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# Numbers do not add up! The pragmatic approach to the framing of medical treatments

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**Abstract**

The risky choice framing effect disclosed that presenting data in a loss scenario lead decision-makers towards risky choices. Conversely, a gain scenario prevents them from taking a risk. Framing effect robustness has been widely confirmed by psychological literature. However, the framing of medical treatments, based on McNeil et al. (1982) paradigm, raised both methodological doubts and contrasting evidence. Our research aimed to investigate the presence and the nature of the framing effect in the McNeil et al. (1982) paradigm. In particular, we thought that the obtained switch of preferences across frames was due to a misleading formulation of the data given in a negative cumulative frequency format. We conducted three studies: (1) we replicated McNeil et al.'s (1982) original study (N=150) with medicine (n=50), statistics (n=50) and lay (n=50) students; (2) we tested (N=180) our hypothesis by comparing a cumulative frequency format with an alternative version, namely a linear progression one; (3) we compared (N=430) the effect of different formats (cumulative frequency, linear progression and interval frequency) on choices. Our results showed that, while the framing effect is present when employing a cumulative frequency format, it disappears when using a linear progression one. Moreover, our results show that decision-makers better understand information when given in a linear progression and an interval frequency format. In the current paper, we argue that the way in which a problem is formulated plays a relevant role in the representation of the decisional task and the decision-making. Keywords: medical framing effect, reverse pattern of choice, understanding numerical information, pragmatic approach.

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# 1 Introduction

Providing patients with the opportunity of making "informed choices" is held to be a fundamental requirement to guarantee dignity, allow self-determination, and promote rational decision-making (Annas, 2017). However, this requirement is challenged in some specific conditions, as for decisions characterised by different risk. For instance, research has shown that medical choices are shaped by how decisional options are communicated and, in particular, that the way in which options are formulated may influence whether taking or not a risk (Edwards et al., 2001). Kahneman (1981) have shown how preferences between two options could be influenced by different formulations of logically equivalent choice situations. On the one hand, people are likely to prefer a risky option when the decisional problem is presented in a loss framework by expressing the outcome in terms of lost resources. On the other, they are likely to prefer a sure option when the decisional problem is presented in a gain framework by stating the results as gained items. This phenomenon is called a "framing effect" and it is traditionally considered as a cognitive bias (Kahneman & Tversky, 1984). Rationality should satisfy some elementary requirements of consistency and coherence that are argued to be systematically violated in one classical framing effect problem, called "Asian Disease" problem (Tversky & Kahneman, 1981). Framing effects have been examined in a variety of studies, and their general robustness has been acknowledged by literature. However, profound differences have been observed among different research designs and domains (Gambara & Piñon, 2005), such as differences involving the presence of a risky alternative, the nature of the task and participants' characteristics (Kühberger, 1998). This is why many authors pointed out the need to understand the circumstances where a given framing effect takes place (Gambara & Piñon, 2005; Kühberger, 1998).

One of the areas that has seemed to be particularly critical is medical decision-making (Gong et al., 2013). Compared with the classical gain/loss framing effects, a reverse pattern of choice has been found in the specific case of the framing of medical treatments (Gong et al., 2013): preferences toward risk are elicited by a positive frame rather than a negative one. For instance, research on choices between different medical treatments — such as surgery over radiation therapy — showed that treatments involving risk (i.e., surgery) are more preferred when therapies' outcomes are described in terms of saved lives. Conversely, the support for the risky option decreases when the therapies' outcomes are described in terms of lost lives (Almashat et al., 2008; McNeil et al., 1982). This is not the case of other medical frameworks, such as drug ratings or preventive behaviour, where preferences align with the classical framing effect.

To clarify the nature of this reverse pattern, we conducted our research on the framing of medical treatments and we focused on the contingencies associated with this particular choice, such as the formulation of the decision problem. In a paradigmatic study, McNeil and colleagues (1982) tested a framing effect by asking participants to choose between two alternative therapies (surgery or radiation) based on their possible consequences in the case of a specific medical problem, an operable lung cancer. Half of the participants



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were assigned to a survival frame (i.e., positive), where outcomes were presented in terms of frequency of survival, whereas the other half was assigned to a mortality frame (i.e., negative), where outcomes were presented in terms of frequency of dying:

> Mortality frame. Of 100 people having surgery, 10 will die during treatment, 32 will have died by one year and 66 will have died by five years. Of 100 people having radiation therapy, none will die during treatment, 23 will die by one year and 78 will die by five years. Which treatment do you prefer?
>
> Survival frame. Of 100 people having surgery, 90 will survive during treatment, 68 will have survived by one year and 34 will have survived by five years. Of 100 people having radiation therapy, all will survive during treatment, 77 will have survived by one year and 22 will have survived by five years. Which treatment do you prefer?

Overall, people preferred surgery, but consistently with researchers' hypothesis, they showed a biased decision trend, choosing surgery less frequently within the mortality frame — 10 will die — (58%) than within the survival frame — 90 will survive — (75%). McNeil and colleagues (1982) interpreted the risk of perioperative death as the most salient disadvantage of surgery compared to radiation therapy. Therefore, they concluded that the perception of perioperative risk could be influenced by the numerical difference perceived across the expression of mortality rates (0% for the radiant — 10% for the surgical) and the survival rates (100% for the radiant — 90% for the surgical). According to the authors, the difference between 0% — 10% is psychologically greater than in the one between 100% — 90%. As a consequence of the different perceptions of perioperative mortality between the two frames, participants choose the surgical alternative in the survival frame more often than in the mortality one. By considering the risky option as the one with the highest perioperative risk (i.e., surgery), these results have been interpreted as a reverse pattern of preferences compared to the classical framing effect (Tversky & Kahneman, 1981): the risk-seeking option is preferred within the positive frame (i.e., survival), whereas the risk-averse option is preferred within the negative frame (i.e., mortality) (Gong et al., 2013; Levin et al., 1998; Jefferies-Sewell, 2015).

Few published studies (Almashat et al., 2008) and unpublished dissertations (Stoner, 2007, Tengs, 1987) have thoroughly replicated McNeil et al.'s (1982) research paradigm. On the one hand, they replicated McNeil's results by finding a framing effect in a cumulative frequency format, where therapies' outcomes are given in terms of the cumulative number of people who have died/survived up to a specific time. For instance, by saying "10 will die during treatment, 32 will have died by one year", the 32 is cumulative since it includes the 10 that died during the treatment. On the other, they found contrasting evidence by adding an interval frequency scenario, where therapies outcomes are given in terms of the absolute number of people who died/survived within a specific time interval (e.g., "10 patients die by the end of the treatment, 22 patients die in the interval between the treatment and 1 year").



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While Almashat et al. (2008) found a framing effect by using intervals, Tengs (1987) did not. However, the different sample sizes and procedures of these studies may account for this contradiction.[1]

To clarify the nature of the framing effect in clinical reasoning and, in particular, to understand the presence of the reverse pattern of choice, we asked whether a pragmatic approach could help to explain the results (Grice, 1975; Sperber & Wilson, 1995). The pragmatic approach is characterised by taking into account the effect of the communicative intent on reasoning, decision making, and problem-solving (Bagassi & Macchi, 2016; Hilton, 1995; Macchi & Bagassi, 2012, 2015; Sher & McKenzie, 2006; Sperber, Cara & Girotto, 1995). Its core assumption is that people's representation of problems stems from what the text of the considered problems communicates: not limited to what is literally said but also to what is implied and then effectively communicated (i.e., conversational implicatures). Indeed, communication should allow an adequate perception of risk to promote informed decision-making, which is crucial in the medical context. This is particularly relevant in the lay understanding of statistical and probabilistic data; which laypeople are able to understand only in case of adequate communication (Koehler & Macchi, 2004; Mosconi, 2016). In other words, the transmission of objective information is a necessary but insufficient condition in decision-making tasks, since if speakers (e.g., a physician, a policy-maker, or experimenters) do not respect the requirements of natural language, their communication may lead to an erroneous representation of the problem and, therefore, to a misleading interpretation (Bagassi & Macchi, 2006).

A pragmatic analysis of McNeil's (1982) texts led us to formulate an alternative hypothesis. We assume that the shift in the preference between the two conditions (from the surgical option to the radiation therapy) stems from the formulation of the decisional problem. By analysing the options employed in the problem, we speculated that their formulation misleads participants to consider the numerical information. As a consequence, they commit errors due to a misperception of the therapies' outcome. In particular, the negative version (i.e., loss scenario) interrupts the logical equivalence between the two frames.

According to Grice (1975), conversational implicatures — namely the implicit part of an utterance — contribute to the way in which we understand a communication. In particular, people's understanding is led by the psychological expectation that the information received through communication is neither redundant (Maxim of Quantity) nor irrelevant (Maxim of Relation). For instance, in McNeil and colleagues' cumulative format, people may consider the progression of numbers as adding new numerical information, as relevant to each specified period. In this case, participants may have the conversational expectation that to the ten who died during the treatment, the ones who died within one and five years should be added. Using the future perfect "32 will have died" instead of the simple future

[1]Almshat et al. (2008) tested the framing effect in the control condition (within-subject design, n=54) of a study aimed at debiasing choices; Tengs (1987) tested the framing effect in two experiments employing a within-subject design. Experiment 1 involved unidentified treatments (n=123), Experiments 2 involved identified treatments (n=68).



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"10 will die" should have helped in understanding the cumulative progression (32 includes the 10 who already died at the beginning). However, we suspect that it was not enough to contrast the expectation of newly added information (new 22 deaths within one year, new 34 deaths within five years). Regarding the positive frame, the expression of outcomes as "90 will survive during treatment, 68 (of these) will have survived within one year. . . " it is a nested formulation that could resolve every ambiguity. It allows the speaker to add new information about the subsets which are still alive after one year and after five years.

We assume that participants show a tendency to add numerical information sequentially in the negative frame. This led them to calculate sequences of numbers in a linear progression (e.g., 10+32+66 vs. 0+23+78) instead of cumulatively (e.g.,10 included in 32 and 32 included in 66 or 23 included in 78). Therefore, we suppose that — in the mortality frame — participants erroneously calculate the total number of deaths, and as a result, decide based on two alternatives (surgical and radiant therapy) whose consequences are misunderstood. Consequently, our hypothesis is that therapies' outcomes would be easily understood if Grice's maxims of quantity and relevance are respected. This can be done by employing a linear progression format, where therapies outcomes are given in terms of disentagled — instead of cumulative — numbers. By changing format, people may easily add numbers without misunderstanding the overall number of deaths in the mortality scenario (e.g., 10+22+34=66 instead of 10+32+66=108).

For what concerns both Tengs' (1987) and Almashat's (2008) interval frequency versions, we did not find any pragmatic issue. Therefore, according to our analysis, the interval frequency format should — as well as the linear progression format — not be a misleading way of conveying numerical data.

The present research has three aims: (1) to replicate McNeil's (1982) original study within three samples which are selected along different degrees of statistical and medical expertise (i.e., students in medicine and statistics, and lay-people); (2) to test the framing effect in linear progression format; (3) to compare the effects that cumulative frequencies, linear progression, and an interval frequency format have on preferences[2] (Almashat et al., 2008; Tengs, 1987). This latter allows to clarify participants' reasons behind choices and to assess the pragmatic adequacy of the different formats.

# 2 Study 1

The study aims to test McNeil's et al. (1982) results about the presence of a framing effect in a medical paradigm. We replicated the original paradigm of McNeil and colleagues (1982) expecting to find the same results, namely a greater preference for the surgical over the radiation therapy in a survival frame than in a mortality one. In addition, we asked participants to explain their choice, and we checked their comprehension of the data according to our theoretical perspective.

[2]Study 3 has been conducted by following the reviewers' suggestions.



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## 2.1 Method

We recruited 150 college students from the University of Milano-Bicocca ($M_{Age}$ =22.67, SD=2.26; F=77, M=73; 50 medicine students, 50 statistics students, and 50 lay participants from different departments). Every participant was asked to read the problem describing the outcome related to two different therapies to treat lung cancer. Participants of each group were randomly assigned to one of two possible versions of this description. The first version presented the results in terms of life saved (survival frame) and the second version presenting the same results in terms of life lost (mortality frame). We employed McNeil and colleagues' (1982) original vignettes (see the introduction). At this point, participants had to choose between the two alternatives, given the fact that the life quality would be the same in both conditions. After these descriptions, participants were asked to decide between the alternatives and, afterwards, they were asked to explain their choice stating which one of the two options could have led to a higher number of deceased patients. All the spontaneous comments that participants gave during the task were recorded. (Italian versions of the materials are here.)

## 2.2 Results

Presenting results in a survival frame induced a preference for the surgical therapy over the radiation option in 81.3% of the participants, while a mortality frame induced its preference decrease to 20.0% of the participants (Figure 1, top left). A chi-square (2X2) was performed to test independence between frame (survival vs. mortality) and choice (radiant vs. surgical) on different groups (meds, stats, and lay; Figure 1). The results we observed confirm the original results and show an even bigger effect than the original study (McNeil et. al, 1982). Overall, choice and frame appeared to be significantly related. In other words, a different pattern of preferences (radiant vs. surgical) was observed between the two frames (survival vs. mortality), [$\chi^2$(1,N=150)=56.437; p<0.01, Phi=.613; C=.523].

Moreover, the dependency of choice on frames was observed to be significant within each group: statistics students [$\chi^2$(1, N=50)=27.000; p<0.01, Phi=.735; C=.592], medicine students [$\chi^2$(1,N=50)=13.607; p<0.01, Phi=.522; C=.463], and lay people [$\chi^2$(1,N=50)=18.116; p<0.01, Phi=.602; C=.516]. The lack of difference among the three considered groups, since each showed a significant difference of preferences across frames (Figure 1b), confirms the presence of a framing effect and further corroborates the original results. Hence, we can support the hypothesis that medicine and statistics students, supposed to have a higher competence dealing with this kind of choice, are influenced by the same bias as lay participants when facing a medical decision. In line with our hypothesis, we observed that several participants expressed doubts about their understandings of the data, influencing their decisional process. As a result of a pragmatic analysis of the decisional problem, we speculate that the formulation could have induced participants to wrongly consider the numerical information and commit errors due to a misperception of the therapies' outcomes. This seems to be



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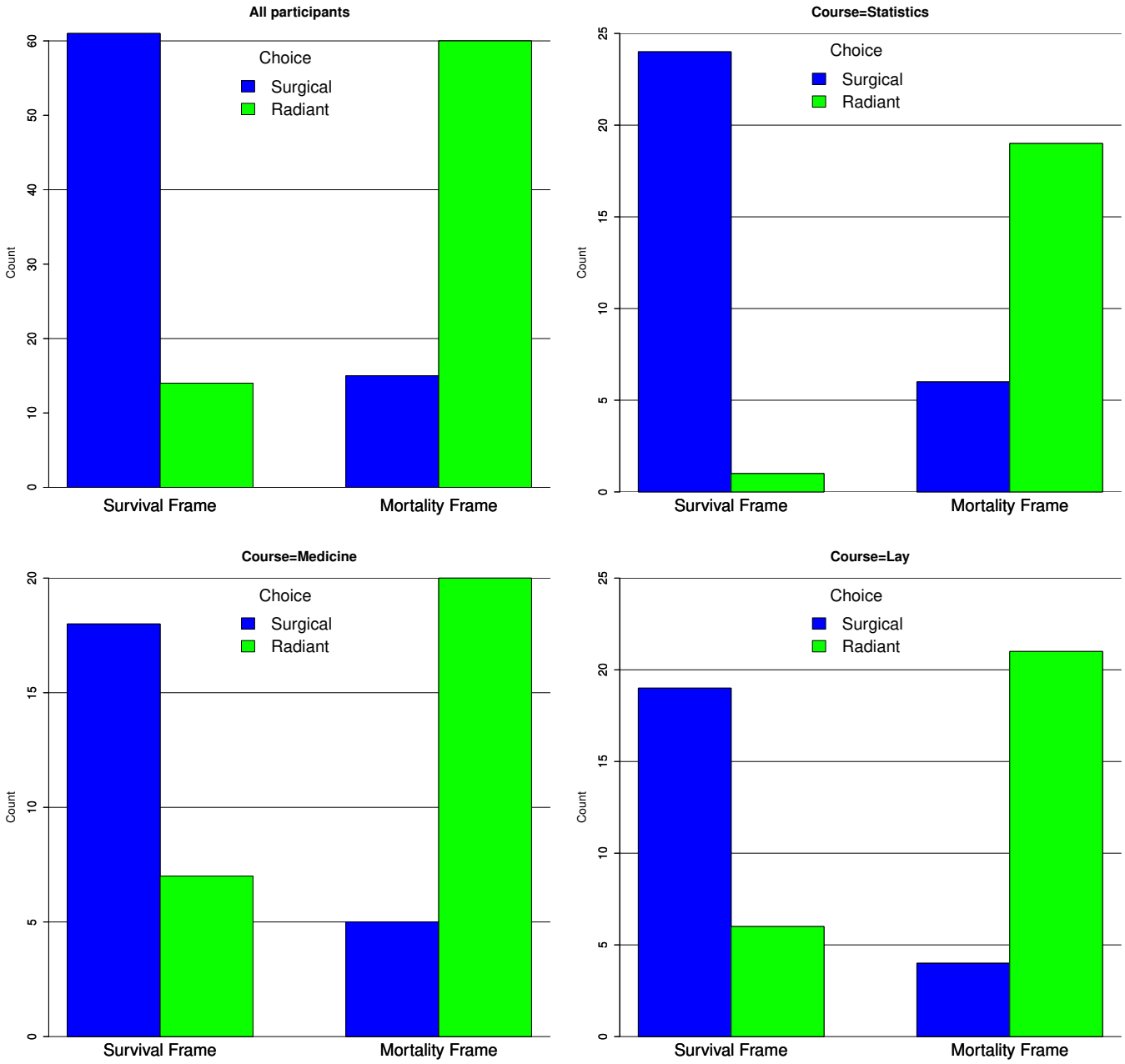


FIGURE 1: Frequencies of preferences (surgical vs. radiant) across frames (survival vs. mortality), for all participants and within each group: statistics students (50), medicine students (50), and lay people (50).

the case of the mortality frame, in which most of the participants reported that something was wrong with the math. Some of them were worried by the fact that the total of the cases reported, in the surgical option, exceeded the starting pool of patients (100) and, for this reason, believed radiation therapy to be the best alternative because of a lower rate of casualties after five years: "I would choose radiant therapy. Even though the result is more than 100. Then, 66+32 makes 98, +10 makes 108 and under 78+23 makes 101. If people



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are 100 cannot be that way". The negative version causes participants to misjudge radiation therapy as a better alternative, over the long term, than surgical: "I choose radiation therapy because statistically the surgical therapy is too dangerous and, therefore, I do not consider it as appropriate. I think surgical therapy is the one that makes the highest number of deaths. I did a simple sum, and I would still prefer the radiant because at least the patients do not die during the therapy" (mortality frame participants' reports).

# 3 Study 2

The results of the Study 1 confirmed the evidence found in McNeil and colleagues (1982). We formulated an alternative hypothesis on the nature of these results since we assume that the shift in the preference between the two conditions (from the surgical option to the radiation therapy in the mortality frame) could be due to the formulation of the decision problem. For this reason, we think that when participants are able to understand the information correctly, they will not have a systematic choice shift across frames. Hence, the aim of this second study is to test the effect of what we believe to be a pragmatically felicitous presentation of the information, namely a communication that respects the conversational maxims. Giving therapies' outcomes in terms of a linear progression would allow participant to form a correct representation of the problem. Therefore, by re-establishing the correct understanding of the options, we will be able to explore whether the pattern of preferences will still be a framing effect. Our hypothesis claims that this will disappear.

## 3.1 Method

We recruited 180 college students from the University of Milano-Bicocca ($M_{Age}$ =23.04, SD=2.77; F=88; M=92). Participants were randomly assigned to one of the two conditions: a control condition, in which the problem was presented in a cumulative frequency format (McNeil et al.,1982), and an experimental condition, in which the problem was presented in a linear progression format. Each participant was asked to read a text describing the outcome of two different treatments, here an example of our linear progression format:

> Mortality frame. Of 100 people having surgery, 10 will die during treatment, 22 more will have died by one year and 34 more will have died by five years. Of 100 people having radiation therapy, 0 will die during treatment, 23 will have died by one year and 55 more will have died by five years. Which treatment do you prefer?
>
> Survival frame. Of 100 people having surgery, 90 will survive during treatment, 68 of these will have survived by one year and 34 of these will have survived by five years. Of 100 people having radiation therapy, 100 will survive during treatment, 77 of these will have survived by one year and 22 of these will have survived by five years. Which treatment do you prefer?



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Participants of each group were randomly assigned to one of two possible versions of this description. The first version presented the results in terms of life lost (mortality frame) and the second version presenting the same results in terms of life saved (survival frame). In the mortality frame, instead of saying "10 will die during the treatment, 32 will have died after one year" we communicated data by following the linear progression suggested by discourse "10 will die during the treatment, 22 more will die after one year". Numbers were changed to make their sum 66 for the surgical therapy (10+22+34) and 78 for the radiant therapy (0+23+55) after five years. This allowed to avoid any confusion over the numerical representation of the problem.

In the survival frame, we managed to highlight the nested nature of data, even though the original formulation was not misleading nor ambiguous. At this point participants had to choose between the two alternatives, after having specified that the life quality would be the same in both conditions. Afterwards, they were asked to explain their choice and to state which of the two options they thought brought to a higher number of patients lost. As we did in the first study, we used a voice recorder to collect spontaneous comments during the task.

## 3.2 Results

A chi-square (2X2) was performed to test independence between frame (survival vs. mortality) and choice (radiant vs. surgical) on different conditions (cumulative vs. linear progression). For what concerns the cumulative frequency condition, we observed that choice and frame appeared to be significantly related. Again, a different pattern of preferences (radiant vs. surgical) was observed between the two frames (survival vs. mortality), [$\chi^2$(1,N=90)=16.335; p<0.01, Phi=.426; C=.392]. Presenting results in a survival frame induced a preference for the surgical therapy over the radiation option in 64.4% of the participants, while a mortality frame induced its preference decrease to 22.2% of the participants (Figure 2, left).

Conversely, in the linear progression condition, choice was observed to be independent on frames [$\chi^2$(1,N=90)=0.055; p>0.05, Phi=.025; C=.025]. The lack of difference of preference between frames (Figure 2, right), confirms the absence of a reverse pattern of choices. These results support our hypothesis since, by having re-established options' correct understanding, we found decisional coherence across frames. While the original formulation of the data interrupts the equivalence requirement across frames, the new formulation did not. As a consequence, the reverse pattern of choices disappears. When presenting text versions that are adequate in a pragmatic perspective, no significant differences arise between the two frames. Indeed, both participants of survival (73.3%) and mortality (71.1%) frames prefer surgical therapy over radiation. Unlike the cumulative frequency version, participants in the linear progression version showed no difficulty in understanding the calculations necessary to correctly understand the presented data. This evidence supports our interpretation, namely that the observed framing effect may be the



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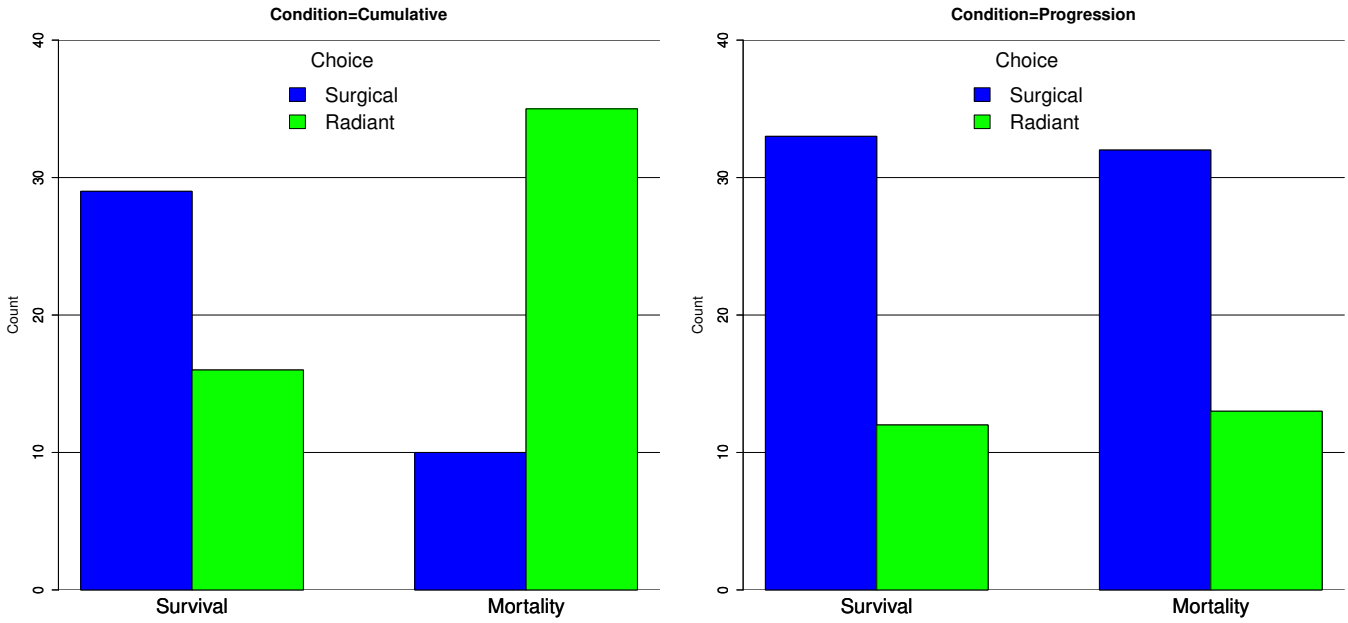


FIGURE 2: Frequencies of preferences (surgical vs. radiant) across frames (survival vs. mortality) in the cumulative frequency condition (left) and in the linear progression condition (right).

result of misperception in a cumulative frequency format. Higher survival rates at five years after the treatment seems to be the major motivation for their decision as shown by spontaneous justifications produced by participants. Hence, consistently with the argument that people showed inconsistent decisions for a misunderstanding of the data, as their coherent answers in the linear progression condition show. However, another study should clarify the nature of these results by investigating the reasons behind choices and participants' understanding of the decisional problem.

# 4 Study 3

Study 2 showed that the framing effect largely disappears in a linear progression format, where therapies outcomes are given in terms of disentangled numbers. As previously explained, our hypothesis is that McNeil et al.'s (1982) cumulative frequency format induced a misperception of therapies' outcomes. A linear progression format eliminated this misperception and re-established psychological equivalence between the therapeutic options. As a consequence, we did not find a significant choice reversal.

Moreover, previous literature showed contradictory results on the effect of using interval frequency formats on choices. According to us, the interval frequency format is a clear way of giving out data, since it clarifies that the number of deaths refers to a specific time interval. The present study has two aims: (1) to compare the effect that different formats (interval frequency, cumulative frequency, and linear progression) have on preferences; (2)



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to investigate how people justify their choices and understand data within each different scenario. Our hypothesis is that — even by providing therapies' outcomes in terms of lives lost — in both a linear progression and in the interval frequency formats, there will be a greater preference for surgical therapy over radiant. Second, we expect that people will justify their choice by referring to a maximum utility reasoning: choosing the treatment which has more benefits over the long term.

## 4.1 Method

We recruited 430 Italian subjects ($M_{Age}$ =29.41, SD=12.7; F=344; M=86) by using Qualtrics online survey platform. Participants were randomly assigned to one of the following three conditions: (a) a control condition, submitting a cumulative frequency format (McNeil et al., 1982); (b) a linear progression format; (c) an interval frequency format based on Almashat et al. (2008). Since Study 1 and 2 evidenced issues in the understanding of McNeil and colleagues' mortality frame (1982), the present study focused on a mortality scenario only (i.e., therapies' outcomes are given in terms of life lost). We used the interval format in our condition three:

> Of 100 patients having radiation therapy, no patients die by the end of treatment, 23 die in the time interval between treatment and 1 year, 55 die in the interval between 1 and 5 years. Of 100 patients having surgery, 10 patients die by the end of treatment, 22 patients die in the interval between treatment and 1 year, 34 patients die in the interval between 1 and 5 years.

After reading the problem, participants had to choose between the two alternatives, given that life quality would have been the same in both conditions. After these descriptions, participants were asked to decide between the alternatives. To assess the understanding of the texts employed in each condition, we asked participants whether the numbers presented in the problem were correct (e.g., "do the numbers add up?"; Appendix, Section 1). Moreover, to investigate the reasons behind their decision, we asked participants to provide a rationale of their choice*:* "Why did you choose the surgical therapy?". We analysed open-ended answers by conducting a qualitative content analysis (Elo & Kyngas, 2008); we categorised and counted each answer by following the rules of an inductively built codebook (Appendix, Table A) which reached intercoder reliability of 87.4 % (Appendix, Table B).

## 4.2 Results

A chi-square (3X2) was performed to test the independence between condition (i.e., cumulative, linear progression, and interval) and choice (i.e., radiant vs. surgical). Overall, we found a significantly different pattern of preferences across conditions ($\chi^2$(2,N=430)=86.203; p<0.01, V=.448; C=.409). Cumulative frequency condition, presenting therapies in terms



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of the cumulative number of people who have died up to a specific time, induced a preference for the radiation therapy (83.0 %) over the surgical (17.0 %). Conversely, both our linear progression and the interval formats, presenting outcomes in disentangled numbers, induced a preference for the surgical therapy, 68.5 % and 59.1 % respectively (Figure 3).

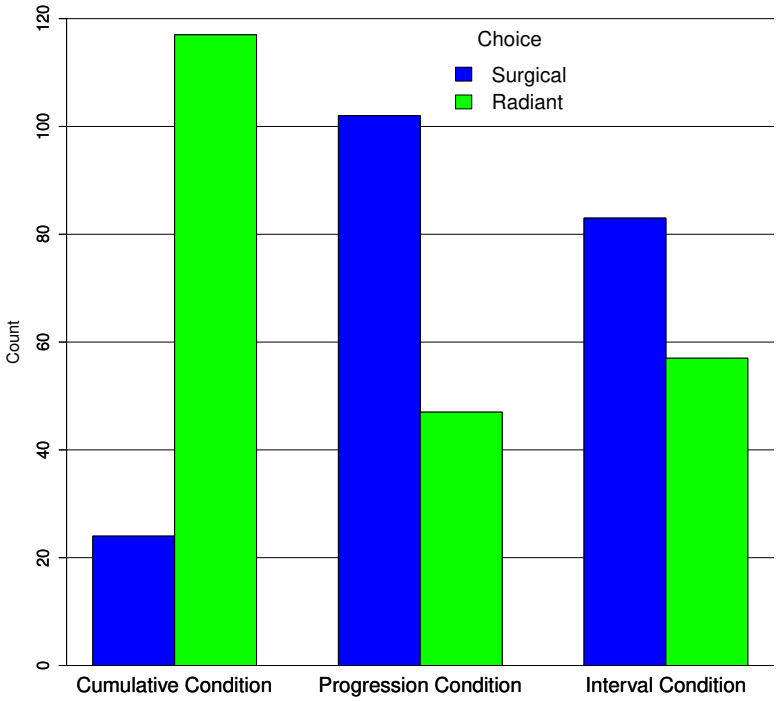


FIGURE 3: Frequencies of preferences (surgical vs. radiant) across conditions (i.e., cumulative, progression and interval).

To investigate which condition is accountable for the significance, we run several chi-square tests (2X2) to compare each condition to one another. A first test showed a significant difference of choice between cumulative frequency and linear progression conditions ($\chi^2$(1,N=290)=78.002; p<0.01, Phi=-.519; C=.460). A second test showed a significant difference of choice between cumulative frequency and interval frequency conditions ($\chi^2$(1,N=281)=53.219; p<0.01, Phi=-.435; C=.399). A third test showed the absence of a significant difference of choice between linear progression and interval frequency conditions ($\chi^2$(1,N=289)=2.635; p>0.05, Phi=.095; C=.095).

According to this evidence, the difference between conditions can be accounted for by cumulative frequency condition, whereas there is no significant difference of choice between linear progression and interval frequency conditions. The presence of a difference the between cumulative frequency condition and the other two confirms our hypothesis that, by employing pragmatically adequate communications, participants would prefer the surgical therapy (i.e., the better option over the long term).

To investigate the nature of these results we first gauged participants' numerical understanding and, second, we analysed the rationale behind their choices. First, we run a



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chi-square test (3X2) between condition and perceived correctness (e.g., numbers do not add up) (Figure 4). We found a significantly different pattern of perceived correctness across conditions ($\chi^2$(2,N=430)=85.076; p<0.01, V=.445; C=.406). In the cumulative frequency condition, 51.8 % of participants reported data to be wrong, i.e., the number of dead people exceeded the number of the total sample initially given (e.g., 10+32+66>100). In the linear progression and interval frequency conditions, numbers were reported to be wrong just in 11.4 % and 10.7 % respectively. Therefore, there was a minor amount of misunderstanding of the text in the latter conditions.

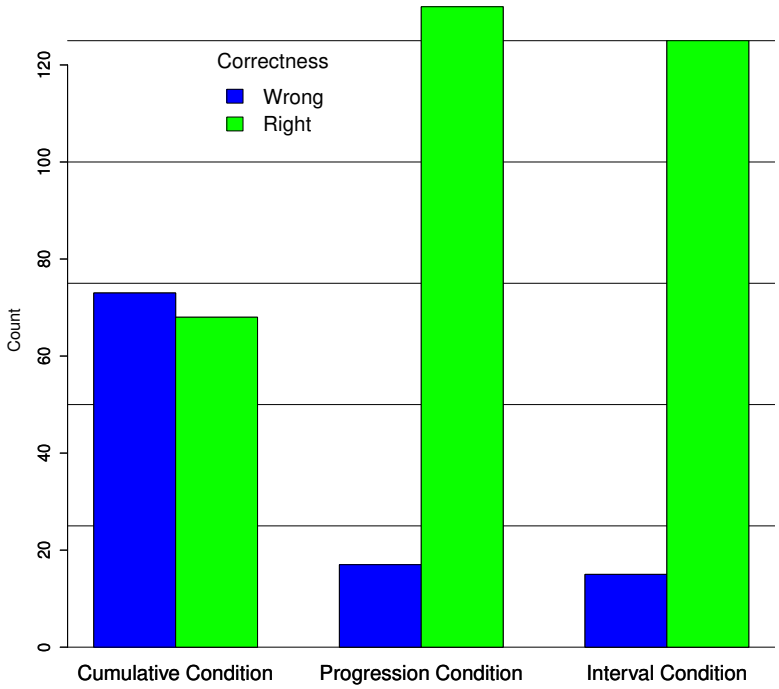


FIGURE 4: Frequencies of participants' perceived correctness (wrong vs. right) across conditions (cumulative, progression, and interval).

Second, by analysing choices justifications we found four main reasons in motivating choices: (1) long-term efficacy (i.e., maximum benefit after 5 years); (2) short-term efficacy (i.e., maximum benefit during the treatment; (3) features of the treatment (e.g., "Less invasive"); (4) others. In line with our hypothesis, the long-term efficacy is the most popular motivation across all conditions, being reported by 57.0 % (245) of the whole participants (out of 430). This motivation is followed by the short-term efficacy, 26.5 % (99) of cases. The remaining reasons accounting for participants' decision-making were the features of the treatment in the 13.3 % (47) and other reasons in the 3.3 % (16).

In the cumulative frequency condition, where the majority (117) chose the radiant therapy, 45.3 % of participants justified it by using a long-term efficacy motivation. However, the radiation therapy does not give an advantage over the long term. This evidence corroborates our hypothesis that participants misunderstood the outcomes of the therapies in McNeil's cumulative frequency format. Apart from that, some participants (37.6%) chose



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TABLE 1: Frequencies and percentages of choice rationale across conditions.

| | Choice (n) | LT Efficacy | ST Efficacy | Features | Other |
|---|---|---|---|---|---|
| Cumulative frequency | | | | | |
| Radiant | 117 | 45.3% (53) | 37.6% (44) | 14.5% (17) | 2.6% (3) |
| Surgical | 24 | 62.5% (15) | 0% (0) | 37.5% (9) | 0% (0) |
| Linear progression | | | | | |
| Radiant | 47 | 23.4% (11) | 68.1% (32) | 6.4% (3) | 2.1% (1) |
| Surgical | 102 | 81.4% (83) | 4.9% (5) | 9.8% (10) | 3.9% (4) |
| Interval frequency | | | | | |
| Radiant | 57 | 24.6% (14) | 57.9% (33) | 10.5% (6) | 7% (4) |
| Surgical | 83 | 83.1% (69) | 0% (0) | 14.5% (12) | 2.4% (2) |

the radiant therapy for its actual advantage, namely the short-term efficacy. Conversely, in both the linear progression and interval frequency conditions, most of the participants chose surgical therapy. Participants justified their decision by using a long-term efficacy explanation, 81.4% in the linear and 83.1% in the interval respectively. Moreover, those who chose the radiant therapy in these conditions did so for its short-term advantage (table 1). This evidence corroborates our hypothesis that both the linear progression and the interval format do not create any misunderstanding.

# 5 General Discussion

The framing effect in medical decision making shown in McNeil et al. (1982) paradigm has been considered inconsistent with the traditional Tversky and Kahneman's effect, showing a so-called reverse pattern of preferences (Gong et al., 2013). In other words, within this paradigm, the risky option is more preferred in a survival frame than in a mortality frame. In the current research, we investigated the nature of this reverse pattern. Moreover, while previous research replicated McNeil et al.'s (1982) results by employing a cumulative frequency format, there is contrasting evidence with employing interval formats (Almashat et al., 2008; Tengs, 1987). To clarify the nature of McNeil's results, we focused on the text of the problem because "the frame that a decision-maker adopts is controlled partly by the formulation of the problem and partly by the norms, habits, and personal characteristics of decision-maker" (Tversky & Kahneman, 1981, p. 453). This is why, at first, we analysed the pragmatic aspects of the text (Gricean maxims) and, afterwards, we formulated our hypothesis: the reverse pattern of preferences originates from the text misunderstanding, which brought participants to represent the data in terms of linear progression instead of cumulative frequency. In the mortality frame, within participants' representations, the



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surgical option would make overall 108 deaths (10 during the treatment + 32 after one year + 66 after five years) instead of 66, whereas the radiation option makes 101 deaths (0 during the treatment + 23 after one year + 78 after five years) instead of 78. On the other hand, participants would represent data correctly in the survival frame. These implications, bringing to an erroneous asymmetrical representation of the data, interrupt logical equivalence between frames. This is the reason why we assumed that the surgical option is considered to be more advantageous in the survival frame than in the mortality one.

First, we conducted our Study 1 to replicate the results of McNeil et al. (1982) with different kinds of participants. This allowed us to investigate the generality of the effect along with different kinds of expertise: medical, statistical expertise on the one hand and lay participants on the other.

Second, we designed a linear progression version of the problem, capable of avoiding any misleading interpretations of the numbers provided. We recruited a sample of lay students since the results obtained in the first experiment showed an absence of differences along with expertise. Presenting data in terms of linear progression preserved a logically equivalent decisional problem, by maintaining the frame of the information and by assuring a formulation of the text which is not misleading. Since the switch of preferences across frames has not been found in a linear progression condition, we can conclude that the reverse pattern preferences in the cumulative frequency condition (surgical options in the survival frame and the radiant one in the mortality frame) was due to misperception. Framing effect, in the cumulative frequency condition, seems to rely on a misleading representation of the data and on a consequent misunderstanding of the options from the participants. In fact, with the new formulation of the text — namely a linear progression format — the incoherent pattern of responses disappeared. Therefore, by eliminating a reverse pattern of choices, our studies re-established coherence with Tversky and Kahneman's theory (1981).

Third, we conducted our Study 3 with a twofold aim: (1) to compare the effect of an interval frequency formulation on choices with the cumulative and linear progression one, and (2) to clarify the nature of people's decisions. In this study, we just employed a mortality scenario (e.g., life lost), being the identified as the source of the misunderstanding in our Study 1 and 2. Study 3 shows that both a linear progression and an interval format do not mislead participants' choices. As a result, most of the participants prefer surgical therapy against the radiant, while in the cumulative frequency format, they still prefer the radiant. Moreover, by checking the perception of data correctness and collecting people's choices rationale, we showed that McNeil's (1982) cumulative formulation is widely misunderstood compared with the linear progression and interval formats. We consider both these elements as proxies for explaining the nature of our results. However, they are both based on participants' perception and awareness. For instance, in the case of perceived correctness of the data, someone could have decided based on an erroneous calculation but without being aware of the mistake. Moreover, in the case of choices rationale, someone could have



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decided based on a heuristic, but explain their choice by using a post hoc justification (e.g., long-term efficacy). Therefore, explaining our results by referring to pragmatics is just one of the possible interpretations of the current results.

To conclude, our results imply that McNeil et al's (1982) medical framing effect is mainly due to problems' mis-formulation and that a linear progression prevents a choice reversal. Moreover, the present research allowed us to clarify previous contrasting evidence on the interval frequency scenario (Almashat, 2008; Tengs, 1987). For instance, participants largely preferred the surgical option over the radiant (59.1 %) in the interval condition of our study 3. This evidence corroborates Tengs's results, in which 62 % of subject opted for the surgical in the mortality frame. We cannot make any claim about the presence/absence of the framing effect in the interval condition, having investigated choices in a mortality scenario only. However, the linear progression format — that do not cause a framing effect — and the interval frequency format can be considered similar since they both describe therapies' outcomes in terms of disentangled frequency.

We are aware of the limitations of this study such as aspects which concern the medical scenario that is far from clinical reality (Edwards et al., 2001). Further research could focus on problems that involve additional therapies outcomes (e.g., quality of life), therapies combination option, or a more specific description of the medical condition depicting the decisional problem as more realistic. However, by questioning the validity of a reverse pattern within this specific paradigm, our results eliminate a misleading formulation within the medical decision-making domain. These results could have implications within the healthcare practice, namely the importance of designing adequate communication to avoid biases in medical decision-making.

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