comply with their medical treatment (Donovan & Blake, 1992).

### Ambiguity aversion and the competence hypothesis

Full compliance among all diseases is presumably not feasible in the near future, but there might be an opportunity to increase medical compliance or at least the knowledge on this subject by taking into account behavioural economic theories. One explanation for medical non-compliance could be due to the way in which ambiguous information is perceived by decision-makers. Ellsberg concluded in his theory of ambiguity aversion that people do not always behave as though they assign numerical probabilities to certain events, and thus that in some situations choices do not reveal judgments of probabilities (Ellsberg, 1961). Instead, people prefer to bet on clear rather than on vague events when the probability of winning is moderate or large, or prefer situations with known risk to situations with unknown risk (Fox & Tversky, 1995). On the contrary, people tend to be ambiguity seeking for small probabilities of winning: people then prefer to bet on a vague rather than a clear bet (Viscusi & Chesson, 1999). This hypothesis has had far-reaching implications for expected utility theory and is been investigated thoroughly by various behavioural economists, including Heath and Tversky. Their competence hypothesis, which contravenes Ellsberg's ambiguity aversion, states that the willingness to bet on an uncertain event does not depend on the estimated likelihood and the precision of that estimate, but on one's general knowledge or understanding of the relevant context (Heath &Tversky, 1991). When people feel knowledgeable about the context of a certain bet, they might tend to bet on vague beliefs, while in bets where they feel less competent they tend to bet on clear situations.

### Research question

Ambiguity aversion and the competence hypothesis have a shown effect on not only daily decision-making, but also on the behaviour of stock traders and business managers (Heath & Tversky, 1991; Viscusi & Chesson, 1999). However, the effect of these theories on medical non-compliance has not yet been investigated. Therefore, the research question of this thesis is:

*Does competence in an ambiguous situation affect compliance with medical treatment?*

The goal of this research is to shed more light on the decision process of a patient when determining whether to comply with their medical treatment. Quantitative research will measure the role of ambiguity and the validity of the competence hypothesis, respectively with a within-subject and a between-subject design. The results will provide a foundation for further scientific research on ambiguous choices and medical non-compliance. Such research will improve the knowledge on causes of non-compliance, which is useful for health policy and scientific studies. The information in applied form will be valuable for healthcare providers, pharmaceutical companies and patients. Eventually, the gained insights can contribute to the search for a solution to this problem.

### Structure

This thesis is structured as follows: section 2 provides a literature review, in which more light is shed on ambiguity aversion, the competence hypothesis and medical non-compliance. Section 3 covers the methodology, in which the design of the experiment is explained. Section 4 first discusses the statistical analysis, then the analysed results. Section 5 provides a conclusion regarding the research question, including limitations of this study and suggestions for further research.

# Theoretical framework

## The Ellsberg paradox

People make numerous decisions every day. Most of the times the precise probabilities of the potential outcomes of these decisions are unknown, resulting in an ambiguous situation. One of the first economists to acknowledge this was F. Knight, who in 1921 made the distinction between measurable precise probabilities and unmeasurable unknown probabilities (Knight, 1921; Moore & Eckel, 2003). According to Knight, one can make a distinction between clear and vague probabilities based on the quantity of evidence available. However, this distinction between clear and vague probabilities and its influence on decision-making was not directly adopted among all economic theories. For example, Savage concluded that vagueness plays no role in rational theory of choice (Savage, 1954; Camerer & Weber, 1992). According to the Savage axioms, people in uncertain situations behave as though they assign subjective probabilities to events or possible outcomes. Furthermore, he argued that one maximizes his or her subjective expected utility with the use of these personal judgments of probability. These subjective probabilities can therefore be revealed by the choices of subjects in an experiment, also known as revealed preferences.

### Two-colour problem

In 1961, D. Ellsberg wrote an influential paper that questioned the Savage axioms in decision-making (Ellsberg, 1961). He used an example known as the two-colour problem to address ambiguity in decisions.

In this situation, two urns are presented as shown in figure 1 (next page). Both urns contain the exact same amount of balls: 100 each. These balls can either be black or red. Urn 1 contains 50 red balls and 50 black balls, but one does not know the proportion of black and red balls in urn 2. Subjects can participate in the following lottery: depending on the outcome of a random draw from one of the urns, one can earn $100 or nothing. In the first round, subjects can earn $100 if the random drawn ball is black. They can choose to bet on a random draw from urn 1 or a random draw from urn 2. In the second round, subjects can earn $100 if the random drawn ball is red. Again, they can choose to bet on urn 1 or urn 2. While most subjects appear to be indifferent between betting on red or black for either urn, they prefer to bet on urn 1 (the known proportion) rather than urn 2 in both bets. This preference is inconsistent with subjective expected utility theory, as it implies that the subjective probabilities of both black and red are greater in urn 1 than in urn 2. Thus, the sum of the subjective probabilities for black and red in urn one seems to be more than one, which is impossible. This paradox in preferences is explained in the equations below.

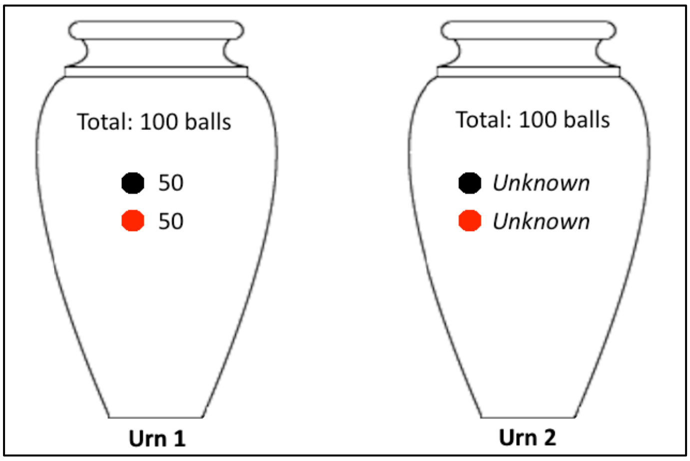


**Figure 1: Visual representation two-color problem**

Notation in equations:

b1 = the event of drawing a black ball from urn 1

b2 = the event of drawing a black ball from urn 2

r1 = the event of drawing a red ball from urn 1

r2 = the event of drawing a red ball from urn 2

Prospect 1: win \$100 if a random drawn ball from the urn is black. People's preferences in this prospect are:

(1) $(b1{:}100, r1{:}0) > (b2{:}100, r2{:}0)$

Prospect 2: win \$100 if a random drawn ball from the urn is red. People's preferences in this prospect are:

(2) $(b1{:}0, r1{:}100) > (b2{:}0, r2{:}100)$

If P denotes probability, the preferences from equation (1) imply:

(3) $P(b1) > P(b2)$

And the preferences from equation (2) imply:

(4) $P(r1) > P(r2)$

However, if we would assume that people assign subjective probabilities according to the theory by Savage, the following equation would hold:

(5) $P(b1) + P(r1) = 1$ and $P(b2) + P(r2) = 1$

What is shown, is that equations (3) and (4) do not match with equation (5). Thus, people's preferences in the two-colour problem violate the Savage axioms, as their beliefs do not sum up to one.

### Ambiguity aversion

This situation, the Ellsberg paradox, became the best-known example of the phenomenon ambiguity aversion, in which people's willingness to act in the presence of uncertainty does not only depend on the perceived probability of the event in question, but also on its vagueness or ambiguity (Fox & Tversky, 1995). The definition of ambiguity according to Ellsberg is 'a quality depending on the amount, type and 'unanimity' of information, and giving rise to one's degree of confidence in an estimate of relative likelihood' (Ellsberg, 1961). Further research on ambiguity aversion has shown that people tend to prefer situations with known probabilities for low probability losses and high probability gains. In situations involving high probability losses and low probability gains, this effect is reversed: people tend to be ambiguity seeking and prefer unknown probabilities to known probabilities. According to the research of Viscusi and Chesson (1999) a probability of winning below 50% evokes ambiguity seeking behaviour, while a probability of winning above 50% triggers ambiguity aversion, as shown in figure 2. This is in line with findings from Kahn & Sarin (1988) Intuitively, for losses this holds that a probability above 50% results in ambiguity seeking behaviour, while a probability of losing below 50% results in ambiguity aversion (Viscusi & Magat, 1992). However, as Viscusi and Chesson (1999) remark themselves, this break point of 50% is arbitrary; for example in the case of a risk of 50% per decade, which can be thought of as an approximate risk of 5% per year.

Probability of winning above 50%: clear bet > vague bet
Probability of winning below 50%: clear bet < vague bet

**Figure 2: Preferences in clear and vague bets**

### Extensions of the two-colour problem

These findings have had far-reaching implications for existing decision theory. The two-colour problem and modified versions have been extensively tested in several situations (Camerer & Weber, 1992). For instance, Viscusi & Chesson used a sample of 266 business owners and managers to test ambiguity seeking behaviour in situations with a high probability of losing (70% chance), and ambiguity averse behaviour in situations with a low probability of losing (30% chance). Both effects were found significant when the business owners had to react in multiple situations with varying risks of storm damage to their businesses (Viscusi & Chesson, 1999). Another example is the experiment by Becker & Brownson in 1964. Their research recreated the original experiment of Ellsberg, but added an option for participants to pay money to avoid the ambiguous urn: the ambiguity premium. This created the opportunity to attach 'ranges of ambiguity' to different urns. Becker and Brownson (1964) argue that ambiguity is associated with the distribution of the probability, thus the range of the distribution of the coloured balls in the urns. An urn with a known proportion of 50 black and 50 red balls has a range of zero and thus an ambiguity of zero. However, an urn containing 100 balls in total, with at least 15 balls of each colour, has a range of 70 as the distribution of, for example the black balls, is between 85 and 15. Following the same reasoning, an urn with 100 balls in total with at least 40 balls of each colour, has a range of 20 as the amount of black (/red) balls is between a minimum of 40 and a maximum of 60 balls. Naturally, the degree of ambiguity is higher in the 15/85 urn compared to the 40/60 urn. The difference in ambiguity between the latter two urns is therefore 70 – 20 = 50. When ambiguity averse participants faced the option of paying a premium in order to avoid a random draw from an urn with an unknown exact proportion, they paid an average of 60% of the difference in the ranges of the two urns. For example, if an ambiguity averse participant could choose between a random draw from urn 1 with a known proportion of 50 black/50 red balls or an urn 2 with at least 15 balls of each colour (total = 100), they would pay a premium of 60% x 70 (range urn 2) – 0 (range urn 1) = 42 cents or dollars. These results confirm ambiguity aversion and show that subjects pay a significant amount to avoid ambiguous situations (Becker & Brownson, 1964). It is worthwhile mentioning that only participants that showed ambiguity aversion in the original two-colour problem by Ellsberg were allowed to participate in this study. Therefore, ambiguity premiums in other studies might be lower than the 60% found by Becker & Brownson.

### Possible explanations

The empirical work on ambiguity aversion is not limited to the Ellsberg experiment and extensions.  Other research focussed on the psychological background of the phenomenon, looking for an explanation for this deviation from (subjective) expected utility theory. One of the explanations is the deceit aversion mechanism (Coleman, 2011). According to this theory, people assume that when specific chances are not mentioned, this is done to deceive the person in question. In the light of ambiguity aversion, this would mean that in the ambiguous situation people feel as though the researcher deceives them, resulting in a preference for the option with clear probabilities.

In the same year as the original article on ambiguity by Ellsberg, Fellner (1961) investigated the same phenomenon. Fellner's more general definition of ambiguity covers one of the psychological essences of ambiguity aversion: 'Ambiguity is uncertainty about probability, created by missing information that is relevant and could be known' (Fellner, 1961). The missing information is a crucial factor in ambiguity aversion. The informational-gap decisional theory states that the discrepancy between what is known and what needs to be known to make a decision is the most important explanation for the Ellsberg paradox and associated theories. Because the proportion of black and red balls in the second urn is not known, there is less information known than needs to be to make a decision to bet on urn 1 or urn 2. One is therefore unable to maximize expected utility (Ben-Haim, 2006).

Ambiguity seeking behaviour is explained by Viscusi & Chesson with what they call a 'hope' effect: in a situation of high probability losses or low probability gains, the ambiguous situation offers a chance of avoiding a negative outcome (Viscusi & Chesson, 1999). An ambiguous option triggers the decision maker to 'hope' for a large likelihood of a better outcome in the vague situation.

### Comparative ignorance

Fox and Tversky looked more into the Ellsberg paradox and ambiguity aversion, by testing the theory with a between subjects design next to the within-subjects set-up that Ellsberg used. Subjects were randomly divided into two groups: one group viewed both urns, the second group either saw only urn 1 with the known proportion of black and red balls, or urn 2 with the unknown proportion. Participants were then asked to state their willingness to pay for a bet in which they would earn $100 if they rightly predicted the colour from a randomly drawn ball from the urns. The group that viewed both urns showed ambiguity aversion, thus behaved according to Ellsberg's findings. However, when subjects had to state their willingness to pay for either urn 1 or urn 2 in isolation, there was no sign of ambiguity aversion. In fact, subjects in the groups that viewed either of the urns in isolation paid slightly less for the clear bet than for the vague bet, which can be interpreted as a preference for the vague bet. Fox and Tversky concluded that this lack of ambiguity aversion was due to the absence of a comparison. This led to they theory of comparative ignorance, where it is believed that the contrast between states of knowledge is the predominant source of ambiguity aversion (Fox & Tversky, 1995). The reasoning behind this is that when people price an uncertain prospect in isolation, they pay no attention to the accuracy of their estimate. However, when confronted with a clear prospect in contrast, they become aware of the missing knowledge regarding the uncertain or vague prospect. This comparison eventually leads to a lower priced vague prospect compared to the clear prospect.

## The competence hypothesis

One of Ellsberg's own explanations for the fact that people do not like to bet on the urn with unknown proportion, is because the information about the proportion is knowable in principle (for example, by the researcher) but not to them (Ellsberg, 1961). This statement was the starting point for the research conducted by Heath and Tversky. At first eye, their experiments had a similar set-up as regular experiments testing ambiguity aversion. However, their results could not be explained by ambiguity aversion (Heath & Tversky, 1991).

### Experiments

Consider the following set-up. Students were asked to predict the outcomes of football games for the upcoming weeks: they selected a team that they thought would win and assess their level of confidence that their prediction would come true on a scale from 0 to 100%. They could then choose to either bet on the team they chose, or to participate in a matched-chance lottery. This personal lottery had matched chances with the self-stated level of knowledge or confidence of the participant. For example, if a subject would predict that team A would win, and he stated that he was 60% confident, the matched-chance lottery would yield a bet with 60% chance of winning and 40% chance of losing  The results showed that when self-assessed knowledge increased, subjects chose to bet on their own judgment more often than to bet on chance.

In a similar set-up, volunteers at a political event where asked to predict the outcomes of the elections for various states in the United States and the probability of their guesses being right. Then, participants had to assess their knowledge of each state and were asked whether they wanted to bet on their own predictions, or participate in a matched chance lottery. Again, results showed that participants that assessed their own knowledge as being high, preferred to bet on their own judgment instead of the matched chance lottery (Heath & Tversky, 1991).

### Explanation

Heath and Tversky concluded from these results and those of similar experiments that 'the willingness to bet on an uncertain event depends not only on the estimated likelihood and the precision of that estimate; it also depends on one's general knowledge or understanding of the relevant context' (Heath & Tversky, 1991). More general, people prefer a bet where they feel knowledgeable and competent concerning the context over a bet with an equal chance. This feeling of competence is determined by what we know relative to what can be known. Such a feeling can be enhanced by general knowledge, experience or familiarity.

People feel less competent when they are aware of the existence of relevant information that is not accessible to them, especially if this information is available to others. This can even be manipulated by simply suggesting a comparison to others who are more knowledgeable.

High-knowledge bet > Matched lottery > Low-knowledge bet

**Figure 3: Implication Competence Hypothesis**

The effect of this, as shown in figure 3, is that people bet on vague beliefs if they feel knowledgeable, but bet on chance when they do not. The same goes for betting on future real-world events or personal skills, both ambiguous. This cannot be explained by ambiguity aversion, as these judgmental probabilities are more ambiguous than lotteries in which chances are matched to participant's own predictions. However, from a psychological perspective, this sounds very reasonable: through trial-and-error, people have learned that they generally do better in situations they understand, than in situations where they have less knowledge. Furthermore, Heath & Tversky argue that when people bet on their own judgment, success will be attributable to their own knowledge, whereas failure in this case can be attributed to chance. On the contrary, people that do not know much about a certain subject cannot claim success for a correct prediction, because it's assumed that they were guessing. They might even be blamed in the case of an incorrect prediction, accusing them of ignorance. Applied to the two-colour problem by Ellsberg, the competence hypothesis explains the preference for urn 1 with known proportions as a result of being aware that the proportion in the second urn can is knowable in principle, but not to them. This makes subjects feel less knowledgeable and less competent, resulting in a preference for the known urn.

The competence hypothesis is less thoroughly researched and tested compared to ambiguity aversion. It is however cited among various domains of decision-making: for example in entrepreneurial economics (Grieco & Hogarth, 2004) and politics (McDermott, 2001). Explanations of the theory and its effect on people's decisions differ among literature. Some stick with the psychological explanation as provided by Heath & Tversky (1991), others maintain a more extreme view. An example of the latter is the following quotation of McDermott (2001), as he states that people's preference according to this theory 'involve clearly narcissistic and often self-serving preferences for betting on one's own knowledge or competence against chance'.

## Medical non-compliance

As with ambiguity aversion, the competence hypothesis has far-reaching implications in both theoretical and practical surroundings. Both theories can be applied in various real-life situations. To maintain within the scope of this paper, these theories will now be more specified towards decision-making in health economics.

In various medical decisions, both clear and vague probabilities play a role. In a lot of cases, a physician can only estimate the probability of a patient suffering from a certain medical condition. These subjective judgments of probabilities have a large effect on the recommendation of a treatment, thus the patient's future health. Research has indicated that alternative descriptions of the same symptoms can result in different probability judgments regarding medical conditions. Redelmeier et al. (1995) show in their study that physicians tend to discount unspecified possibilities. A more detailed description of an implicit hypothesis generally increases the judged probability of this hypothesis, which might increase the propensity to treat.

Besides subjective judgment of probabilities, ambiguity is of influence in medical decision-making. Most studies in health economics or medical decision-making assume ambiguity neutrality and known probabilities. Berger, Bleichrodt and Eeckhoudt (2013) argue that ignoring ambiguity aversion might distort treatment recommendations, as unknown probabilities are present in almost every medical decision. Examples are risks to the public health such as epidemics, and on a micro-level in the case of doctors making treatment recommendations. The article uses an established and popular model by Klibanoff et al. (2003) to investigate two types of ambiguity regarding the treatment of patients. The first, diagnostic ambiguity, represents the situation in which the probability of the illness of a patients is unknown: is the patient sick or not? The second type of ambiguity is therapeutic ambiguity, in which the effects of the treatments are ambiguous. From the constructed model, it shows that both types of ambiguity have an influence on the propensity to treat, and cause an ambiguity averse decision-maker to deviate from the optimal choice when ambiguity increases.

Han et al. tried to develop a measure of aversion to ambiguity regarding medical tests and treatments, based on a national mail survey in the United States. They found the following characteristics associated with ambiguity aversion regarding medical tests and treatments: older age, non-white race, lower education, lower income and female sex (Han et al., 2009). Still, the link between the health domain and ambiguity aversion is relatively understudied.

On the contrary, one situation in medical decision-making that has been extensively researched is non-compliance to medical treatment. No scientific research has been done on this behaviour and the possible influence of the competence hypothesis in the presence of ambiguous events. Before focussing on the application of this theory onto non-compliance, existing literature on non-compliant behaviour is covered.

### Definition non-compliance

Compliance or adherence refers to the extent to which a patient's behaviour corresponds with agreed recommendations from a healthcare provider. This implies sticking to medication in a broad way: not only taking oral pills for example, but also following a diet or executing lifestyle changes (WHO, 2003). The terms compliance and adherence are used interchangeably. The difference between those is the consent of a patient: adherence requires the patient's agreement on the recommendations of the health care provider, while compliance refers to the day-to-day medication taking (Health Prize, 2014). Patients can either forget to take drugs, or deliberately make the decision to not take their medication. This is referred to as unintentional and intentional non-compliance.

### Consequences

The effects of non-compliance on an individual patient vary by disease, but can be as severe as death (Ho et al., 2009). Consequences of not taking medication go beyond the individual patients' state of health: nations' health costs increase dramatically as research has shown that non-compliant patients cost more and compliant patients costs less (Ho et al., 2005; Roebuck et al., 2011; Sokol et al., 2005). Furthermore, pharmaceutical companies are confronted with demand leakage on a large scale: estimates go from 30$ million per year to a loss of $177 billion per year (IMS, 2008). Also, practice-outcome gaps cause medical practitioners to misjudge the efficacy of medication (Bangalore et al., 2007).

### Measurement

To measure the compliance rate of a patient, different kinds of methods are used. The mean possession rate (MPR) uses prescription refill records to calculate for how many days a patient possessed the medication within a defined time period: a fully compliant patient has a MPR score of 1. Other measurements include: subjective ratings by patient and health care provider, standard administered questionnaires, electronic monitoring devices and biochemical measurements (Health Prize, 2014). Each of these methods has their plus sides and flaws. While health care providers tend to overestimate adherence, patients' own rating are not the most reliable source as well. Furthermore, many of these measures do not account for a certain stage in which the non-adherent behaviour can take place:

approximately 25% of the patients do not even pick up their prescription at the pharmacy (IMS, 2013). This is also referred to as primary non-adherence: when a patient does not pick up newly prescribed medication (or an appropriate alternative) within an acceptable period of time after it was prescribed (Halpern et al., 2011). When patients do not refill their prescription on time, do not take their medications as prescribed or stop their medication completely, this is referred to as secondary non-adherence (Solomon & Majumdar, 2010).

### Primary and secondary non-compliance

Roselund et al. (2004) have further researched the different stages of the medication process in which non-adherent behaviour can take place. 18% of the respondents stated they failed to fill a prescription at least once over the past 12 months; this group is primary non-adherent. Secondary non-adherent behaviour can take place in several stages in the process of medical regimens. Of all respondents, 30% took a prescription medication less often than prescribed, 26% stated they delayed filling a prescription, 21% stopped taking a prescription medication sooner than prescribed and 14% took a prescription medication in smaller doses than prescribed. These percentages vary when looking at per disease.

### Reasons and causes of non-compliance

#### *Self-stated reasons*

For many years it was assumed that forgetfulness was the main cause of medical non-compliance. Research has shown that there are actually many reasons besides forgetting to take medication, such as not liking the idea of taking a pill or not trusting the doctor (Health Prize, 2014). Patients that actively chose not to take their medication (intentional non-compliance) stated several reasons to do so (shown in figure 4): 20% of the patients stated they did not want the side effects of the drug, 17% thought the drug costs too much, 14% did not think they needed the drug, 10% had trouble picking up the drug, 1% did not know how to use the drug and 14% had other reasons (Roselund et al., 2004).

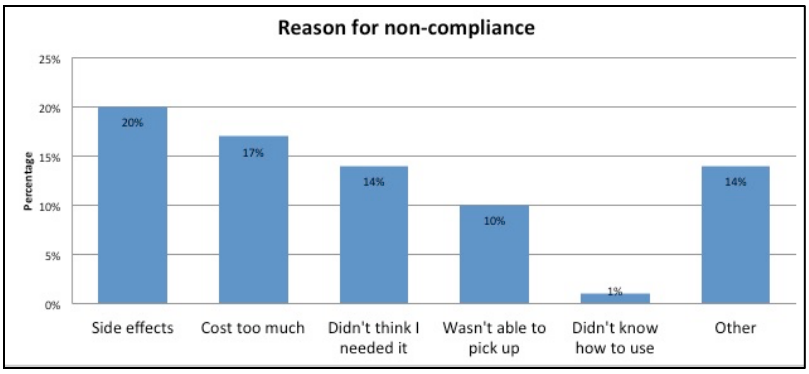


Figure 4: Reasons not to take medication

### *Psychological factors*
Some researchers found that women are less compliant than men in general (Roselund et al., 2004), while others found that women are more persistent in medication (obtain refills of a drug) and that men are more compliant (Neslin et al., 2008). In general no socio-demographic factors such as age, level of education or race are of large significant influence on non-adherence, however research has brought other factors to light that might affect this behaviour (WHO, 2003). One factor is the involvement of a patient in healthcare decisions. Roselund et al. (2004) described four types of patients with an increasing degree of involvement in health care processes: the accepting, the informed, the involved and the in control patients. The accepting patients rely entirely on doctors for information and decisions. The informed patients also rely on their doctors most of the time, but also do research after appointments to learn more about a diagnosis or prescribed treatment. Patients that see themselves as a partner of their doctor when making decisions are considered involved patients. The type of patients with the highest degree of involvement in the health care process are the in control patients. These patients typically believe that they know what's best considering their own health, and use information from various sources to diagnose their own conditions. Instead of asking for recommendations regarding treatments from their doctor, they determine themselves which treatments they will request. Involved and in control patients play the most active role in their own care, visit their doctors most often and take the highest number of prescription medications. However, counter intuitively, these patients are most likely to show intentional non-adhering behaviour. This knowledge can be extended with the findings of Camacho et al. (2014). In their research, customer-initiated informational empowerment, where customer and expert share solution-relevant information, reduced both unintentional and intentional non-adherence. However, decisional empowerment, where the expert leaves the final decision to the customer, led to the opposite: it increased both unintentional and intentional non-adherence. As women tend to fall in the in control category, this might explain why some researchers found an effect for gender on non-compliant behaviour.

### *Characteristics of the treatment*
Research has shown that not only characteristics of a patient, but also characteristics of the medication used can influence adherence. Branded drugs enjoy better compliance than generic variations, which can be caused by the fact that higher cost drugs usually enjoy more therapy and are related to more serious disease (Neslin et al., 2008). Patients that take oral pills tend to be more adhering than patients that take eye drops (Bangalore et al., 2008).

This could be explained by the ease of use of the medication, as confusion on how to take medication is mentioned as one of the main reasons for non-adherence.

### *Patient-provider relationship*

For many years it was assumed that non-compliance was caused by a failure of the patient. However, over the past two decades, literatures view on this has changed (Donovan & Blake, 1992). More attention has been drawn to the doctor-patient relationship and the way information is communicated towards the patient. Since then it has become clear that patient-provider relationships that are characterized by cultural competence, patient trust and shared decisions lead to higher adherence levels (IMS, 2013). Overall, continuous contact between patient and healthcare provider and frequent check-ups are proven to have a positive influence on patients' ability to stick to medication regimens (Brookhart et al., 2007).

## The competence hypothesis in non-compliance

### Decision-making in the presence of side effects

As found by Roselund et al. (2004), patients state that avoiding side effects is one of the main reasons to not take medication according to the prescription. The distinction between vague and clear events is actually present in this decision process, which opens the possibility to apply the competence hypothesis to this situation. This forms the main issue of this research.

Consider a patient with particular symptoms that can be treated with medication X. The decision process is described in figure 5.

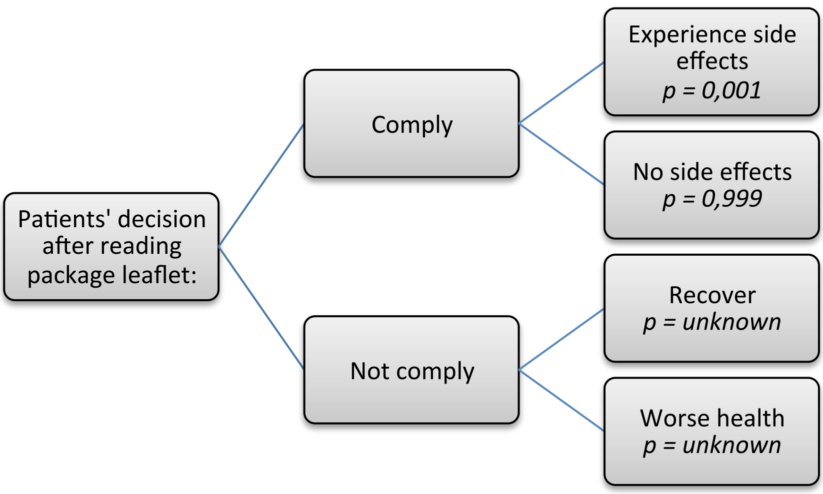


Figure 5: Decision process

Taking medication X can however cause adverse effects, with a certain probability that is stated on the package leaflet of the medicine. After acknowledging this, the patient can decide to comply with the treatment by taking medication X as recommended, or not to comply. In real-world situations, a patient could question the efficacy of the medication: there might be a possibility that the medication does not work. In this research, the efficacy of the medication is guaranteed to maintain a non-ambiguous choice option, leaving two possible outcomes when a patient decides to comply: recovery while experiencing a side effect and recovery without a side effect. The probabilities for these outcomes are according to the required information on the package leaflet (i.e. '1 in 1000 patients experience nausea after taking this medicine' translates to a probability of p=0,001 to experience nausea). However, when the patient decides not to comply, the outcome is ambiguous. Again, we assume two possible outcomes, but this time without a known probability. The patient does not know whether he will still recover without having taken medication X, or if he will get in worse health due to untreated symptoms.

The competence hypothesis suggests that when people feel more competent or knowledgeable about the context, they tend to choose the ambiguous situation more often. In the described situation, this feeling of competence would apply to one's personal state of health. A diminished feeling of competence regarding one's personal state of health would result in a less chosen ambiguous situation, thus a higher rate of compliance.

# Methodology

## Hypotheses

This section focuses on the research method that will be used to provide an answer to the question '*Does competence in an ambiguous situation affect compliance with medical treatment?*' The required data to answer this question is collected with the use of a questionnaire. This type of survey allows the researcher to collect data within a limited time period and to analyse the data with the use of statistical tests.

In order to test for the competence hypothesis, first a baseline in compliance rate needs to be measured. Varying the chance on experiencing a side effect when taking the medication, while maintaining the same symptoms and medical condition, can do this. When these chances are varied, a potential effect of the ambiguous situation might be brought to light. The first hypothesis is therefore:

> H1: *Participants choose to comply more often when the chance of recovery without a side effect when taking medication is large (0,999), than when this chance is small (0,75).*

To maintain a credible situation, a large chance of having a side effect is represented as 25%. A larger chance would not be realistic because of the permanent inspection by governmental health organisations on medication and side effects (IGZ, 2015).

As previous literature has shown, people tend to be ambiguity averse when the probability of winning is large (Ellsberg, 1961). Viscusi & Magat (1992) confirmed that a small probability of losing also results in ambiguity averse behaviour. In the decision process regarding medical non-compliance, patients' status quo is suffering from a medical condition. The option of 'winning' holds recovery without a side effect, which can be achieved by either not taking the medication but still recover or by taking the medication and not experiencing side effects. 'Losing' in this situation means recovering while experiencing the side effect of the prescribed medication. Theory would predict that people choose to comply more often when the chance of recovering while experiencing a side effect is small. On the contrary, research has shown that people tend to be ambiguity seeking when the probability of losing is high (Viscusi & Magat, 1992). A large chance of having a side effect from the medication would therefore lead to less people complying with their medical treatment, as no compliance represents the ambiguous option. However, the Savage axioms on subjective probabilities could explain the same outcomes. According to his theory, people attach subjective probabilities to uncertain events and make decisions in such a way that they maximize these subjective probabilities (Savage, 1954). If the first hypothesis is found to be true, this could mean that subjects attach a subjective probability somewhere between 0,75 and 0,999 to the uncertain event of recovering without needing medication. For example, if the attached subjective probability is 0,8 this implies that this person believes that the chance he/she will recover without using medication is 80%. In that case, it would make perfect sense to comply if the chance of recovering without a side effect is above this 80% (thus, 99,9%) and not to comply if the chance of recovering without a side effect is below this 80% (thus, 75%). This research design does not allow detangling the theory of ambiguity aversion and the theory of attached subjective probabilities from each other. Thus, if the first hypothesis appears to be true, besides setting a baseline in compliance rate this might also suggest that ambiguity plays a role in this decision, but it is no conclusive evidence.

The first hypothesis will be tested with a within-subject design: all subjects will answer a question where the chance of having a side effect is low, and a question where this chance is relatively high.

The competence hypothesis states that people who feel more knowledgeable and competent considering the context tend to choose the ambiguous situation more often than people who feel less competent. Applied to the decision to comply or not, this leads to the second hypothesis:

H2: *Participants with an enhanced feeling of competence will choose not to comply more often than to comply, compared to participants with a diminished feeling of competence.*

The second hypothesis will be tested with a between-subject design: one group will be primed with a feeling of competence, the other group will be primed with a diminished feeling of competence.

## Participants

This research is conducted with healthy subjects that were asked to imagine having a certain medical condition. As literature has shown that a lot of factors might influence compliance to medical treatment, selection of participants has been done as much at random as possible to avoid having to control for all of these factors. There were no exclusion criteria based on the characteristics of the participant.

Participants were invited through an online message on social media to participate in an online questionnaire, by clicking on a provided link. The subjects were made aware of the fact that all responses remained completely anonymous, as this might stimulate people to answer more truthfully.  A total of 108 subjects have participated in the survey.

## Survey

The data is collected over the course of a week between the 2nd and 9th of July 2015, with the use of a questionnaire created with the online service Qualtrics.

Each participant viewed a minimum of eight questions and a maximum of ten questions, as some questions where only relevant if the participant answered positive on the previous question. On average, participants used 6 minutes to complete the questionnaire.

The first page of the questionnaire contained information regarding the purpose of the study, an e-mail address to allow participants to ask questions regarding the survey and the statement that all responses remained anonymous. The second page emphasized the importance of reading the text introduction of each question thoroughly, as it would help the participant to answer the questions and imagine the situation better.

### *Measuring the baseline compliance rate*

The first question described symptoms of a medical condition: hay fever. The participants were asked to imagine suffering from these symptoms. Then, information regarding the chance of having side effects of the prescribed medication for hay fever was shown. In order to make a clear distinction between an ambiguous situation and a situation with clear chances, the possible outcomes for both complying and not complying were described. Participants were asked to state their willingness to comply by taking this medication as prescribed on a zero to ten-point scale, with zero representing 'non-compliant' and ten representing 'fully compliant'.

The next question was exactly the same as the first one, with the same medical condition and side effect. However, this question mentioned a different chance of risking the side effects of the medication: in the first question this proportion was 1 in 1000 patients ($p=0,001$), in the second question this was 250 in 1000 patients ($p=0,25$). To control for order effects, these two questions were randomized in order among participants: some participants started with the '1 in 1000'-question, while others started with the '250 in 1000'-question.

### *Diminished and enhanced feeling of competence*

The third question described the exact same medical condition, symptoms and side effects. However, as this question tested the second hypothesis between subjects, the questionnaire portal randomly assigned the participants to either the group of an enhanced feeling of competence, or a diminished feeling of competence.

The feeling of competence is determined by what people know, relatively to what can be known. Ones feeling of competence can be enhanced by general knowledge of familiarity

(Heath & Tversky, 1991). Therefore, the group that was primed with an enhanced feeling of competence regarding their state of health, was shown the following additional information:
*'You have a professional photo taken of you tomorrow. You have read some articles on hay fever and learned that people who have been living healthy for the past few weeks usually suffer only one day from hay fever. You know that you have been sleeping well, eating healthy and exercising regularly for the past few weeks.'*

On the contrary, ones feeling of competence can be diminished when they are aware of the existence of relevant information that is not accessible to them, especially if this information is available to others (Heath & Tversky, 1991). Therefore, the group that was primed with a diminished feeling of competence regarding their state of health, was shown the following additional information:

*'You have a professional photo taken of you tomorrow. Some people that suffer from hay fever recover within a day without medication. Others can have the symptoms for as long as 2 weeks. You do not know whether you're in the first group or in the latter. Your doctor is the only one that knows this, but he is on a vacation for 2 weeks.'*

These sections of text appeared bold in the questionnaire, to attract participants' attention and make sure they would read them. Both groups were informed that they had a professional picture taken of them the next day, to ensure they would feel pressured to make a decision. Subjects in both groups were again asked to state their willingness to comply on a scale from zero to ten. The next question asked the participants in both groups to rate their feeling of competence while making the decision in the previous question on a scale from one to five, with one representing the feeling of 'not competent' and five representing 'competent'.

### *History of compliant behaviour and demographics*

At this point in the questionnaire, each subject had answered three questions regarding compliance and one question regarding their feeling of competence while making the last decision to comply.

The next question, shown to all participants of the survey, asked whether they where prescribed medication in the past two years. If participants stated yes, they were asked to recall the last time they where prescribed medication and if they took the medication exactly according to the prescription. It participants stated they did not, a question was asked regarding the reason to not take the medication. To answer this question, participants had to choose the most important reason that affected their behaviour from a choice list. The answer options in this list were according to the self-stated reasons for non-compliance as found by Roselund et al. (2004). These options included: I did not want the side effects of the prescription, I did not think I needed the medication, I was not able to pick up my medication, I did not know how to use the medication, I forgot how to take my medication and 'other'. To control for order effects, the order of these reasons was randomized except for the 'other' option, which remained at the bottom of all options. These questions regarding the history of compliant behaviour of the participant is used to analyse the data in blocks.

If the respondents were not described any medication the past two years or took this medication exactly according to the prescription, they where directed to the last three questions. Participants were asked whether they ever had suffered from hay fever and to state their gender and age. These questions were asked at the end of the questionnaire to control for anchoring and to avoid unwittingly priming of the respondent.

The full questionnaire as used in this research is provided in Appendix 1 on page 42.

# Results

## Statistical analysis

The results of the conducted survey are analysed with the use of various statistical tests. Nonparametric tests are applied, as this type of tests requires far less assumptions from the data compared to parametric tests. Furthermore, nonparametric tests require a smaller sample size, can handle with variables measured in all scales and allow outliers to have less impact.

The Wilcoxon signed rank test is a within-subjects test that is used to compare two paired samples from the same population. This test is used to compare the difference in compliance rates between two questions that are answered by all participants, such as a comparison between the answers on question 1 and question 2. Furthermore, this test is also used to test the significance of the compliance or competence rate of a question in isolation. In order to do so, an artificial variable is created to act as a variable with exactly the median that is tested with the null hypothesis.

The Wilcoxon rank sum test, also known as the Mann Whitney U test, is a between-subjects test. This test is used to compare the answers to questions between two different samples. An example is the comparison between the median compliance rates of question 3a and question 3b. As participants were assigned to one of two treatment groups (enhanced competence or diminished competence), half of the participants filled in question 3a, while the other half filled in question 3b. The difference in median compliance and competence rates between these questions is analysed with the use of the Wilcoxon rank sum test.

Statistically seen, the Wilcoxon signed rank test and the Mann Whitney U test, test for the differences in medians, instead of a difference in the mean. This is because of the method that is used: all observations are ranked, after which a comparison is made between the sum of ranks of the two samples. The consequence of this method is that outliers have a larger impact than would be the case if means were compared. However, only extreme outliers could cause a median to deviate from the mean. An overview of the variables in this dataset shows that there are no such outliers present: all means are equal to the medians. Thus, these two tests remain suitable to test the effect of certain variables. In line with scientific practice (such as in Redelmeier et al., 1995), the comparison between two samples that is analysed with these tests is still referred to as a comparison of means (Stoop, 2015).

Besides hypothetical situations with an imaginary condition, the questionnaire also included questions on previous compliance with medication, reasons for previous non-compliance, experience with hay fever and demographics. The answers to these questions provide a way to divide the sample into two or more samples, based on the answer to these questions and thus specific characteristics of the participant. To some of these questions only a 'yes or no' answer was possible, resulting in two samples of participants based on their answer. The differences in mean compliance or competence rates between these samples are then analysed with the use of a Wilcoxon rank sum test. However, some questions provided participants with more than two answer possibilities to choose from, resulting in more than two samples. As the Wilcoxon rank sum statistic tests for the difference between two samples, this test is no longer suitable. To test if the medians of more than two different samples come from the same population, the Kruskal-Wallis test is used. An example is question 7, where participants that did not comply with previous medication are asked to state the most important reason to do so. To analyse this question further, a binomial test is used. This statistic tests the probability that participants chose their reason to not comply with previous medication at random, or deliberately chose their answer.

Another method to analyse the differences between two groups of participants (for instance 'had hay fever' versus 'has not had hay fever'), is a probit regression, in which compliance would be the dependent binary variable. One of the assumptions of this parametric test is no perfect collinearity, meaning that none of the variables is a constant and no variable has a perfect linear relationship with the dependent variable or another independent variable. Thus, a probit regression only works when there is sufficient variance in the data. This dataset does not contain sufficient variance to perform such a regression, as variables such as 'never had hay fever' and 'gender male' correlate too strong with the binary variable 'compliance'.

The Fisher exact test is used to test whether two independent samples such as males versus females are distributed over two classes: 'previously complied with medication' versus 'did not comply with previous medication'.

An overview of the means (medians), number of observations and p-values for all tests that are used to analyse the data can be found in Appendix 2 on page 47. In this chapter, p-values of statistical tests are mentioned between brackets. A significance level (α) of 10% is used, unless mentioned otherwise. All unfinished and incomplete questionnaires are deleted from the dataset, leaving 108 independent observations. The ten variables are constructed with the answers to the ten questions from the questionnaire.

## Hypothesis 1

*Participants choose to comply more often when the chance of recovery without a side effect when taking medication is large (0,999), than when this chance is small (0,75).*

The first hypothesis measures the compliance rate when confronted with two different chances on experiencing a side effect. In the first question of the questionnaire participants were asked to state their willingness to comply on a scale from 0 to 10 when the chance of having a side effect is small (1 in 1000 people). On this scale, a compliance rate below 5 implies non-compliance, while a compliance rate above 5 implies a willingness to comply. The mean compliance rate of question one is 8,35, which is significantly different from 5, what would be the average if participants chose at random (p=0,000).

In the second question of the questionnaire, participants were again asked to state their willingness to comply on a scale from 0 to 10. However, in this question the chance of having a side effect is relatively large: 250 in 1000 people experienced the side effect. The mean compliance rate of this question is 6,35, which implies that compliance is chosen more often than no compliance.  This average of 6,35 differs significantly from an average of 5, which would be the average is participants chose at random (p=0,000). The compliance rates in question 1 and 2 are shown in figure 6.

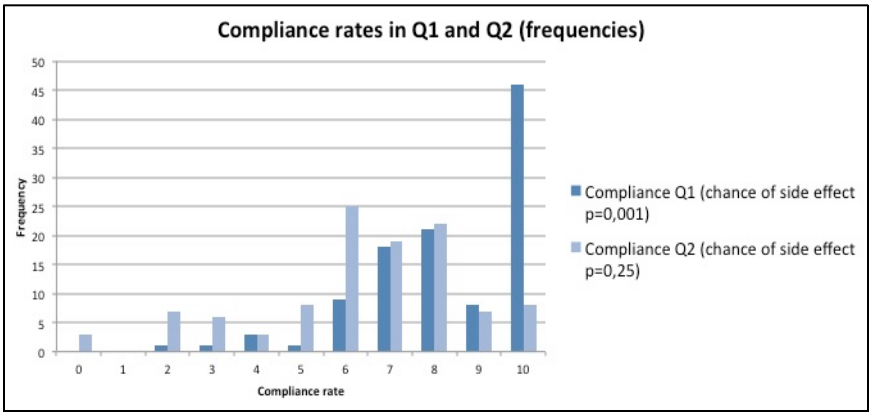


Figure 6: Compliance rates Q1 and Q2

The mean compliance rate of question 2 is below the mean compliance rate of question 1: respectively 6,35 and 8,35. This difference between compliance rates is significant (p=0,000). Thus, participants choose to comply significantly more in question 1 compared with question 2, confirming the first hypothesis. The difference in compliance rates between question 1 and 2 suggests that the presence of the ambiguous option plays a role. However, this cannot be interpreted as ambiguity averse or ambiguity seeking behaviour as these results can also be predicted by expected utility theory.

To conclude, the first hypothesis is confirmed.

## Hypothesis 2

*Participants with an enhanced feeling of competence will choose not to comply more often than to comply, compared to participants with a diminished feeling of competence.*

The participants of the survey were randomly assigned to one of two treatments: either the condition in which their feeling of competence regarding their state of health was enhanced, or the condition where this feeling was diminished. Then, participants were again asked to state their willingness to comply with the medical treatment. According to the competence hypothesis by Heath and Tversky (1991), the average compliance rate in the enhanced condition (question 3a) should be lower than the average compliance rate in the diminished condition (question 3b). The average compliance in question 3a is 7,2407, while the average compliance rate in question 3b is 7,8333. Both of these values differ significantly from 5 (p=0,000 for both values). This is according to the expectations from the theory, and thus according to the second hypothesis. The compliance rates in question 3a and 3b are shown in figure 7. However, when these two means are compared, they do not statistically differ from each other (p=0,6027). This implies that the second hypothesis is not true: participants in the enhanced condition do not comply less often than participants in the diminished condition.

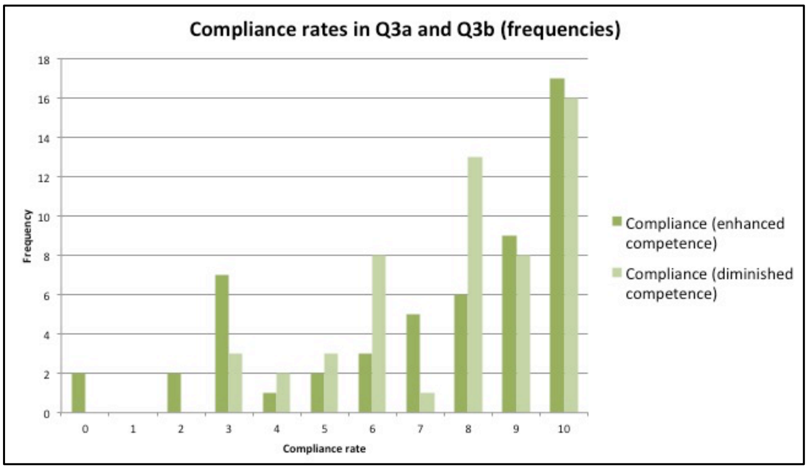


Figure 7: Compliance rates Q3a and Q3b

The chance of experiencing a side effect mentioned in both the enhanced and the diminished condition was the same as the one mentioned in question 1: 1 in 1000 people, thus 0,999. This allows for a comparison between the compliance rates among these three questions. The average compliance rate in question 1 is 8,35, while the compliance rates in the enhanced and the diminished condition are respectively 7,2407 and 7,8333. The average compliance rate differs significantly between question 1 and question 3a (enhanced condition, p=0,0157) but not between question 1 and question 3b (diminished condition, p=0,2981). Thus, participants in the enhanced condition report a significantly lower compliance rate in the enhanced condition, compared to the compliance rate in which no effort was made to influence ones feeling of competence. Assuming that participant's feeling of competence while answering question 1 is their 'true' feeling of competence, one might conclude according to the competence hypothesis that this feeling of competence was initially lower then when being primed with an enhanced feeling of competence. This can be concluded because of the expected decrease in compliance rate when one has an enhanced feeling of competence.

The fourth question of the questionnaire asked participants to state their feeling of competence on a scale from 1 to 5 while making the compliance decision in question 3. Participants in the enhanced condition rated their feeling of competence on average with 4,02, while participants in the diminished condition rated their feeling of competence with 3,87. Both values differ significantly from 3, which would be the average if participants choose their answer at random (p=0,000 for both values). While these values confirm our expectations, they do not statistically differ from each other (p=0,4317). The competence rates in question 4a and 4b are shown in figure 8. Participants that were primed to feel more competent while making their decision in question 3, did not feel significantly more competent than participants that where primed to feel less competent. This could partially explain the lack of significant difference in compliance rates in question 3: the differences in compliance rates in question 3 was supposed to be triggered by unequal feelings of competence among the two conditions, but there is no statistical dissimilarity among participants in such feeling.

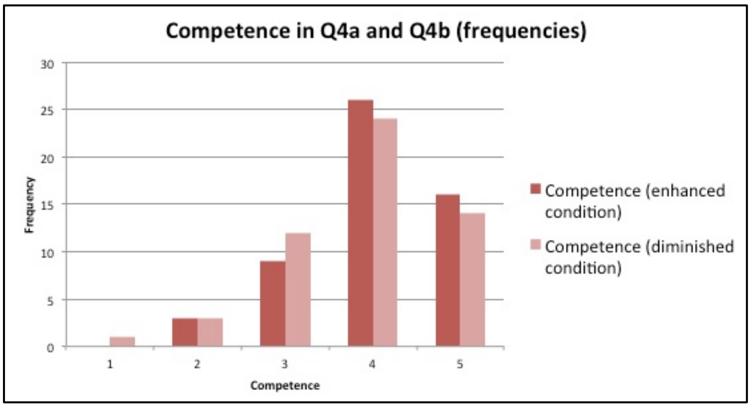


Figure 8: Competence rates Q4a and Q4b

To conclude, the second hypothesis could not be confirmed.

## Differences in samples based on characteristics

Average compliance and competence rates that do not differ significantly from each other are not mentioned, but the p-values of all performed statistical test are. An overview of the means, number of observations and p-values for these tests can be found in Appendix 2 on page 47.

### Participants that have been prescribed medication before

The fifth question of the questionnaire asked participants whether a doctor had prescribed them medication in the past two years. Participants could answer 'yes' or 'no'. When participants have been prescribed medication, they might answer different than those who have not. Participants with experience regarding prescribed medication might have an increased feeling of competence regarding medical decisions, comprehend the questions better and imagine the hypothetical situations more easily. Therefore, the sample of the complete survey is divided into two samples based on participants' answers to this question: 84 participants that stated 'yes', and a remaining 24 that stated 'no'. The compliance and competence rates in question 1 to 4 is then compared between these two samples. The average compliance rates for question 1, question 2 and the questions in the enhanced condition (3a and 4a) do not differ significantly between the two samples (p=0,4317 for Q1; p=0,1087 for Q2; p=0,1398 for Q3a; p=0,6543 for Q4a).

However, the average compliance and competence rates do differ significantly in question 3b and 4b (respectively figure 9 and 10), thus the diminished condition. On average, participants who have had prescriptive medication before have a compliance rate of 8,09, while people who have not had prescriptive medication before have an average compliance rate of 6,81 (p=0,0516). Participants who have had prescriptive medication have a mean competence rate of 4,04, while participants who have not been prescribed medication before have a mean competence rate of 3,18 (p=0,0098). If a significance level of 12,5% instead of 10% would be maintained, the differences in compliance rates in

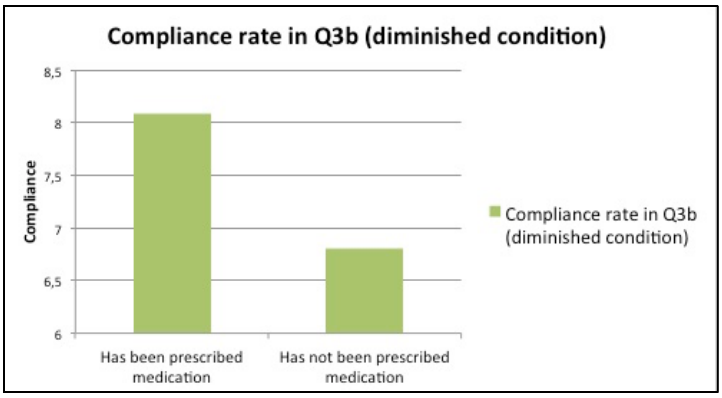


Figure 9: Differences in compliance rates in Q3b

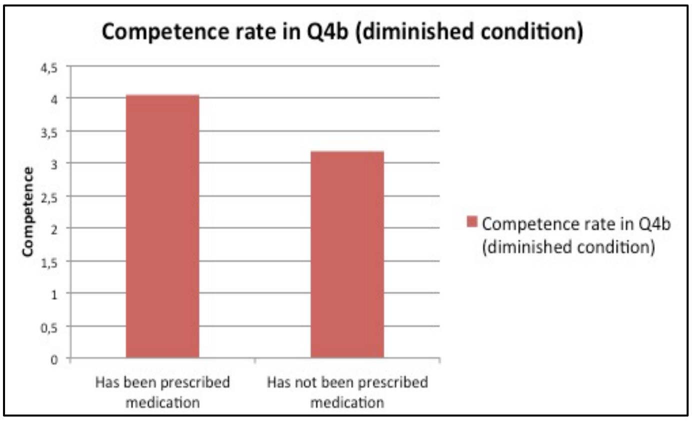


Figure 10: Differences in competence rates in Q4b

question 2 would be significant as well (p=0,1087). Participants that have had prescribed medication before have a mean compliance rate of 6,5119, while participants who have not had prescribed medication have a mean compliance rate of 5,7916. The definition of the p-value is that this sample result or a more extreme one will occur in p% of the cases if H0 is true. This implies that, if the null hypothesis of equal means between people who have had prescribed medication and people who have not is true, the two different means as found would occur in 10,87% of the cases. To conclude, when maintaining a significance level of 10%, people who have had prescriptive medication before have a higher average compliance rate and a higher average feeling of competence in the diminished condition, compared to participants who have not had prescriptive medication before.

### Compliance with previously prescribed medication

Participants that stated that a doctor had prescribed them medication in the past two years were directed to a follow-up question. This question asked participants whether they had been fully compliant with the previously prescribed medication. Subjects could answer 'yes' or 'no'. People who have been compliant before could tend to be more compliant in general, which would result in a higher average compliance rate for this group. Therefore, the survey is divided into two samples based on their answer to this question. From the 84 participants that stated that they had been prescribed medication in the past two years, 60 participants were fully compliant with their medication while the other 24 were not.

The competence rates in the diminished condition (Q4b) do differ significantly between people who have been compliant before and those who have not been (p=0,0768). Participants that complied with their previous medication have a mean competence rate of 4,18, while participants that were not compliant with their previous medication have a mean competence rate of 3,18. The average compliance and competence rates in questions 1 to 4a did not differ significantly between the two samples (p=0,6256 for Q1; p=0,5033 for Q2; p=0,8655 for Q3a, p=0,6209 for Q3b; p=0,8437 for Q4a). Thus, people who have been compliant with previous medication feel significantly more competent in the diminished condition, compared to participants that have not been compliant with previous medication.

### Reason for previous non-compliant behaviour

The 24 participants that stated that they had not been compliant with their previously prescribed medication were directed to a follow-up question regarding their reason to do so. Frequencies for each answer are visualized in figure 11 (next page). When participants would select their reason from the choice list at random, the expected proportion that would choose for each reason would be 4.

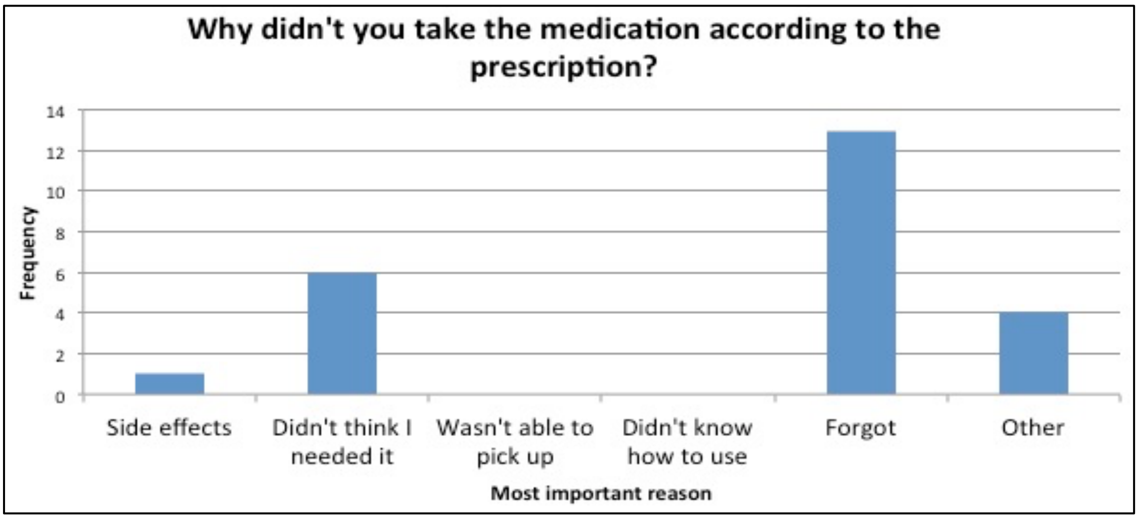


Figure 11: Reasons not to take medication

When tested individually whether the observed proportions per reason are significant (thus, significantly different from 4), the following results appear:

| Reason | Expected frequency | Observed frequency | P-value |
|---|---|---|---|
| **I did not want the side effects** | 4 | 1 | (p=0,1641) |
| **I did not think I needed the medication** | 4 | 6 | (p=0,2724) |
| **I was not able to pick up my prescription** | 4 | 0 | (p=0,0243) |
| **I did not know how to use the medication** | 4 | 0 | (p=0,0243) |
| **I forgot to take my medication** | 4 | 13 | (p=0,00003) |
| **Other** | 4 | 4 | (p=1) |
| **Total** | **24** | **24** | |

Table 1: Eexpected and observed frequencies

To conclude, the observed frequencies for the reasons 'wasn't able to pick up', 'didn't know how to use' and 'forgot' differ significantly from the expected frequencies. Most participants stated that they forgot to take their medication, which is in line with the findings from the World Health Organization (WHO, 2003).

These reasons also provide a means to divide the participants that have not complied with previous medication in 4 different samples (as two reasons were not chosen, those two samples hold zero observations). One could argue that participants with a certain reason to not comply might have different compliance or competence rates compared to participants with other reasons. The average compliance and competence rates in question 1 to question 4b do differ among the four samples. However, these differences are not significant on a

10% significance level (p=0,2147 for Q1, p=0,5274 for Q2, p=0,12 for Q3a, p=0,1490 for Q3b, p=0,4091 for Q4a and p=0,3910 for Q4b). As the sample size for each reason is low, these results are not entirely unexpected. The answers to question 3a do differ significantly among the reasons if the significance level is set at 12,5%.

| Stated reason for non-compliance | Average compliance rate Q3a (enhanced condition) | Number of observations |
|---|---|---|
| **I didn't want the side effects** | 9 | 1 |
| **I didn't think I needed the medication** | 6 | 3 |
| **I forgot to take my medication** | 9 | 3 |
| **Other** | 10 | 1 |

Table 2: Compliance rates per reason

With a p-value of 0,12, this would mean that the abovementioned results would occur in 12% of the cases if the median average compliance rates among all four samples (one for each reason) are all equal. In general, maintaining a significance level of 10%, participants with different reasons for their previous non-compliance behaviour do not give significantly different answers to the compliance and competence questions of the survey.

### Participants who ever had hay fever

In order to research the influence of ambiguous choice options in medical non-compliance, subjects are asked to imagine a hypothetical situation in which they suffer from a medical condition. In this survey, the medical condition 'hay fever' is chosen. Each participant has been given information on the symptoms of hay fever and asked to imagine suffering from such. However, participants that have suffered from their hay fever in real life, and maybe even had experience with prescription drugs to treat hay fever, might behave different from the participants that have not. Participants that have no experience with hay fever, might have trouble to imagine having this condition and thus behave different from hay fever patients. To compare these two types of participants to each other, the total sample of the survey is divided into two samples, based on the answers to question 8 ('Have you ever had hay fever?'). Of all participants, 41 have experience with hay fever, while 67 have not. We compare the average compliance rates of these samples to each other, and test whether the differences are significant. The compliance rates in question 1 and 2 are shown in figure 12 (next page). In the first question, participants were asked to state their willingness to comply if the chance of having a side effect was small: 1 in 1000 people experienced the side effect. People who have had hay fever before, had a mean compliance rate of 7,82, while people who did not have hay fever before had a mean compliance rate of 8,67. These averages differ significantly from each other (p=0,059). In the second question, participants' willingness to comply was measured when the chance of having a side effect was relatively large (250/1000). Participants that stated they had been suffering from hay fever before have a mean compliance rate of 5,92, while participants that have not had hay fever before have a mean compliance rate of 6,61. These averages do not differ significantly from each other on a 10% significance level, but do differ significantly when a significance level of 12,5% is maintained (p=0,1085). Though people with hay fever answered lower compliance rates throughout the whole questionnaire, the mean compliance and competence rates in question 3a to question 4b do not differ significantly from each other (p=0,3635 for Q3a, p=0,6005 for Q3b, p=0,674 for Q4a and p=0,2565 for Q4b). In conclusion, people who have experience with hay fever are less compliant in question 1, where there is a small chance of having a side effect, compared to people who have not.  If a significance level of 12,5% is maintained, participants who have experience with hay fever are also less compliant in question 2 (where there is a relatively large chance of having a side effect), compared to participants that have no experience with hay fever.

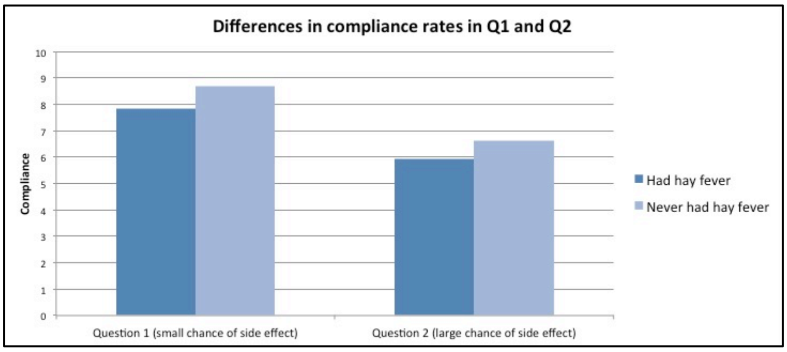

Figure 12: Differences in compliance rates in Q1 and Q2

## Gender

As the influence of gender on non-compliant behaviour is still debated within literature (Roselund et al., 2004; Neslin et al., 2008), it might be interesting to test for differences in compliance rates between these two groups. The total sample consists of 85 females and 23 males (figure 13). Testing for the differences in average compliance and competence rates yields no significant differences (p=0,2673 for Q1, p=0,5079 for Q2, p=0,2829 for Q3a, p=0,8196 for Q3b, p=0,6701 for Q4a and p=0,7582 for Q4b). According to Neslin et al., men are more compliant with medical treatment (Neslin et al., 2008). As all

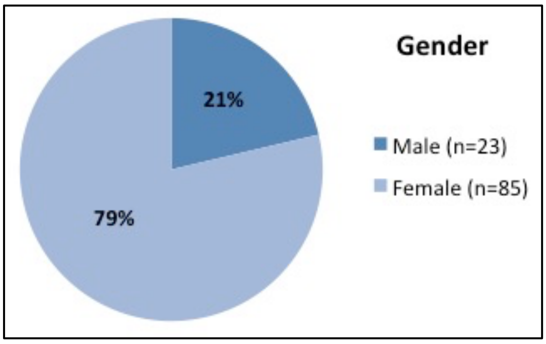

Figure 13: Gender among participants

participants answered whether they were fully compliant with previous prescribed medication, the answers to this question can be compared between males and females. In total 84 participants stated they had been prescribed medication in the past two years, of which 16 are male and 68 are female. Five males had not been compliant with this medication, the other eleven males had been. Within the 68 females, 19 had not been compliant with their previous medication, while 49 females were fully compliant with this medication. These differences in proportion are not significant (p=0,506). Within this sample, there are no differences found in both hypothetical compliance and competence rates and actual self-stated compliance rates between men and women. This is in line with findings from the World Health Organization (WHO, 2003).

### Age

According to the research of Han et al. on a measure of ambiguity aversion in medical tests and treatments, people of older ages tend to be more ambiguity averse than people of young age (Han et al., 2009). This could imply different compliance rates for older aged participants. The sample consists of 1 participant aged younger than eighteen, 103 participants between the age of eighteen and twenty-nine, 2 participants between the age of thirty and forty-nine and 2 participants aged 50 or older. When dividing the total sample in four samples, one for each age category, we can compare the average compliance and competence rates between ages. However, none of the differences are significant (p=0,5422 for Q1, p=0,2384 for Q2, p=0,8808 for Q3a, p=0,4831 for Q3b, p=0,9834 for Q4a and p=0,2671 for Q4b). Within this sample, there are no statistically significant differences in compliance and competence rates found between age categories. However, it is worthwhile mentioning that over 95% of the sample consisted of female participants.

# Conclusion

## Main findings

This study has researched the effects of the presence of an ambiguous choice option in medical non-compliance, by looking into the competence hypothesis. The decision to follow medical treatment in the presence of side effects displays a choice between a vague and a clear situation, and thus opens the opportunity to explore the influence of ambiguity in medical decision-making. The goal of this study was therefore to answer the research question '*Does competence in an ambiguous situation affect compliance with medical treatment?'*

The main finding of this research is that the competence hypothesis has no significant effect on the decision to comply or not to comply with medical treatment. People's willingness to comply did not decrease when primed with a short message with the purpose of enhancing ones the feeling of competence on personal health. Also, participants that were showed a short text that should diminish their feeling of competence did not show a higher compliance rate, resulting in a non-confirmed third hypothesis. The lack of difference in compliance rates between the two treatments is explained by the fact that there was no difference found in the self-rated competence levels between the two groups. The priming of the subjects was therefore of no effect.

The results from the survey suggest that ambiguity plays a role in the decision to comply with medical treatment, as compliance rates differ depending on the chances that a side effect might occur. People tend to choose the clear option of complying more often when chances of losing are low, and choose the clear option less often when chances of losing are relatively high. However, these results do not confirm ambiguity averse or ambiguity seeking behaviour, as these can also be explained with the use of Savage's subjective probabilities (Savage, 1954). Also, the chance on experiencing a side effect that is marked as relatively high in this research, is not large enough to reach a percentage of more than 50% that should evoke ambiguity seeking behaviour as found by Viscusi & Chesson (1999).

An interesting finding of this study is that in some cases, experience in real-life with prescribed medication increases both compliance and feeling of competence. Previous compliant participants with actual medication also felt more competent in the hypothetical situation, compared to participants that were not compliant with previous medication. The experience with medication and persisting with medication therefore seems to have a positive effect on willingness to comply and feelings of competence, which is also found in previous literature (Briesacher et al., 2008; Atkins & Fallowfield, 2006).

The answer to the research question is that the competence hypothesis does not affect the ambiguous situation in the decision to comply or not comply with medical treatment. Signs of a possible influence of ambiguous events on decisions emphasize the urge for more research on the competence hypothesis and the presence of ambiguous choice options in the health domain.

## Limitations

As with every scientific study, this research comes with some limitations. The first limitation is the priming of the participants, which had no significant effects within the research. Subjects were shown a short text message that should trigger either an enhanced or diminished feeling of competence regarding their personal state of health. However, subjects show no differences in feeling of competence, when the two treatment groups were compared to each other. In order to investigate a possible relationship between feelings of competence and compliance rates, a difference in feelings of competence is crucial. Priming might not be the best approach to create differences in these feelings. A better method would be to follow the procedure of Heath and Tversky (1991). In their original experiments regarding the competence hypothesis, participants were asked up front to rate their feeling of competence regarding a certain topic, after which this actual self-stated level was used to compare differences in preferences between low and high feelings of competence. This actual feeling of competence will be more reliable and valid in a research, compared to a primed feeling.

The second limitation concerns the size of the sample. The number of participants in this study is in line with previous experiments on ambiguity aversion and the competence hypothesis. However, some results are just short to being significant on a 10% significance level (for example, p=0,1085). A solution could be an increased number of participants. A larger sample could reveal whether these effects are not significant in general, or not significant in a small sample.

## Recommendations for future research

As literature mentions, ambiguity in the health domain is still relatively understudied (Han et al., 2009). This study explored one small aspect of ambiguity by focusing on the competence hypothesis and the presence of side effects. Although the gained insights shed more light onto the phenomenon, the findings also raise new questions.

Ambiguity aversion and ambiguity seeking behaviour could not be confirmed in this research design. However, the decision-making process of compliance in the presence of side effects lends itself to investigate such phenomenon. Such research should focus on a set-up like the experiments with business owners by Viscusi & Chesson (1999).

While the competence hypothesis had no significant effect in this research design, its influences on medical decision-making maintain an interesting hypothesis. To further investigate this, one could follow the original experiments of Heath & Tversky (1991). Besides asking participants for their feeling of competence regarding their personal state of health before starting the questionnaire (as mentioned in the section 'Limitations'), one could also copy the matched-chance lottery principle as used in the original experiments. This allows the researcher to make more robust conclusions on the competence hypothesis.

The experiment of this study is conducted with healthy subjects that were asked to imagine suffering from a medical condition, after which their willingness to comply in the hypothetical situation was asked. However, the external validity of the competence hypothesis in the medical domain might be increased when actual patients that are confronted with prescribed medication are used. Such applied work is valuable in order to bridge the gap between theory and real world.

# References

Atkins, L., & Fallowfield, L. (2006). Intentional and non-intentional non-adherence to medication amongst breast cancer patients. *European Journal of Cancer*, 42(14), 2271-2276.

Bangalore, S., Kamalakkannan, G., Parkar, S., & Messerli, F. H. (2007). Fixed-dose combinations improve medication compliance: a meta-analysis. *The American journal of medicine*, 120(8), 713-719.

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

Ben-Haim, Y. (2006). *Info-gap decision theory: decisions under severe uncertainty*. Academic Press.

Berger, L., Bleichrodt, H., & Eeckhoudt, L. (2013). Treatment decisions under ambiguity. *Journal of health economics*, *32*(3), 559-569.

Briesacher BA, Andrada SE, Fouayzi H, Chan Ka (2008). Comparison of drug adherence rates among patients with seven different medical conditions. *Pharmacotherapy*. 28(4): 437-443.

Brookhart, M. A., Patrick, A. R., Schneeweiss, S., Avorn, J., Dormuth, C., Shrank, W. & Solomon, D. H. (2007). Physician follow-up and provider continuity are associated with long-term medication adherence: a study of the dynamics of statin use. *Archives of internal medicine*, 167(8), 847-852.

Camacho, N., De Jong, M., & Stremersch, S. (2014). The effect of customer empowerment on adherence to expert advice. *International Journal of Research in Marketing*, 31(3), 293-308.

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

Coleman, T. (2011). Probability, Expected Utility, and the Ellsberg Paradox. *Available at SSRN 1770629*.

Donovan, J. L., & Blake, D. R. (1992). Patient non-compliance: deviance or reasoned decision-making? *Social science & medicine*, 34(5), 507-513.

Ellsberg, D. (1961). Risk, ambiguity, and the Savage axioms. *The quarterly journal of economics*, 643-669.

Fellner, W. (1961). Distortion of subjective probabilities as a reaction to uncertainty. *The Quarterly Journal of Economics*, 670-689.

Fox, C. R., & Tversky, A. (1995). Ambiguity aversion and comparative ignorance. *The quarterly journal of economics*, 585-603.

Grieco, D., & Hogarth, R. (2004). Excess entry, ambiguity seeking and competence: An experimental investigation, published by Università Bocconi, Milan.

Halpern, R., Becker, L., Iqbal, S. U., Kazis, L. E., Macarios, D., Badamgarav, E. (2011). The association of adherence to osteoporosis therapies with fracture, all-cause medical costs, and all-cause hospitalizations: A retrospective claims analysis of female health plan enrollees with osteoporosis. *Journal of Managed Care Pharmacy*, *17*(1), 25-39.

Han, P. K., Reeve, B. B., Moser, R. P., & Klein, W. M. (2009). Aversion to ambiguity regarding medical tests and treatments: measurement, prevalence, and relationship to sociodemographic factors. *Journal of health communication*, *14*(6), 556-572.

Haynes, R. B., McDonald, H., Garg, A. X., & Montague, P. (2002). Interventions for helping patients to follow prescriptions for medications. *The Cochrane Library*.

Health Prize (2014). Medication Non-Adherence: An Ancient Problem In Need of Modern Solutions, white paper retrieved from https://healthprize.com, visited on 27/02/2015.

Heath, C., & Tversky, A. (1991). Preference and belief: Ambiguity and competence in choice under uncertainty. *Journal of risk and uncertainty*, *4*(1), 5-28.

Ho, P. M., Bryson, C. L., & Rumsfeld, J. S. (2009). Medication adherence its importance in cardiovascular outcomes. *Circulation*, *119*(23), 3028-3035.

IGZ (2015) Medicatieveiligheid, retrieved from http://www.igz.nl/onderwerpen/curatieve-gezondheidszorg/medicatieveiligheid/, viewed at 12/06/2015.

IMS (2008) Reviving the Primary Care Market, retrieved from http://www.imshealth.com/deployedfiles/consulting/Global/Content/Our%20Latest%20Thinking/Static%20Files/InVivoArticle_Reviving%20the%20Primary%20Care%20Market.pdf, visited on 06/03/2015.

IMS (2013). Avoidable Costs in U.S. Healthcare, retrieved from http://www.imshealth.com/deployedfiles/imshealth/Global/Content/Corporate/IMS%20Institute/RUOM-2013/IHII_Responsible_Use_Medicines_2013.pdf, visited on 27/02/2015.

Kahn, B. E., & Sarin, R. K. (1988). Modeling ambiguity in decisions under uncertainty. *Journal of Consumer Research*, 265-272.

Klibanoff, P., Marinacci, M., & Mukerji, S. (2003). A smooth model of decision making under ambiguity. *Available at SSRN 395600*.

Knight, F. H. (1921). Risk, uncertainty and profit. *New York: Hart, Schaffner and Marx*.

McDermott, R. (2001). The psychological ideas of Amos Tversky and their relevance for political science. *Journal of Theoretical Politics*, *13*(1), 5-33.

Moore, E., & Eckel, C. (2003). Measuring ambiguity aversion. *Unpublished manuscript, Department of Economics, Virginia Tech*.

Neslin, S. A., Rhoads, E. E., & Wolfson, P. (2009). A model and empirical analysis of patient compliance and persistence in pharmaceuticals. Unpublished Manuscript, Tuck School of Business, Dartmouth College.

Redelmeier, D. A., Koehler, D. J., Liberman, V., & Tversky, A. (1995). Probability judgment in medicine discounting unspecified possibilities. *Medical Decision Making*, *15*(3), 227-230.

Roebuck, M. C., Liberman, J. N., Gemmill-Toyama, M., & Brennan, T. A. (2011). Medication adherence leads to lower health care use and costs despite increased drug spending. *Health Affairs*, *30*(1), 91-99.

Roselund, T., Lovich, D., Lubkeman, M., & Flanagan, A. (2004). Biopharmaceutical Marketing Excellence: Driving Business Results. *Journal of Medical Marketing: Device, Diagnostic and Pharmaceutical Marketing*, 4(3), 209-218.

Savage, Leonard J. (1954). *The Foundations of Statistics.* New York: Wiley.

Sifferlin, A. (2013) We're Living Longer – and Healthier, retrieved from http://healthland.time.com/2013/07/29/were-living-longer-and-healthier/ visited on 12/05/2015.

Sokol, M., McGuigan, K., Verbrugge, R., Epstein, R. S. (2005). Impact of medication adherence on hospitalization risk and healthcare cost. *Medical Care*, *43*(6), 521-530.

Solomon, M. D., & Majumdar, S. R. (2010). Primary non-adherence of medications: lifting the veil on prescription-filling behaviors. *Journal of general internal medicine*, *25*(4), 280-281.

Stoop, J. (2015) 'Statistical Tests in Experiments', *Lecture Experimental Economics*, Erasmus University Rotterdam, 26th of March 2015: sheet 38-45.

Viscusi, W. K., & Chesson, H. (1999). Hopes and fears: the conflicting effects of risk ambiguity. *Theory and Decision*, *47*(2), 157-184.

Viscusi, W. K., & Magat, W. A. (1992). Bayesian decisions with ambiguous belief aversion. *Journal of Risk and Uncertainty*, *5*(4), 371-387.

WHO (2003) Adherence to long-term therapies, retrieved from http://www.who.int/chp/knowledge/publications/adherence_full_report.pdf, visited on 24/02/2015.

## Appendix 1 - Questionnaire

**[Each black bar represents a next page in the questionnaire. Participants had to click an arrow below to continue to the next page.]**

Thank you for participating in this questionnaire.

This questionnaire is part of my survey for my master thesis Behavioural Economics at the Erasmus University. Participation is anonymous. The questionnaire is in English, however some words are also in Dutch between brackets. Example: (NL: Nederlands)

If you have any questions on this survey, please do not hesitate to e-mail me at 333036bo@student.eur.nl

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To answer the following questions, you are asked to imagine a hypothetical situation in which you are suffering from a medical condition. To help you imagine this situation, you are given some information at the beginning of each question. Please read this information carefully, as this will help you to imagine having the disease and answer the questions better.

Good luck!

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**[Question 1 – randomized order with question 2. For some participants this question appeared second.]**

Imagine you are suffering for several days from the following symptoms: sneezing, coughing, watering red eyes and a sore throat.

You visit your doctor, who concludes you are suffering from severe hay fever (NL: hooikoorts). The doctor then prescribes you medication X. This is a new drug that works in 100% of the cases of hay fever. You should take one pill each day over the course of two uninterrupted weeks.

You read the package leaflet, which contains the following information:

*'Taking medication X might cause adverse effects: one in 1000 people who took this medication experienced severe headache.'* (NL: stevige hoofdpijn)

You now have the choice to not take your medication (= not comply) or to fully take your medication as prescribed (= comply). If you decide not to take your medication there are two possible outcomes: either you will keep suffering from hay fever, or you will still recover without medication X. If you decide to comply there are also two possible outcomes: either you recover without the side effect, or you recover while having severe headaches. What would be your willingness to comply in this situation?

Not comply Comply

0 1 2 3 4 5 6 7 8 9 10

**[Question 2 – randomized in order with question 1. For some participants this question appeared first.]**

Imagine you are suffering for several days from the following symptoms: sneezing, coughing, watering red eyes and a sore throat.
You visit your doctor, who concludes you are suffering from severe hay fever (NL: hooikoorts). The doctor then prescribes you medication Y. This is a new drug that works in 100% of the cases of hay fever. You should take one pill each day over the course of two uninterrupted weeks.
You read the package leaflet, which contains the following information:

*'Taking medication Y might cause adverse effects: 250 in 1000 people who took this medication experienced severe headache.'* (NL: stevige hoofdpijn)

You now have the choice to not take your medication (= not comply) or to fully take your medication as prescribed (= comply). If you decide not to take your medication there are two possible outcomes: either you will keep suffering from hay fever, or you will still recover without medication Y. If you decide to comply there are also two possible outcomes: either you recover without the side effect, or you recover while having severe headaches. What would be your willingness to comply in this situation?

| Not comply | | | | | | | | | Comply | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**[Subjects were randomly assigned to one of the conditions: either the enhanced feeling of competence or the diminished feeling of competence. Both groups are asked to assess their feeling of competence on the next question page.]**

**[Question 3a - Enhanced feeling of competence]**

Imagine you are suffering for several days from the following symptoms: sneezing, coughing, watering red eyes and a sore throat.
You visit your doctor, who concludes you are suffering from severe hay fever (NL: hooikoorts). The doctor then prescribes you medication Z. This is a new drug that works in 100% of the cases of hay fever. You should take one pill each day over the course of two uninterrupted weeks.
You read the package leaflet, which contains the following information:

*'Taking medication Z might cause adverse effects: one in 1000 people who took this medication experienced severe headache.'* (NL: stevige hoofdpijn)

**You have a professional photo taken of you tomorrow. You have read some articles on hay fever and learned that people who have been living healthy for the past few weeks usually suffer only one day from hay fever. You know that you have been sleeping well, eating healthy and exercising regularly for the past few weeks.**

You now have the choice to not take your medication (= not comply) or to fully take your medication as prescribed (= comply). If you decide not to take your medication there are two possible outcomes: either you will keep suffering from hay fever, or you will still recover without medication Z. If you decide to comply there are also two possible outcomes: either you recover without the side effect, or you recover while having severe headaches. What would be your willingness to comply in this situation?

| Not comply | | | | | | | | | Comply | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

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**[Question 3b - Diminished feeling of competence]**

Imagine you are suffering for several days from the following symptoms: sneezing, coughing, watering red eyes and a sore throat.
You visit your doctor, who concludes you are suffering from severe hay fever (NL: hooikoorts). The doctor then prescribes you medication Z. This is a new drug that works in 100% of the cases of hay fever. You should take one pill each day over the course of two uninterrupted weeks.
You read the package leaflet, which contains the following information:

*'Taking medication Z might cause adverse effects: one in 1000 people who took this medication experienced severe headache.'* (NL: stevige hoofdpijn)

**You have a professional photo taken of you tomorrow. Some people that suffer from hay fever recover within a day without medication. Others can have the symptoms for as long as 2 weeks. You do not know whether you're in the first group or in the latter. Your doctor is the only one that knows this, but he is on a vacation for 2 weeks.**

You now have the choice to not take your medication (= not comply) or to fully take your medication as prescribed (= comply). If you decide not to take your medication there are two possible outcomes: either you will keep suffering from hay fever, or you will still recover without medication Z. If you decide to comply there are also two possible outcomes: either you recover without the side effect, or you recover while having severe headaches. What would be your willingness to comply in this situation?

| Not comply | | | | | | | | | Comply | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

---

**[Question 4 – viewed by all participants after question 3a or 3b]**

You just made a decision to comply or not comply with medication Z. How competent (NL: bekwaam) did you feel while making this decision?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Not competent | | | | Competent |

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**[Question 5 – viewed by all participants. If the answer was 'yes', participants were directed to question 6. If the answer was 'no', questions were skipped until demographics.]**

Has a doctor prescribed you medication in the past two years?

- Yes
- No

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**[Question 6 – if the answer was 'no', participants where directed to question 7. If the answer was 'yes', questions were skipped until demographics.]**

Recall the last time you were prescribed medication. Did you take the medication exactly according to the prescription?

- Yes
- No

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**[Question 7 – Answer options were randomized, except for 'other' option, which remained the bottom option.]**

Why didn't you take the medication according to the prescription? Choose the most important reason that affected your behaviour:

- I did not want the side effects of the prescription
- I did not think I needed the medication
- I was not able to pick up my prescription
- I did not know how to use the medication
- I forgot to take my medication
- Other

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**[Q8 – Q10 Demographics, viewed by all participants]**

Have you ever had hay fever?

- Yes
- No

What is your gender?

- Male
- Female

What is your age?

- Younger than 18
- Between 18 and 29 years
- Between 30 and 49 years
- 50 years or above

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Thank you for participating in the questionnaire.

## Appendix 2 – Statistical analysis

All numbers are rounded to four decimals. The Wilcoxon signed rank test and the Mann Whitney U test officially test for differences in the medians among samples. However, as this sample contains no outliers, all medians and means are equal ($\theta$=$\mu$). In line with scientific practice, the comparison between two samples that is measured with these tests is referred to as a comparison of means (Stoop, 2015).

### Hypothesis 1

Question 1: willingness to comply if chance of having a side effect is small (1 in 1000 people experienced a side effect)

| Variable (answer to question) | Test | Hypothesis | Number of observations | Observed value | P-value |
|---|---|---|---|---|---|
| **Q1** | Wilcoxon signed rank | H0: $\mu$=5<br>Ha: $\mu \neq 5$ | 108 | $\mu$=8,35 | P=0,000 |

Question 2: willingness to comply if chance of having a side effect is large (250 in 1000 people experienced a side effect)

| Variable (answer to question) | Test | Hypothesis | Number of observations | Observed value | P-value |
|---|---|---|---|---|---|
| **Q2** | Wilcoxon signed rank | H0: $\mu$=5<br>Ha: $\mu \neq 5$ | 108 | $\mu$=6,35 | P=0,000 |
| **Q1, Q2** | Wilcoxon signed rank | H0: $\mu_{Q1} = \mu_{Q2}$<br>Ha: $\mu_{Q1} \neq \mu_{Q2}$ | 108 | $\mu_{Q1}$=8,35<br>$\mu_{Q2}$=6,35 | P=0,000 |

### Hypothesis 2

Question 3a/3b: willingness to comply if in enhanced competence condition (Q3a) or diminished competence condition (Q3b)

Question 4a/4b: feeling of competence in enhanced competence condition (Q4a) or diminished competence condition (Q4b)

| Variable (answer to question) | Test | Hypothesis | Number of observations | Observed value | P-value |
|---|---|---|---|---|---|
| **Q3a** | Wilcoxon signed rank | H0: $\mu$=5<br>Ha: $\mu \neq 5$ | 54 | $\mu$=7,2407 | P=0,000 |
| **Q3b** | Wilcoxon signed rank | | 54 | $\mu$=7,8333 | P=0,000 |
| **Q3a & Q3b** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{Q3a} = \mu_{Q3b}$<br>Ha: $\mu_{Q3a} \neq \mu_{Q3b}$ | 54 (Q3a)<br>54 (Q3b) | $\mu_{Q3a}$=7,2407<br>$\mu_{Q3b}$=7,8333 | P=0,6027 |
| **Q1, Q3a** | Wilcoxon signed rank | H0: $\mu_{Q1} = \mu_{Q3a}$<br>Ha: $\mu_{Q1} \neq \mu_{Q3a}$ | 54 | $\mu_{Q1}$=8,35<br>$\mu_{Q3b}$=7,2407 | P=0,0157 |
| **Q1, Q3b** | Wilcoxon signed rank | H0: $\mu_{Q1} = \mu_{Q3b}$<br>Ha: $\mu_{Q1} \neq \mu_{Q3b}$ | 54 | $\mu_{Q1}$=8,35<br>$\mu_{Q3b}$=7,8333 | P=0,2981 |
| **Q4a** | Wilcoxon signed rank | H0: $\mu$=3<br>Ha: $\mu \neq 3$ | 54 | $\mu$=4,0185 | P=0,000 |

| | | | | | |
|---|---|---|---|---|---|
| **Q4b** | Wilcoxon signed rank | | 54 | μ=3,8703 | P=0,000 |
| **Q4a & Q4b** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{Q4a} = \mu_{Q4b}$ Ha: $\mu_{Q4a} \neq \mu_{Q4b}$ | 54 (Q4a) 54 (Q4b) | $\mu_{Q4a}$=4,0185 $\mu_{Q4b}$=3,8703 | P=0,4317 |

## Differences in samples based on characteristics

### Participants that have been prescribed medication before

Question 5: 'Has a doctor prescribed you medication in the past two years?' Answers: yes/no.

| Variable (answer to question) | Test | Hypothesis | Number of observations | Observed value | P-value |
|---|---|---|---|---|---|
| **Q1 & Q5** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 84 (yes) 24 (no) | $\mu_{yes}$ = 8,4523 $\mu_{no}$ = 8 | P=0,4317 |
| **Q2 & Q5** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 84 (yes) 24 (no) | $\mu_{yes}$ = 6,5119 $\mu_{no}$ = 5,7916 | P=0,1087 |
| **Q3a & Q5** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 41 (yes) 13 (no) | $\mu_{yes}$ = 7,5365 $\mu_{no}$ = 6,3076 | P=0,1398 |
| **Q3b & Q5** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 43 (yes) 11 (no) | $\mu_{yes}$ = 8,093 $\mu_{no}$ = 6,8181 | P=0,0516 |
| **Q4a & Q5** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 41 (yes) 13 (no) | $\mu_{yes}$ = 4 $\mu_{no}$ = 4,0769 | P=0,6543 |
| **Q4b & Q5** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 43 (yes) 11 (no) | $\mu_{yes}$ = 4,0465 $\mu_{no}$ = 3,1818 | P=0,0098 |

### Compliance with previously prescribed medication

Question 6: 'Recall the last time you were prescribed medication. Did you take the medication exactly according to the prescription?' Answers: yes/no.

| Variable (answer to question) | Test | Hypothesis | Number of observations | Observed value | P-value |
|---|---|---|---|---|---|
| **Q1 & Q6** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 60 (yes) 24 (no) | $\mu_{yes}$ = 8,55 $\mu_{no}$ = 8,2083 | P=0,6256 |
| **Q2 & Q6** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 60 (yes) 24 (no) | $\mu_{yes}$ = 6,6333 $\mu_{no}$ = 6,2083 | P=0,5033 |
| **Q3a & Q6** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 33 (yes) 8 (no) | $\mu_{yes}$ = 7,4242 $\mu_{no}$ = 8 | P=0,8655 |
| **Q3b & Q6** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 27 (yes) 16 (no) | $\mu_{yes}$ = 7,962 $\mu_{no}$ = 8,3125 | P=0,6209 |
| **Q4a & Q6** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 33 (yes) 8 (no) | $\mu_{yes}$ = 4 $\mu_{no}$ = 4 | P=0,8437 |
| **Q4b & Q6** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$ Ha: $\mu_{yes} \neq \mu_{no}$ | 27 (yes) 16 (no) | $\mu_{yes}$ = 4,1851 $\mu_{no}$ = 3,8125 | P=0,0768 |

### Reason for previous non-compliant behaviour

Question 7: 'Why didn't you take the medication according to the prescription? Choose the most important reason that affected your behaviour.' Answers: I did not want the side effects of the prescription, I did not think I needed the medication, I was not able to pick up my prescription, I did not know how to use the medication, I forgot to take my medication, Other.

| Variable (answer to question) | Test | Hypothesis | Expected frequency | Observed frequency | P-value |
|---|---|---|---|---|---|
| **Q7 (side effects)** | Binomial | H0: p = 1/6<br>Ha: p ≠ 1/6 | 4 | 1 | P=0,1641 |
| **Q7 (don't need medication)** | Binomial | H0: p = 1/6<br>Ha: p ≠ 1/6 | 4 | 6 | P=0,2724 |
| **Q7 (not able to pick up prescription)** | Binomial | H0: p = 1/6<br>Ha: p ≠ 1/6 | 4 | 0 | P=0,0243 |
| **Q7 (did not know how to use medication)** | Binomial | H0: p = 1/6<br>Ha: p ≠ 1/6 | 4 | 0 | P=0,0243 |
| **Q7 (forgot to take medication)** | Binomial | H0: p = 1/6<br>Ha: p ≠ 1/6 | 4 | 13 | P=0,00003 |
| **Q7 (other)** | Binomial | H0: p = 1/6<br>Ha: p ≠ 1/6 | 4 | 4 | P=1 |

| Variable (answer to question) | Test | Hypothesis | Number of observations | Observed value | P-value |
|---|---|---|---|---|---|
| **Q1 & Q7** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \ldots = \theta_6$<br>Ha: $\theta_1 \neq \theta_2 \neq \ldots \neq \theta_6$ | 1 (side effect)<br>6 (don't need)<br>0 (can't pick up)<br>0 (don't know how)<br>13 (forgot)<br>4 (other) | $\mu_{sideeffect}$ = 10<br>$\mu_{don'tneed}$ = 7,1666<br>$\mu_{forgot}$ = 8,769<br>$\mu_{other}$ = 7,5 | P=0,2147 |
| **Q2 & Q7** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \ldots = \theta_6$<br>Ha: $\theta_1 \neq \theta_2 \neq \ldots \neq \theta_6$ | 1 (side effect)<br>6 (don't need)<br>0 (can't pick up)<br>0 (don't know how)<br>13 (forgot)<br>4 (other) | $\mu_{sideeffect}$ = 8<br>$\mu_{don'tneed}$ = 6<br>$\mu_{forgot}$ = 6,3846<br>$\mu_{other}$ = 5,5 | P=0,5274 |
| **Q3a & Q7** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \ldots = \theta_6$<br>Ha: $\theta_1 \neq \theta_2 \neq \ldots \neq \theta_6$ | 1 (side effect)<br>3 (don't need)<br>0 (can't pick up)<br>0 (don't know how)<br>3 (forgot)<br>1 (other) | $\mu_{sideeffect}$ = 9<br>$\mu_{don'tneed}$ = 6<br>$\mu_{forgot}$ = 9<br>$\mu_{other}$ = 10 | P=0,12 |
| **Q3b & Q7** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \ldots = \theta_6$<br>Ha: $\theta_1 \neq \theta_2 \neq \ldots \neq \theta_6$ | 0 (side effect)<br>3 (don't need)<br>0 (can't pick up)<br>0 (don't know how)<br>10 (forgot)<br>3 (other) | $\mu_{don'tneed}$ = 6,6667<br>$\mu_{forgot}$ = 8,6<br>$\mu_{other}$ = 9 | P=0,149 |

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| **Q4a & Q7** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \ldots = \theta_6$<br>Ha: $\theta_1 \neq \theta_2 \neq \ldots \neq \theta_6$ | 1 (side effect)<br>3 (don't need)<br>0 (can't pick up)<br>0 (don't know how)<br>3 (forgot)<br>1 (other) | $\mu_{sideeffect} = 4$<br>$\mu_{don'tneed} = 3{,}3333$<br>$\mu_{forgot} = 4{,}6667$<br>$\mu_{other} = 4$ | P=0,4091 |
| **Q4b & Q7** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \ldots = \theta_6$<br>Ha: $\theta_1 \neq \theta_2 \neq \ldots \neq \theta_6$ | 0 (side effect)<br>3 (don't need)<br>0 (can't pick up)<br>0 (don't know how)<br>10 (forgot)<br>3 (other) | $\mu_{don'tneed} = 3{,}6667$<br>$\mu_{forgot} = 4$<br>$\mu_{other} = 3{,}333$ | P=0,3910 |

### Participants who ever had hay fever

Question 8: 'Have you ever had hay fever?' Answer: yes/no.

| Variable (answer to question) | Test | Hypothesis | Number of observations | Observed value | P-value |
|---|---|---|---|---|---|
| **Q1 & Q8** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$<br>Ha: $\mu_{yes} \neq \mu_{no}$ | 41 (yes)<br>67 (no) | $\mu_{yes} = 7{,}8292$<br>$\mu_{no} = 8{,}6716$ | P=0,0590 |
| **Q2 & Q8** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$<br>Ha: $\mu_{yes} \neq \mu_{no}$ | 41 (yes)<br>67 (no) | $\mu_{yes} = 5{,}9268$<br>$\mu_{no} = 6{,}6119$ | P=0,1085 |
| **Q3a & Q8** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$<br>Ha: $\mu_{yes} \neq \mu_{no}$ | 16 (yes)<br>38 (no) | $\mu_{yes} = 6{,}6875$<br>$\mu_{no} = 7{,}4736$ | P=0,3635 |
| **Q3b & Q8** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$<br>Ha: $\mu_{yes} \neq \mu_{no}$ | 25 (yes)<br>29 (no) | $\mu_{yes} = 7{,}48$<br>$\mu_{no} = 8{,}1379$ | P=0,6002 |
| **Q4a & Q8** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$<br>Ha: $\mu_{yes} \neq \mu_{no}$ | 16 (yes)<br>38 (no) | $\mu_{yes} = 4{,}125$<br>$\mu_{no} = 3{,}9736$ | P=0,6750 |
| **Q4b & Q8** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{yes} = \mu_{no}$<br>Ha: $\mu_{yes} \neq \mu_{no}$ | 25 (yes)<br>29 (no) | $\mu_{yes} = 4{,}04$<br>$\mu_{no} = 3{,}724$ | P=0,2565 |

### Gender

Question 9: 'What is your gender?' Answer: male/female.

| Variable (answer to question) | Test | Hypothesis | Number of observations | Observed value | P-value |
|---|---|---|---|---|---|
| **Q1 & Q9** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{male} = \mu_{female}$<br>Ha: $\mu_{male} \neq \mu_{female}$ | 23 (male)<br>85 (female) | $\mu_{male} = 8{,}5652$<br>$\mu_{female} = 8{,}2941$ | P=0,2673 |
| **Q2 & Q9** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{male} = \mu_{female}$<br>Ha: $\mu_{male} \neq \mu_{female}$ | 23 (male)<br>85 (female) | $\mu_{male} = 6{,}0869$<br>$\mu_{female} = 6{,}4235$ | P=0,5079 |
| **Q3a & Q9** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{male} = \mu_{female}$<br>Ha: $\mu_{male} \neq \mu_{female}$ | 13 (male)<br>41 (female) | $\mu_{male} = 6{,}3076$<br>$\mu_{female} = 7{,}5365$ | P=0,2829 |
| **Q3b & Q9** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{male} = \mu_{female}$<br>Ha: $\mu_{male} \neq \mu_{female}$ | 10 (male)<br>44 (female) | $\mu_{male} = 7{,}2$<br>$\mu_{female} = 7{,}9772$ | P=0,8196 |

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| **Q4a & Q9** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{male} = \mu_{female}$<br>Ha: $\mu_{male} \neq \mu_{female}$ | 13 (male)<br>41 (female) | $\mu_{male}$ = 4,1538<br>$\mu_{female}$ = 3,9756 | P=0,6701 |
| **Q4b & Q9** | Wilcoxon rank sum (Mann-Whitney U) | H0: $\mu_{male} = \mu_{female}$<br>Ha: $\mu_{male} \neq \mu_{female}$ | 10 (male)<br>44 (female) | $\mu_{male}$ = 4<br>$\mu_{female}$ = 3,8409 | P=0,7582 |

| Variable (answer to question) | Test | Hypothesis | Number of observations | Observed value | P-value |
|---|---|---|---|---|---|
| **Q6 & Q9** | Fisher exact test | H0: samples are evenly distributed over the two classes. Ha: samples differ in distribution. | 16 (male)<br>68 (female) | Males: 5 not compliant, 11 compliant<br>Females: 19 not compliant, 49 not compliant | P=0,506 |

### Age

Question 10: 'What is your age?' Answer: younger than 18, between 18 and 29 years, between 30 and 49 years, 50 years or above.

| Variable (answer to question) | Test | Hypothesis | Number of observations | Observed value | P-value |
|---|---|---|---|---|---|
| **Q1 & Q10** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \theta_3 = \theta_4$<br>Ha: $\theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4$ | 1 (<18 yrs)<br>103 (18-29 yrs)<br>2 (30-49 yrs)<br>2 (>50 yrs) | $\mu_{<18yrs}$ = 6<br>$\mu_{19\text{-}29yrs}$ = 8,3592<br>$\mu_{30\text{-}49yrs}$ = 9<br>$\mu_{>50yrs}$ = 8,5 | P=0,5422 |
| **Q2 & Q10** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \theta_3 = \theta_4$<br>Ha: $\theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4$ | 1 (<18 yrs)<br>103 (18-29 yrs)<br>2 (30-49 yrs)<br>2 (>50 yrs) | $\mu_{<18yrs}$ = 7<br>$\mu_{19\text{-}29yrs}$ = 6,4368<br>$\mu_{30\text{-}49yrs}$ = 2,5<br>$\mu_{>50yrs}$ = 5,5 | P=0,2384 |
| **Q3a & Q10** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \theta_3 = \theta_4$<br>Ha: $\theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4$ | 1 (<18 yrs)<br>52 (18-29 yrs)<br>0 (30-49 yrs)<br>1 (>50 yrs) | $\mu_{<18yrs}$ = 9<br>$\mu_{19\text{-}29yrs}$ = 7,173<br>$\mu_{>50yrs}$ = 9 | P=0,8808 |
| **Q3b & Q10** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \theta_3 = \theta_4$<br>Ha: $\theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4$ | 0 (<18 yrs)<br>51 (18-29 yrs)<br>2 (30-49 yrs)<br>1 (>50 yrs) | $\mu_{19\text{-}29yrs}$ = 7,7647<br>$\mu_{30\text{-}49yrs}$ = 9,5<br>$\mu_{>50yrs}$ = 8 | P=0,4831 |
| **Q4a & Q10** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \theta_3 = \theta_4$<br>Ha: $\theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4$ | 1 (<18 yrs)<br>52 (18-29 yrs)<br>0 (30-49 yrs)<br>1 (>50 yrs) | $\mu_{<18yrs}$ = 4<br>$\mu_{19\text{-}29yrs}$ = 4,0192<br>$\mu_{>50yrs}$ = 4 | P=0,9834 |
| **Q4b & Q10** | Kruskal-Wallis | H0: $\theta_1 = \theta_2 = \theta_3 = \theta_4$<br>Ha: $\theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4$ | 0 (<18 yrs)<br>51 (18-29 yrs)<br>2 (30-49 yrs)<br>1 (>50 yrs) | $\mu_{19\text{-}29yrs}$ = 3,8235<br>$\mu_{30\text{-}49yrs}$ = 4,5<br>$\mu_{>50yrs}$ = 5 | P=0,2671 |