

All's well that ends well:
How do people perceive sequential percentage
changes?

Dissertation

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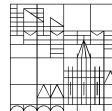
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Zusammenfassung

Diese Dissertation präsentiert drei Fachartikel darüber, wie Menschen sequentielle prozentuale Veränderungen wahrnehmen. Insbesondere wird dabei untersucht, wie Menschen die Konsequenzen sequentieller prozentualer Veränderungen objektiv einschätzen und subjektiv bewerten. Der erste Artikel basiert auf der Verwendung der fehlerhaften additiven Strategie, mit der die objektiven Ergebnisse sequentieller prozentualer Veränderungen geschätzt werden. Insbesondere wird darin die Persistenz der Strategie der fehlerhaften additiven Schätzung angesichts widersprüchlicher Hinweisreize und als Funktion der rechnerischen Fähigkeiten untersucht. Die Ergebnisse lassen darauf schließen, dass hohe Verluste und gute rechnerischen Fähigkeiten die Menschen teilweise daran hindern, die Strategie der fehlerhaften additiven Schätzung anzuwenden. Die Strategie der additiven Schätzung ist jedoch nach wie vor die dominante Strategie, die in den meisten Situationen angewendet wird und zu schwerwiegenden Fehlern führt, wobei Gesamtverluste als Gesamtgewinne missverstanden werden.

Unter der Annahme, dass Menschen die Strategie der additiven Schätzung verwenden, untersuchen der zweite und der dritte Fachartikel die subjektiven affektiven Bewertungen für sequentielle prozentuale Veränderungen. Insbesondere wenn zwei Optionen angeboten werden (eine einzelne Veränderung und eine mathematisch oder additiv äquivalente Sequenz von prozentualen Änderungen), gehe ich davon aus, dass die subjektiven Präferenzen für Sequenzen von prozentualen Änderungen durch den Wunsch nach einem "Happy End" bestimmt werden, so dass ein positives Ende einem negativen Ende vorgezogen wird. Darüber hinaus untersuchte ich die Rolle der realen und wahrgenommenen Äquivalenz, die Bewertung sequentieller prozentualer Änderungen weiter beeinflussen könnte. Die Ergebnisse meines Fachartikels 2 zeigen, dass Menschen eine fehlerhafte additive Strategie einsetzen, jedoch nicht immer. Insbesondere stelle ich fest, dass Menschen die additive Strategie nicht benutzen, wenn die Gesamtänderung zu einem Verlust führt und wenn die beiden vorgestellten Optionen additiv gleich sind, wenn sie sich in Wirklichkeit mathematisch unterscheiden. Außerdem stelle ich fest, dass subjektive Präferenzen für die Reihenfolge prozentualer Änderungen, die zum gleichen Gesamtergebnis führen, vom Wunsch nach einem Happy End geleitet werden, sodass ein positives Ende (Gewinn) einem

negativen Ende (Verlust) vorgezogen wird. Insbesondere bevorzugten die Menschen ein Happy End, wenn die beiden dargestellten Optionen richtig oder falsch als gleich empfunden wurden.

Der dritte Fachartikel baut auf den Ergebnissen des zweiten Artikels auf und testet die Hypothese, dass Menschen im Allgemeinen ein Happy End bevorzugen. Diese Präferenz sollte jedoch gestärkt werden, wenn die Sequenzen von Änderungen mit einer zeitlichen Trennung als Funktion des Rezenzeffekts dargestellt werden, was die Abhängigkeit vom letzten Ergebnis für die endgültigen Bewertungen erhöht. Darüber hinaus sollte dieser Effekt stärker ausgeprägt sein, wenn die präsentierten Informationen unbekannt/überraschend sind, da unerwartete Ergebnisse die Aufmerksamkeit auf überraschende Ereignisse lenken können, die dann als Grundlage für das endgültige Urteil dienen. Die Ergebnisse des Fachartikels 3 reproduzieren die Ergebnisse des Fachartikels 2 und zeigen, dass Menschen ein Happy End bevorzugen. Dieser Effekt war etwas ausgeprägter bei Sequenzen von prozentualen Änderungen, die mit einer zeitlichen Trennung dargestellt wurden. Darüber hinaus lenkte die Überraschung die Aufmerksamkeit auf das unerwartete Ergebnis, so dass ein Happy End sowohl bei Gesamtgewinnen als auch bei Gesamtverlusten bevorzugt wurde, unabhängig davon, ob die Sequenzen mit oder ohne eine zeitliche Trennung präsentiert wurden. In der Abwesenheit einer Überraschung war die Präferenz für ein Happy End jedoch nur bei Gesamtverlusten und nicht bei Gesamtgewinnen vorhanden. Kurz zusammengefasst, meine Dissertation erweitert die bestehende Literatur, indem sie einen umfassenden Überblick über die Schätzstrategien und die affektiven Bewertungen gibt, die Wahrnehmung sequentieller prozentualer Änderungen bestimmen. Mit meinen drei Forschungsaufsätzen konnte ich die bisherigen Forschungsergebnisse reproduzieren und zeigen, dass die Verwendung einer fehlerhaften additiven Strategie weit verbreitet ist und tatsächlich erhebliche Kosten für den Entscheidungsträger verursacht. Über die vorhandenen Ergebnisse hinaus präsentiere ich auch eine solide Grundlage für die Forschung von entscheidenden psychologischen Faktoren, die einen indirekten Einfluss auf die Wahrnehmung der Menschen von Informationen haben können, die als mehrere prozentuale Änderungen dargestellt werden. Im größeren Rahmen lassen meine Forschungsergebnisse darauf schließen, dass für eine effektive Kommunikation von prozentualen Veränderungen sowohl explizite als auch implizite Faktoren berücksichtigt werden müssen, da Personen wahrscheinlich empfindlich auf Hinweisreize

reagieren, die über die Verwendung der Regel der additiven Schätzung bei der Bewertung von sequentiellen prozentualen Änderungen hinausgehen.

Summary

This dissertation presents three research papers on how people perceive sequential percentage changes. Specifically, it explores how people objectively estimate and subjectively evaluate the consequences of sequential percentage changes. The first research paper builds on the use of the erroneous additive strategy used to estimate the objective outcomes of sequential percentage changes. Specifically, the paper investigates the persistency of the erroneous additive estimation strategy in light of conflicting cues and as a function of numeracy. The findings suggest that the presence of high magnitudes of losses and high numerical skills to some extent prevent people from using the erroneous additive estimation strategy. However, the additive estimation strategy still prevails to be the dominant strategy used in most situations resulting in grave errors, with overall losses being misconstrued as overall gains.

Assuming that people use an additive estimation strategy, the second and the third research paper investigate the subjective affective evaluations for sequential percentage changes. Specifically, when presented with two options (a single change and a mathematically or additively equivalent sequence of percentage changes), I posit that the subjective preferences for sequences of percentage changes will be governed by the want for a "happy ending" such that a positive end will be preferred over a negative end. Additionally, I explored the role of equivalence, both real and perceived, that might further influence the evaluations of sequential percentage changes. The results of my research paper 2 indicate that people employ an erroneous additive strategy; however, not always. Specifically, I find that people deviate from using the additive strategy when the overall change results in a loss and when the two options presented are additively the same when, in reality, they are mathematically different. Furthermore, I find that subjective preferences for the sequences of percentage changes resulting in the same overall outcome are governed by the want for a happy ending such that a positive end (gain) is preferred over a negative end (loss). Specifically, people preferred a happy ending when the two options presented were correctly or incorrectly perceived to be the same.

The third research paper builds on the findings of the second research paper and tested the hypothesis that people, in general, would prefer a happy ending. However, this preference should

be strengthened when the sequences of changes are presented with temporal separation as a function of the recency effect, which increases the dependency on the last outcome for the final evaluation. Furthermore, this effect should be stronger when the information presented is unknown/surprising as encountering unexpected outcomes can shift attention to surprise evoking events which then serve as a basis for the final judgment. The results of research paper 3 replicate the findings of research paper 2 and show that people prefer a happy ending, and this effect was slightly more pronounced with sequences of percentage changes that were presented with temporal separation. Moreover, surprise shifted the attention to the unexpected outcome such that a happy ending was preferred both in the case of overall gains and overall losses, irrespective of whether the sequences were presented with or without temporal separation. However, in the absence of surprise, the preference for a happy ending was present only in the case of overall losses and not in overall gains. In a nutshell, my thesis contributes to the existing literature by providing a comprehensive overview of the estimation strategies and the affective evaluations governing the perceptions of sequential percentage changes. With my three research papers, I was able to replicate the previous research findings and show that the use of an erroneous additive strategy is prevalent and indeed results in serious costs for the decision maker. However, beyond the existing findings, I provide a solid groundwork for exploring crucial psychological factors that may have an indirect impact on how people perceive information, presented as multiple percentage changes. At a larger level, my research suggests that both explicit and implicit factors need to be taken into account for effective communication of percentage changes as people are likely to be sensitive to cues that go beyond the use of the additive estimation rule in the evaluation of sequential percentage changes.

Table of Contents

ACKNOWLEDGEMENTS	III
ZUSAMMENFASSUNG	VI
SUMMARY	IX
CHAPTER 1.....	1
1.1 INTRODUCTION.....	2
1.2 THEORETICAL BACKGROUND.....	3
1.2.1 Perception of multiple percentage changes: Additive estimation strategy	3
1.2.2 Affective evaluations	4
1.2.3 Role of individual differences	5
1.3 OVERVIEW OF RESEARCH PAPERS	6
1.3.1 Research Paper 1: Testing the persistency of the additive estimation strategy.....	6
1.3.2 Research paper 2: Subjective preferences for a happy ending.....	7
1.3.3 Research paper 3: Role of anticipation, recency effect, and surprise	9
1.4 GENERAL DISCUSSION	10
1.4.1 Pervasiveness of the additive estimation strategy	10
1.4.2 Subjective preferences beyond objective outcomes	11
1.5 IMPLICATIONS FOR FUTURE RESEARCH	12
1.6 CONCLUSIONS	13
CHAPTER 2.....	15
ABSTRACT	16
2.1 INTRODUCTION.....	16
2.1.1 Theoretical Background.....	17
2.1.2 Present research objectives.....	19
2.2 METHOD	20
2.2.1 Overview	20
2.2.2 Participants	21
2.2.3 Materials and Design	21

2.2.4	Measures	24
2.2.5	Procedure.....	25
2.3	RESULTS	26
2.3.1	Numeracy and corresponding tools	26
2.3.2	Overall choice accuracy and decision tools	26
2.3.3	Choice accuracy: Conflicting and non-conflicting trials	26
2.3.4	Conflicting trials: Influence of loss position, loss magnitude, and numeracy	28
2.4	DISCUSSION.....	28
2.4.1	Limitations and Future work	29
2.5	CONCLUSIONS	30
CHAPTER 3	32
	ABSTRACT	33
3.1	INTRODUCTION.....	33
3.1.1	Theoretical Background.....	35
3.1.2	Present research and hypotheses.....	38
3.2	STUDY 1	40
3.2.1	Participants	40
3.2.2	Design	40
3.2.3	Materials.....	40
3.2.4	Procedure.....	42
3.3	RESULTS	43
3.3.1	Numeracy, cognitive reflection scores, and corresponding strategies.....	43
3.3.2	Do people use the additive estimation strategy?	43
3.3.3	Do order and overall change influence the chosen outcomes?	44
3.3.4	Do people prefer a happy ending?	46
3.3.5	Do the chosen outcomes predict preference for a happy ending?	48
3.4	DISCUSSION.....	49
3.5	STUDY 2.....	50
3.5.1	Participants	50
3.5.2	Design	51

Table of Contents

3.5.3	Materials.....	51
3.5.4	Procedure.....	52
3.6	RESULTS	54
3.6.1	Numeracy and cognitive reflection scores	54
3.6.2	Outcomes chosen and the corresponding estimation strategies	54
3.6.3	Influence of order and overall change on the chosen outcomes.....	55
3.6.4	Preference for a happy ending.....	59
3.6.5	Perception of equivalence and preference for a happy ending.....	62
3.7	GENERAL DISCUSSION	64
3.7.1	Limitations and Future Research.....	66
3.8	CONCLUSIONS	67
CHAPTER 4	69
	ABSTRACT	70
4.1	INTRODUCTION.....	70
4.1.1	Theoretical background.....	72
4.1.2	Present research and hypotheses.....	75
4.2	STUDY 1 OVERVIEW	76
4.2.1	Participants	76
4.2.2	Design	77
4.2.3	Materials.....	77
4.2.4	Procedure.....	79
4.3	RESULTS	79
4.3.1	Numeracy and cognitive reflection scores	79
4.3.2	Outcomes and corresponding estimation strategies.....	80
4.3.3	Influence of order, presentation mode, and overall change	80
4.3.4	Preferences: Role of order and presentation mode	83
4.4	DISCUSSION.....	86
4.5	STUDY 2 OVERVIEW	87
4.5.1	Participants	88
4.5.2	Design	88

4.5.3	Materials.....	89
4.5.4	Procedure.....	90
4.6	RESULTS	91
4.6.1	BNT, CRT, and corresponding strategies	91
4.6.2	Estimation strategies	92
4.6.3	Role of order, overall change, presentation mode, and surprise	92
4.6.4	Preference for happy ending: Role of order, presentation mode, and surprise	96
4.7	GENERAL DISCUSSION	101
4.7.1	Limitations and Future Research.....	102
4.8	CONCLUSIONS	103
APPENDIX A		105
APPENDIX B		115
APPENDIX C		119
LIST OF CONTRIBUTIONS.....		130
PUBLICATIONS.....		132
REFERENCES.....		134

Chapter 1

Synopsis

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1.1 Introduction

Percentage changes are commonly used in the communication of everyday information. For example, a discount on a product can be advertised as either a single discount of 40% or a mathematically equivalent sequence of discounts (e.g., -25%, -20%). Estimating the overall result of the double discount requires the use of a multiplicative strategy $[(1-25/100) \times (1-20/100) - 1] \times 100$ as each of these percentage changes is associated with different base values. Therefore, the overall discount is equivalent to the single discount of 40%, irrespective of whether the discount of 25% is estimated first or second. However, people have been found to employ an erroneous additive strategy (Chen & Rao, 2007), thereby, overestimating the overall discount to be 45%, $(-20 + (-25))$, which makes the double discount appear larger as opposed to the actual single discount of 40%.

The three research papers presented as a part of the dissertation all contribute to a better understanding of how people perceive such sequential percentage changes. With respect to the estimation of the objective outcomes, the use of the additive estimation strategy and the errors associated with neglecting base values have been documented in several studies (e.g., Kruger & Vargas, 2008; Chen & Rao, 2007; Newall, 2016; Davis & Bagchi, 2018; Chen et al., 2012). Therefore, in research paper 1, I extend the findings related to the use of the erroneous additive estimation strategy and investigate the persistency of the additive estimation strategy in light of conflicting information and numeracy. Furthermore, decision makers are known to base their judgments not only on straightforward estimation strategies but also on emotions associated with anticipated future outcomes (Mellers & McGraw, 2001) or unexpected future outcomes (e.g., Chen & Rao, 2002; Davis & Bagchi, 2018). In my second and the third research paper, I investigate the factors that influence the affective evaluations, governing the perceptions of sequential percentage changes.

In this general introduction, I provide an overview of my three research papers presented in chapters 2, 3, and 4. First, I begin by providing a theoretical background that sets the tone for investigating the relevant research questions. After providing a brief overview of each of the research papers, I conclude this chapter by presenting the general discussion and implications for future research.

1.2 Theoretical Background

1.2.1 Perception of multiple percentage changes: Additive estimation strategy

Erroneous processing of multiple percentage changes has gained significant attention in the consumer as well as the financial domains (e.g., Davis & Bagchi, 2018; Newall, 2016; Chen & Rao, 2007). Specifically, in one of the studies, Chen & Rao (2007) investigated how people evaluate the overall result of two percentage changes (e.g., +40%, -25%) that are mathematically equivalent to a single percentage change (e.g., +5%). Based on Thaler (1985), the outcome types were categorized as pure increases (i.e., two percentage increases), pure decreases (i.e., two percentage decreases), mixed increases (i.e., a sequence of percentage increase and decrease resulting in an overall gain) and mixed decreases (i.e., a sequence of percentage increase and decrease resulting in an overall loss). The respective percentage changes were presented as favorable and unfavorable increases and decreases in price changes (e.g., gas prices, mutual funds, among others). The results indicated that people erroneously added two sequential percentage changes to estimate the overall change (Net Effect). On the one hand, the use of the additive estimation strategy leads to an overestimation of the overall change in mixed increases (e.g., -25%, +40%) and pure decreases (e.g., -15%, -25%). On the other hand, it leads to an underestimation of the overall change in mixed decreases (e.g., -40%, +25%), and pure increases (e.g., +25%, +50%), (Chen & Rao, 2007). While the additive estimation strategy provides a convincing description of how people estimate sequential percentage changes, it remains unclear so far if factors other than the additive outcome of the sequence of percentage changes can influence the estimation strategies people use to evaluate the consequences of sequential percentage changes. In research paper 1, I explore the persistency of the additive estimation strategy. I do so by investigating the role of two conflicting cues; the position of losses as well as the magnitude of losses in sequences of percentage gains and losses, which may prevent people from using the additive estimation strategy.

1.2.2 Affective evaluations

Literature on intertemporal choice has shown that anticipation of known outcomes along with a preference for negative time discounting predicts the tendency to postpone positive outcomes, thereby, resulting in "savouring gain" and "avoiding dread" for negative outcomes. Therefore, people prefer sequences of outcomes with an improving trend (e.g., preference for increasing wage profiles) over sequences with a declining trend, and exhibit a preference for a "happy ending" (Loewenstein, 1987; Guyse et al., 2002; Loewenstein & Sicherman, 1991; Read & Powell, 2002; Ross & Simonson, 1991). Drawing on the memory literature, liking for an improving sequence can be explained by the recency effect which results in the last outcome being a governing factor for the final evaluation (Miller & Campbell, 1959; Chen & Rao, 2002).

On the other hand, encountering unexpected outcomes can shift attention to surprise evoking events which then serve as a basis for the final judgment (Davis & Bagchi, 2018; Chen & Rao 2002; Heilman et al., 2002; Noordewier et al., 2016). The paper by Davis & Bagchi (2018) shows that two factors namely, the order of percentage changes (large first/large second) and presentation modes (simultaneous; without temporal separation, sequential; with temporal separation), influence the evaluation of multiple discounts and surcharges, through the processes of anchoring (e.g., Tversky & Kahneman, 1974; Epley & Gilovich, 2010) and surprise (e.g., Chen & Rao 2002; Heilman et al., 2002). Specifically, the authors found that multiple discounts (e.g., -11%, -18%) on a \$ 5 gift card led to positive deal evaluations when the larger percentage change was presented first as opposed to second, in the simultaneous presentation mode. However, when the same discounts were presented sequentially, the second percentage shifted the reference point for the final evaluation, due to surprise and, therefore, the deal was evaluated more positively when the larger percentage change was presented second as opposed to first. However, the effects of the order and the presentation modes have been tested in a limited manner only for certain outcome types of percentage changes (i.e., two percentage increases or two percentage decreases). Moreover, the preferences based on a happy ending have also been tested in a limited manner (Davis & Bagchi, 2018). Specifically, the findings of Davis & Bagchi (2018) suggest that people would prefer a happy ending when the events of a sequence are presented with temporal separation, but not otherwise. Furthermore, people may also prefer a happy start (i.e., when the larger discount was presented first) in the simultaneous presentation mode. In research paper 2, I explore if the

want for the happy ending could be prevalent as a general human tendency resulting in differential preferences for otherwise equivalent outcomes. I do so by manipulating the order of events in a sequence. As an extension, in my third research paper, I manipulate both the order and the presentation modes and compare how the affective evaluations differ when the sequences are presented with and without temporal separation, in the presence and absence of surprise.

1.2.3 Role of individual differences

Past researches have focused mainly on numerical inadequacy in the assessment of risky situations (e.g., Peters et al., 2006; Peters et al., 2007; Nelson et al., 2008). Appropriate understanding of this information is based on people's numeracy or simply put their skill to deal with numbers (Peters et al., 2006). Understanding of numbers along with mathematical skills is necessary to make sense of numerical information presented in various formats such as text, graphs, charts among others (Reyna et al., 2009). Moreover, people with high numeracy give more attention to numbers, and are adept at understanding and interpreting numerical information (Peters et al., 2007). It has been found that even highly educated laypersons and health professionals have an incomplete understanding of probabilities, risks, and other chance-related concepts (Lipkus et al., 2001; Nelson et al., 2008). However, numeracy in the context of sequential percentage changes has been explored only in a limited manner (Newall, 2016; Davis & Bagchi, 2018). For example, in the study by Newall (2016), numeracy was highlighted as one of the important factors for predicting the accuracy in estimation of return sequences of percentage changes (e.g., +50%, -50%). Based on the finding of Newall (2016), in research paper 1, I expect that people with high numeracy should be more accurate and, therefore, less susceptible to the use of the additive estimation strategy. The Berlin Numeracy Test popularly known for the measurement of risk literacy (BNT; Cokely et al., 2012) was used to measure the numeracy of the participants. In addition to the role of numeracy, I explore the role of cognitive reflection in research papers 2 and 3 by implementing the modified version of the Cognitive Reflection Test (emphCRT; Frederick, 2005; developed by Mata, 2016).

1.3 Overview of Research Papers

1.3.1 Research Paper 1: Testing the persistency of the additive estimation strategy

Several studies in the past have focused on how people erroneously employ the additive strategy in estimating sequences of percentage changes (e.g., Chen & Rao, 2007; Newall, 2016; Davis & Bagchi, 2018; Chen & Sun, 2018). In my research, I explored the persistency of the additive estimation strategy. In doing so, I proposed that a loss (%) at the end of the series signalling a negative ending and losing all previous gains as well as the presence of a large loss (%) will play a role in preventing people from using the erroneous additive estimation strategy.

For the study, I extended the setup of Chen & Rao (2007) and presented pairs of percentage series, consisting of 3 percentages each, and asked people to choose the series resulting in the better overall change. I manipulated the position of the loss in the series (i.e., first or last in the series). The magnitudes of the losses were intrinsic in the stimuli, such that one of the two series always consisted of a relatively larger loss. The choice of the series resulting in the better overall change was used as a measurement to investigate the estimation strategies used by people. On a majority, similar to the findings of Chen & Rao (2007), I find that the use of the additive estimation strategy is rather persistent and leads to the underestimation of gains and overestimation of losses. As a new finding, I was able to show that the error associated with the additive estimation strategy even results in the misinterpretation of the overall direction of the change such that overall losses were misconstrued as overall gains. Furthermore, a loss at the end of the series does not prevent people from using the additive estimation strategy. However, high loss magnitudes may to some extent act as a warning sign for people to avoid using the additive estimation strategy. In the majority of the cases, however, the use of the additive estimation strategy is pervasive and leads to grave errors in the interpretation of the overall change. Additionally, I explored the role of numeracy in conjunction with the estimation strategy and found that the people with high numerical skills might be more accurate and, thereby, less prone to using the erroneous additive estimation strategy as opposed to people with low numerical skills.

1.3.2 Research paper 2: Subjective preferences for a happy ending

While the use of the additive estimation strategy and the errors associated with neglecting base values have been documented in several studies (e.g., Kruger & Vargas, 2008; Chen & Rao, 2007; Newall, 2016; Davis & Bagchi, 2018; Chen et al., 2012), there is limited evidence on the factors imperative for effective communication of sequential percentage changes. Research beyond the use of the additive estimation strategy specifies factors embedded in a sequence such as the order of percentage changes as well as the presentation mode that influence the perception of sequential percentage changes (Davis & Bagchi, 2018). Following this stream of research, research paper 2 presents a comprehensive view of the role of order, governing the preferences for sequential percentage changes, amounting to gains and losses. With regards to the estimation strategies, similar to the existing literature, I predicted that people will resort to using the additive estimation strategy to evaluate the objective outcomes of sequences of percentage changes. However, I posited that the subjective affective evaluations of sequences of percentage changes will be governed by the want for a "happy ending" such that a positive end (gain/large gain) will be preferred over a negative end (loss/large loss). Additionally, I explored the role of equivalence, both real and perceived, that might further influence the evaluations of sequential percentage changes.

In two-description based studies, I employed investment scenarios and investigated estimation strategies and preferences for a "happy ending" by manipulating the order of gains and losses in sequences of percentage changes. In both my studies, I implemented the setup proposed by Chen & Rao (2007) and asked the participants to compare the results of single vs. two percentage changes. In my first study, I included tasks where the overall change of the two percentage changes was mathematically equivalent to the single percentage change (Chen & Rao, 2007). In my second study, I also included tasks where the overall change of the two percentage changes appeared identical because it was additively equivalent to the single percentage change, but was in fact different. The outcome types for the mixed and the pure percentage changes were classified based on Thaler (1985) as mixed gains and mixed losses (i.e., a sequence of a gain and a loss resulting in an overall gain or an overall loss) and pure gains and pure losses (i.e., two gains and two losses, resulting in an overall gain and an overall loss, respectively). I predicted that an inclination towards a happy ending would govern the preferences for sequential percentage

changes such that for mixed percentage changes, a loss followed by a gain will be preferred over a gain followed by a loss ($[Lg] > [Gl]$). For pure percentage changes, a small gain followed by a large gain will be preferred over a large gain followed by a small gain ($[gG] > [Gg]$) and vice versa for losses ($[Ll] > [ll]$).

Similar to the literature on *mental accounting* (Thaler, 1985), two people were shown to experience financial changes. One person always experienced the single percentage change while the other person always experienced the sequence of two percentage changes. The changes were described as occurring on different days. The main task in each scenario was to adopt their perspective and evaluate their situations by answering two short questions on relative happiness (preference) and overall financial result (outcome). The results indicate that people employ an erroneous additive strategy, however, not always. Specifically, I find that people deviate from using the additive strategy in light of overall losses and in tasks where the single percentage change and the overall change of the two percentage changes are additively the same. Specifically, I find that the additive equivalence in some ways alerted the participants to recognize that the two options may not actually be the same and, thereby, aided in providing the correct answers.

Moreover, in the case of mixed losses, people systematically chose the single loss percentage as the better financial outcome instead of the sequence of two percentage changes. This choice was made more often when the sequence of changes ended in a loss as compared to a gain. In mathematically equivalent tasks, the choice of single loss percentage indicates that people widely used some other incorrect strategies as opposed to the additive estimation strategy. On the other hand, in the additively equivalent tasks, the choice of single loss percentage actually resulted in participants choosing the correct answer. Additionally, I find that numeracy plays a role in helping people correctly estimate the consequences of sequential percentage changes. Furthermore, subjective preferences for the sequences of mixed percentage changes are governed by the want for a happy ending such that a positive end (gain) is preferred over a negative end (loss). Specifically, the effect of the order was found to be prominent for people who objectively estimate the single percentage change, and the two percentage changes to be the same with either the correct multiplicative strategy or the incorrect additive strategy. However, there was no effect of order governing the preferences for pure percentage changes.

1.3.3 Research paper 3: Role of anticipation, recency effect, and surprise

Research has shown that implicit factors of order and presentation mode influence the perception of sequential percentages through the processes of anchoring and surprise (Davis & Bagchi, 2018). Following this stream of research, I explored the role of anticipation, surprise, and the recency effect that might govern the affective evaluations of sequential percentage changes. From a mathematical point of view, manipulation of order and presentation mode does not change the aggregate result of the sequences of percentage changes and, hence, should not affect the overall evaluations (Davis & Bagchi, 2018). However, I predicted that the order and presentation mode should influence the perceptions of sequential percentage changes based on the want for a happy ending: A positive end will be preferred over a negative end. Furthermore, due to the recency effect, the order effect should be intensified with temporal separation and even more so in the presence of surprise. To test the hypotheses centered on the role of anticipation and the recency effect, I conducted my first study wherein I presented people with sequences of mixed and pure percentage changes (Based on Thaler, 1985) in two different presentation modes (simultaneous and sequential). Participants were always informed that two percentage changes would be presented on their investments. In the simultaneous presentation mode, the two changes were presented on the same page. Whereas, in the sequential presentation mode, each percentage change was presented on a different page. The main task in each scenario was to integrate and evaluate the changes on the investment, by answering two short questions pertaining to the preference and the overall financial outcome.

My second study is similar to my first study except for the addition of the surprise factor and time pressure. Therefore, I manipulated the order of percentage changes, presentation mode, and surprise in financial decision scenarios. I presented single, two, and three percentage changes on the investments and introduced unpredictability and surprise by not informing the participants about the number of changes that were to occur on their investments. Furthermore, a time limit for responses was imposed primarily for the participants to not engage in using calculation devices and, therefore, be intuitive with their responses. Taken together the findings of my two studies suggest two main conclusions. First, for mixed percentage changes, people prefer a happy ending, and slightly more so when there is temporal separation between the percentage changes presented, indicating that the recency effect might be in place. As a second conclusion, I infer that in the

presence of surprise, preference for a happy ending is higher in the case of both overall gains and overall losses, irrespective of whether the sequences of changes were presented with or without temporal separation. However, there was no effect of the order, presentation mode, or surprise governing the preferences for pure percentage changes.

1.4 General Discussion

The aim of this dissertation was to contribute to a better understanding of how people perceive sequential percentage changes. Therefore, I investigated how people objectively estimate as well as subjectively evaluate sequential percentage changes. The findings from the three research papers replicate the use of the incorrect additive strategy used to estimate the consequences of sequential percentage changes. Additionally, I find new evidence on how people affectively evaluate sequential percentage changes beyond the use of the straightforward additive estimation strategy. In this section, I discuss what these results imply for research on the perception of percentage changes and further discuss the future implications.

1.4.1 Pervasiveness of the additive estimation strategy

In real life, relative percentage changes are commonly used to describe changes such as double discounts in the consumer domain, stock market fluctuations, and macro-economic information: increase or decrease in inflation, unemployment rates, among others. Despite the widespread use of percentage formats, people erroneously estimate the consequences of sequential percentage changes (e.g., Chen & Rao, 2007). In my research paper 1, I find that the use of the additive estimation strategy in light of sequential percentage changes seems to be rather persistent despite conflicting cues and high numeracy. While high magnitudes of losses as well as high numeracy to some extent prevent people from using incorrect strategies, it remains indisputable that percentage changes are perceived to be complex and can lead to grave errors implying serious costs for the decision maker. A deeper understanding of the estimation strategies as well as the psychological processes associated with the perception of sequential percentage changes seems crucial for

understanding how such percentage changes can be communicated in a manner that is beneficial rather than detrimental to the audience.

1.4.2 Subjective preferences beyond objective outcomes

An important implication of my research paper 2 remains the fact that people are not always using the additive strategy and are likely to deviate from the same based on how the percentage changes are presented or framed. According to the *behavioural decision theory* (BDT; Kahneman & Tversky, 1979), rather than following the traditional economic model of maximising utility, people may be influenced by perceptual biases stemming from how the same information is presented differently, resulting in a reversal of preferences for equivalent information. Similarly, in my research, I find that the framing of information influences both the objective outcomes as well as the subjective preferences for sequential percentage changes. Specifically, in my second research paper, the outcomes chosen differ based on whether the overall change is a gain or a loss and whether the sequence of changes ends with a gain or a loss. Next, I find that the preferences for mixed percentage changes were influenced by the order in which the percentage changes were presented (i.e., first gain/loss or last gain/loss). People largely prefer a happy ending when two options are the same (mathematically) or appear the same (additively). On the surface level, my studies partially align with the intertemporal choice literature, with results showing that people follow a gain-savouring principle and prefer a happy ending (e.g., Loewenstein, 1987; Loewenstein & Sicherman, 1991). However, with further exploration, I find that real or perceived equivalence might additionally impact the preference for a sequence. In sum, I find that people who correctly or incorrectly perceive the two options to be the same show a preference for a happy ending.

Overall, my research suggests that the perception of percentage changes can be influenced by placing a positive percentage change at the end of the sequence, even if the overall result of the sequence is negative. Similarly, in my research paper 3, I replicate the finding that people prefer sequences ending on a happy note and additionally find that this preference was a bit more pronounced with temporal separation, indicating that there might be a small recency effect at play. Although, contrary to my predictions as well as the results of Davis & Bagchi (2018), the emotion of surprise did not intensify the order effect in the sequential presentation mode. However, surprise

shifted the attention to the unexpected outcome such that a happy ending was preferred both in the case of overall gains and overall losses. However, in the absence of surprise, the preference for a happy ending was present only in the case of overall losses and not in overall gains.

1.5 Implications for future research

Taken together the findings of my research suggest that the objective estimates of sequential percentage changes often go wrong, while the subjective evaluations indicate a preference for a happy ending. Concerning the preferences, I explored the role of order of gains and losses and presentation modes. However, there might be other crucial factors such as the time period between the changes that might also have a psychological impact. Furthermore, there might be other emotions other than anticipation and surprise which can play a role in how people perceive percentage changes. For example, it is possible that presenting people with sequential options can instill feelings of regret towards better options that were available in the past (Mogilner et al., 2013). Therefore, similar to the literature related to foregone payoffs (e.g., Grosskopf et al., 2006; Yechiam & Busemeyer, 2006), providing information about unchosen alternatives can provide interesting insights on the role of regret (e.g., Zeelenberg & Pieters, 2004), governing the affective evaluations of sequential percentage changes. In general, the presence of the recency effect also continues to be an interesting avenue for future research. For example, it is possible that the recency effect in verbal formats (as in my research) can be reduced by presenting graphical information in the end, as the use of visual cues draws more attention. Therefore, presenting them at the end may reduce the expected recency effect (Hellmann et al., 2017). Moreover, it has been shown that graphical information is likely to be weighted more in comparison with textual information (Lurie & Mason, 2007). Overall, a comparison of the order effect across different presentation formats can be useful in promoting the understanding of sequential percentage changes. At a larger level, future research should be directed at exploring explicit estimation strategies in conjunction with implicit factors that have an indirect impact on the perception of sequential percentage changes.

1.6 Conclusions

Overall, my thesis contributes to the existing literature by providing a comprehensive overview of the estimation strategies and the affective evaluations governing the perceptions of sequential percentage changes. With my three research papers, I was able to replicate the previous research findings and show that the use of an erroneous additive strategy is prevalent and indeed results in serious costs for the decision maker. However, beyond the existing findings, I provide a solid groundwork for exploring crucial psychological factors that may have an indirect impact on how people perceive sequential percentage changes. At a broader level, my research suggests that both explicit and implicit factors need to be taken into account for effective communication of information represented as multiple percentage changes.

Chapter 2

Sequential percentage changes: Testing the persistency of the erroneous additive strategy as a function of the order of events, the magnitude of losses, and numeracy

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Abstract

How do people estimate sequential changes presented as relative percentages? Research has shown that people use an erroneous additive estimation strategy instead of the correct multiplicative strategy for evaluating the consequences of sequential percentage changes. In our research, we explore the persistency of the additive estimation strategy. In doing so, we propose that a loss (%) at the end of the series signalling a negative ending and losing all previous gains and the presence of a large loss (%) will play a role in preventing people from using the erroneous additive estimation strategy. Using a binary forced-choice setup, participants were presented with series of three percentage changes on hypothetical financial investments and were asked to choose the series resulting in the better overall change. Results indicate that a loss at the end of the series does not prevent people from using the additive estimation strategy. However, high loss magnitudes may, to some extent, act as a warning sign for people to avoid using the additive estimation strategy. In most cases, however, the use of the additive estimation strategy is pervasive and leads to grave errors in the interpretation of the overall change. Additionally, we explore the role of numeracy in conjunction with the estimation strategy and find that people with high numerical skills might be more accurate and, thereby, less prone to using the erroneous additive estimation strategy than people with low numerical skills.

2.1 Introduction

Consider a scenario where you have invested a part of your salary into a short-term fund for one week. You discover that the value of your investment has changed twice. After a few days, the value of your investment has increased by 20%. At the end of the week, the value of your investment has decreased by 30%. What is the overall value of your investment? Regardless of frequent encounters with such information, it has been found that people make errors in estimating and interpreting the overall result of sequential percentage changes. Specifically, they apply a simplistic yet erroneous additive rule (e.g., Chen & Rao, 2007). To correctly estimate the overall value, one is required to use a multiplicative strategy $[(1+20/100) \times (1-30/100) - 1] \times 100$, as the percentage changes are relative to each other and, thereby, associated with different base values. The percentage changes can be calculated in any order (i.e., +20% first or second) and

would yield the same overall change amounting to a loss of 16%. Drawing from the above example, the use of the additive estimation strategy ($+20 + (-30)$), results in an erroneous underestimation of the overall change (-10%) in comparison to the actual change (-16%).

The widespread use of the additive estimation strategy can be attributed to various reasons such as difficulty associated with comprehending the mathematical properties of percentages, innumeracy, a certain "*whole number dominance*" among others (Chen & Rao, 2007). However, it remains unclear so far if factors other than the additive outcome of the sequence of percentage changes can influence the estimation strategies people use to evaluate the consequences of sequential percentage changes. Our research, therefore, aims to explore the persistency of the additive estimation strategy. In doing so, we employ financial decision scenarios and present people with series of positive and negative percentage changes, framed as gains and losses. We propose that positioning losses (%) at the end of the series as well as high magnitudes of losses (%) will play a role in preventing people from using the additive estimation strategy. Given that people have an option to choose between two series: A loss at the end of the series will be perceived as more consequential as compared to a loss at the beginning of the series. Furthermore, the presence of a large loss (%) will serve as a cue to avoid an overall large loss or a relatively smaller gain. Additionally, we explore the role of numerical abilities in the understanding of sequential percentage changes. We begin by elaborating on the additive estimation error commonly associated with evaluating sequential percentage changes and further present the theory for explaining our hypotheses concerning the position of the loss (%) and the magnitude of the loss (%).

2.1.1 Theoretical Background

2.1.1.1 Additive estimation error

Several studies have focused on how people erroneously employ the additive strategy for estimating the consequences of sequential percentage changes (e.g., Chen & Rao, 2007; Newall, 2016; Davis & Bagchi, 2018; Chen & Sun, 2018). For example, in the research by Chen & Rao (2007), sequences of two percentage changes (e.g., -25% , $+40\%$) along with a single mathematically equivalent percentage change (e.g., $+5\%$) were presented as favorable and unfavorable increases and decreases in different contexts such as gasoline prices, mutual funds,

fuel efficiency among others. Based on Thaler (1985), the sequences of percentage changes were classified as pure increases (i.e., two percentage increases), pure decreases (i.e., two percentage decreases), mixed increases (i.e., a sequence of percentage increase and decrease resulting in an overall positive result) and mixed decreases (i.e., a sequence of percentage increase and decrease resulting in an overall negative result). Participants were asked to rate their attitude towards the offers, their purchase intention, choose an estimate indicating the overall change based on four options and explain why they chose the particular option as the overall change.

Overall, Chen & Rao's (2007) results show that people erroneously added two sequential percentage changes to estimate the overall change, as close to 60% of the participants chose the estimate which amounted to the sum of the two percentage changes presented in the scenarios. The purchase intention and attitude towards the offers were also mostly in line with the additive estimation error. Furthermore, about half of the participants provided reasoning that corroborated with the use of the erroneous additive strategy. The authors also identified a few boundary conditions and showed that factors such as motivation, the face validity of the overall change, and calculation difficulty play a role in reducing the participants' additive error. For example, in one of the studies pertaining to the face validity of the overall change, results indicated that two percentage decreases ($-70%$, $-45%$) resulting in an illogical answer additively ($-115%$) acted as a warning to the participants, thereby, resulting in fewer errors and overall improved accuracy (Chen & Rao, 2007). However, in the context of our study, the use of the additive estimation strategy does not take into account the effect of the order of percentage changes (i.e., which percentage change is first or last in a sequence) or the change magnitude (i.e., size of the percentage changes in the sequence). Instead, it merely assumes that the overall additive outcome of the sequence plays a vital role in governing the final choice.

2.1.1.2 Peak-end rule: Role of order and change magnitude

A prominent theory, which provides an indirect although reasonable direction for investigating the role of order and change magnitude in the context of sequential percentage changes, includes the *Peak-end rule*. According to the *Peak-end rule*, people retrospectively evaluate subjective experiences, based on how the experience was at its "peak," which is considered as the most intense moment, and its "end" indicating the finality of the event. Furthermore, the duration of experience

does not play a role in the final evaluation of the experience (e.g., Kahneman et al., 1993; Fredrickson & Kahneman, 1993; Redelmeier & Kahneman, 1996; Schreiber & Kahneman, 2000). For example, in the study by Redelmeier & Kahneman (1996), participants were asked to evaluate their pain during colonoscopy procedures. One group experienced a shorter procedure, whereas the other group experienced a longer procedure where additional pain of lesser intensity was induced towards the end of the procedure. The results indicate that participants in the shorter procedure group rated their experience more negatively as opposed to the group which experienced the longer procedure, indicating that the evaluations were based on an average of the pain felt at the peak (i.e., the worst moment) and the end, without taking into account the duration for which the pain was felt.

However, the peak-end rule has not been translated to explaining the estimation strategies used to evaluate sequential percentage changes. While we do not test for the peak-end rule directly in our study, we focus on the elements of the peak-end rule in the following manner. We investigate the "end effect" by manipulating the order, specifically the loss (%) position. For example, although the net effect of (-80%, +50%) is equal to the net effect of (+50%, -80%) people may perceive the two series differently while calculating the overall change, since a loss (%) at the end of the series may signal losing a significant amount of the previous gain and result in feelings of disappointment. Therefore, we predict that a loss (%) at the end of the series will be perceived as more consequential as compared to a loss (%) at the beginning of the series. Similarly, we investigate the peak or the "intense" effect separately by manipulating the magnitude of the loss and predict that a large loss in a series (e.g., -50%, +15%) in comparison with the series consisting of a small loss (e.g., -15%, +80%) will serve as a cue for avoiding overall large losses or relatively smaller gains. However, it is essential to note that avoiding the series with the larger loss could also prove to be a misleading cue in some instances (e.g., -50%, +70% vs. -30%, +15%) and, thereby, result in an incorrect judgment.

2.1.2 Present research objectives

Our study builds on the finding of the use of the additive estimation strategy, as first proposed by Chen & Rao (2007). While the additive estimation strategy provides a convincing description of how people estimate sequential percentage changes, we suspect that the account may be

incomplete as both the effects of the order and change magnitude cannot be predicted by the additive strategy. Therefore, we explore other inaccurate strategic elements that people might use to estimate sequential percentage changes and extend the existing literature on percentage processing in the following manner. First, we investigate the persistency of the additive estimation strategy by exploring the cues of loss position and loss magnitude in series of changes framed as percentage gains and losses. We do so by extending the setup of Chen & Rao (2007) and present pairs of percentage series, consisting of 3 percentages each, and ask people to choose the series resulting in the better overall change. Second, we explore individual differences by investigating the influence of numeracy on the estimation strategies used to evaluate sequential percentage changes. Past research has focused mainly on numerical inadequacy in assessing risky situations (e.g., Peters et al., 2006; Peters et al., 2007; Nelson et al., 2008; Reyna et al., 2009). For example, people with high numeracy are known to pay more attention to numbers and are adept at understanding and interpreting numerical information and, thereby, make better decisions compared to people with low numeracy (Peters et al., 2007). However, numeracy in the context of sequential percentage changes has been explored only in a limited manner (Newall, 2016; Davis & Bagchi, 2018). For example, in Newall (2016) study, numeracy was highlighted as one of the crucial factors for predicting the accuracy in estimating return sequences of percentage changes (e.g., +50%, -50%). Based on this finding, we expect that people with higher numeracy should be more accurate and, therefore, less susceptible to the use of the additive estimation strategy.

2.2 Method

2.2.1 Overview

The focus of the study was to test our hypotheses regarding the role of the position of loss and magnitude of loss to investigate the persistency of the erroneous additive estimation strategy. We manipulated the position of the loss in the series (i.e., first or last in the series). The magnitudes of the losses were intrinsic in the stimuli, such that one of the two series always consisted of a relatively larger loss. The choice of the series resulting in the better overall change was used as a measurement to investigate the estimation strategies used by people.

2.2.2 Participants

The study was programmed in Unipark (Version [EFS, 2016]). A total of 200 participants (95 females; $M_{age} = 37$ years, $SD_{age} = 12.62$) were recruited via Amazon Mechanical Turk. They received a basic compensation of US-\$ 0.80 for completing the study and an additional bonus of up to US-\$ 1.08 based on the performance. We excluded the data of 2 participants who indicated that their data could not be trusted. Our final sample consists of 198 participants (94 females; $M_{age} = 37$ years, $SD_{age} = 12.64$). All of them were residents of the United States, and 196 (98.99%) participants chose English as their native language. 112 (56.57%) of them had obtained a Bachelor's degree or higher.

2.2.3 Materials and Design

To select our trials, we first investigated the extent to which the correct multiplicative strategy and the incorrect additive strategy differed in their predictions concerning the overall change of sequences of percentage changes. The analysis for the trial selection was completed in RStudio (R version 3.2.0; R core team, 2015). We mapped out the space of percentage changes ranging between -100% and $+100\%$ and simulated the overall change as overall gains and losses. For the majority of the percentage pairs between -100% and $+100\%$, both strategies either predict an overall gain (e.g., $+15\%$, $+25\%$) or an overall loss (e.g., -20% , -30%). For a small minority of the percentage pairs (e.g., $+100\%$, -60%), the two strategies have differing qualitative predictions (i.e., the correct multiplicative strategy predicts an overall loss and the incorrect additive strategy predicts an overall gain). A detailed version of the analysis conducted for the trial selection can be found in Appendix A1.1.

Using the evidence from the overlaps and discrepancies between the predictions of the correct multiplicative strategy and the incorrect additive strategy for two percentage changes, we constructed two types of trials, namely conflicting and non-conflicting, with three percentage changes. The trials were to be presented in a binary forced-choice setup, and the following features differentiated the two types of trials. In the conflicting trials, one of the series resulted in a higher additive change while the other series resulted in a higher overall product. In the non-conflicting trials, both the additive strategy and the multiplicative strategy predicted the same choice. Next,

based on the overall change, these series were distinguished as a qualitative taxonomy of pure and mixed outcomes. In trials with pure outcomes, the overall change of both the series resulted in either an overall gain or an overall loss. In trials with mixed outcomes, the magnitude of the overall change and the direction of the overall change qualitatively differed based on the strategy used. This distinction allows us to identify two types of errors associated with the use of the additive estimation strategy: *Errors of magnitude* and *Errors of direction*.

Errors of magnitude. In trials with pure outcomes, the magnitude of the overall gain or the overall loss differed such that the use of the erroneous additive estimation strategy resulted in the underestimation of the overall gains and overestimation of the overall losses in comparison with the actual overall change estimated with the correct multiplicative strategy.

Errors of direction. In trials with mixed outcomes, the choice of the series based on the incorrect additive strategy predicted an overall gain, whereas the same choice of series based on the correct multiplicative strategy actually resulted in an overall loss. Examples of the decision trials can be found in Appendix A2.1.

The design of the study consisted of 2 factors: position of loss (2 levels: *loss first, loss last*) x trials (2 levels: *conflicting, non-conflicting*) with both the factors manipulated within subjects. Participants were randomly assigned to one of the two groups (position of loss was counterbalanced in these two groups). The presentation order of the decision trials was randomized for each participant in each of the groups. A total of 36 decision trials (14 non-conflicting and 22 conflicting) were presented¹.

¹ The hypotheses regarding the loss position and the loss magnitude are relevant only for the conflicting trials wherein the correct multiplicative strategy and the incorrect additive strategy predict different choices. In the non-conflicting trials, the choices cannot be differentiated as both the strategies predict the same choice. Furthermore, in the non-conflicting trials avoiding the relatively larger loss would result in participants choosing the incorrect answer.

Table 2.1 illustrates the important decision trials that allow us to distinguish between the correct and the incorrect strategy and investigate the effect of loss position and loss magnitude. Each of the trials involved repeatedly comparing two series consisting of three numbers each. Each of the three numbers in the series was expressed as a percentage of the current amount on the participants' accounts, including the effects of all previous changes. Each series consisted of two positive percentage changes and one negative percentage change. A positive percentage change indicated a gain, whereas a negative percentage change indicated a loss. The percentage changes in the series ranged between -100% and $+100\%$, with the loss magnitude ranging between 8% and 98% . In each of the decision trials, participants were asked to choose the series with the better overall change. Figure 2.1 illustrates the layout of a decision trial.

Table 2.1: Illustration of the important decision trials relevant for testing the effects of loss position, loss magnitude, and for identifying the use of the correct multiplicative strategy and the incorrect additive strategy.

Series	Trials	Loss position	Position effect	Magnitude effect	Strategy identification
+70%, +46%, -67% +13%, +45%, -32%	Conflicting	Loss last	+1	+1	+1
-67% , +46%, +70% -32% , +45%, +13%	Conflicting	Loss first	-1	+1	+1
+80%, +19% -73% +46%, +13%, -66%	Non-conflicting	Loss last	-1	-1	-1
-73% , +19% + 80% -66% , +13%, +46%	Non-conflicting	Loss first	-1	-1	-1

Note. +1 denotes the trials wherein the effects of loss position and loss magnitude can be identified, and the strategies (i.e., the correct multiplicative strategy and the incorrect additive strategy) can be differentiated. -1 denotes the trials wherein the position effects and the magnitude effects cannot be identified, and the two strategies cannot be differentiated.

A

Choose the series with the better overall change:

- 91%, +73%, +80%
- 53%, +39%, +56%

B

Choose the series with the better overall change:

- +80%, +73%, -91%
- +56%, +39%, -53%

Figure 2.1: Layout of the decision trials. (A) Loss first. (B) Loss last. Each of the percentage changes marked with the (+) sign represent gains, and the percentage changes marked with the (-) sign represent losses. The trials presented are conflicting in nature with a mixed outcome. The correct answer according to the multiplicative strategy involves choosing the second series in each of the above trials (target) as the overall change of the second series is better multiplicatively (+1.9%) as compared to the first series (decoy) (-72%). However, with the additive estimation strategy, the first series in each of the trials (decoy) is expected to be chosen as the better option as the additive change of the first series is higher (+62%) as compared to the additive change of the second series (+42%). Concerning the magnitude of the loss, the loss of 91% would be considered as a relatively larger loss than the loss of 53% in each of the above trials. We expect that both the cues of loss magnitude and the loss position at the end of the series should prevent people from using the additive estimation strategy and help identify the correct option.

2.2.4 Measures

2.2.4.1 Strategy identification, the effect of loss magnitude

Choice accuracy on 22 (of 36; 61.10%) conflicting decision trials were assessed to identify the use of the erroneous additive estimation strategy and to assess if the presence of a large loss prevented people from using the additive strategy.

2.2.4.2 Effect of loss position

Choice accuracy on 11 (of 22; 50%) conflicting decision trials wherein the position of the loss was at the end of the series was assessed to identify if a loss at the end of the series prevented people from using the additive strategy.

2.2.4.3 Errors of magnitude and Errors of direction

The errors of magnitude associated with the use of the additive estimation strategy were assessed by measuring choice accuracy on 8 (of 22; 36.36%) conflicting decision trials resulting in pure outcomes, whereas the errors of direction were assessed by measuring the choice accuracy on 14 (of 22; 63.63%) conflicting decision trials resulting in mixed outcomes.

2.2.4.4 Numeracy

The Berlin Numeracy Test, popularly known for the measurement of risk literacy (BNT; Cokely et al., 2012), was used to measure the participants' numeracy. We used the computer-adaptive version of the BNT consisting of 2–3 questions based on performance, with the scores ranging from 1–4 for each of the participants. The questionnaire of the BNT can be found in Appendix A3.1.

2.2.5 Procedure

After providing the consent to be a part of the study, participants were directed to read the instructions of the decision trials. On the instructions page, participants were randomly assigned to one of the two groups, which were generated to counterbalance the loss position in each of the trials. After this, they completed an example task that illustrated the decision trial's layout and then went on to complete the 36 decision trials presented to them in random order. In each decision trial, participants combined and compared the individual gains and losses of both the series and chose the series resulting in the better overall change (i.e., the series resulting in a larger overall gain or a lower overall loss). They were rewarded with an incentive of US- \$ 0.03 (per trial) for correctly choosing the series resulting in a larger overall gain or a lower overall loss. After completing the decision trials, participants were asked to specify the tools and strategies used to answer the decision trials. Followed by which, they were directed to complete the BNT and were subsequently asked to specify the tools they used to answer the numeracy questions. As one of the final steps, participants were required to complete the demographics form.

2.3 Results

2.3.1 Numeracy and corresponding tools

Mean score on the BNT (out of 4 possible correct) was found to be 2.01 ($Mdn = 1$, $SD = 1.26$, $range = 1-4$). Concerning the tools, 48 responses provided were not based on any calculation and were classified as intuitive responses. 147 responses indicated the use of no external tools for calculation, 5 using external tools such as a calculator, 13 using a pen and paper strategy, and 2 with some other strategies. The overall distribution of the BNT scores can be found in Appendix A3.2.

2.3.2 Overall choice accuracy and decision tools

Mean percentage of correct choices in the 36 decision trials amounted to 54.43%. Analyzing the decision tools used, we find that 56 responses were reported to be intuitive (i.e., not based on any calculation), 146 indicated the use of no external tools for calculation, 24 indicated the use of a calculator, and lastly, 15 responses indicated the use of a pen and paper strategy. Concerning the decision strategies, 138 responses indicated that participants separately estimated the change of each series (row by row) while 67 responses indicated an estimation strategy based on a column by column comparison of changes in the series. Lastly, about 10 responses indicated the use of some other strategies.

2.3.3 Choice accuracy: Conflicting and non-conflicting trials

Accuracy in the non-conflicting trials wherein both the correct multiplicative strategy and the incorrect additive strategy predicted the same choice was higher (88.13%) than the accuracy in the conflicting trials wherein the two strategies predicted different choices (32.99%). Lower accuracy in the conflicting trials and higher accuracy in the non-conflicting trials indicates that people more often used the incorrect additive estimation strategy to evaluate the overall change of the series of percentage changes. As a next step, we investigated the extent of the errors of magnitude and direction associated with the use of the additive estimation strategy. In doing so, we analyzed the

choices in the conflicting trials resulting in pure outcomes and mixed outcomes. Results indicate low accuracy on both the trials with pure outcomes (33.08%) and mixed outcomes (32.94%), suggesting that the use of the additive estimation strategy not only led to the underestimation of gains and overestimation of losses (errors of magnitude) but also resulted in the misjudgment of an overall loss as an overall gain (errors of direction). Furthermore, we find a significant moderate positive correlation between the numeracy scores and the overall accuracy on the 36 decision trials $r = 0.41$, $t(196) = 6.23$, $p < 0.01$ (2-tailed). Figure 2.2 illustrates the accuracy on the three different types of decision trials per the numeracy scores. In the next section, we present the results pertaining to the factors of loss position and loss magnitude, manipulated to test the persistency of the additive estimation strategy.

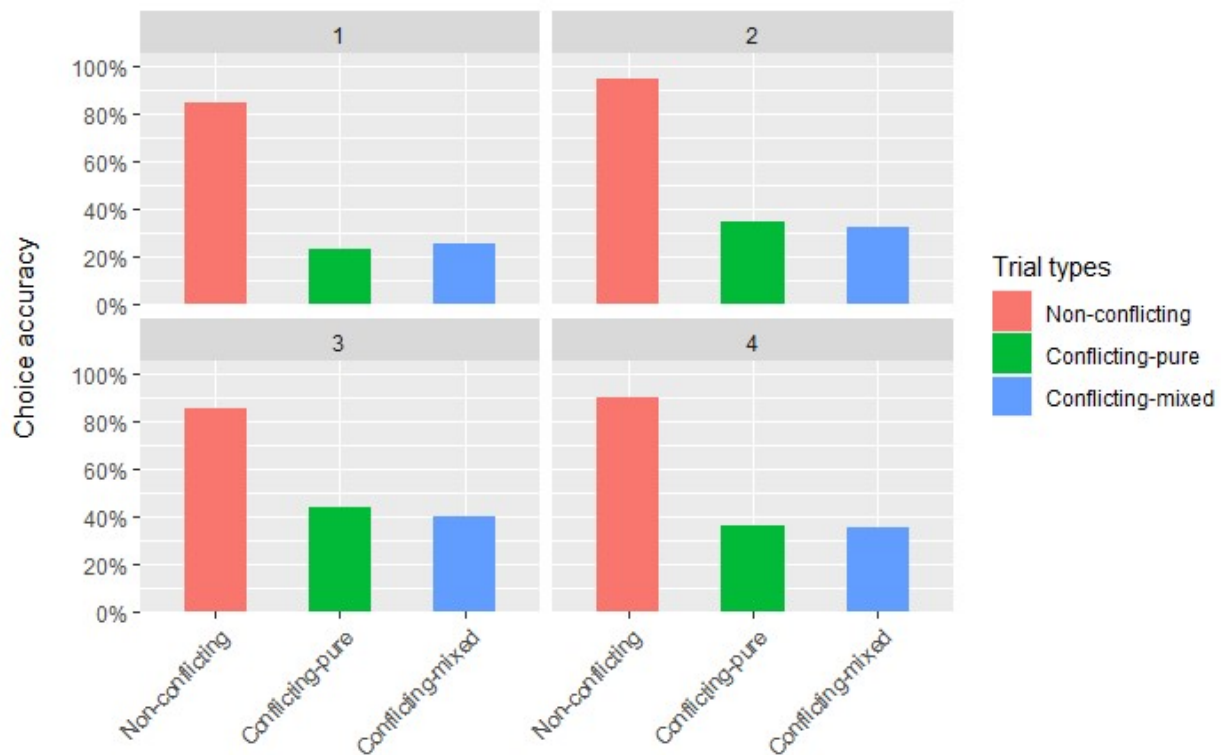


Figure 2.2: Accuracy of choices on the three types of decision trials in accordance with the numeracy scores (range = 1–4). We find that the accuracy in the non-conflicting trials wherein the correct multiplicative strategy and the incorrect additive strategy predicted the same choice is not affected by numeracy scores. However, in the conflicting trials wherein the two strategies predicted different choices, people with high numeracy are relatively more accurate than people with low numeracy.

2.3.4 Conflicting trials: Influence of loss position, loss magnitude, and numeracy

We predicted that a loss at the end of the series will be perceived as more consequential than a loss at the beginning of the series. Moreover, a large loss will serve as a cue to avoid the series resulting in an overall large loss or a relatively smaller gain. To test our hypotheses, we conducted a binary logistic regression analysis using the lme4 package (Bates et al., 2015) in RStudio (R version 3.2.1; R core team, 2015), with the choices on the conflicting trials (0 = Incorrect, 1 = Correct) as the dependent variable. The incorrect responses (0) imply the use of the additive estimation strategy. The correct responses (1) imply the use of the correct multiplicative strategy and, thereby, avoidance of the additive strategy. Order (-1 = loss first, $+1$ = loss last), numeracy scores (range, 1–4), were included as the predictors, and the magnitude of the relatively larger loss in each of the conflicting trials was included as covariates in the model.

Results indicate that a loss at the end of the series did not improve the accuracy on the decision trials ($B = 0.03$, $SE = 0.06$, $z = 0.57$, $p = 0.571$, 95% CI $[-0.09, 0.16]$; loss first = 32.55%, loss last = 33.43%). However, we find an effect of the larger losses in the series such that people were more accurate in light of high loss magnitudes as compared to low loss magnitudes ($B = -0.01$, $SE = 0.002$, $z = -5.65$, $p < 0.001$, 95% CI $[-0.02, -0.01]$). Furthermore, we find a significant relationship between the numeracy scores and choices made on the decision trials indicating that people with higher numeracy scores were more accurate as opposed to people with lower numeracy scores and, therefore, perhaps less prone to the use of the erroneous additive estimation strategy ($B = 0.23$, $SE = 0.12$, $z = 1.97$, $p = 0.049$, 95% CI $[0, 0.47]$).

2.4 Discussion

The current study aimed to investigate the persistency of the erroneous additive estimation strategy commonly used to evaluate sequential percentage changes. In doing so, we borrowed the elements, namely the "end effect" and the "intense effect" from the Peak-end rule and proposed that a loss at the end of the series will be considered more consequential than the same loss at the beginning of the series. Furthermore, a large loss would prevent people from using the straightforward additive estimation strategy. Our results indicate that a loss at the end of the series signalling losing all

previous gains does not prevent people from using the additive estimation strategy. However, high magnitudes of losses may, to some extent, act as a warning sign for people to avoid using the additive estimation strategy. Although, the sensitivity to the losses is also likely to reduce with low magnitudes of losses. Similar to the findings of Newall (2016), we find that numerical skills may play an essential role in preventing people from using error-prone strategies for estimating sequential percentage changes. However, we find that people with very high numeracy also do not correctly estimate the sequential percentage changes most of the time. On a majority, similar to the findings of Chen & Rao (2007), we find that the use of the additive estimation strategy is rather persistent and leads to the underestimation of gains and overestimation of losses. As a new finding, we were able to show that the error associated with the use of the additive estimation strategy even results in misinterpretation of the overall direction of the change. Specifically, overall losses were misconstrued as overall gains. In real life, relative percentage changes are commonly used to describe changes such as double discounts in the consumer domain, stock market fluctuations, and macro-economic information: increase or decrease in inflation, unemployment rates, among others. Our findings suggest that these percentage changes are likely to be grossly misinterpreted, implying severe economic costs for the decision maker.

2.4.1 Limitations and Future work

Though novel in our approach, the study is not without limitations. First, with the use of the binary forced-choice setup, some caution is warranted in interpreting the results as choosing the correct answer may not always indicate the use of the correct multiplicative strategy. For example, avoiding the larger loss could also simply result in people choosing the correct answer without necessarily applying the correct strategy. However, our choice of tasks proves to be a good test of the persistency of the additive strategy in light of conflicting cues and numeracy. Second, in our study, the order of losses was not manipulated between sequences. Specifically, we did not present the participants with trials wherein the loss was placed in the first position in one series and the last position in the other series. Participants, therefore, encountered decision trials only where the loss in each series was either at the first position or at the last position. Therefore, with our setup, we can only provide a partial account of the effect of order in terms of the loss position, but we cannot completely justify the presence or absence of the effect with our results.

Future work can be directed towards comprehensively discerning the effects of order. Furthermore, exploration of psychological processes that may impact not just the estimation strategy but also the affective states of the decision maker may be an interesting avenue for future research. For example, how people feel about the sequences of changes when a loss is at the end of the series instead of a gain? Understanding the relationship between the estimation strategies and the affective evaluations (i.e., whether they operate independently or in conjunction) can help build a comprehensive theory explaining how people perceive sequential percentages.

2.5 Conclusions

Sequential percentage changes are commonly used to represent changes in various domains. Despite the widespread use of percentage formats, people erroneously estimate the consequences of sequential percentage changes. Specifically, the use of the additive estimation strategy in light of sequential percentage changes seems to be rather persistent despite conflicting cues and high numeracy, implying serious costs for the decision maker. A deeper understanding of the estimation strategies and the psychological processes associated with the perception of sequential percentage changes seems crucial for understanding how such percentage changes can be communicated in a manner that is beneficial rather than detrimental to the audience.

Chapter 3

Preferences for sequences of percentage changes are more than based on objective outcomes: Effects of order, equivalence, and overall direction of change

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Abstract

To estimate the combined result of sequential percentage changes, people employ an erroneous additive strategy as opposed to the correct multiplicative strategy. Assuming that people use an additive strategy, we investigate the subjective preferences for sequential percentage changes based on the order of gains and losses in a sequence. Using an established experimental paradigm, we ask participants to estimate the consequences of sequential percentage changes and evaluate their preferences by asking them to compare single percentage change and mathematically equivalent two percentage changes that may be incorrectly perceived as being different based on the additive strategy (Study 1), and single percentage change and additively equivalent two percentage changes which may be incorrectly perceived as being the same based on the additive strategy (Study 2). The results indicate that people employ an erroneous additive strategy; however, not always. Specifically, we find that people deviate from using the additive strategy in light of overall losses and in tasks where the single percentage change and the overall change of the two percentage changes are additively the same. Additionally, we find that numeracy plays a role in helping people correctly estimate the consequences of sequential percentage changes. Furthermore, we find that subjective preferences for the sequences are governed by the want for a happy ending such that a positive end (gain) is preferred over a negative end (loss). Specifically, the order of gains and losses plays a prominent role for people who objectively estimate the single percentage change and the two percentage changes to be the same with either the correct multiplicative strategy or the incorrect additive strategy.

3.1 Introduction

Various private and public entities frequently incorporate numerical formats such as frequencies and percentages to communicate myriad of changes to the general public. Specifically, the use of percentages is seemingly common as they are particularly valuable for measuring the amount of change over a period of time and/or to express an increase or a decrease in relation to a certain base value. Furthermore, percentage changes can be expressed as a single change or as a sequence of changes. For example, a discount on a product can be advertised as either a single discount of 40% or a mathematically equivalent sequence of discounts (e.g., -25%, -20%). Estimating the

overall result of the double discount requires the use of a multiplicative strategy $[(1-25/100) \times (1-20/100) - 1] \times 100$ as each of these percentage changes is associated with different base values. Therefore, the overall discount is equivalent to the single discount of 40%, irrespective of whether the discount of 25% is estimated first or second. However, people have been found to employ an erroneous additive strategy (Chen & Rao, 2007), thereby, overestimating the overall discount to be 45%, $(-20 + (-25))$, which makes the double discount appear larger as opposed to the actual single discount of 40%.

While the use of the additive estimation strategy and the errors associated with neglecting base values have been documented in several studies (e.g., Kruger & Vargas, 2008; Chen & Rao, 2007; Newall, 2016; Davis & Bagchi, 2018; Chen et al., 2012), there is limited evidence on the factors imperative for effective communication of sequential percentage changes. Research beyond the use of the additive estimation strategy specifies factors embedded in a sequence, such as order of percentage changes as well as the presentation mode that influence the perception of sequential percentage changes (Davis & Bagchi, 2018). Following this stream of research, the current paper presents a comprehensive view of the role of order, governing the preferences for sequential percentage changes, amounting to gains and losses. Regarding the estimation strategies, similar to the existing literature, we predict that people will use the additive estimation strategy to evaluate the objective outcomes of sequences of percentage changes. However, we posit that the subjective affective evaluations of sequences of percentage changes will be governed by the want for a "happy ending" such that a positive end (gain/large gain) will be preferred over a negative end (loss/large loss). Additionally, we explore the role of equivalence, both real and perceived, that might further influence the evaluations of sequential percentage changes. The next sections of the paper are organised in the following manner. First, we begin by elaborating on the commonly recognised error regarding the estimation of sequential percentage changes. Second, we examine the literature on the factors that go beyond the additive aggregation rule, in governing the perception of sequential percentage changes. Third, we examine the existing frameworks and theories that provide a basis to investigate the role of the order of events in a sequence.

3.1.1 Theoretical Background

3.1.1.1 Processing multiple percentage changes: Additive aggregation rule

Erroneous processing of multiple percentage changes has gained significant attention in the consumer as well as the financial domains (e.g., Davis & Bagchi, 2018; Newall, 2016; Chen & Rao, 2007). Specifically, in one of the studies, Chen & Rao (2007) investigated how people evaluate the final result of two percentage changes (e.g., +40%, -25%) that are mathematically equivalent to a single percentage change (e.g., +5%). Based on Thaler (1985), the outcome types were categorized as pure increases (i.e., two percentage increases), pure decreases (i.e., two percentage decreases), mixed increases (i.e., a sequence of percentage increase and decrease resulting in an overall gain) and mixed decreases (i.e., a sequence of percentage increase and decrease resulting in an overall loss). The respective percentage changes were presented as favorable and unfavorable increases and decreases in price changes (e.g., gas prices, mutual funds, among others). The results indicated that people erroneously add two sequential percentage changes to estimate the overall change (Net Effect). On the one hand, the use of the additive estimation strategy leads to an overestimation of the overall change in mixed increases (e.g., -25%, +40%) and pure decreases (e.g., -15%, -25%). On the other hand, it leads to an underestimation of the overall change in mixed decreases (e.g., -40%, +25%) and pure increases (e.g., +25%, +50%) (Chen & Rao, 2007).

3.1.1.2 Beyond the additive aggregation rule

A recent paper by Davis & Bagchi (2018) shows that two factors, namely, the order of percentage changes (large first/large second) and presentation mode (simultaneous: without temporal separation, sequential: with temporal separation), influence the evaluation of multiple discounts and surcharges, through the processes of anchoring (e.g., Tversky & Kahneman, 1974; Epley & Gilovich, 2010) and surprise (e.g., Chen & Rao 2002; Heilman et al., 2002). Mathematically speaking, the manipulation of order and presentation mode does not change the final result of the sequences of percentage changes and should not affect the overall evaluations. Nevertheless, when multiple percentages were presented as discounts on price changes, the order and the presentation modes were shown to play a combined role in the overall evaluations. In the simultaneous presentation mode, people evaluated the offer more positively when the larger percentage change

was presented first, as opposed to when the larger percentage change was presented second. In the sequential presentation mode, in contrast, the unexpected second percentage change shifted the attention from the first percentage change, thereby, resulting in more positive evaluations of the offer when the larger percentage change was presented second. The results of the studies by Davis & Bagchi (2018) extend the scope of research on percentage changes by showing that the additive error is prevalent but somewhat limited as the use of the additive estimation strategy does not predict a difference in overall results based on variations in order or presentation mode. For example, a sequence consisting of a gain of 15% and a loss of 50% additively results in a loss of 35% irrespective of whether the gain of 15% is presented first or second, with or without temporal separation. Nevertheless, the study by Davis & Bagchi (2018) remains limited as the proposed effects of order and presentation mode have been tested under very specific circumstances, with a focus on a subset of the possible outcome types of percentage changes (i.e., two increases or decreases resulting in an overall increase or an overall decrease). We, therefore, investigate the effects of order more broadly by systematically varying the valences of percentage changes in a sequence as well as the direction of the overall change and, thus, include all possible outcome types of percentage changes.

3.1.1.3 Perception of multiple outcomes: Theory of mental accounting

The *theory of mental accounting* (Thaler, 1985) provides a useful framework for understanding the perception of multiple gains and losses. Rooted in the value function of *prospect theory* (Kahneman & Tversky, 1979), mental accounting (MA) predicts happiness or maximizing utility based on the principles of integration and segregation in light of economically equivalent gains and losses. For instance, with mixed gains wherein a large gain (+\$100) and a small loss (-\$10) results in an overall gain (+\$90), MA predicts that people should be happier integrating the two events (i.e., as a net gain of \$90) as compared to thinking about each of the two events separately (i.e., as +\$100 and -\$10), as the value of integrating the large gain and a small loss is larger than segregating them, thus $v(x) + v(-y) < v(x - y)$. Based on the abovementioned value function, preferences for segregation and integration were predicted for four outcome types: Preference for (1) segregating pure gains (two gains), (2) integrating mixed gains (a large gain and a small loss),

(3) integrating pure losses (two losses) (4) segregating mixed losses (a large loss and a small gain) (Thaler, 1985).

While the MA principles are known to be widely applied in various economic and non-economic settings (e.g., Thaler, 1999; Thaler & Johnson, 1990; Linville & Fischer, 1991), MA at best provides limited evidence in explaining the perception of sequential percentage changes (Chen & Rao, 2007; Heath et al., 1995; Chen & Sun, 2018). For example, Chen & Rao (2007) showed that the erroneous adding of mixed percentage changes resulting in a gain (e.g., +40%, -25%) would lead to a reversal of MA principles when compared with a mathematically equivalent single percentage change (+5%). People will prefer the events to be segregated and not integrated as the additive result of the two percentage changes is higher (+15%) than the single percentage gain (+5%). However, in the absence of the additive error, participants were found to be indifferent between the single change and the economically equivalent two changes when presented differently. Therefore, the principles of MA were not found to be applicable in the context of sequential percentage changes (Chen & Rao, 2007). Although, Chen & Sun (2018) show that replication of MA principles depends not only on the computational error but also on the events being categorized in the same mental account or not. Specifically, they found that individuals who employ the additive estimation strategy and perceive no difference between the result of the two percentage changes (+5%, -33%) and nominally (additively) equivalent single percentage change (-28%), MA principle of integration for the mixed gain is replicated when the events are categorized into two different mental accounts. However, when the events are categorized in the same mental account, people who make the additive error are likely to be indifferent between the two additively equivalent albeit mathematically different options.

Furthermore, MA remains limited in explaining how the order of events might influence the preferences for sequences of percentage changes. For example, a mixed gain is always meant to be integrated irrespective of the order of gains and losses in a sequence. We, therefore, borrow the framework of MA only for investigating the effect of order for the four possible outcome types of percentage changes (pure gains, pure losses, mixed gains, and mixed losses) and further explore the role of real and perceived equivalence by presenting single vs. two percentage changes that are economically identical but maybe misperceived as being different due to the use of the additive strategy (as in, Chen & Rao, 2007) and single vs. two percentage changes that are economically

different, but maybe misperceived as being equivalent due to the use of the additive strategy, (as in, Chen & Sun, 2018).

3.1.1.4 Intertemporal choice: "Happy ending."

The perception of events in a sequence based on the order of events can be explained by how the end of a sequence is perceived. In this regard, various studies relating to intertemporal choice literature illustrate negative time discounting in sequential outcomes, which results in a tendency to postpone positive outcomes until the end ("savouring gain") and getting over the negative outcomes at the beginning ("avoiding dread"). Therefore, people might prefer sequences of outcomes with an improving trend (e.g., preference for increasing wage profiles) over sequences that are "constant" or show a declining trend and exhibit a preference for a sequence with a "happy ending" (Loewenstein, 1987; Guyse et al., 2002; Loewenstein & Sicherman, 1991; Loewenstein & Prelec, 1991; Read & Powell, 2002; Ross & Simonson, 1991). Furthermore, liking for an improving sequence can also be explained by the recency effect, which makes the last outcome an important factor for the final evaluation (Miller & Campbell, 1959; Chen & Rao, 2002). In the context of percentage changes, if people savor their gains and like happy endings, a sequence of two percentage changes (e.g., +40%, -25%) is likely to be preferred more when the sequence ends with a gain (+40%) as opposed to when the same sequence ends with a loss (-25%). However, the preferences based on a happy ending have been tested in a limited manner (Davis & Bagchi, 2018). Specifically, the findings of Davis & Bagchi (2018) suggest that people would prefer a happy ending when the events of a sequence are presented with temporal separation, but not otherwise. Furthermore, people may also prefer a "happy start" when the sequence of percentage changes is presented together without temporal separation. However, it remains unknown if want for the happy ending could be prevalent as a general human tendency resulting in differential preferences for otherwise equivalent outcomes.

3.1.2 Present research and hypotheses

In two-description based studies, we employ investment scenarios and investigate estimation strategies and preferences for a "happy ending" by manipulating the order of gains and losses in

sequences of percentage changes. In both our studies, we implemented the setup proposed by Chen & Rao (2007) and asked the participants to compare the results of single vs. two percentage changes. In our first study, we included tasks where the overall change of the two percentage changes was mathematically equivalent to the single percentage change (Chen & Rao, 2007). In our second study, we also included tasks where the overall change of the two percentage changes was additively equivalent to the single percentage change (as in, Chen & Sun, 2018). The outcome types for the mixed and the pure percentage changes were classified based on Thaler (1985) as mixed gains and mixed losses (i.e., a sequence of a gain and a loss resulting in an overall gain or an overall loss) and pure gains and pure losses (i.e., two gains and two losses, resulting in an overall gain and an overall loss, respectively). We predicted that people would use the additive estimation strategy to evaluate the consequences of sequential percentage changes. Additionally, we predicted that inclination towards a happy ending would govern the preferences for sequential percentage changes such that for mixed percentage changes, a loss followed by a gain will be preferred over a gain followed by a loss ($[Lg] > [Gl]$). For pure percentage changes, a small gain followed by a large gain will be preferred over a large gain followed by a small gain ($[gG] > [Gg]$) and vice versa for losses ($[Ll] > [Ll]$).

Our research focuses on investigating preferences for a happy ending based on the order of percentage changes. Similar to the literature on mental accounting (Thaler, 1985), two people were shown to experience financial changes. One person always experienced the single percentage change while the other person always experienced the sequence of two percentage changes. The changes were described as occurring on different days. The main task in each scenario was to adopt their perspective and evaluate their situations by answering two short questions on relative happiness (preference) and the overall financial result (outcome). The use of two separate measures allows us to clearly distinguish between the estimation strategies as well as the preferences for a happy ending based on the order of gains and losses in sequences of percentage changes.

3.2 Study 1

3.2.1 Participants

The study was programmed in Unipark (Version [EFS, 2018]). A total of 201 participants (89 females; $Mage = 35$ years, $SDage = 10.53$) were recruited via Amazon Mechanical Turk. They received a basic compensation of US-\$ 1.20 for completing the study and an additional bonus of up to US-\$ 0.85 based on the accuracy of responses on tasks with a correct and an incorrect answer. All 201 participants completed the study. However, we excluded the data of 5 participants who indicated that their data could not be trusted. Our final sample consists of 196 participants (87 females; $Mage = 35$ years, $SDage = 10.63$). All of them were residents of the United States, and 194 (98.98%) participants chose English as their native language. 107 (54.59%) of them had obtained a Bachelor's degree or higher.

3.2.2 Design

The experimental design of the study consisted of 2 factors: order (2 levels: *gain-loss*, *loss-gain*) x overall change (2 levels: *overall gains*, *overall losses*), with both the order and the overall change manipulated within subjects. The participant pool was divided into four groups, and the presentation order of the tasks was counterbalanced in each of the groups.

3.2.3 Materials

Each participant completed 5 decision tasks. One of the 5 decision tasks was an attention check. The 4 actual decision tasks included 1 mixed gain and 1 mixed loss, presented in two orders (i.e., *gain-loss* and *loss-gain*). The percentage changes presented in the decision tasks were the same as in Chen & Rao (2007). Each of these tasks involved repeatedly comparing financial events experienced by two people called Person A and Person B. Person A experienced a single percentage change, resulting in an overall gain or an overall loss. Whereas Person B experienced the sequence of two percentage changes consisting of a gain and a loss, resulting in an overall gain or an overall loss. In all the decision tasks, the overall change of the sequence of two percentage changes was mathematically equivalent to the single percentage change (i.e., both Person A and

Person B experienced the same overall gain or the same overall loss). An example of the decision task can be found in Appendix B1.1.

There were two main dependent measures for each of the decision tasks, namely, preference and outcome. To investigate the preferences for sequences of percentage changes, as a first question, participants were asked which of the two persons is happier (in case of an overall gain) or more upset (in case of an overall loss), relative to each other. We used a 7-point response scale, marked with Person A on the left side of the scale (1 = "extremely more happy/upset", 2 = "moderately more happy/upset", 3 = "slightly more happy/upset"), mid-point (4 = "both feel the same") and Person B marked on the right side of the scale (5 = "slightly more happy/upset", 6 = "moderately more happy/upset", 7 = "extremely more happy/upset").

To investigate if people use the additive estimation strategy, as a second question, participants were asked which of the two persons is facing the better financial outcome (in case of an overall gain) or the worse financial outcome (in case of an overall loss), relative to each other. Similar to the preference measure, we used a 7-point response scale, marked with Person A on the left side of the scale (1 = "extremely better/worse outcome", 2 = "moderately better/worse outcome", 3 = "slightly better/worse outcome"), mid-point (4 = "both face the same outcome") and Person B marked on the right side of the scale (5 = "slightly better/worse outcome", 6 = "moderately better/worse outcome", 7 = "extremely better/worse outcome"). In all the decision tasks, choosing the option "both face the same outcome" implied the use of the correct strategy.

As mentioned above, half of the decision tasks resulted in overall losses, where participants were asked which of the two persons is more upset and facing the worse financial outcome. For the analysis, these negatively formulated scales were recoded to be in line with the responses to the positively worded questions. Therefore, in this study, two changes (>4) always indicates the use of the additive estimation strategy or liking for two changes, while single change (<4) always indicates the use of other incorrect strategies or liking for the single change, on the respective measures of preference and outcome. Table 3.1 provides an overview of the stimuli, along with the predicted preferences and outcomes. Additionally, the modified version of the Cognitive Reflection Test (emphCRT; Frederick, 2005; developed by Mata, 2016), a 3-item questionnaire, for measuring cognitive reflection, and the Berlin Numeracy Test (BNT; Cokely et al., 2012), consisting of 4 items, for measuring risk literacy, were implemented for assessing individual

differences. The questionnaires of the CRT and the BNT can be found in Appendix B2.1 and Appendix B2.2, respectively.

Table 3.1: Overview of the four decision tasks and the corresponding predictions for preferences and outcomes.

Tasks	Stimuli	Outcomes (correct strategy)	Outcomes (additive strategy)	Preferences
Mixed gain	Gain-loss	No	Two	Single
Person A	+5%	difference	changes	change
Person B	+40%, -25%			
Mixed gain	Loss-gain	No	Two	Two
Person A	+5%	difference	changes	changes
Person B	-25%, +40%			
Mixed loss	Gain-loss	No	Two	Single
Person A	-25%	difference	changes	change
Person B	+25%, -40%			
Mixed loss	Loss-gain	No	Two	Two
Person A	-25%	difference	changes	Changes
Person B	-40%, +25%			

3.2.4 Procedure

After providing the consent to be a part of the study, participants were directed to read the instructions concerning the decision tasks. On the instructions page, participants were randomized into one of the four groups where we counterbalanced the factors of order and overall change. Next, they completed an example task to familiarize themselves with the format of the response scale used for assessing the preferences and the outcomes. After completing the example task, participants began with the actual decision tasks. In each task, participants compared and evaluated

the financial events experienced by two people Person A and Person B, and responded to two questions. First, "Which of the two persons is happier/more upset?" Second, "Which of the two persons is facing the better/worse financial outcome?" Participants received an amount of US-\$ 0.10 in each decision task for correctly choosing the option "both face the same outcome." After completion of the decision tasks, participants were asked to specify the tools and strategies used to answer the decision tasks. Followed by which they were directed to complete the CRT and the BNT. Participants were once again asked to specify the tools used for answering the questions and indicate their familiarity with each of the tests, followed by the completion of the socio-demographic form.

3.3 Results

3.3.1 Numeracy, cognitive reflection scores, and corresponding strategies

Mean score on the Berlin Numeracy Test (BNT) was found to be 1.37 ($Mdn = 1$, $SD = 1.28$, $range = 0-4$). For the cognitive reflection test (CRT) the mean score was found to be 1.59 ($Mdn = 2$, $SD = 1.25$, $range = 0-3$). Concerning the tools and strategies used for answering the numeracy and cognitive reflection questions, 166 responses indicated the use of no external tools, 3 responses indicated the use of a calculation device, 26 responses indicated the use of a pen and paper strategy, and 1 response indicated the use of an online search engine. Finally, 80 (40.82%) participants indicated that they were familiar with the BNT, whereas 82 (41.84%) participants indicated familiarity with the CRT.

3.3.2 Do people use the additive estimation strategy?

Participants were asked which of the two persons is facing the better or the worse financial outcome. We predicted that the outcomes chosen by the participants will be based on the use of the additive estimation strategy. Therefore, we classified the outcome responses as corresponding to three main estimation strategies: correct, additive, and other. Proportions of outcomes chosen with the correct strategy were found to be 26.02%. In line with the prediction, 52.04% of the outcomes chosen implied the use of the additive estimation strategy. Lastly, 21.94% of the

outcomes chosen implied the use of other incorrect strategies. Concerning the decision task tools, 152 responses indicated the use of no external tools, 32 indicated the use of a calculator, 14 with a pen and paper strategy, and 2 with the use of an online search engine.

3.3.3 Do order and overall change influence the chosen outcomes?

We did not make any predictions regarding the influence of order and overall change on the chosen outcomes. However, to investigate if there were any effects, we conducted a mixed-effect regression analysis with the package "nlme" (v3.1-147; Pinheiro et al., 2020; R Core Team, 2020) in RStudio (R version 3.5.3; R core team, 2019). Outcomes were included in a continuous manner as the dependent variable, order (2 levels: gain-loss (-1), loss-gain (+1)), and overall change (2 levels: overall gains (-1), overall losses (+1)), were included as the predictors. Additionally, the standardized scores of CRT and BNT were included as the covariates in the model. We estimated the results of the complete model and consequently report the significance of the factors by using a chi-square analysis conducted with the package "car" (Fox et al., 2012). Note that the coding of factors and the method of analysis remain the same unless specified otherwise. Lastly, all the visualizations were made using the package "ggplot2" (Wickham, 2009).

Results indicate a main effect of the order of gains and losses, such that the outcome means were higher when the sequence of changes ended in a gain as opposed to a loss (Wald $\chi^2 = 7.77$, $df = 1$, $p = 0.005$, $M_{\text{gain-loss}} = 4.43$, $M_{\text{loss-gain}} = 4.71$). The outcome means were also found to be higher in the case of overall gains as compared to overall losses, indicated by a main effect of overall change (Wald $\chi^2 = 143.00$, $df = 1$, $p < 0.001$, $M_{\text{gain}} = 5.17$, $M_{\text{loss}} = 3.97$). However, we find that the influence of order on the chosen outcomes was prominent only in the case of overall losses, indicated by a significant interaction between order and overall change (interaction, Wald $\chi^2 = 7.77$, $df = 1$, $p = 0.005$, overall losses: $M_{\text{gain-loss}} = 3.69$, $M_{\text{loss-gain}} = 4.25$). Figure 3.1 illustrates the outcomes as proportions and the corresponding estimation strategies across the two orders and the overall changes. Specifically, we find that in the case of overall losses, the proportions of single percentage change chosen as the better outcome were higher when the sequence of changes ended in a loss as opposed to when the sequence of changes ended in a gain ($\text{Prop}_{\text{singlechange: gain-loss}} = 42.86\%$, $\text{loss-gain} = 27.55\%$). Consequently, the proportions of two percentage changes chosen as

the better outcome were higher when the sequence of changes ended in a gain as opposed to when the sequence of changes ended in a loss (Prop_{twochanges}: gain-loss = 33.16%, loss-gain = 40.82%). Lastly, the proportions of outcomes indicating no difference varied between the two orders such that people more often chose the two options to be the same when the sequence of changes ended in a gain as compared to a loss (Prop_{nodifference}: gain-loss = 23.98%, loss-gain = 31.63%).

On the contrary, in the case of overall gains, the proportions of outcomes chosen differed only slightly between the two orders. Specifically, the proportions of the two percentages chosen as the better outcome were very high in both the orders (Prop_{twochanges}: gain-loss = 68.88%, loss-gain = 65.31%). While the proportions of the single percentage change chosen as the better outcome were very low in both the orders (Prop_{singlechange}: gain-loss = 9.18%, loss-gain = 8.16%). Lastly, the proportions of outcomes indicating no difference varied only slightly between the two orders (Prop_{nodifference}: gain-loss = 21.94%, loss-gain = 26.53%). Furthermore, we find a marginal effect of numeracy on the outcomes chosen such that people with higher numeracy more often correctly indicated the single change and the overall change of the sequence of two changes to be equivalent (Wald $\chi^2 = 3.34$, $df = 1$, $p = 0.068$). However, we do not find any effect of the CRT scores on the outcomes chosen (Wald $\chi^2 = 1.95$, $df = 1$, $p = 0.162$). In the next section, we elaborate on the results related to the preferences for sequences of percentage changes.

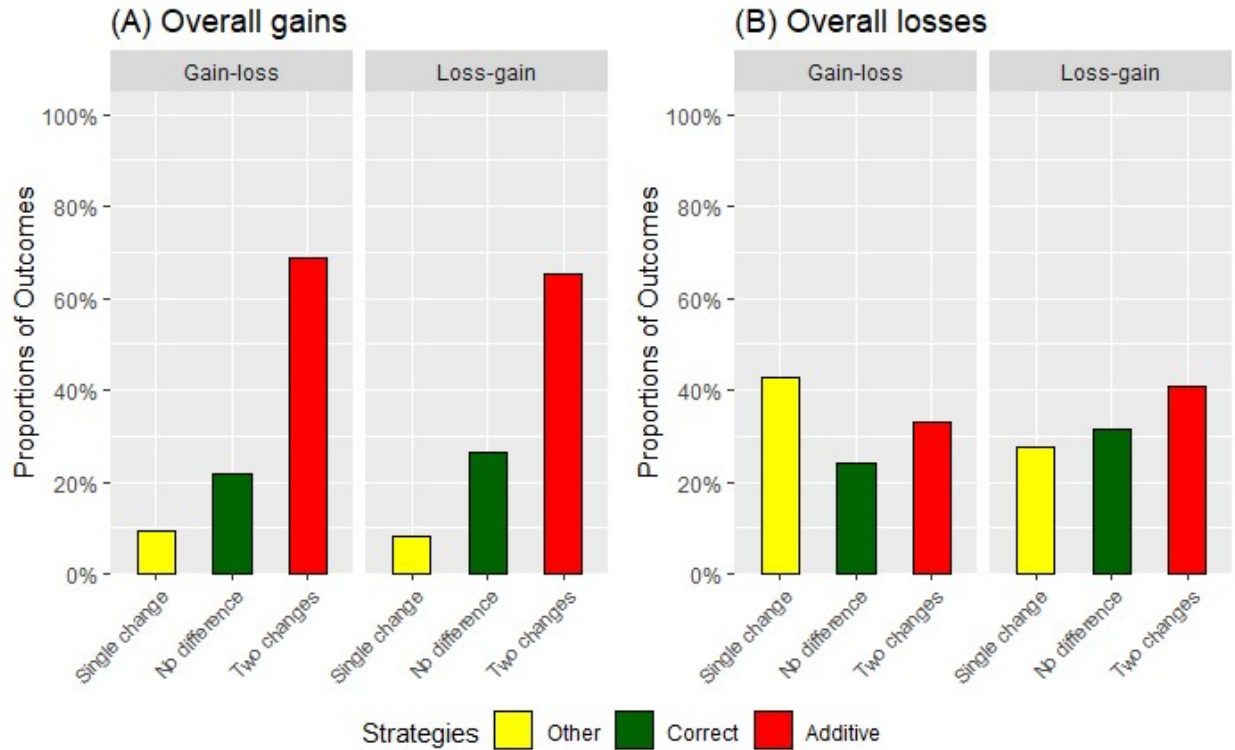


Figure 3.1: Proportions of outcomes chosen and the corresponding estimation strategies ($N = 196$, $tasks = 4$). In all the panels, "No difference" indicates the correct answer. (A) Overall gains. The use of the additive strategy was dominant in both the orders as indicated by the high proportions of two changes chosen as the better outcome in each of the two orders (gain-loss, loss-gain). (B) Overall losses. The single percentage change was chosen as the better outcome more so when the sequence of two changes ended in a loss (gain-loss) as compared to when the sequence of two changes ended in a gain (loss-gain).

3.3.4 Do people prefer a happy ending?

Recall that we are interested in assessing the preferences for sequences of percentage changes, based on the order of gains and losses. We predicted that the want for a "happy ending" would govern the preferences such that a loss followed by a gain will be preferred over a gain followed by a loss ($[Lg] > [Gl]$). Participants were asked which of the two persons is happier or more upset. In the regression model, preferences were included in a continuous fashion as the dependent variable, and the factors of order and overall change were included as the predictors. In addition to the standardized CRT and BNT scores, the chosen outcomes were centered on the mean and

were treated as covariates in the model. The package "Rmisc" (Hope, 2013) was used to estimate the standard errors depicted in the visualization of the preferences in both studies.

As predicted, the results indicate higher preference ratings for sequences of percentage changes when a loss was followed by a gain as opposed to when a gain was followed by a loss (Wald $\chi^2 = 17.78$, $df = 1$, $p < 0.001$, $M_{\text{Gain-loss}} = 4.16$, $M_{\text{Loss-gain}} = 4.71$). We did not make any predictions regarding the influence of overall change. However, we find that the preference ratings were higher in the case of overall gains as compared to overall losses (Wald $\chi^2 = 11.62$, $df = 1$, $p = 0.001$, $M_{\text{Gain}} = 5.00$, $M_{\text{Loss}} = 3.88$). Though, the preference ratings did not differ across the two orders for the two overall changes, indicated by a non-significant interaction between order and overall change (interaction, *NS*, Wald $\chi^2 = 0.37$, $df = 1$, $p = 0.540$). Figure 3.2 illustrates the mean preference ratings across the two overall changes and the two orders. Furthermore, the outcomes chosen were found to be significant predictors of the preferences (Wald $\chi^2 = 610.74$, $df = 1$, $p < 0.001$). Lastly, we find a marginal effect of BNT such that people with higher numeracy were found to be indifferent between the single change and the overall change of the two percentage changes (Wald $\chi^2 = 3.35$, $df = 1$, $p = 0.067$). However, we do not find any effects of the CRT scores on the preference ratings (Wald $\chi^2 = 0.44$, $df = 1$, $p = 0.507$). In the next section, we explore the relationship between the chosen outcomes and the preference for a happy ending.

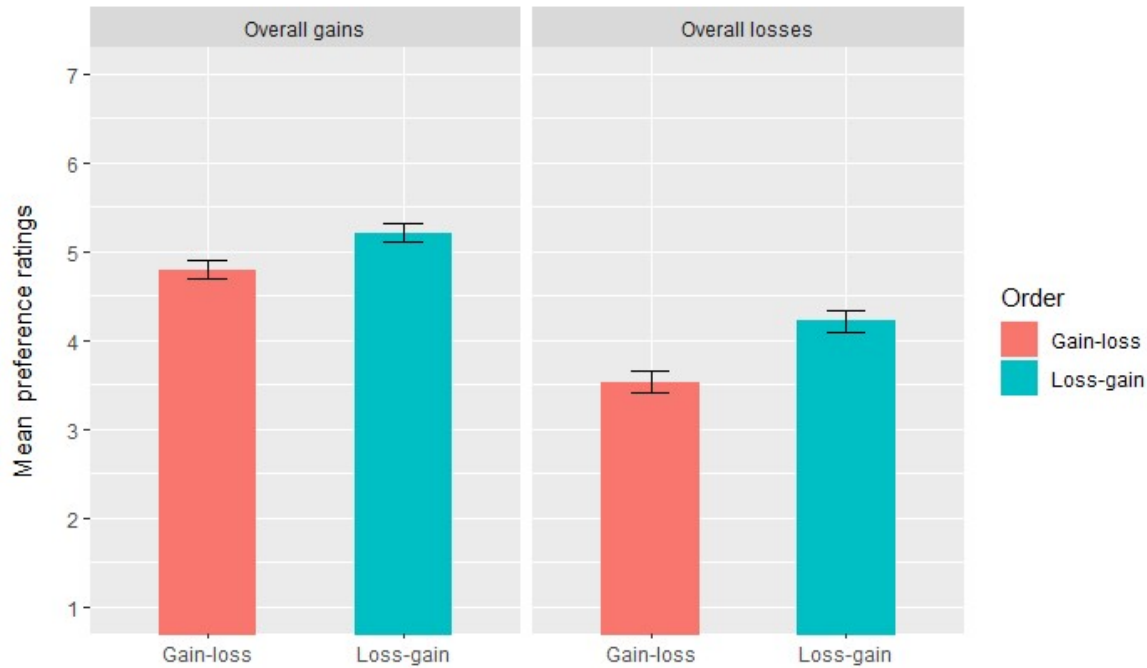


Figure 3.2: Mean preference ratings across the two orders and overall changes ($N = 196$, $tasks = 4$). Preference ratings were higher when the sequence of two changes ended in a gain (loss-gain) as compared to when the sequence of two changes ended in a loss (gain-loss), indicating that people preferred a happy ending, in both overall gains and overall losses. Bars represent \pm one standard error of the mean.

3.3.5 Do the chosen outcomes predict preference for a happy ending?

As the next step, we investigated if the choice of single percentage change, two percentage changes, or no difference between the two could be a governing factor for the preferred happy ending. Figure 3.3 illustrates the chosen outcomes and the corresponding preferences across the two orders. Overall, we find that the chosen outcomes and preferences were consistent. However, some participants who responded correctly and indicated no difference between the overall change of the two percentage changes and the single percentage change preferred the sequence of two percentage changes more when a loss was followed by a gain ($\text{Prop}_{\text{nodifference; loss-gain}} = 17.65\%$) as compared to when a gain was followed by a loss ($\text{Prop}_{\text{nodifference; gain-loss}} = 2.45\%$). On the other hand, for participants who incorrectly chose the single percentage change or the two percentage changes as the better financial outcome, preferences for sequences of percentage

changes were similar across the two orders ($\text{Prop}_{\text{singlechange}}: \text{gain-loss} = 8.72\%$, $\text{loss-gain} = 6.40\%$; $\text{Prop}_{\text{twochanges}}: \text{gain-loss} = 38.24\%$, $\text{loss-gain} = 44.85\%$).

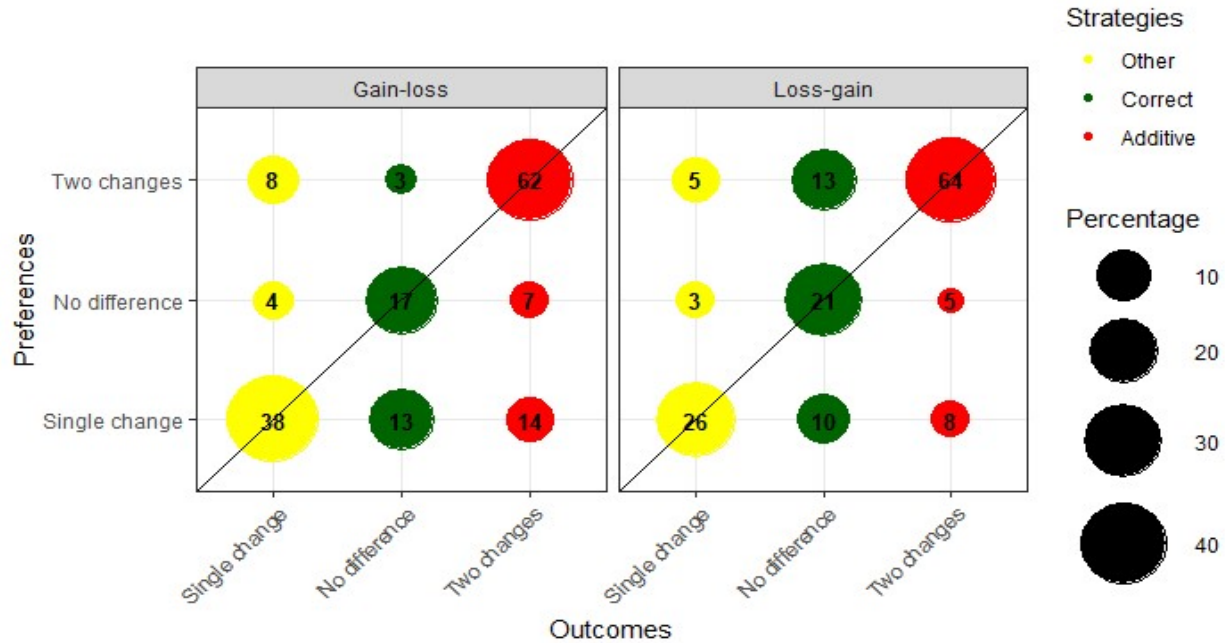


Figure 3.3: Proportions of outcomes and the corresponding preferences across the two orders ($N = 196$, $tasks = 4$). In each of the panels, the numbers indicate the proportions of participants, and the size of the circle represents the proportions of outcomes. Specifically, we find that participants who correctly indicated no difference between the overall change of the two percentage changes and the single percentage change show a higher preference for the sequence of two changes ending in a gain (loss-gain) as compared to the sequence of two changes ending in a loss (gain-loss).

3.4 Discussion

The focus of our first study was to investigate the estimation strategies as well as the preferences based on the order of gains and losses for mixed percentage changes. Concerning the estimation strategies, we replicate the findings of Chen & Rao (2007), as well as Davis & Bagchi (2018), where we find that about half the outcomes, were chosen based on the use of the additive estimation strategy. As a new finding, our results indicate differences in the chosen outcomes based on the order of percentage changes and the overall change. Specifically, when the two percentage

changes were presented with a single percentage gain, people were more likely to choose the two percentage changes as the better outcome in both the orders. This indicates that people were predominantly using the additive estimation strategy when the overall change amounted to gains. However, in the case of overall losses, when the two percentage changes were presented with a single percentage loss, the single percentage change was systematically chosen as the better financial outcome, indicative of the use of some other incorrect strategies, but not the additive estimation strategy. Furthermore, the single percentage change was chosen more often as the better outcome when the sequence of two changes ended in a loss as compared to when the sequence of two changes ended in a gain.

With respect to the preferences, we find that the ratings for sequences of percentage changes were influenced by the order of gains and losses in the sequence. Overall, in line with our hypothesis, a gain in the end, was preferred over a loss in the end, indicating that people indeed liked to have a happy ending. However, the order effect was found to be more enhanced for people who correctly chose both the overall change of the two percentage changes and the single percentage change to be the same. Consequently, for people who incorrectly perceived the single percentage change or the two percentage changes to be resulting in a better financial outcome, the preferences for the sequence of percentage changes were rather consistent across the two orders. Lastly, we find that numeracy helps people in correctly recognizing the mathematical equivalence of the single change and the two percentage changes and reduces the tendency to prefer one option over the other. However, we did not find any evidence of cognitive reflection influencing the outcomes or preferences. To further investigate the order effect for equivalent outcomes, we conducted a second study with tasks where the overall change of the two percentage changes was additively equivalent to the single percentage change. In addition to that, we tested for the proposed order effect in pure percentage changes.

3.5 Study 2

3.5.1 Participants

The study was programmed in Unipark (Version [EFS, 2018]). A total of 182 participants (76 females; $M_{age} = 36$ years, $SD_{age} = 10.12$) were recruited via Amazon Mechanical Turk. They

received a basic compensation of US-\$ 1.80 for completing the study and an additional bonus of up to US-\$ 1.25 based on the accuracy of responses on tasks with a correct and an incorrect answer. All 182 participants completed the study. However, we excluded the data of 5 participants who indicated that their data could not be trusted. Our final sample consists of 177 participants (74 females; $M_{age} = 36$ years, $SD_{age} = 10.19$). All of them were residents of the United States and 175 (98.87%) participants chose English as their native language. 97 (54.80%) of them had obtained a Bachelor's degree or higher.

3.5.2 Design

The experimental design of the study included 3 factors: order (2 levels: *gain-loss*, *loss-gain*, for mixed percentage changes and 2 levels: *large-small*, *small-large*, for pure percentage changes) x overall change (2 levels: *overall gains*, *overall losses*) x type (2 levels: *mathematically equivalent*, *additively equivalent* single vs. two percentage changes), with all the three factors manipulated within subjects. The tasks were presented in two blocks. The order of gains and losses in a sequence was randomized in the first block (the order of gains and losses in block 2 was opposite of that in block 1). Additionally, the presentation order of the tasks was randomized for each participant.

3.5.3 Materials

Each participant completed 18 decision tasks. Two of the 18 decision tasks were attention checks. Among the 16 actual decision tasks included were 2 mixed gains, 2 mixed losses, 2 pure gains, and 2 pure losses presented in each of the two orders. The decision tasks were similar to that in Study 1, with two people being shown as experiencing financial events. Person A experienced the single percentage change, and Person B experienced the sequence of two percentage changes. As in Study 1, the overall change of the sequence of two percentage changes was mathematically equivalent to the single percentage change in 8 (50%) of the tasks. As an extension, we included 8 (50%) tasks where the overall change of the sequence of two percentage changes was additively equivalent to the single percentage change. An example of the decision task can be found in Appendix B1.2. In this study, only the percentage changes presented in the mathematically

equivalent mixed gain and the mixed loss decision tasks were the same as in Chen & Rao (2007). Table 3.2 provides an overview of the stimuli and predictions for the preferences as well as the outcomes.

For each of the decision tasks, the 7-point response scales for preference and outcome were included as the dependent variable. However, in this study, the questions for the preference and the outcome measure were worded differently. For the preference measure, the question was worded as, "Both A and B experienced gains (or losses), but which of the 2 persons is happier (or more upset)?" and for the outcome measure, it was worded as "Both A and B experienced gains (or losses), but which of the 2 persons is facing the better financial outcome?" Therefore, participants were aware in each task, whether the two people were experiencing overall gains or overall losses. Furthermore, with respect to the outcome measure, the question was always framed as "Which person is facing the better financial outcome" (instead of worse financial outcome for overall losses, as in Study 1). Similar to Study 1, for the analysis, preference responses from the 7-point scale were reverse coded for tasks amounting to overall losses (i.e., mixed losses and pure losses).

3.5.4 Procedure

Similar to Study 1, participants were first required to provide consent to be a part of the study. Followed by which they were presented with the instructions pertaining to the decision tasks. On the instructions page, we randomized the order factor for each of the tasks that were to be presented in the first block. Next, an example task was provided for the participants to get familiar with the actual decision task. For each decision task, participants compared the financial events experienced by Person A and Person B and answered two questions. First, "Both A and B experienced gains (or losses), but which of the 2 persons is happier/more upset?" Second, "Both A and B experienced gains (or losses), but which of the 2 persons is facing a better financial outcome?" Participants received an amount of US-\$ 0.05 for each correct answer. Upon completion of the decision task, they were asked to specify the tools used to solve the tasks. Followed by which they were directed to complete the CRT and the BNT and answer some associated questions concerning the tools

used and indicate their familiarity with each of the tests. As a final step, participants were required to provide demographic information.

Table 3.2: Overview of the 16 decision tasks and the corresponding predictions for preferences and outcomes.

Tasks	Stimuli	Outcomes (correct strategy)	Outcomes (additive strategy)	Preferences
Mathematically equivalent tasks				
Mixed gain				
Person A	+5%	No	Two	Two changes Single change
Person B	-25%, +40% +40%, -25%	difference	changes	
Mixed loss				
Person A	-25%	No	Two	Two changes Single change
Person B	-40%, +25% +25%, -40%	difference	changes	
Pure loss				
Person A	-40%	No	Single	Two changes Single change
Person B	-25%, -20% -20%, -25%	difference	change	
Pure gain				
Person A	+50%	No	Single	Two changes Single change
Person B	+20%, +25% +25%, +20%	difference	change	
Additively equivalent tasks				
Mixed gain				
Person A	+15%	Single	No	Two changes Single change
Person B	-25%, +40% +40%, -25%	change	difference	
Mixed loss				
Person A	-30%	Single	No	Two changes Single change
Person B	-50%, +20% +20%, -50%	change	difference	
Pure loss				
Person A	-45%	Two	No	Two changes Single change
Person B	-25%, -20% -20%, -25%	changes	difference	
Pure gain				
Person A	+55%	Two	No	Two changes Single change
Person B	+20%, +35% +35%, +20%	changes	difference	

3.6 Results

3.6.1 Numeracy and cognitive reflection scores

Mean score on the BNT (out of 4 possible correct) was found to be 1.57 ($Mdn = 1$, $SD = 1.35$, $range = 0-4$). For the CRT (out of 3 possible correct) the mean score was found to be 1.71 ($Mdn = 2$, $SD = 1.12$, $range = 0-3$). With respect to the tools, 150 responses indicated the use of no external tools, 2 with the use of a calculator, 24 using a pen and paper strategy, and 1 with the use of an online search engine. With respect to familiarity, 74 (41.81%) participants indicated that they were familiar with the BNT, whereas 77 (43.50%) participants indicated that they were familiar with the CRT.

3.6.2 Outcomes chosen and the corresponding estimation strategies

Overall accuracy on the 16 decision tasks was found to be 40.68%. Similar to Study 1, in the tasks where the overall change of the two percentage changes was mathematically equivalent to the single percentage change, the proportions of outcomes chosen with the correct strategy were found to be 32.70%. About half, 49.36% of the outcomes chosen implied the use of the additive estimation strategy. Lastly, 17.94% of the outcomes chosen implied the use of other incorrect strategies. Furthermore, we find differences in how people estimated the outcomes of mathematically and additively equivalent tasks. Specifically, in the tasks where the overall change of two percentages was additively equivalent to the single percentage change, the proportions of outcomes chosen with the correct strategy were found to be higher, and the outcomes chosen using the additive strategy were found to be lower (Correct = 48.66%, additive = 35.66%, other = 15.68%) in comparison with the outcomes chosen in the mathematically equivalent tasks (Correct = 32.70%, additive = 49.36%, other = 17.94%). Concerning the decision tools, 136 responses indicated the use of no external tools, 31 indicated the use of a calculator, and 11 with a pen and paper strategy.

3.6.3 Influence of order and overall change on the chosen outcomes

In order to investigate the effects of order and overall change on the chosen outcomes, we conducted two mixed-effect regression analyses, separately for mixed percentage changes and pure percentage changes. Outcomes in their continuous form were included as the dependent variable. Factors of order (2 levels: gain-loss (-1) and loss-gain (+1)) for mixed percentage changes and large-small (-1), small-large (+1) for pure percentage changes), type (2 levels: mathematically equivalent tasks (-1) and additively equivalent tasks (+1)) and overall change were included as the predictors. Additionally, the standardized scores of CRT and BNT were included in the model as the covariates. We begin by reporting the results concerning the mixed percentage changes.

3.6.3.1 Mixed percentage changes

Results indicate that the outcome means were not influenced by the order of gains and losses (Wald $\chi^2 = 1.45$, $df = 1$, $p = 0.228$, $M_{\text{Gain-loss}} = 4.06$, $M_{\text{Loss-gain}} = 4.14$). However, the outcome means were higher when the overall change amounted to gains as opposed to losses (Wald $\chi^2 = 45.68$, $df = 1$, $p < 0.001$, $M_{\text{Gain}} = 4.38$, $M_{\text{Loss}} = 3.82$). As in Study 1, people systematically chose the single change as the better outcome in the case of overall losses and more so when the sequence of changes ended in a loss as opposed to a gain, indicated by a marginally significant interaction between order and overall change (Wald $\chi^2 = 3.23$, $df = 1$, $p = 0.072$, overall losses: $M_{\text{gain-loss}} = 3.73$, $M_{\text{loss-gain}} = 3.92$). Specifically, in the case of overall losses, the proportions of single percentage change chosen as the better outcome were higher when the sequence of changes ended in a loss as opposed to a gain (Prop_{singlechange}: gain-loss = 44.63%, loss-gain = 38.14%). Consequently, the proportions of two percentage changes chosen as the better outcome were slightly higher when the sequence ended in a gain as opposed to when the sequence ended in a loss (Prop_{twochanges}: gain-loss = 24.01%, loss-gain = 28.53%). However, the proportions of outcomes indicating no difference were similar across the two orders (Prop_{nodifference}: gain-loss = 31.36%, loss-gain = 33.33%). In the case of overall gains, the proportions of outcomes chosen did not differ between the two orders. Specifically, the proportions of two percentages chosen as the better outcome were found to be the highest in both the orders (Prop_{twochanges}: gain-loss = 44.92%, loss-gain = 42.09%), followed by the proportions of outcomes indicating no difference between the single change and the two changes

(Prop_{nodifference}: gain-loss = 30.51%, loss-gain = 32.77%) and lastly the proportions of single percentage change were chosen the least, as the better outcome in both the orders (Prop_{singlechange}: gain-loss = 24.58%, loss-gain = 25.14%).

Next, we find that the outcomes chosen were influenced by the type of task such that the outcome means were higher in the mathematically equivalent tasks as compared to the additively equivalent tasks (Wald $\chi^2 = 277.32$, $df = 1$, $p < 0.001$, $M_{\text{mathematicallyequivalent}} = 4.59$, $M_{\text{additivelyequivalent}} = 3.61$). Figure 3.4 illustrates the proportions of outcomes chosen for each of the types of tasks across the two orders and the overall changes. Furthermore, the outcomes chosen in each type of task were influenced by the overall change (interaction, Wald $\chi^2 = 15.43$, $df = 1$, $p < 0.001$). Specifically, the proportions of two percentage changes chosen as the better outcome were higher in the case of overall gains (Mathematically equivalent tasks = 61.30 %, additively equivalent tasks = 25.71%) as compared to overall losses (Mathematically equivalent tasks: = 40.40%, additively equivalent tasks = 12.15%). Consequently, the proportions of single percentage change chosen as the better outcome were higher in the case of overall losses (Mathematically equivalent tasks = 29.10%, additively equivalent tasks = 53.67%) as compared to overall gains (Mathematically equivalent tasks = 9.32%, additively equivalent tasks = 40.40%). The proportions of outcomes indicating no difference between the single change and the two changes did not vary much between overall gains (Mathematically equivalent tasks = 29.38%, additively equivalent tasks = 33.90%) and overall losses (Mathematically equivalent tasks = 30.51%, additively equivalent tasks = 34.18%). Finally, similar to Study 1, we find an effect of numeracy on the outcomes chosen (Wald $\chi^2 = 7.50$, $df = 1$, $p = 0.006$). Additionally, the outcomes were also found to be influenced by the CRT scores such that people with higher scores tended to be more correct with indicating the outcome in each of the decision tasks (Wald $\chi^2 = 11.08$, $df = 1$, $p = 0.001$).

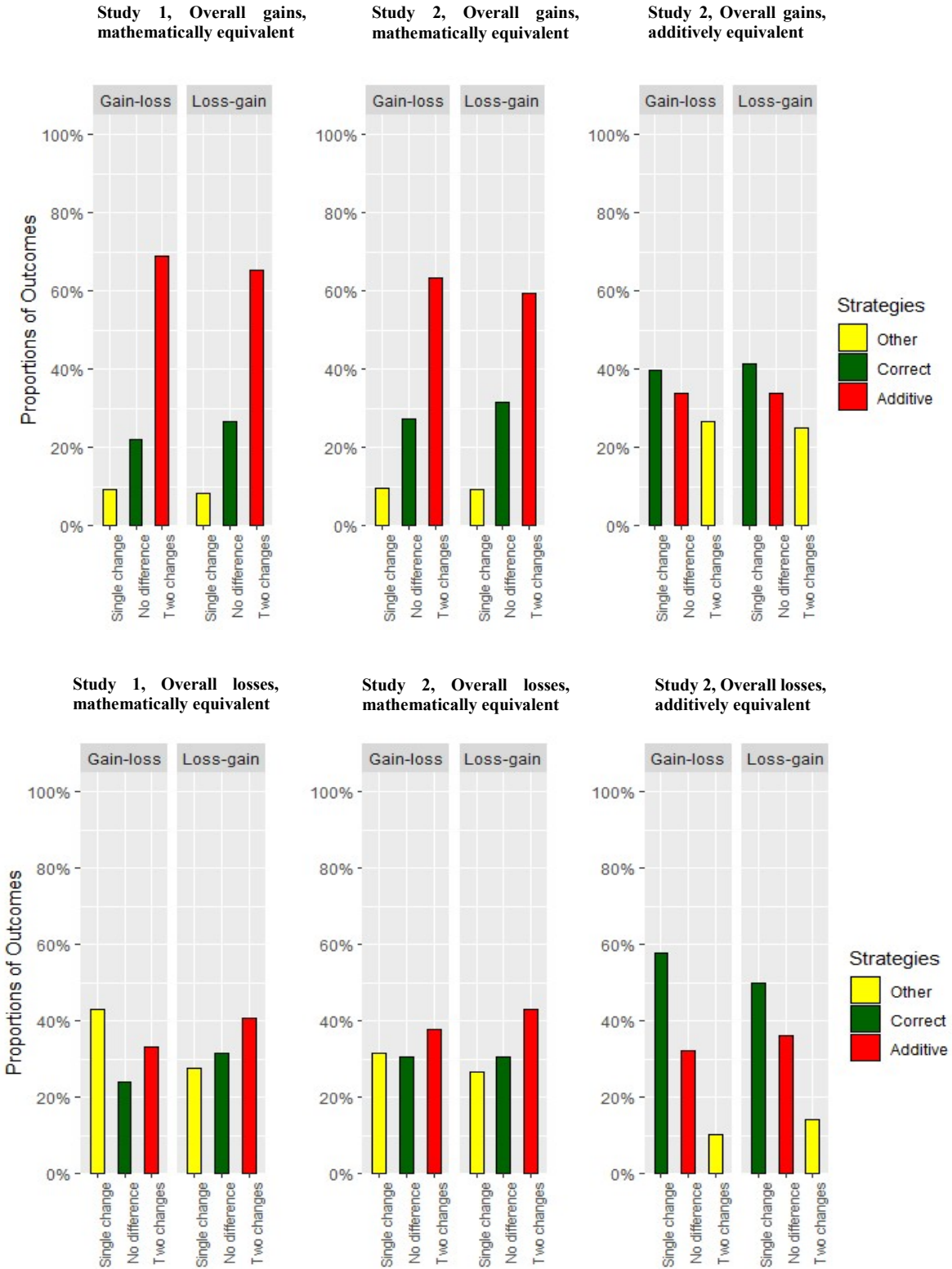


Figure 3.4: Proportions of outcomes chosen across the two orders and overall change for each of the types of tasks for mixed percentage changes, Study 1 (N = 196, tasks = 4), Study 2 (N = 177, tasks = 8).

3.6.3.2 Pure percentage changes

For pure percentage changes, we did not find any influence of the order of gains and losses on the outcomes chosen (Wald $\chi^2 = 0.21$, $df = 1$, $p = 0.648$, $M_{\text{Large-small}} = 4.03$, $M_{\text{Small-large}} = 4.05$). The outcomes chosen were not influenced by the overall change (Wald $\chi^2 = 1.63$, $df = 1$, $p = 0.202$, $M_{\text{Gain}} = 4.08$, $M_{\text{Loss}} = 3.99$). However, a main effect of the type of task was found to be significant such that the outcome means were higher in the additively equivalent tasks as opposed to the mathematically equivalent tasks (Wald $\chi^2 = 326.58$, $df = 1$, $p < 0.001$, $M_{\text{mathematicallyequivalent}} = 3.56$, $M_{\text{additivelyequivalent}} = 4.51$). Moreover, we find strong influences of the overall change and the type of tasks (interaction, Wald $\chi^2 = 9.87$, $df = 1$, $p = 0.002$). Figure 3.5 illustrates the outcomes chosen in mathematically equivalent and additively equivalent tasks across the two overall changes. Specifically, in tasks where the overall change of the two percentage changes was additively equivalent to the single percentage change, the proportions of single percentage change chosen as the better outcome were slightly higher in overall losses ($\text{Prop}_{\text{singlechange}} = 15.54\%$) as compared to overall gains ($\text{Prop}_{\text{singlechange}} = 9.32\%$). Consequently, the proportions of two percentage changes chosen as the better outcome were higher in overall gains ($\text{Prop}_{\text{twochanges}} = 55.65\%$) as compared to overall losses ($\text{Prop}_{\text{twochanges}} = 44.92\%$). Lastly, the proportions of outcomes indicating no difference between the overall change of the two percentage changes and the single percentage change were found to be similar across overall gains and overall losses (Overall gains: $\text{Prop}_{\text{nodifference}} = 35.03\%$; overall losses: $\text{Prop}_{\text{nodifference}} = 39.55\%$). However, in tasks where the overall change of the two percentage changes was mathematically equivalent to the single percentage change, the proportions of outcomes did not differ between overall gains ($\text{Prop}_{\text{singlechange}} = 46.89\%$, $\text{Prop}_{\text{nodifference}} = 36.44\%$, $\text{prop}_{\text{twochanges}} = 16.67\%$) and overall losses ($\text{prop}_{\text{singlechange}} = 48.87\%$, $\text{prop}_{\text{nodifference}} = 34.46\%$, $\text{prop}_{\text{twochanges}} = 16.67\%$). Furthermore, we find a significant effect of numeracy on the outcomes chosen such that people with high numeracy were more accurate in correctly indicating the better outcome in each of the decision tasks as compared to people with low numeracy (Wald $\chi^2 = 3.94$, $df = 1$, $p = 0.047$). However, we find no significant effects of CRT on the outcomes chosen (Wald $\chi^2 = 2.84$, $df = 1$, $p = 0.092$).

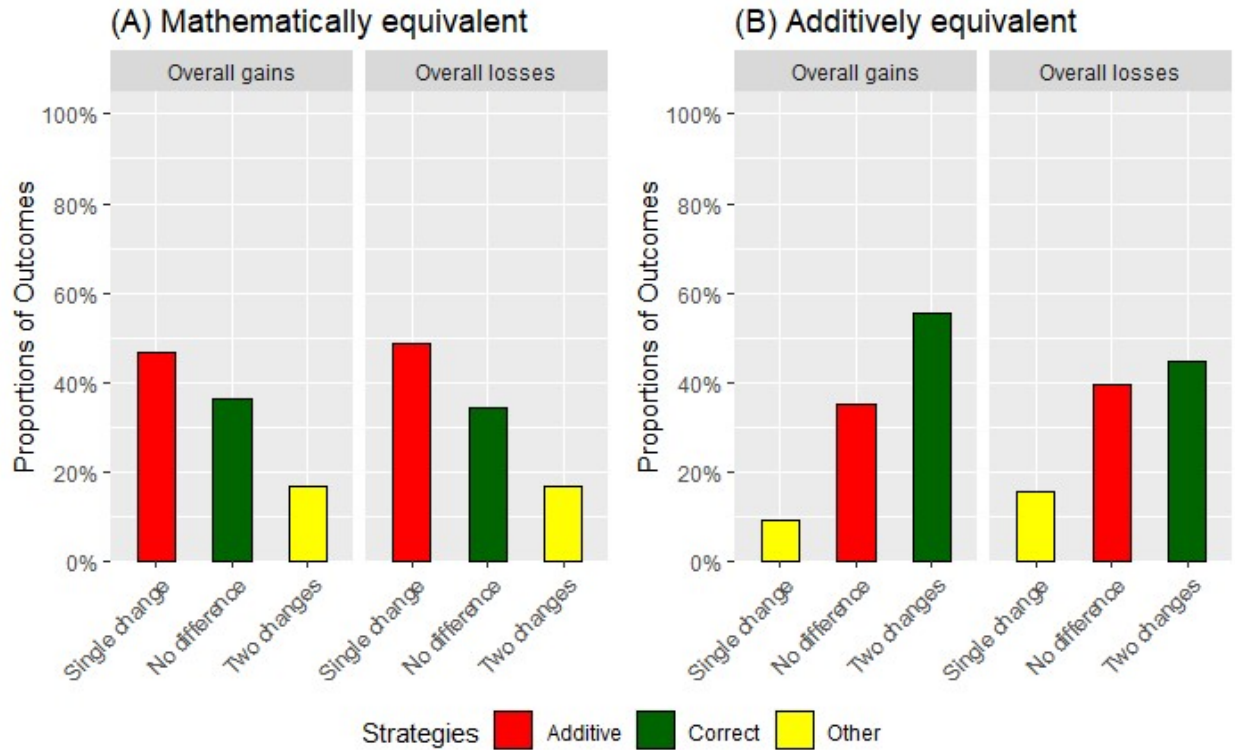


Figure 3.5: Proportions of outcomes chosen across the overall changes for the pure percentage changes ($N = 177$, tasks = 8). (A) Mathematically equivalent tasks. The additive strategy is seemingly dominant as indicated by the high proportions of single change chosen as the better outcome, irrespective of the overall change. (B) Additively equivalent tasks. People chose the two changes as the better outcome more often in case of overall gains as compared to overall losses and thereby, were also more correct when the overall change amounted to gains as compared to losses.

3.6.4 Preference for a happy ending

As in Study 1, we assessed the preferences for percentage changes based on the order of gains and losses. For mixed percentage changes, the hypothesis was the same as in Study 1, where we predicted that a loss followed by a gain would be preferred over a gain followed by a loss ($[Lg] > [Gl]$). For pure percentage changes, we predicted that a small gain followed by a large gain would be preferred over a large gain followed by a small gain ($[gG] > [Gg]$) and vice versa for losses ($[Ll] > [lL]$). We begin by reporting the results of the mixed percentage changes.

3.6.4.1 Mixed percentage changes

Similar to Study 1, the results indicate higher preference ratings for the sequences of changes ending in a gain as opposed to sequences of changes ending in a loss (Wald $\chi^2 = 55.48$, $df = 1$, $p < 0.001$, $M_{\text{Gain-loss}} = 3.65$, $M_{\text{Loss-gain}} = 4.26$) and in the case of overall gains as compared to overall losses (Wald $\chi^2 = 21.41$, $df = 1$, $p < 0.001$, $M_{\text{Gain}} = 4.29$, $M_{\text{Loss}} = 3.62$). Furthermore, the preference ratings were found to be influenced by the type of task (Wald $\chi^2 = 19.59$, $df = 1$, $p < 0.001$, $M_{\text{Mathematicallyequivalent}} = 4.36$, $M_{\text{Additivelyequivalent}} = 3.55$). Additionally, we find that, in the case of overall losses the preferences were slightly higher for the sequences of changes ending in a gain as compared to the sequences of changes ending in a loss, indicated by a marginally significant interaction between order and overall change (interaction, Wald $\chi^2 = 3.20$, $df = 1$, $p = 0.074$, overall loss; $M_{\text{Gain-loss}} = 3.21$, $M_{\text{Loss-gain}} = 4.03$). Figure 3.6 illustrates the preferences based on the order and the overall change. Next, we find that the preferences were governed by the overall change and whether the sequences were mathematically or additively equivalent to the single percentage change (interaction, Wald $\chi^2 = 11.35$, $df = 1$, $p = 0.001$). Figure 3.7 illustrates the preference ratings for the two types of tasks across the two overall changes. Overall, as mentioned before, the preference ratings were higher in the case of overall gains as compared to overall losses. However, the preference ratings were generally higher in tasks where the overall change of the two percentage changes was mathematically equivalent to the single percentage change in comparison with the tasks where the overall change of the two percentage changes was additively equivalent to the single percentage change. Furthermore, preferences were found to be dependent on the outcomes chosen (Wald $\chi^2 = 433.85$, $df = 1$, $p < 0.001$). Similar to Study 1, the preference ratings were not influenced by the CRT scores (Wald $\chi^2 = 2.82$, $df = 1$, $p = 0.093$). Furthermore, there was no influence of numeracy on the preference ratings (Wald $\chi^2 = 1.36$, $df = 1$, $p = 0.243$).

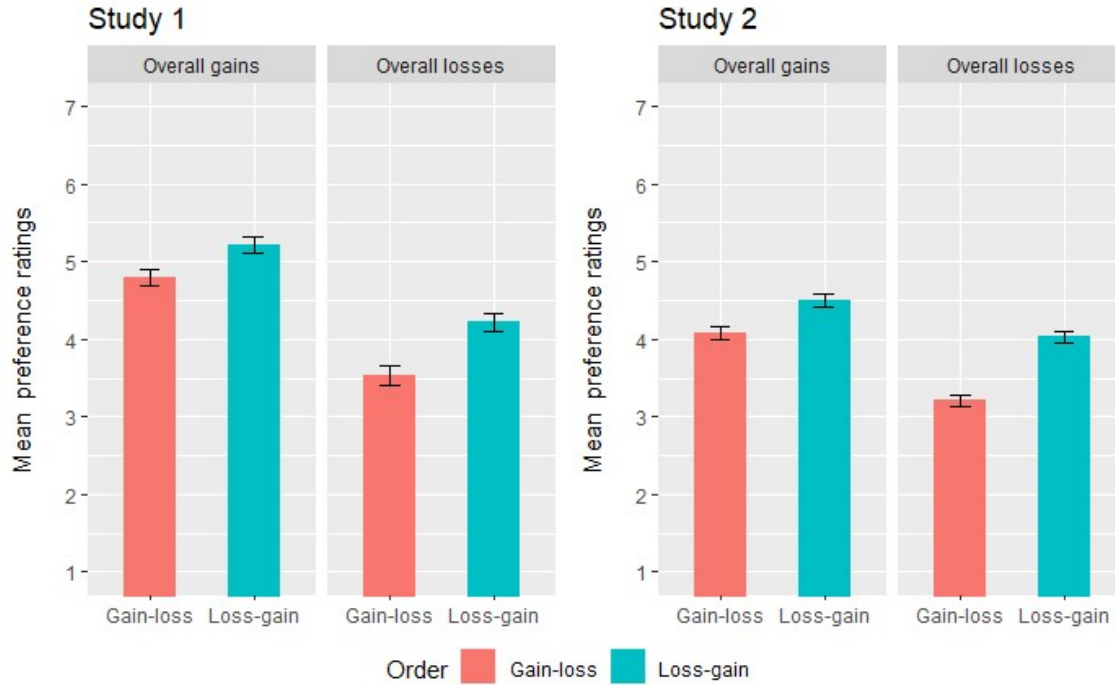


Figure 3.6: Mean preference ratings across the two overall changes and the two orders, for the mixed percentage changes, Study 1 ($N = 196$, $tasks = 4$), Study 2 ($N = 177$, $tasks = 8$). Bars represent \pm one standard error of the mean.

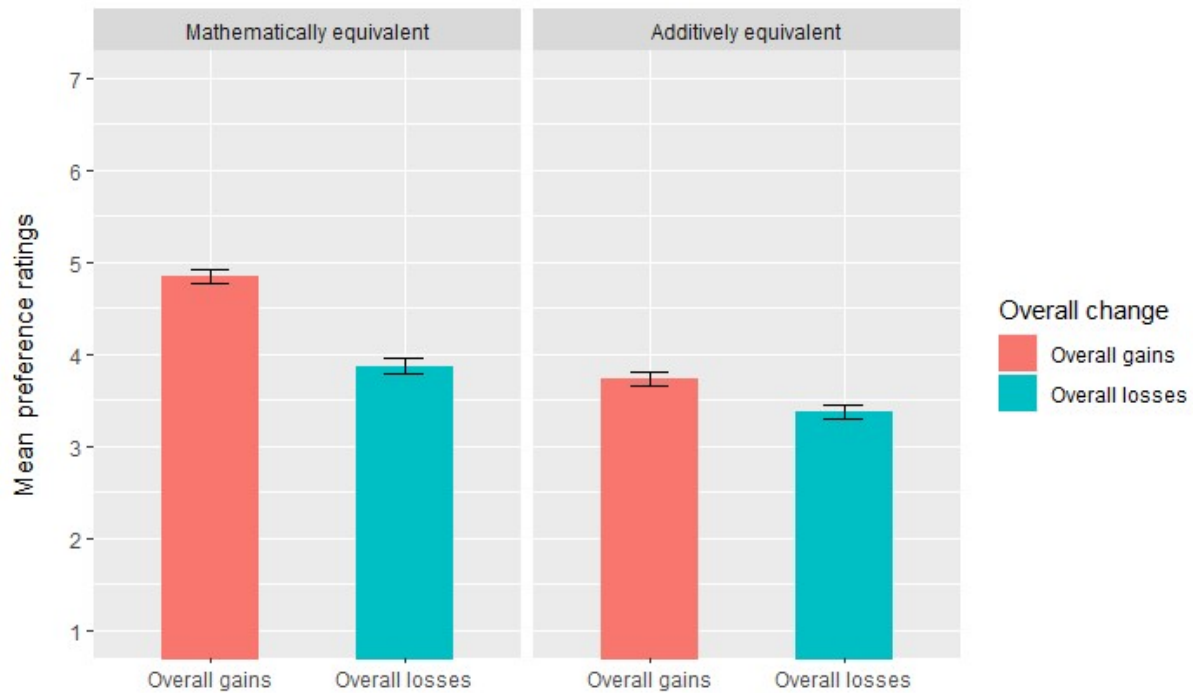


Figure 3.7: Mean preference ratings across the two types of tasks and the two overall changes for the mixed percentage changes ($N = 177$, $tasks = 8$). Bars represent \pm one standard error of the mean.

3.6.4.2 Pure percentage changes

Contrary to our predictions, a positive ending consisting of a larger gain or a smaller loss did not result in higher preferences for sequences of pure percentage changes (Wald $\chi^2 = 0.04$, $df = 1$, $p = 0.845$, $M_{\text{Large-small}} = 3.90$, $M_{\text{Small-large}} = 3.90$). Instead, the preferences were rather governed by the overall change such that the ratings were higher in the case of overall gains as compared to overall losses (Wald $\chi^2 = 16.84$, $df = 1$, $p < 0.001$, $M_{\text{gain}} = 4.10$, $M_{\text{loss}} = 3.70$). Furthermore, the preference ratings were found to be influenced by the type of task (Wald $\chi^2 = 29.66$, $df = 1$, $p < 0.001$, $M_{\text{mathematicallyequivalent}} = 3.50$, $M_{\text{additivelyequivalent}} = 4.31$). The outcomes chosen were also found to be significant predictors of preferences (Wald $\chi^2 = 421.93$, $df = 1$, $p < 0.001$). However, preferences were not influenced by the numeracy (Wald $\chi^2 = 0.62$, $df = 1$, $p = 0.432$) or the CRT scores (Wald $\chi^2 = 0.96$, $df = 1$, $p = 0.326$).

3.6.5 Perception of equivalence and preference for a happy ending

In our first study, we found that people who correctly chose both the single percentage change and the overall result of the two percentage changes to be the same indicated preference for a happy ending. To investigate if a similar pattern exists for people who additively chose both the single percentage change and the overall result of the two percentage changes to be the same, we investigated the relationship between the outcomes chosen and the preferences. We included only mixed percentage changes for this analysis as there was no effect of order in pure percentage changes. Figure 3.8 illustrates the proportions of outcomes and the corresponding preferences across the two studies. Similar to Study 1, we find that people who correctly indicated both the overall change of the two percentages and the single percentage change to be the same mathematically show a higher preference for the sequence of percentage changes ending in a gain as opposed to a loss (Prop_{nodifference}: gain-loss = 4.72%, loss-gain = 18.40%). Furthermore, we find a similar pattern of results for participants who incorrectly perceived the overall change of the two percentages and single percentage to be the same additively (Prop_{nodifference}: gain-loss = 4.98%, loss-gain = 19.09%). Additionally, with respect to the additively equivalent tasks, we find that some participants who were correct also showed a difference in preference based on order such that the gain, in the end, was preferred over a loss in the end (Prop_{singlechange}: gain-loss = 3.60%, loss-gain = 11.11%).

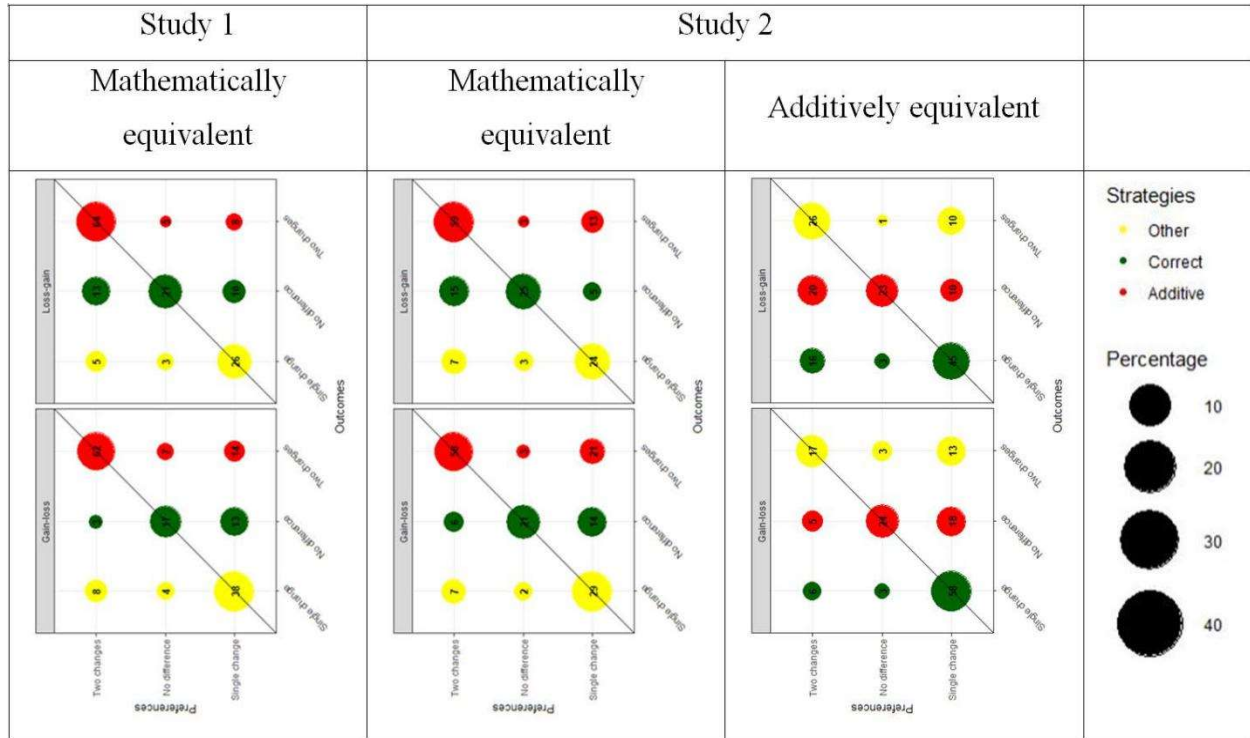


Figure 3.8: Proportions of outcomes and the corresponding preferences across the two orders for the mixed percentage changes, Study 1 ($N = 196$, $tasks = 4$), Study 2 ($N = 177$, $tasks = 8$). In each of the panels, the numbers indicate the proportions of participants, and the size of the circle represents the proportions of outcomes. We find that participants who correctly perceived no difference between the overall change of the two changes and the single change and participants who incorrectly perceived the single change and the overall change of the two changes to be the same show a higher preference for the sequence of two changes ending in a gain (loss-gain) as compared to the sequence of two changes ending in a loss (gain-loss).

3.7 General Discussion

The current findings indicate that factors beyond the additive estimation rule govern the estimation strategies and preferences for sequences of percentage changes. Consistent with the previous literature, we find that people use the additive estimation strategy to evaluate the results of sequential percentage changes (e.g., Chen & Rao, 2007; Davis & Bagchi, 2018). Similar to the results of Chen & Sun (2018), the use of the additive estimation strategy led to a false perception of equivalence among options that were additively the same, although mathematically different. However, further comparisons show that the use of additive estimation strategy might have been lesser in additively equivalent tasks as compared to mathematically equivalent tasks. Specifically, when people perceived the single change and the two percentage changes to be different when in fact, they were mathematically equivalent, they were more inclined towards using the erroneous additive strategy to estimate the overall result of the sequence of two percentage changes. However, when people recognised that the single percentage change and the sequence of two percentage changes were additively the same, the additive equivalence in some ways alerted the participants to recognise that the two options may not actually be the same and, thereby, aided in providing the correct answers.

An important implication of our research, therefore, remains the fact that people are not always using the additive strategy and are likely to deviate from the same based on how the percentage changes are presented or framed. According to the *behavioural decision theory* (BDT; Kahneman & Tversky, 1979), rather than following the traditional economic model of maximising utility, people may be influenced by perceptual biases stemming from how the same information is presented differently, resulting in a reversal of preferences for equivalent information. Similarly, in our research, we find that the framing of information influences both the objective outcomes as well as the subjective preferences for sequential percentage changes. Specifically, the outcomes chosen differ based on whether the overall change is a gain or a loss and whether the sequence of changes ends with a gain or a loss. This is interesting because mathematically speaking, neither the order nor the overall direction of the change should influence the objective outcomes. However, we find that in the case of mixed losses, people systematically chose the single loss percentage as the better financial outcome instead of the sequence of two percentage changes. In mathematically equivalent tasks, the choice of single loss percentage indicates that people widely used some other

incorrect strategies as opposed to the additive estimation strategy to evaluate the consequences of mixed losses.

On the other hand, in additively equivalent tasks, the choice of single percentage change actually resulted in participants choosing the correct answer. Furthermore, the choice of single percentage change chosen as the better outcome was found to be higher when the sequences of changes ended in a loss as opposed to a gain. This indicates that in the case of overall losses, the objective outcomes and, thereby, the corresponding estimation strategies may also be influenced by the want for a happy ending. However, in overall gains, irrespective of the order of gains and losses, people more often chose the two percentage changes as the better outcome, implying the use of the additive estimation strategy in mathematically equivalent tasks and the use of some other incorrect strategies in additively equivalent tasks.

In the context of mental accounting (MA), as in the study of et al. (1995), our findings indicate a reversal of MA principles. Specifically, with mathematically equivalent gains and losses, we find that people who used the other incorrect strategy integrated the mixed losses. In contrast, people who used the additive estimation strategy segregated the mixed gains instead of following the MA principles of segregating mixed losses and integrating mixed gains, as proposed by Thaler (1985). For pure percentage changes, however, we did not find any effect of the order on the outcomes chosen but rather an effect of the overall direction of the change and the type of task. More specifically, in additively equivalent tasks, people often chose the two changes to be the better outcome in the case of overall gains as compared to overall losses and were subsequently more correct when the overall change amounted to gains. Lastly, concerning the objective outcomes, we find that numeracy plays an important role in preventing people from using error-prone strategies.

Next, we find that the preferences for mixed percentage changes were influenced by the order in which the percentage changes were presented (i.e., first gain/loss or last gain/loss). People largely prefer a happy ending when two options are the same (mathematically) or appear the same (additively). On the surface level, our studies partially align with the intertemporal choice literature, with the results showing that people follow a gain-savouring principle and prefer a happy ending (e.g., Loewenstein, 1987; Loewenstein & Sicherman, 1991). However, with further exploration, we find that real or perceived equivalence might also impact the preference for a sequence. In sum, we find that people who correctly or incorrectly perceive the two options to be

the same show a preference for a happy ending. One of the main aspects of rational decision-making involves making choices that are logical and, therefore, should remain unchanged by how the information is presented or framed (Mandel, 2014; Arrow, 1982; Tversky & Kahneman, 1986).

Nevertheless, irrational choices as a result of framing have been demonstrated frequently in risky decision making (e.g., Tversky & Kahneman, 1981). Similarly, our results imply that people who can correctly estimate the objective outcomes of mathematically equivalent tasks are also susceptible to framing effects and, thereby, show a reversal in preferences based on whether the sequence ends on a positive note or not. Overall, our research suggests that the perception of percentage changes can be influenced by placing a positive percentage change at the end of the sequence, even if the sequence's overall result is negative. However, for pure percentage changes, we neither find an effect of the order based on the need for a happy ending nor as a result of anchoring as proposed by Davis & Bagchi (2018). Instead, the preferences are governed only by whether the overall change is a gain or a loss. However, it is important to note here that our tasks were constructed with certain mathematical constraints for the sequence to be mathematically and additively equivalent to the single percentage change. Therefore, we suspect that for pure percentage changes, the difference in magnitudes of percentage changes was not large enough to realize (e.g., +20%, +25%), which possibly resulted in a lack of the order effect.

3.7.1 Limitations and Future Research

Our research remains limited in some ways. First, we did not directly measure how people feel but rather asked the participants to make evaluations about fictitious people facing hypothetical financial changes. Therefore, the generalization of the results to the real world may remain limited. Second, with respect to the estimation strategies, we incorporated a rating scale to record the responses. Consequently, the difference between the response points, "slightly better/worse outcome," "moderately better/worse outcome," and "extremely better/worse outcome," remain ambiguous. Instead, it may be more informative to ask for the actual estimates as in the studies of Chen & Rao (2007) for clearer categorisation of outcomes. Third, while we were able to show that people more often chose the single loss percentage in the case of mixed losses, it remains unclear what strategy they might be using. For example, while comparing a single loss percentage (e.g., -25%) with a mixed loss (e.g., +25%, -40%), people may compare only the magnitudes of the

loss percentage changes and choose the single loss as the better outcome, as the magnitude of the single loss (-25%) is lower than that of the loss in the sequence (-40%). However, our tasks are not balanced in this regard to allow for a thorough investigation of the other strategies. Therefore, exploring strategies other than the correct and the additive strategy might be useful in further understanding the perception of gains and losses. Concerning the preferences, we explored the role of order of gains and losses in a sequence. However, there might be other crucial factors such as the presentation mode as proposed by Davis & Bagchi (2018) or the time period between the changes that might have a psychological impact. At a larger level, future research should be directed at exploring explicit estimation strategies in conjunction with implicit factors that have an indirect impact on the perception of sequential percentage changes.

3.8 Conclusions

Percentage changes are commonly used in the communication of everyday information. The complex nature of percentages makes people susceptible to using an incorrect additive estimation strategy, which is easy and relatively intuitive instead of opting to apply the correct, albeit a complicated multiplicative procedure. However, we find that decision makers are not always influenced exclusively by the additive outcome of the sequences. Instead, they are likely to be influenced by the order of gains and losses in a sequence and the overall change. Therefore, it remains crucial to integrate both explicit factors, such as the use of an additive estimation strategy, as well as implicit factors such as order of percentage changes, for effective communication as it could impact the perceptions of people who not only commit errors but also that of a rational decision maker.

Chapter 4

Affective evaluations of sequential percentage changes: Role of anticipation, the recency effect, and surprise

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Abstract

Research has shown that implicit factors such as order and presentation mode influence the perception of sequential percentages through the processes of anchoring and surprise. Following this stream of research, we explored the role of anticipation, surprise and the recency effect governing the affective evaluations of sequential percentage changes. In doing so, we manipulated the order and presentation mode of sequences of percentage changes in financial decision scenarios. Participants were asked to estimate the results of sequences of percentage changes and affectively evaluate the changes on the investment, in terms of how happy or unhappy they feel with the percentage changes presented. The results indicate that people employ an erroneous additive strategy to estimate the consequences of sequential percentage changes. However, we find that affective evaluations for the sequences were driven by the emotion of anticipation with people exhibiting a tendency for a happy ending. Specifically, a positive percentage change in the end was preferred over a negative percentage change in the end. Furthermore, the inclination for a happy ending was found to be slightly pronounced with temporal separation, indicative of a small recency effect. Moreover, the preference for a happy ending was intensified with surprise for sequences resulting in both overall gains and overall losses, irrespective of whether the sequences were presented with or without temporal separation.

4.1 Introduction

Percentage changes are used to communicate everyday information such as discounts on consumer products, stock market fluctuations, macroeconomic information, and unemployment rates, among others. Consider a scenario wherein Person A has invested an amount of \$100 in Stock X. After a few days, he discovers that the value of his investment has decreased by 40%. By the end of the week, the value of his investment has increased by 25%. What is the overall percentage change on the investment of Person A? Estimating the overall change of the investment requires the application of stepwise multiplicative operations. As a first step, the 40% decrease should be applied to the initial value $100 + (100 \times (-40/100))$, and as a second step, the 25% increase should be applied to the intermediate value $60 + (60 \times (+25/100))$. Therefore, the overall percentage change on the investment can be calculated as $100 + (100 \times (-25/100))$, which results in a total

loss of 25%. Alternatively, the two percentage changes' overall change can be calculated by applying the formula, $p+q+pq/100$ wherein p is the first percentage change, and q is the second percentage change ($-40+25+(-40 \times 25/100) = -25\%$). Furthermore, calculation of percentage changes is not dependent on the order and, therefore, any of the two percentages changes above can be calculated first or second (e.g., +25% first, -40% second or vice versa); both orders resulting in an overall loss of 25%. However, people have been found to employ an erroneous one-step additive rule instead of the correct two-step multiplicative procedure (e.g., Chen & Rao, 2007; Newall, 2016). The application of a simplistic additive rule has consequences for real-world decision making. From the above example, a novice investor using a simplistic additive rule ($-40+25$) can mistakenly underestimate the overall change of the investment as a total loss of 15% compared to the actual loss of 25%.

Perception of percentage changes has been studied in various contexts (e.g., Davis & Bagchi, 2018; Newall, 2016; Chen et al., 2012; Chen & Rao, 2007; Kruger & Vargas, 2008; Heath et al., 1995). One of the key findings of some of these studies indicates the erroneous processing of multiple percentage changes with the use of a simple additive rule (e.g., Chen & Rao, 2007; Davis & Bagchi, 2018). However, the role of emotions as guidelines to preferences has been explored only in limited ways in the context of multiple percentage changes (Davis & Bagchi, 2018). The paper by Davis & Bagchi (2018) shows that two factors, namely, the order of percentage changes (large first/large second) and the presentation modes (simultaneous; without temporal separation, sequential; with temporal separation), influence the evaluation of multiple discounts and surcharges, through the processes of anchoring (e.g., Tversky & Kahneman 1974; Epley & Gilovich, 2010) and surprise (e.g., Chen & Rao, 2002; Heilman et al., 2002). Therefore, the goal of our paper is to explore and extend the research on affective evaluations of sequential percentage changes, framed as gains and losses in financial decision scenarios. Similar to the existing literature (e.g., Chen & Rao, 2007; Davis & Bagchi, 2018), we predict that people will use an additive strategy to estimate the overall change of multiple percentage changes. For the affective evaluations, we posit that the order and the presentation modes of percentage changes will impact the preference for the sequence of changes. From a mathematical point of view, manipulation of the order and presentation modes does not change the aggregate result of the

sequences of percentage changes and should not affect the overall evaluations (Davis & Bagchi, 2018). However, we expect the order and the presentation modes to influence the affective evaluations of sequential percentage changes based on the anticipation and a want for a happy ending i.e., a positive end will be preferred over a negative end. Furthermore, due to the recency effect, the order effect should be intensified with temporal separation and more so in the presence of surprise. In the next sections, we draw on several theories to explain the basis of our hypotheses.

4.1.1 Theoretical background

4.1.1.1 Processing multiple percentage changes: Role of anchoring and surprise

Decision makers are known to base their judgments not only on straightforward estimation strategies but also on emotions associated with unexpected future outcomes (e.g., Chen & Rao, 2002; Davis & Bagchi, 2018). Encountering unexpected outcomes can shift attention to surprise evoking events which then serve as a basis for the final judgment (Davis & Bagchi, 2018; Chen & Rao 2002; Heilman et al., 2002; Noordewier et al., 2016). For example, recent work by Davis & Bagchi (2018) shows how factors of order and presentation mode influence the perception of multiple percentage changes through the process of anchoring and feelings of surprise. Specifically, the authors found that multiple discounts (e.g., -11%, -18%) on a \$5 gift card led to positive deal evaluations when the larger percentage change was presented first as opposed to second, in the simultaneous presentation mode. However, when the same discounts were presented sequentially, the unexpected second percentage shifted the reference point for the final evaluation. Therefore, the deal was evaluated more positively when the larger percentage change was presented second as opposed to first. Similarly, the authors were able to mirror the effect of the order and the presentation modes for surcharges (e.g., +10%, +5%). The effects of order and presentation modes were particularly found to be significant for about half the people who used non-additive strategies to estimate the overall result of the percentage changes presented (Davis & Bagchi, 2018; experiment 3). In the absence of surprise, however, the evaluations did not differ between the two presentation modes. Specifically, only a main effect of the order was found such that a larger percentage first led to more positive evaluations as opposed to a larger percentage second in both the simultaneous and the sequential presentation mode. The results of the studies by Davis & Bagchi (2018) show that the use of the additive strategy is prevalent; however, it does

not provide a complete account of how people estimate sequential percentage changes. For example, the additive result of a sequence of two gains (e.g., +20%, +25%) would result in an overall gain of 45%, irrespective of whether the gain of 20% is presented first or second, with or without temporal separation. However, the effects of order and presentation mode also have been tested in a limited manner only for certain outcome types of percentage changes (i.e., two percentage increases or two percentage decreases). Therefore, we extend the research by systematically varying the valences and the overall change of the percentage changes and, therefore, include all possible outcome types of percentage changes. By doing so, we also extend the exploration of the role of surprise and investigate how unexpected gains and losses influence the affective evaluations of sequential percentage changes.

4.1.1.2 Perception of multiple outcomes: Theory of mental accounting

Based on the value function proposed by (Kahneman & Tversky, 1979), *the theory of mental accounting* (MA) (Thaler, 1985) predicts how people perceive multiple outcomes. For instance, with mixed outcomes, wherein a large gain (+\$120) and a small loss (-\$20) results in an overall gain (+\$100), the psychological value of integrating the large gain and a small loss is considered to be higher than that of segregating them, $v(x) + v(-y) < v(x - y)$. Therefore, people should be happier thinking about the combined gain (i.e., \$100) compared to thinking about the gain of \$100 and the loss of \$20 separately. Thaler (1985) proposed such segregation and integration principles for maximizing utility or happiness for four possible outcome types based on the value function. Preference for (1) segregating pure gains (two gains) (2) integrating mixed gains (a large gain and a small loss) (3) integrating pure losses (two losses) (4) segregating mixed losses (a large loss and a small gain) (Thaler, 1985). However, in the context of multiple percentage changes, mental accounting cannot explain the choices governed by the additive aggregation rule (Chen & Rao, 2007) or the order and the presentation mode, as found by Davis & Bagchi (2018). For example, Chen & Rao (2007) showed that the use of the additive strategy for evaluating the consequences of a mixed gain (e.g., +40%, -25%) when compared with a mathematically equivalent single gain (e.g., +5%), would result in a higher preference for segregation as compared to integration, as the additive result of the two percentage changes is higher (+15%) than the single percentage gain (+5%). Furthermore, a mixed gain, as in the example above, should be preferred to be integrated

irrespective of the order of the percentage changes or the presentation modes. Overall, MA principles may not provide a reasonable account of how people perceive sequential percentage changes. Therefore, we consider the four possible outcome types proposed by Thaler (1985) and explore the role of anticipation, the recency effect, and surprise by manipulating the order and presentation mode of sequential percentage changes.

4.1.1.3 Role of anticipation: Intertemporal choice literature

The literature on intertemporal choice has shown that anticipation of known outcomes and a preference for negative time discounting predicts the tendency to postpone positive outcomes, thereby, resulting in “savouring gain” and avoiding “dread” for negative outcomes. Therefore, people prefer sequences of outcomes with an improving trend (e.g., preference for increasing wage profiles) over sequences with a declining trend and exhibit a preference for a “happy ending” (Loewenstein, 1987; Guyse et al., 2002; Loewenstein & Sicherman, 1991; Read & Powell, 2002; Ross & Simonson, 1991). Drawing on the memory literature, liking for an improving sequence can be explained by the recency effect, which results in the last outcome being a governing factor for the final evaluation (Miller & Campbell, 1959; Chen & Rao, 2002). Therefore, due to the recency effect, the consequences of two equivalent sequences can be evaluated differently, depending on how the valences associated with each event in the sequence are ordered (Hellmann et al., 2017; Theis et al., 2012; Pinsker, 2007). For example, in the study by Hellmann et al. (2017) the authors found that non-professional investors rated a company’s performance higher when the positive news about the company was presented in the end as opposed to when the negative news was placed in the end. Furthermore, the recency effect has been found to be present irrespective of whether the information is presented with or without temporal separation (Pinsker, 2011). In the study by Pinsker (2011), participants were provided with the background information of a company wherein all pieces of information were either presented together, or one by one and consequently were asked to evaluate the stock prices of the company. Results showed that evaluations were impacted by the most recently encountered cue in both the simultaneous and the sequential presentation mode. However, the recency effect was lesser in simultaneous presentation mode as there was more opportunity to compare and evaluate the information altogether as

opposed to the sequential presentation mode, wherein the final evaluations are more dependent on the last piece of information.

4.1.2 Present research and hypotheses

Centered on the role of anticipation and the recency effect, we build our hypotheses for our first study in the following manner. Based on Thaler (1985), we classify sequences with opposite valences as mixed percentage changes and the same valences as pure percentage changes. Mixed percentage changes include sequences of gains and losses resulting in an overall gain (e.g., -25% , $+40\% = +15\%$) or an overall loss (e.g., -40% , $+25\% = -15\%$). Pure percentage changes include sequences of only gains (e.g., $+20\%$, $+45\% = +65\%$) or only losses (e.g., -25% , $-20\% = -45\%$). Based on the tendency to savor positive outcomes, we expect people to be happier when the sequence ends with a gain as opposed to a loss for the mixed percentage changes. Therefore, we predict that a loss followed by a gain will be preferred over a gain followed by a loss ($[Lg] > [Gl]$). For the pure percentage changes, we expect people to be happier when a larger gain is presented in the end in the case of overall gains and when a smaller loss is presented in the end in the case of overall losses. Hence, we predict that a small gain followed by a large gain will be preferred over a large gain followed by a small gain ($[gG] > [Gg]$) and vice versa for losses ($[Ll] > [lL]$). Furthermore, the proposed order effect should be stronger when there is temporal separation as opposed to when there is no temporal separation because of the reduction in the recency effect in the simultaneous presentation mode. Our second study is similar to our first study, except for the addition of the surprise factor and time pressure. We introduced surprise by not informing the participants about the number of changes that were to be presented on their investments. Furthermore, we introduced time pressure primarily for the participants to not use calculation devices and, therefore, be intuitive with their responses.

Our research focuses on the estimation strategies and the factors governing the affective evaluations of multiple percentage changes. Similar to the work of Davis & Bagchi (2018), we explore the role of the order and the presentation modes. However, our research is fundamentally different in multiple ways. First, we explore the emotions of anticipation and posit that the recency effect explains the effect of order and the presentation modes as opposed to anchoring, as proposed

by Davis & Bagchi (2018). Second, we extend their study to percentage changes with opposite valences and explore how unexpected gains and losses influence the affective evaluations of multiple percentage changes. Third, we also include sequences of three percentage changes along with sequences of two percentage changes. In the consumer domain, as in the studies of Davis & Bagchi (2018), it is likely that people encounter only two percentage changes (e.g., double discounts). Although, in the financial domains, one may be required to evaluate sequences consisting of more than two percentage changes (e.g., stock investments). However, we do not predict any differences between the perception of two and three percentage changes. At a larger level, we contribute to the existing literature on processing multiple percentage changes by offering perspectives centered on the role of emotions.

4.2 Study 1 Overview

In our first study, we manipulated the order of gains and losses and the presentation modes in financial decision scenarios. The outcome types for mixed and pure percentage changes were classified based on Thaler (1985) as mixed gains and mixed losses (i.e., a sequence of a gain and a loss resulting in an overall gain or an overall loss) and pure gains and pure losses (i.e., a sequence of two gains or two losses, resulting in an overall gain or an overall loss). Participants were always informed that two percentage changes would be presented on their investments. In the simultaneous presentation mode, the two changes were presented on the same page. Whereas in the sequential presentation mode, each percentage change was presented on a different page. The main task in each scenario was to integrate and evaluate the changes on the investment by answering two short questions pertaining to the preference and the overall financial outcome.

4.2.1 Participants

The study was programmed in Unipark (Version [EFS, 2019]). A total of 200 participants (73 females; $M_{age} = 34$ years, $SD_{age} = 9.71$) were recruited via Amazon Mechanical Turk. They received a basic compensation of US-\$ 1.80 for completing the study and an additional bonus of up to US-\$ 1.35 based on the accuracy of responses on tasks with a correct and an incorrect answer.

All 200 participants completed the study. However, 5 participants indicated that their data could not be trusted and were, therefore, excluded from the analysis. Our final sample consists of 195 participants (71 females; $M_{age} = 34$ years, $SD_{age} = 9.77$). All of them were residents of the United States, and 190 (97.44%) participants chose English as their native language. 106 (54.36%) of the participants had obtained a Bachelor's degree or higher.

4.2.2 Design

The design of the study consisted of three main factors: order (2 levels: *gain-loss*, *loss-gain*, for mixed percentage changes and 2 levels: *large-small*, *small-large*, for pure percentage changes) x overall change (2 levels: *overall gains*, *overall losses*) x presentation mode (2 levels: *simultaneous*, *sequential*). The presentation mode was manipulated between subjects, while the order and the overall change were manipulated within subjects. The tasks were presented in two blocks. The order of gains and losses was randomized in the first block for each of the tasks. Whereas the order of gains and losses in block 2 was reverse of that in block 1. The order in which the tasks were presented to the participants was randomized as well.

4.2.3 Materials

Each participant completed 10 decision tasks. 2 of the 10 decision tasks were attention checks. Among the 8 actual decision tasks relevant for our hypotheses, we included 1 mixed gain, 1 mixed loss, 1 pure gain, and 1 pure loss. The tasks were presented in two orders, either simultaneously or sequentially. Participants imagined having invested a substantial amount of their money in a short-term fund. They were asked to evaluate the investment after having imagined a short period of time elapsing between the two percentage changes occurring on the investment. An example of the decision task can be found in Appendix C1.1. In order to evaluate the investment, participants answered two main questions. The preference measure was used to assess the affective evaluation of the situations described in the decision tasks. As a first question, participants were asked to rate their happiness (in case of an overall gain) or unhappiness (in case of an overall loss) with the investment. Participants recorded their answers on a 7-point response scale, (1 = "extremely unhappy", 2 = "moderately unhappy", 3 = "slightly unhappy", 4 = "neutral", 5 = "slightly happy",

6 = “moderately happy”, 7 = “extremely happy”). For the predictions and the analysis, preferences are considered relative to the order of gains and losses in a sequence (i.e., less happy in one order and more happy in the other order).

As a second question, participants were asked to estimate the overall financial outcome of the investment. The outcome measure was divided into two parts, making it a total of 16 questions for the 8 decision tasks. First, participants were asked to classify the overall change of the investment as a gain or a loss. Second, they were asked to indicate (as a number) the percentage by which the value of the investment had changed overall. Hence, responses to both the questions of the outcome measure combined were used to assess the accuracy (i.e., correctly classifying the overall financial outcome as a gain or a loss and correctly indicating the percentage by which the value of the investment had changed). Table 4.1 provides an overview of the stimuli and the predictions for both the outcomes and the preferences for each of the tasks. Finally, for assessing individual differences we implemented the modified version of the Cognitive Reflection Test (emphCRT; Frederick, 2005; developed by Mata, 2016), a 3-item questionnaire, for measuring cognitive reflection. Additionally, the Berlin Numeracy Test (BNT; Cokely et al., 2012), a 4-item questionnaire, known for the measurement of risk literacy was used to measure the numeracy of the participants. The questionnaires can be found in Appendix C2.1 and Appendix C2.2, respectively.

Table 4.1: Overview of the 8 decision tasks and the corresponding predictions for the outcomes and the preferences.

Tasks	Stimuli	Order of (%) changes	Overall change	Correct estimate	Additive estimate	Preference
Mixed gain	+ 40%, - 25%	Gain-loss	Gain	5%	15%	Less happy
Mixed gain	- 25%, + 40%	Loss-gain	Gain	5%	15%	More happy
Mixed loss	+ 25%, - 40%	Gain-loss	Loss	25%	15%	Less happy
Mixed loss	+ 40%, + 25%	Loss-gain	Loss	25%	15%	More happy
Pure gain	+ 45%, + 20%	Large-small	Gain	74%	65%	Less happy
Pure gain	+ 20%, + 45%	Small-large	Gain	74%	65%	More happy
Pure loss	- 20%, - 30%	Small-large	Loss	44%	50%	Less happy
Pure loss	- 30%, - 20%	Large-small	Loss	44%	50%	More happy

4.2.4 Procedure

After providing the consent to be a part of the study, participants were directed to read the instructions related to the decision tasks. On the instructions page, the order factor for each of the tasks was randomly determined, and participants were assigned to one of the two groups wherein the tasks were presented either in the simultaneous presentation mode or the sequential presentation mode. After which, the participants completed an example task to familiarize themselves with the actual decision task and the corresponding measures. In each decision task, participants imagined having invested a substantial amount of their money in a short-term fund and evaluated the investment by answering two short questions. As a first question, they were asked, “How happy or unhappy do you feel about the investment?” The second question consisted of two parts: First, “Is the overall change a gain or a loss?” and second, “By how much percent has the investment’s value changed overall?” Participants were incentivized with an amount of US-\$ 0.05 for correctly classifying the overall change as a gain or a loss and US-\$ 0.05 for providing the correct estimate in each decision task. The responses within the range of $\pm 2\%$ of the correct answer were considered as correct and incentivized. After completing the decision tasks, participants were asked to specify the tools and strategies used to answer the decision tasks. Followed by which, they were directed to complete the CRT and the BNT. Participants were once again asked to specify the tools used for answering the questions and indicate their familiarity with each of the tests, followed by completion of the demographic form.

4.3 Results

4.3.1 Numeracy and cognitive reflection scores

Mean score on the Berlin numeracy test (out of 4 possible correct) was found to be 1.65 ($Mdn = 1$, $SD = 1.47$, $range = 0-4$). For the cognitive reflection test (out of 3 possible correct) the mean score was found to be 1.71 ($Mdn = 2$, $SD = 1.27$, $range = 0-3$). With respect to the tools and the strategies, 157 responses indicated the use of no external tools, 4 indicated the use of a calculator, 35 using a pen and paper strategy, and 4 with the use of other strategies such as an online search engine. Concerning familiarity, 102 (52.31%) participants indicated that they were familiar with

the Berlin Numeracy Test, whereas 86 participants (44.10%) indicated that they were familiar with the Cognitive Reflection Test.

4.3.2 Outcomes and corresponding estimation strategies

For each of the decision tasks, the outcome measure consisted of two questions. As a first question, people were asked to classify the overall change as a gain or loss. As a second question, participants were asked to indicate the percentage by which the value of the investment had changed. Concerning the estimation strategies, we predicted that the participants' estimates would be based on the use of an additive strategy. Therefore, we classified the responses to the two questions into three categories, namely correct, additive, and other. The other category consists of estimates which are neither based on the correct multiplicative strategy nor on the erroneous additive strategy. Results indicate that 28.21% of the outcomes were calculated using the correct strategy. About half, 44.10% of the outcomes, were estimated using the additive strategy. Finally, 27.69% of the outcomes were estimated with some other incorrect strategies. With respect to the decision tools, 152 responses were not based on any external tools, 31 using a reference amount such as \$100 or \$1000 for calculating the changes on the investment, 36 with the use of a calculator, 15 based on the use of a pen and paper strategy and 6 using other strategies such as an online search engine.

4.3.3 Influence of order, presentation mode, and overall change

As a next step, we investigated if there was an influence of the order, presentation modes, and overall change on the estimation strategies used by people. Therefore, we conducted two multiple regression analyses separately for mixed and pure percentage changes using the package “nlme” (v3.1-147; Pinheiro et al., 2020; R Core Team, 2020). The estimation strategies (1= correct, 2 = additive, 3 = other) were treated as the dependent variable. The factors of order (2 levels: gain-loss (-1) and loss-gain (+1) for mixed percentage changes and large-small (-1), small-large (1) for pure percentage changes), overall change (2 levels: overall gains (-1) and overall losses (+1)) and presentation mode (2 levels: simultaneous (-1), sequential (+1)), were included as the predictors. The standardized scores of the BNT and the CRT were included as the covariates in the model.

We estimated the results of the complete model and report the results of the chi-square analysis, conducted using the package “car” (Fox et al., 2012). For the analysis of the estimation strategies, the coding of factors and the covariates remain the same across both studies unless specified otherwise. Lastly, the visualizations in the studies were created with the package “ggplot2” (Wickham, 2009). We begin by reporting the outcome results of the mixed percentage changes.

4.3.3.1 Mixed percentage changes

Results indicate no main effect of the order (Wald $\chi^2 = 0.22$, $df = 1$, $p = 0.641$) or the presentation mode (Wald $\chi^2 = 2.50$, $df = 1$, $p = 0.114$) on the estimation strategies. Furthermore, we find no main effect of the overall change (Wald $\chi^2 = 1.69$, $df = 1$, $p = 0.193$). Additionally, there was no difference in the estimation strategies based on the order of percentage changes between the simultaneous and the sequential presentation mode (interaction, *NS*, Wald $\chi^2 = 0.40$, $df = 1$, $p = 0.525$). However, the estimation strategies were found to be influenced by the order of percentage changes across overall gains and overall losses, indicated by a marginally significant interaction between order and overall change (interaction, Wald $\chi^2 = 3.64$, $df = 1$, $p = 0.056$). Figure 4.1 illustrates the estimation strategies as proportions across the two overall changes and the two orders. Specifically, in the case of overall losses, the use of the additive strategy was found to be slightly higher when the sequence of changes ended in a loss (Gain-loss = 46.15%) as opposed to when the sequence of changes ended in a gain (Loss-gain = 38.46%). Consequently, the use of the other strategy was found to be lower when the sequence of changes ended in a loss (Gain-loss = 25.64%) as opposed to when the sequence of changes ended in a gain (Loss-gain = 31.79%). The estimates based on the correct strategy were found to be similar between the two orders (Gain-loss = 28.21%, Loss-gain = 29.74%).

However, in the case of overall gains, the outcomes based on the three strategies were found to be similar between the two orders, except for the other strategy, which was slightly higher when the sequence of changes ended in a loss (Gain-loss; additive = 43.08%, correct = 28.72%, other = 28.21%), as opposed to when the sequence of changes ended in a gain (Loss-gain; additive = 45.64%, correct = 31.28%, other = 23.08%). Finally, the estimation strategies were influenced by both the numeracy (Wald $\chi^2 = 15.60$, $df = 1$, $p < 0.001$) as well as the CRT (Wald $\chi^2 = 17.43$, df

$= 1, p < 0.001$), such that people who scored high in both the tests were more accurate in estimating the consequences of the percentage changes.

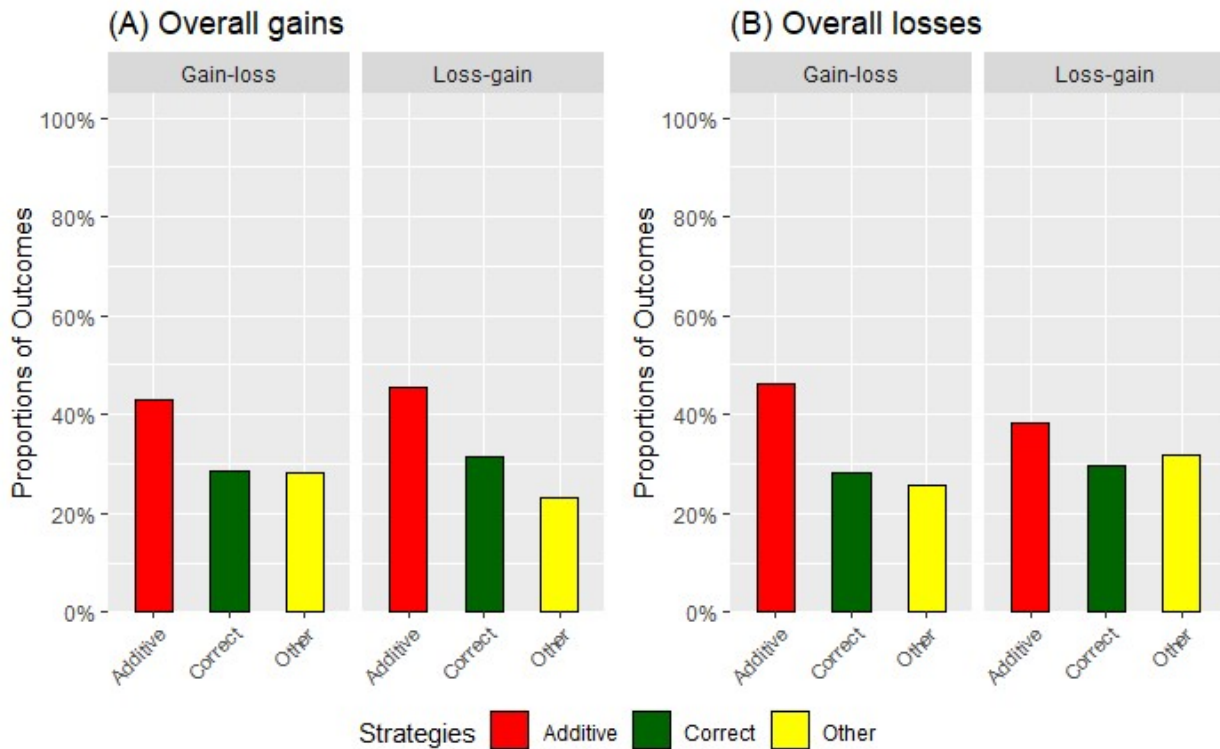


Figure 4.1: Proportions of outcomes based on the three estimation strategies across the two orders and the overall changes for the mixed percentage changes ($N = 195$, $tasks = 4$).

4.3.3.2 Pure percentage changes

For pure percentage changes, we find no effect of the order on the estimation strategies (Wald $\chi^2 = 0.45$, $df = 1$, $p = 0.504$). There was no influence of the presentation mode as well (Wald $\chi^2 = 0.83$, $df = 1$, $p = 0.363$). The effect of the overall change on the estimation strategies was also found to be non-significant (Wald $\chi^2 = 2.84$, $df = 1$, $p = 0.092$). Furthermore, we find no significant interaction between the order and the presentation mode (Wald $\chi^2 = 0.26$, $df = 1$, $p = 0.609$). Instead, the estimation strategies were only found to be influenced by the performance on the BNT (Wald $\chi^2 = 20.24$, $df = 1$, $p < 0.001$) as well as the CRT (Wald $\chi^2 = 5.13$, $df = 1$, $p = 0.024$).

4.3.4 Preferences: Role of order and presentation mode

Recall that we are interested in assessing the preferences for sequential percentage changes based on two factors, namely, the order and the presentation modes. Participants were asked how happy or unhappy they feel with their investment (1 = “extremely unhappy,” 7 = “extremely happy”). We made two separate predictions for the mixed and pure percentage changes. For the mixed percentage changes, we predicted that a loss followed by a gain would be preferred over a gain followed by a loss ([Lg] > [Gl]). For the pure percentage changes, a small gain followed by a large gain would be preferred over a large gain followed by a small gain ([gG] > [Gg]) and vice versa for losses ([Ll] > [Ll]). We predicted a two-way interaction between the order and the presentation modes and expected that the order effect would occur in both the presentation modes, although stronger in the sequential presentation mode as opposed to the simultaneous presentation mode. Similar to the analysis of the estimation strategies, we conducted two multiple regression analyses with the preferences included as the dependent variable and order, presentation modes, and overall change as the predictors. In addition to the standardized scores of the CRT and BNT, we included the estimation strategies used by the participants (additive, correct, and other) as covariates in the model. Lastly, the standard errors depicted in the visualization of the preferences were estimated with the package "Rmisc" (Hope, 2013), for both the studies. We begin by reporting the results of the mixed percentage changes.

4.3.4.1 Mixed percentage changes

Results indicate a higher preference for the sequences of percentage changes when a loss was followed by a gain as opposed to when a gain was followed by a loss, indicated by a main effect of the order (Wald $\chi^2 = 14.78$, $df = 1$, $p < 0.001$). Preference ratings were also higher in the case of overall gains than overall losses, indicated by a main effect of the overall change (Wald $\chi^2 = 550.07$, $df = 1$, $p < 0.001$). However, we do not find any effects of the presentation mode on the preference ratings (Wald $\chi^2 = 1.02$, $df = 1$, $p = 0.314$). The preference ratings based on the order of gains and losses were found to be slightly different between the two presentation modes, indicated by a marginally significant interaction between the order and presentation mode (Wald $\chi^2 = 2.96$, $df = 1$, $p = 0.085$). Figure 4.2 illustrates the preference ratings for the two orders in each of the two presentation modes. However, contrary to our predictions, the preference ratings based

on the order differed more prominently in the simultaneous presentation mode as compared to the sequential presentation mode. Lastly, preferences were found to be influenced by people's estimation strategies (Wald $\chi^2 = 19.02$, $df = 2$, $p < 0.001$). Furthermore, the CRT scores were found to have an influence such that people who scored low on the CRT indicated higher preference ratings as compared to people who scored high (Wald $\chi^2 = 8.03$, $df = 1$, $p = 0.005$). However, we find no effect of numeracy on the preference ratings (Wald $\chi^2 = 0.15$, $df = 1$, $p = 0.698$).

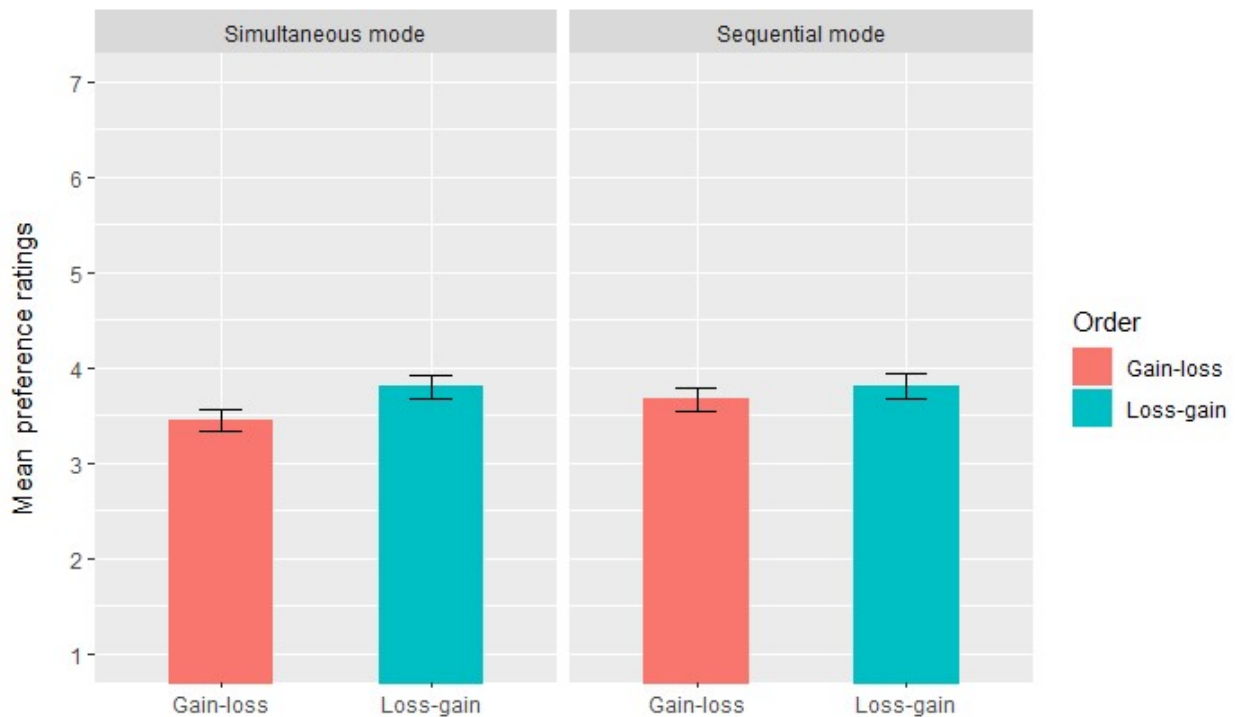


Figure 4.2: Mean preference ratings for the two orders in each of the presentation modes, for the mixed percentage changes ($N = 195$, $tasks = 4$). Overall, people preferred the sequences of changes ending in a gain as opposed to a loss. However, the preference for sequences ending in a gain was not higher in the sequential presentation mode as compared to the simultaneous presentation mode. Bars represent \pm one standard error of the mean.

4.3.4.2 Pure percentage changes

Results indicate no influence of the order on the preference ratings (Wald $\chi^2 = 0.75$, $df = 1$, $p = 0.385$). There were no effects of the presentation modes as well (Wald $\chi^2 = 0.90$, $df = 1$, $p = 0.343$). Figure 4.3 illustrates the preference ratings for the two orders in each of the two presentation modes. Rather, the preference ratings were found to be influenced only by the overall change, with

preference ratings being higher in the case of overall gains as opposed to overall losses (Wald $\chi^2 = 2053.02$, $df = 1$, $p < 0.001$). Moreover, contrary to our predictions, preference ratings based on the order were not higher in the sequential presentation mode as compared to the simultaneous presentation mode (Wald $\chi^2 = 0.86$, $df = 1$, $p = 0.353$). Furthermore, there was no influence of the estimation strategies on the preference ratings (Wald $\chi^2 = 1.51$, $df = 2$, $p = 0.470$). Finally, the preference ratings were found to be impacted by the performance on the CRT (Wald $\chi^2 = 3.68$, $df = 1$, $p = 0.055$). Although, there was no influence of numeracy on the preference ratings (Wald $\chi^2 = 0.18$, $df = 1$, $p = 0.674$).

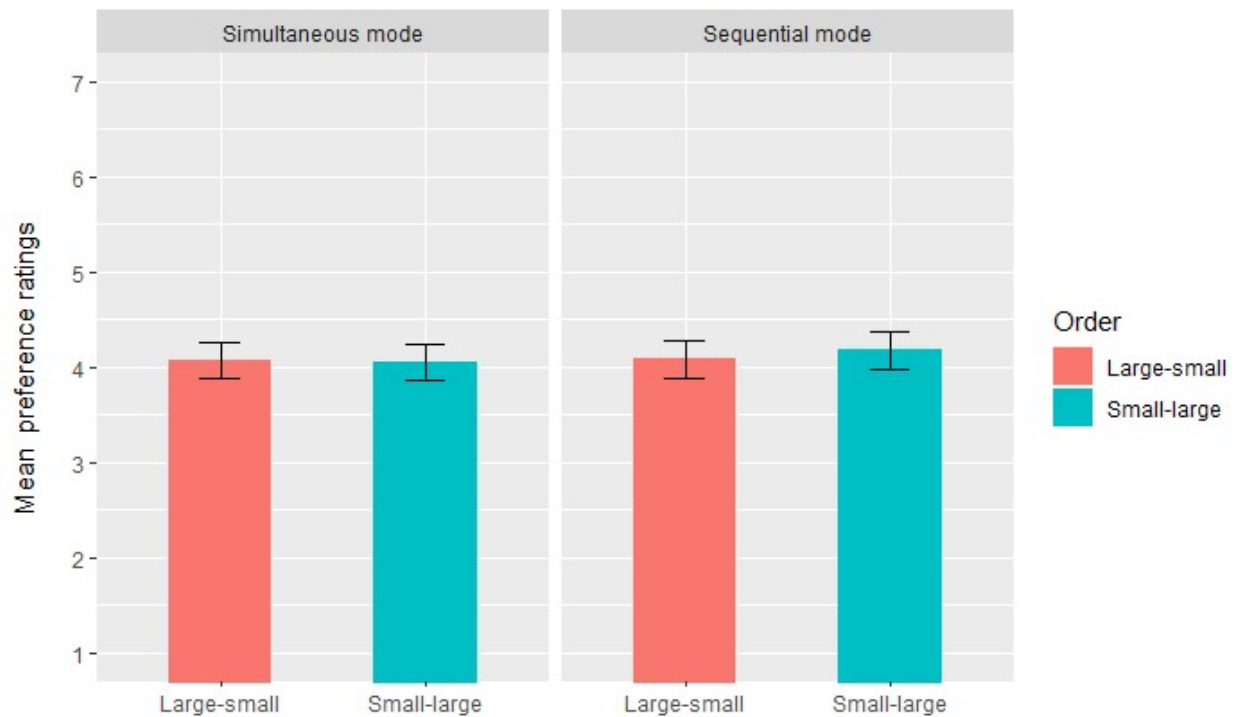


Figure 4.3: Mean preference ratings for the two orders in each of the two presentation modes, for the pure percentage changes ($N = 195$, $tasks = 4$). The graphs indicate that people did not show the predicted inclination for a happy ending, neither in the simultaneous presentation mode nor in the sequential presentation mode. Bars represent \pm one standard error of the mean.

4.4 Discussion

We find that the estimation strategies and the affective evaluations of sequential percentage changes were influenced by the order of percentage changes and the overall change. Regarding the estimation strategies, we replicate the findings of Chen & Rao (2007) and Davis & Bagchi (2018), where we find that about half the outcomes were estimated using an additive strategy. As a new finding, we find that the estimation strategies for mixed percentage changes may be governed by the order and overall change of the sequence of percentage changes. However, we do not find any influence of the order, presentation mode, or the overall change on the strategies used to estimate the consequences of pure percentage changes. Lastly, numeracy and cognitive ability were found to play an important role in preventing people from using incorrect strategies. Next, the preferences for mixed percentage changes were influenced by the order in which the percentage changes were presented (i.e., first gain/loss or last gain/loss) but we did not find evidence for higher preferences when the changes were presented sequentially, without temporal separation. Therefore, our study aligns with the intertemporal literature with results showing that people follow a gain-savouring principle and prefer a happy ending (e.g., Loewenstein, 1987; Loewenstein & Sicherman, 1991). Specifically, a gain in the end (positive end) was preferred over a loss in the end (negative end). However, the order effect was not stronger in the sequential presentation mode as compared to the simultaneous presentation mode.

Specifically, in our study, we associate the lack of the recency effect in the sequential presentation mode with three reasons. First, in both the presentation modes, people were aware that only two percentage changes would be presented on the investment. Second, they were instructed to take into account both pieces of information for the evaluations. Third, participants had unlimited time to respond to the corresponding questions. Therefore, responding to the questions only after combining all the information first and having unlimited time to answer could have resulted in participants processing information similarly in both the presentation modes. The lack of a stronger effect in the sequential presentation mode is similar to the findings of Davis & Bagchi (2018), wherein they found that in the absence of surprise, evaluations were found to be similar in the simultaneous and sequential presentation mode.

On the other hand, preferences were not influenced by the order or the presentation modes for the pure percentage changes. Only the overall change was considered to evaluate preferences.

Therefore, we neither found the predicted recency effect nor an anchoring effect as found by Davis & Bagchi (2018) for pure percentage changes.

The study provided evidence of the effect of order for the mixed percentage changes but not for the pure percentage changes. However, the difference in the order effect between the two presentation modes was not established. Therefore, in our second study, we aim to improve our experimental setup in two main ways. As a first step, we instructed the participants in the sequential presentation mode differently such that they take into account each piece of information separately. Second, we added time pressure for recording the preferences and estimates. Aside from improving our first study, we extended our next study by adding the factor of surprise and predicted the order effect to be more prominent in the sequential presentation mode, in the presence of surprise.

4.5 Study 2 Overview

Our second study is similar to our first study except for the addition of the surprise factor and time pressure. Therefore, we manipulated the order of gains and losses, presentation modes, and surprise in financial decision scenarios. The outcome types for mixed and pure percentage changes classified based on Thaler (1985) were the same as in the first study. We presented single, two, and three percentage changes on the investments and introduced unpredictability and surprise by not informing the participants about the number of changes that were to occur on their investments. The time pressure was not varied as a factor but was introduced to prevent people from using calculation devices. Similar to two percentage changes, the order of the three percentages were manipulated in such a way that a sequence ended in a gain or a loss in case of mixed percentage changes (for example, gain-gain-loss, loss-loss-gain and reverse order loss-gain-gain, gain-loss-loss) and with a large or small gain or loss (increasing gains and losses and reverse order decreasing gains and losses) for pure percentage changes. In the simultaneous presentation mode, the changes were presented on the same page. In the sequential presentation mode, each of the changes was presented on a separate page with a fixation cross of 1 second presented in between the changes. Participants were required to keep a running total of their changes and instructed to evaluate the information one by one instead of altogether as in the simultaneous presentation mode. In the surprise present condition, participants were not informed about the number of changes on their

investment. Whereas in the surprise absent condition, participants were informed about the number of changes on the investment before each task. The main task in each scenario was to take into account the information about the investment and evaluate the changes by answering two short questions relating to preference and overall financial outcome. Participants had unlimited time to view the changes presented. However, they were required to respond to the two questions within a time limit. All responses were mandatory and were recorded irrespective of the participants responding within the stipulated time limit or not.

4.5.1 Participants

The study was programmed in Unipark, (Version [EFS, 2019]). A total of 402 participants (155 females; $M_{age} = 36$ years, $SD_{age} = 10.50$) were recruited via Amazon Mechanical Turk. They received a basic compensation of US-\$ 1.25 for completing the study and an additional bonus of up to US-\$ 1.65 based on the accuracy of responses on tasks with a correct and an incorrect answer. All 402 participants completed the study. However, 22 participants were removed as their data could not be trusted and were thereby, also excluded from the analysis. Our final sample consists of 380 participants (149 females; $M_{age} = 36$ years, $SD_{age} = 10.53$). All of them were residents of the United States and 373 (98.16%) participants chose English as their native language. 221 (58.16%) of them had obtained a Bachelor's degree or higher.

4.5.2 Design

The design of the study consisted of four main factors: Order (2 levels: *gain-loss*, *loss-gain*, for mixed percentage changes and 2 levels: *large-small*, *small-large*, for pure percentage changes) x overall change (2 levels: *overall gains*, *overall losses*) x presentation mode (2 levels: *simultaneous*, *sequential*) x surprise (2 levels: *present*, *absent*) with the order, presentation mode and surprise manipulated between subjects and overall change manipulated within subjects. The levels of the order factor were randomized and counterbalanced group-wise. The order in which the tasks were presented was randomized as well.

4.5.3 Materials

Each participant completed 18 decision tasks. Six of the 18 decision tasks were single percentage changes. Among the 12 actual decision tasks relevant for our hypotheses, we included 4 mixed gains, 4 mixed losses, 2 pure gains, and 2 pure losses, each presented in one of the two orders, in either simultaneous or sequential presentation mode, with or without surprise. Examples of the decision tasks and the corresponding measures can be found in Appendix C1.2. Similar to Study 1, in each of the tasks, participants imagined having invested a substantial amount of their money in a short-term fund. The two dependent variables, preference and outcome were the same as in Study 1. Table 4.2 provides an overview of stimuli and predictions for both the preferences as well as the outcomes for each of the tasks. As a first question, participants were asked to rate their happiness (in case of an overall gain) or unhappiness (in case of an overall loss) with the investment. The outcome measure was divided into two parts. As a first question, participants were asked if the overall change is a gain or a loss. As a second question, participants were asked to indicate (as a number) the percentage by which the value of the investment had changed overall. A time limit of 5 seconds was assigned to answer the preference question and a time limit of 10 seconds was assigned to answer the two parts of the outcome question.

Table 4.2: Overview of the 12 decision tasks and the corresponding predictions for the outcomes and the preferences.

Tasks	Stimuli	Order of (%) changes	Overall change	Correct estimate	Additive estimate	Preference
Mixed gain	+40%, -25%	Gain-loss	Gain	5%	15%	Less happy
Mixed gain	-25%, +40%	Loss-gain	Gain	5%	15%	More happy
Mixed gain	+50%, -20%	Gain-loss	Gain	20%	30%	Less happy
Mixed gain	-20%, +50%	Loss-gain	Gain	20%	30%	More happy
Mixed gain	+50%, +10%, -20%	Gain-gain-loss	Gain	32%	40%	Less happy
Mixed gain	-20%, +10%, +50%	Loss-gain-gain	Gain	32%	40%	More happy
Mixed gain	+55%, -15%, -5%	Gain-loss-loss	Gain	25%	35%	Less happy
Mixed gain	-5%, -15%, +55%	Loss-loss-gain	Gain	25%	35%	More happy
Mixed loss	+25%, -40%	Gain-loss	Loss	25%	15%	Less happy
Mixed loss	-40%, +25%	Loss-gain	Loss	25%	15%	More happy
Mixed loss	+20%, -50%	Gain-loss	Loss	40%	30%	Less happy
Mixed loss	-50%, +20%	Loss-gain	Loss	40%	30%	More happy
Mixed loss	+20%, +10%, -60%	Gain-gain-loss	Loss	47%	30%	Less happy
Mixed loss	-60%, +10%, +20%	Loss-gain-gain	Loss	47%	30%	More happy
Mixed loss	+35%, -15%, -30%	Gain-loss-loss	Loss	20%	10%	Less happy
Mixed loss	-30%, -15%, +35%	Loss-loss-gain	Loss	20%	10%	More happy
Pure gain	+45%, +20%	Large-small	Gain	74%	65%	More happy
Pure gain	+20%, +45%	Small-large	Gain	74%	65%	Less happy
Pure gain	+10%, +20%, +30%	Increasing gains	Gain	72%	60%	More happy
Pure gain	+30%, +20%, +10%	Decreasing gains	Gain	72%	60%	Less happy
Pure loss	-20%, -30%	Small-large	Loss	44%	50%	Less happy
Pure loss	-30%, -20%	Large-small	Loss	44%	50%	More happy
Pure loss	-10%, -20%, -30%	Increasing losses	Loss	50%	60%	Less happy
Pure loss	-30%, -20%, -10%	Decreasing losses	Loss	50%	60%	More happy

4.5.4 Procedure

Similar to Study 1, participants provided consent and were directed to read the instructions related to the decision tasks. On the instructions page, they were randomly assigned to one of the 8 experimental groups (2 order x 2 mode x 2 surprise). Next, the participants completed an example

task to familiarize themselves with the actual decision task and the corresponding measures. In each decision task, the participants viewed either a single change, two changes, or three changes on the investment and evaluated the investments by answering two questions. As a first question they were asked, “How happy or unhappy do you feel about the investment?” Participants were instructed to record their responses within 5 seconds. The second question consisted of two parts: “Is the overall change a gain or a loss?” and “By how many percent has the investment’s value changed overall?” For the outcome questions, participants were instructed to record their responses within 10 seconds. They were incentivized with an amount of US-\$ 0.02 for correctly classifying the overall change as a gain or a loss and US-\$ 0.02 for providing the correct estimate in each decision task. Additionally, for adhering to the time limit, they received an incentive of up to US-\$ 0.04, in each of the decision tasks. After completion of the decision tasks, participants specified the tools and strategies used to answer the decision tasks. Followed by which, they were directed to complete the CRT and the BNT. Participants were once again asked to specify the tools used for answering the questions and indicate their familiarity with each of the tests. As the last step, they were directed to provide some demographic details.

4.6 Results

4.6.1 BNT, CRT, and corresponding strategies

Mean score on the Berlin numeracy test (out of 4 possible correct) was found to be 1.50 ($Mdn = 1$, $SD = 1.39$, range = 0–4). For the cognitive reflection test (out of 3 possible correct) the mean score was 1.76 ($Mdn = 2$, $SD = 1.17$, range = 0–3). With respect to the tools and the strategies, 318 responses indicated the use of no external tools, 6 indicated the use of a calculator, 56 using a pen and paper strategy, and 6 with the use of other strategies such as an online search engine. Finally, 199 (52.37%) participants indicated that they were familiar with the Berlin Numeracy Test whereas 195 (51.32%) indicated that they were familiar with the Cognitive Reflection Test.

4.6.2 Estimation strategies

Similar to Study 1, we classified the responses to the two questions as based on the correct, additive, or other strategies. The results indicate that 15.07% of the outcomes were calculated using the correct strategy, more than half of the outcomes, 53.95% were calculated using the additive strategy and 30.99% of the outcomes were calculated with some other incorrect strategies. With respect to the decision tools, 326 responses indicated answering of the decision tasks without the use of any external tools, 38 with the use of a calculator, 29 using a pen and paper strategy, 39 using a reference amount of \$100 or \$1000 for calculating the percentage changes and 2 indicated resorting to using a search engine such as Google.

4.6.3 Role of order, overall change, presentation mode, and surprise

Similar to Study 1, we conducted two multiple regression analyses with the estimation strategies as the dependent variable. In addition to the order, overall change, and presentation modes, the factor of surprise (2 levels, present (-1), absent (+1)), was included as the predictor. We begin by reporting the results of mixed percentage changes.

4.6.3.1 Mixed percentage changes

The estimation strategies were not found to be influenced by the order of percentage changes (Wald $\chi^2 = 0.0002$, $df = 1$, $p = 0.988$) or the presentation modes (Wald $\chi^2 = 0.10$, $df = 1$, $p = 0.754$). There was no influence of the overall change on the estimation strategies as well (Wald $\chi^2 = 0.33$, $df = 1$, $p = 0.566$). The estimation strategies also did not differ between the surprise present and the surprise absent condition (Wald $\chi^2 = 2.80$, $df = 1$, $p = 0.094$). However, we find that the estimation strategies seem to be influenced by the order of percentage changes as well as the overall change, indicated by an interaction (Wald $\chi^2 = 4.25$, $df = 1$, $p = 0.039$). Although, upon analyzing the interaction the estimation strategies were found to be similar, in each of the two orders and overall changes (see figure 4.4). Specifically, the use of the additive strategy was found to be the highest, followed by the use of the other strategy, and lastly, the use of the correct strategy was found to be the lowest. Finally, there was no difference in the estimation strategies based on the order of percentage changes in the simultaneous and the sequential presentation mode, in the

presence of surprise (interaction, *NS*, Wald $\chi^2 = 0.01$, $df = 1$, $p = 0.940$). Instead, the estimation strategies were found to be influenced by numeracy (Wald $\chi^2 = 43.97$, $df = 1$, $p < 0.001$) as well as the scores on the CRT (Wald $\chi^2 = 42.87$, $df = 1$, $p < 0.001$).

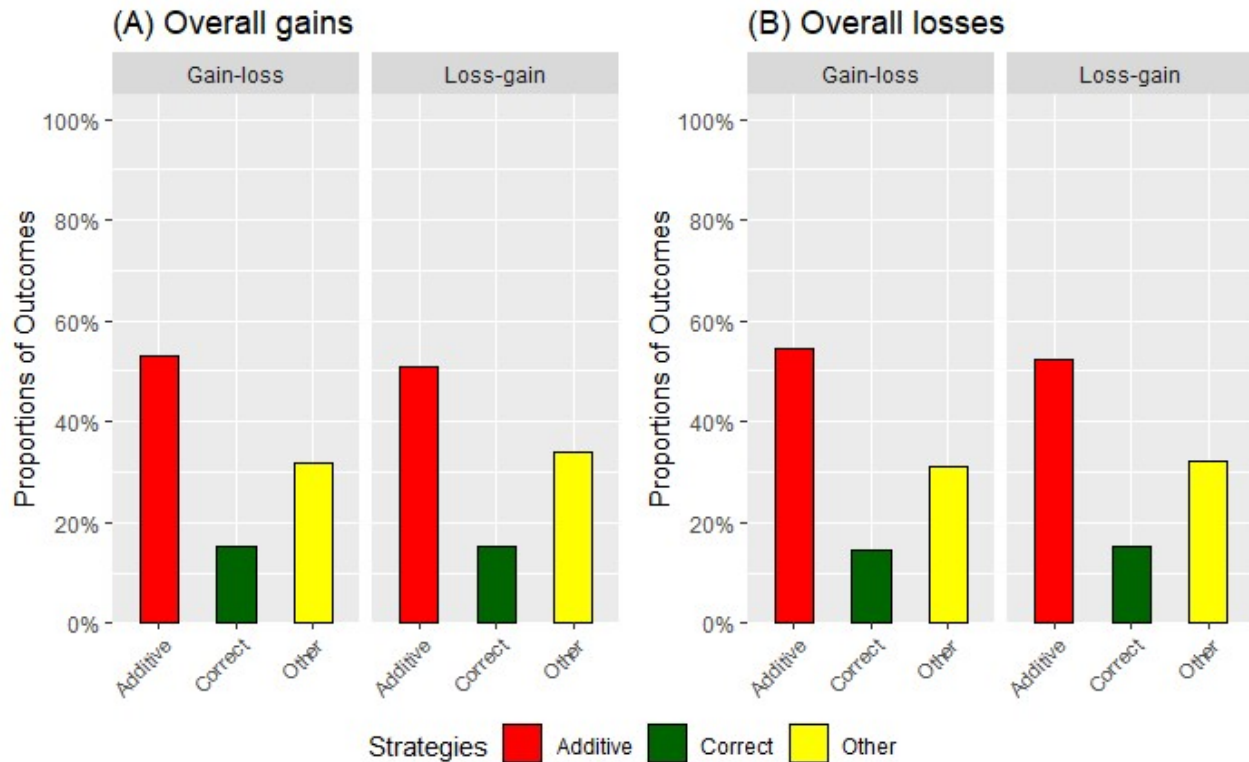


Figure 4.4: Proportions of outcomes based on the three estimation strategies across the two overall changes and orders, for the mixed percentage changes ($N = 380$, $tasks = 8$).

4.6.3.2 Pure percentage changes

For the pure percentage changes, we find no effect of the order on the estimation strategies (Wald $\chi^2 = 0.0006$, $df = 1$, $p = 0.980$). Furthermore, there was no influence of the presentation mode (Wald $\chi^2 = 0.12$, $df = 1$, $p = 0.733$) or the overall change (Wald $\chi^2 = 1.02$, $df = 1$, $p = 0.313$). However, we find a main effect of surprise on the estimation strategies (Wald $\chi^2 = 6.08$, $df = 1$, $p = 0.014$) and a significant interaction between overall change, surprise and the presentation modes (Wald $\chi^2 = 3.94$, $df = 1$, $p = 0.047$). Analyzing the interaction, we find that the estimation strategies were found to be different in the presence and absence of surprise in the sequential presentation

mode as compared to the simultaneous presentation mode (see figure 4.5) and in the case of overall gains and overall losses (see figure 4.6). Specifically, in the sequential presentation mode, the use of the additive strategy and the other strategy was found to be higher, while the proportions of outcomes estimated using the correct strategy were found to be lower in the presence of surprise (Additive = 61.54%, correct = 10.16%, other = 28.30%), as compared to when the surprise was absent (Additive: 57.58%, correct: 18.43%, other: 23.99%). A similar pattern can be observed in the simultaneous mode, although to a lesser degree, in the presence of surprise (Additive: 55.67%, correct: 13.14%, other: 31.19%). as compared to when the surprise was absent (Additive: 51.34%, correct: 18.28%, other: 30.38%). Similarly, in the case of overall losses, the use of the additive strategy and the other strategy was found to be slightly higher and the use of the correct strategy was found to be lower in the presence of surprise (Additive = 58.78%, correct = 11.70%, other = 29.52%) in comparison with the absence of surprise (Additive = 55.73%, correct = 18.75%, other = 25.52%). And a similar pattern is seen in the case of overall gains in the presence of surprise (Additive = 58.24%, correct = 11.70%, other = 30.05%) as compared to when the surprise was absent (Additive = 53.39%, correct = 17.97%, other = 28.65%). However, the estimation strategies did not differ based on the order, between the simultaneous and the sequential presentation mode, in the presence of surprise (Wald $\chi^2 = 0.01$, $df = 1$, $p = 0.914$). Lastly, the estimation strategies were found to be influenced by numeracy (Wald $\chi^2 = 37.24$, $df = 1$, $p < 0.001$) as well as the CRT (Wald $\chi^2 = 14.27$, $df = 1$, $p < 0.001$).

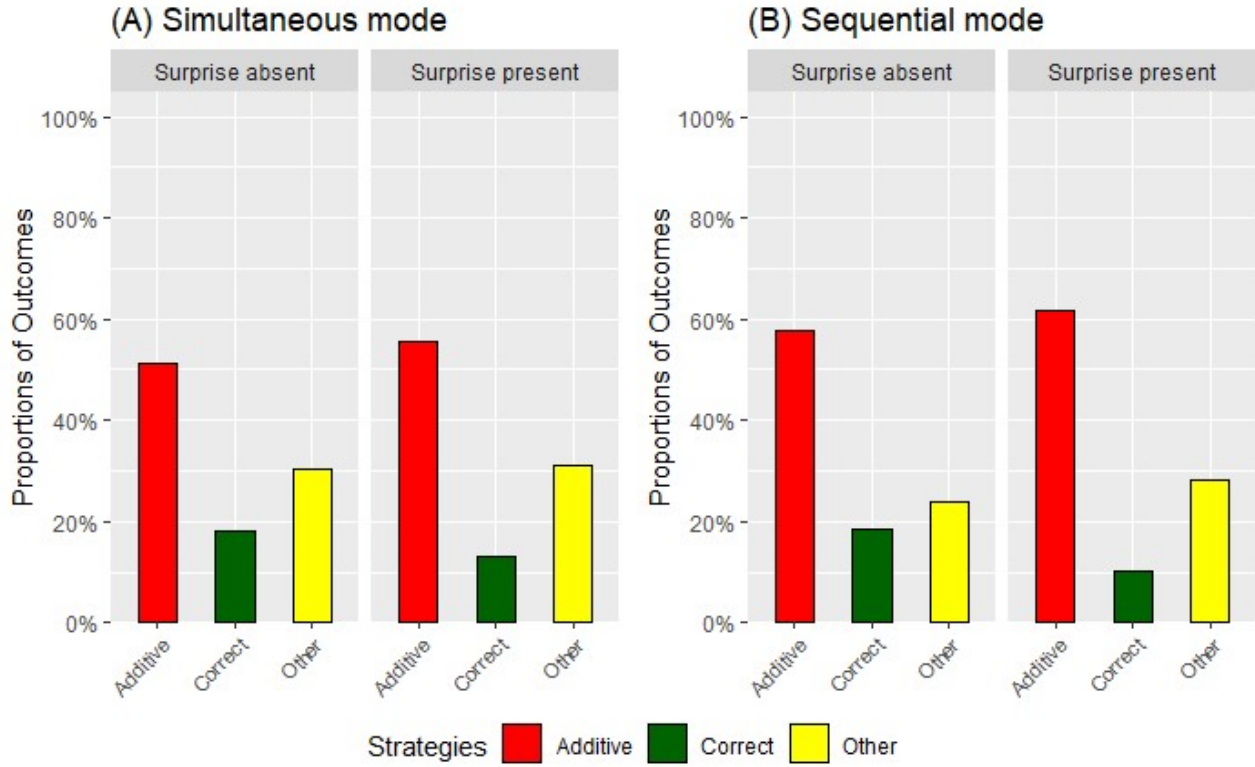


Figure 4.5: Proportions of outcomes for the pure percentage changes based on the three estimation strategies across the two presentation modes, in the presence and absence of surprise ($N = 380$, $tasks = 4$).

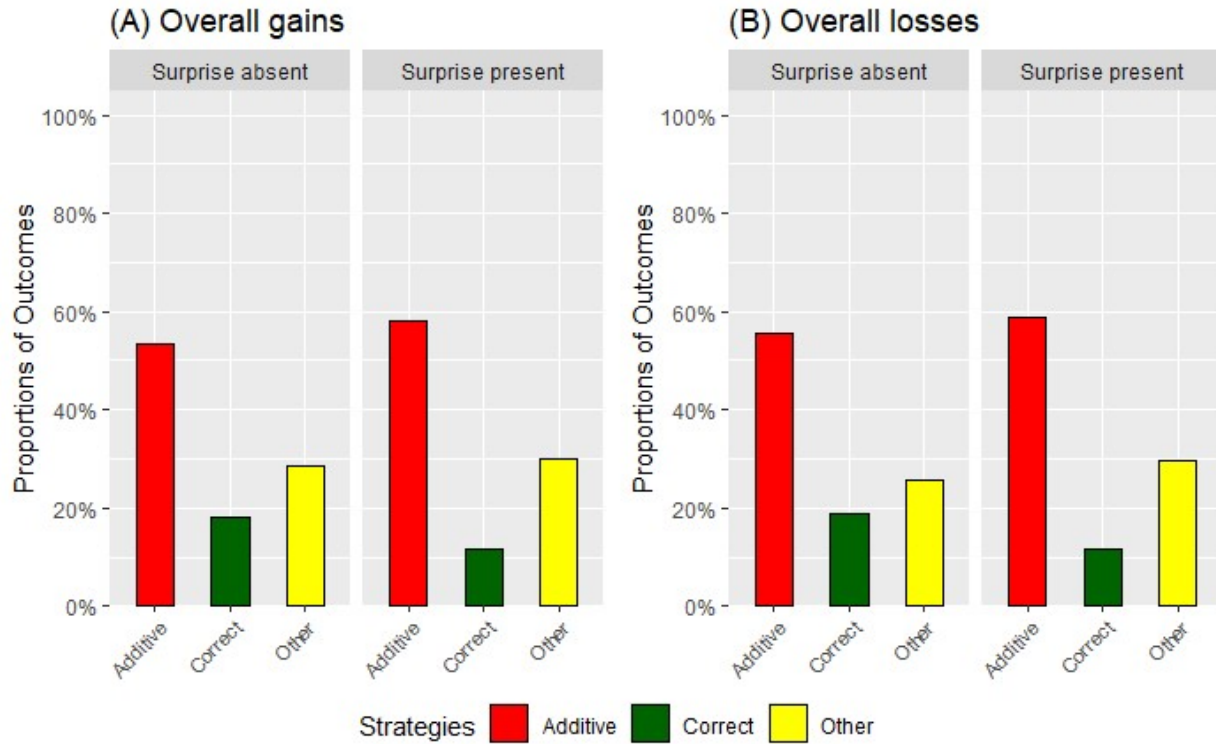


Figure 4.6: Proportions of outcomes for the pure percentage changes based on the three estimation strategies across the two overall changes, in the presence and absence of surprise ($N = 380$, $tasks = 4$).

4.6.4 Preference for happy ending: Role of order, presentation mode, and surprise

Similar to Study 1, we made two separate predictions for the mixed percentage changes and the pure percentage changes. We predicted a three-way interaction between order, presentation mode, and surprise and expected that the order effect will be stronger in the sequential presentation mode as opposed to the simultaneous presentation mode and more so in the presence of surprise.

4.6.4.1 Mixed percentage changes

Preference ratings were not higher for sequences when a loss was followed by a gain as opposed to when a gain was followed by a loss, indicated by a non-significant main effect of the order (Wald $\chi^2 = 0.0028$, $df = 1$, $p = 0.958$). Similarly, we do not find a main effect of the presentation mode (Wald $\chi^2 = 0.30$, $df = 1$, $p = 0.581$) or surprise (Wald $\chi^2 = 0.22$, $df = 1$, $p = 0.639$). However, preference ratings were found to be higher in the case of overall gains as opposed to overall losses,

indicated by a main effect of the overall change (Wald $\chi^2 = 1649.05$, $df = 1$, $p < 0.001$). Furthermore, the effect of the order was found to be more prominent in the sequential presentation mode as opposed to the simultaneous presentation mode, indicated by a marginally significant interaction between the order and presentation modes (Wald $\chi^2 = 3.80$, $df = 1$, $p = 0.051$). However, contrary to our predictions, there was no difference in the preference ratings based on the order, between the simultaneous and the sequential presentation mode, in the presence of surprise (Wald $\chi^2 = 1.46$, $df = 1$, $p = 0.227$). Figure 4.7 illustrates the preference ratings in each of the presentation modes, across the two orders, in the presence and absence of surprise. Furthermore, preference ratings for the sequence of changes ending in a gain were found to be higher in the presence of surprise, both for overall gains and overall losses, indicated by a marginally significant interaction between overall change, order, and surprise (Wald $\chi^2 = 3.69$, $df = 1$, $p = 0.055$). Figure 4.8 illustrates the preference ratings across the two orders and the overall changes in the presence and absence of surprise. However, in the absence of surprise, the preferences for the sequence of changes ending in gain were slightly higher only in the case of overall losses but not in the case of overall gains. Lastly, preferences were found to be influenced by the estimation strategies used by people (Wald $\chi^2 = 6.45$, $df = 2$, $p = 0.040$). Furthermore, CRT was found to have an influence such that people who scored low indicated higher preference ratings as compared to people who scored high (Wald $\chi^2 = 10.55$, $df = 1$, $p = 0.001$). However, the effect of numeracy on the preference ratings was found to be only marginally significant (Wald $\chi^2 = 3.50$, $df = 1$, $p = 0.061$).

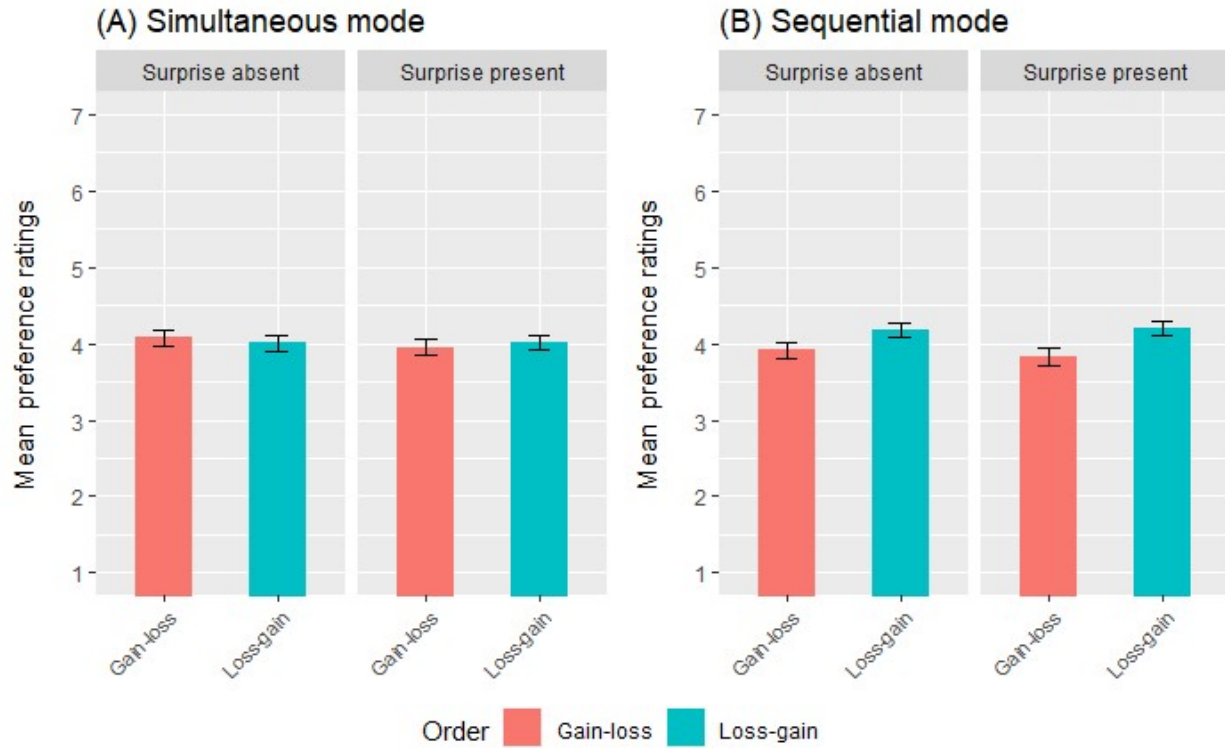


Figure 4.7: Mean preference ratings for the mixed percentage changes for the two orders, in each of the two presentation modes and in the presence and absence of surprise ($N = 380$, $tasks = 8$). (A) Simultaneous mode. There was no difference in the preference ratings between the two orders in the presence and absence of surprise (B) Sequential mode. Preferences were higher for the sequence of changes ending in a gain. However, surprise did not influence the preference ratings. Bars represent \pm one standard error of the mean.

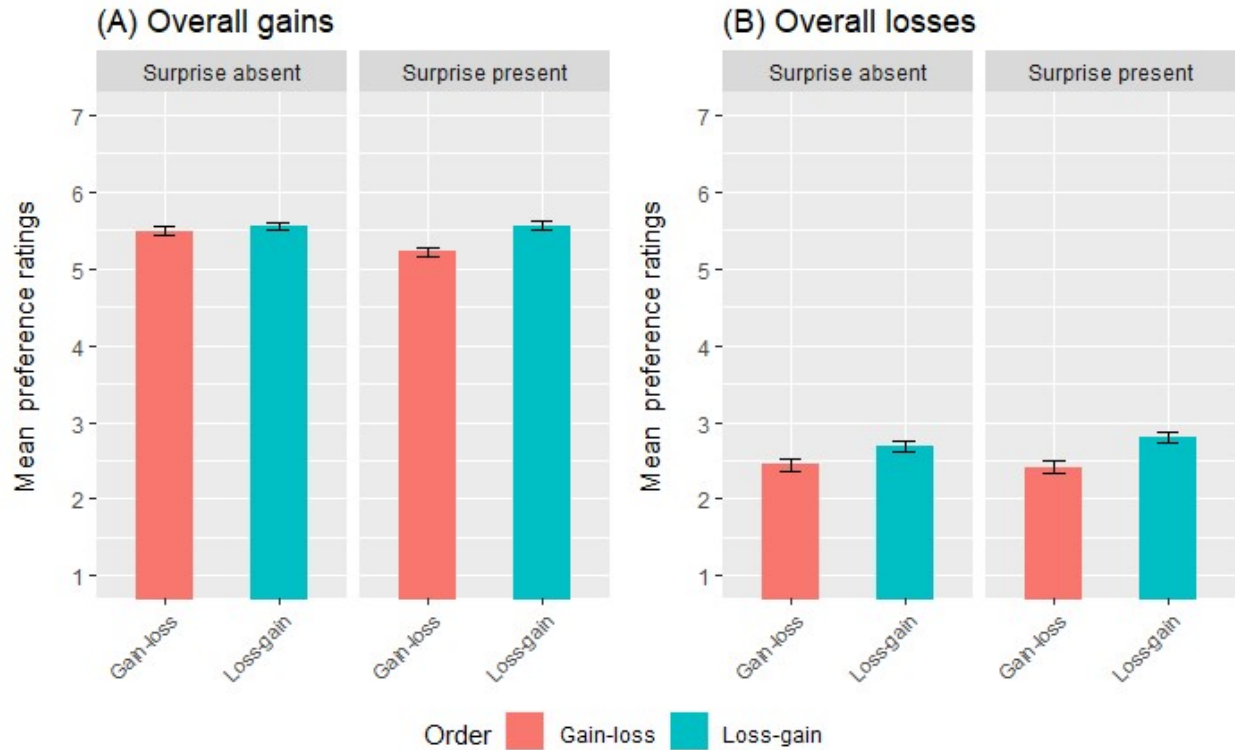


Figure 4.8: Mean preference ratings for the mixed percentage changes for the two orders and the overall changes in the presence and absence of surprise ($N = 380$, $tasks = 8$). (A) Overall gains. The preference ratings were found to be higher when the sequence of changes ended in a gain as opposed to a loss in the presence of surprise. However, the preference ratings did not differ between the two orders in the absence of surprise. (B) Overall losses. Preference ratings were higher for the sequence of changes ending in a gain, and more so in the presence of surprise as compared to the absence of surprise. Bars represent \pm one standard error of the mean.

4.6.4.2 Pure percentage changes

Results indicate no effect of the order on the preference ratings (Wald $\chi^2 = 0.16$, $df = 1$, $p = 0.688$). There was no effect of the presentation mode (Wald $\chi^2 = 0.0011$, $df = 1$, $p = 0.974$) or the presence of surprise (Wald $\chi^2 = 0.52$, $df = 1$, $p = 0.472$) on the preference ratings. However, preference ratings were found to be higher in the case of overall gains as opposed to overall losses, indicated by a main effect of the overall change (Wald $\chi^2 = 4341.02$, $df = 1$, $p < 0.001$). Moreover, contrary to our predictions, there was no difference in the preference ratings based on the order, between the simultaneous and the sequential presentation mode, in the presence of surprise (Wald $\chi^2 = 0.01$, $df = 1$, $p = 0.943$). Figure 4.9 illustrates the preference ratings for the two orders in each of the

presentation modes, in the presence and absence of surprise. Lastly, preferences were found to be influenced by the estimation strategies used by people (Wald $\chi^2 = 19.12$, $df = 2$, $p < 0.001$). Furthermore, CRT was found to have an influence such that people who scored low on the CRT indicated higher preference ratings as compared to people who scored high (Wald $\chi^2 = 7.98$, $df = 1$, $p = 0.005$). However, we find no effect of numeracy on the preference ratings (Wald $\chi^2 = 1.54$, $df = 1$, $p = 0.214$).

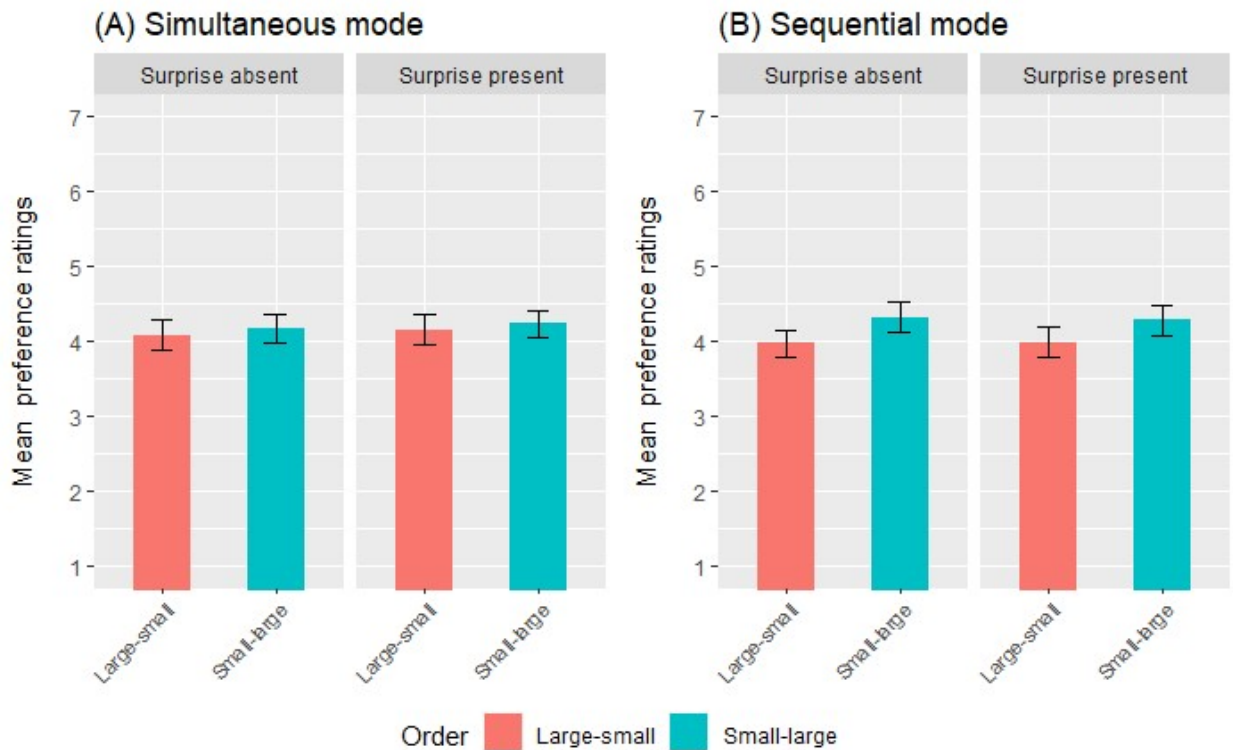


Figure 4.9: Mean preference ratings for the pure percentage changes, for the two orders in each of the two presentation modes, in the presence and absence of surprise ($N = 380$, $tasks = 4$). Bars represent \pm one standard error of the mean.

4.7 General Discussion

The focus of our present research was to investigate the estimation strategies as well as the affective evaluations of sequential percentage changes. We specifically explored the role of anticipation, the recency effect, and surprise by manipulating factors of order and presentation mode. With regards to the estimation strategies, similar to the previous literature, we find that the participants predominantly used an additive strategy to estimate the consequences of sequential percentage changes (e.g., Chen & Rao, 2007; Davis & Bagchi, 2018). Furthermore, the estimation strategies are governed to some extent by surprise especially in the case of pure percentage changes where we found that people are likely to be less correct when the sequences were presented with temporal separation and both in the case of overall gains and overall losses. Lastly, with respect to the estimation strategies, both numeracy and cognitive reflection seems to play an important role in preventing people from using incorrect strategies. With regards to the affective evaluations, we find that the order and presentation mode influence the perception of sequential percentage changes. Specifically, in our first study, we found that preferences for mixed percentage changes were influenced by the order such that people preferred a gain in the end as opposed to a loss in the end. However, the preference based on the order did not differ between the simultaneous presentation mode and the sequential presentation mode. Therefore, similar to the intertemporal choice literature, we were able to show that people exhibit a preference for a happy ending (e.g., Loewenstein, 1987; Loewenstein & Sicherman, 1991). This is also similar to the results found by Hellmann et al. (2017) wherein the authors showed that non-professional investors gave higher evaluations for a company's performance when the positive information was presented second as opposed to when it was presented first.

Upon improvement of our experimental setup specifically by changing the instructions and including time pressure for the responses, the preference ratings for the sequence of changes ending on a happy note were only slightly higher in the sequential presentation mode as compared to the simultaneous presentation mode. This indicates that there might be a small recency effect at play. However, in the second study contrary to our predictions as well as the results of Davis & Bagchi (2018), the emotion of surprise did not intensify the order effect in the sequential presentation mode. Instead, the preference for a happy ending was found to be more pronounced in the presence of surprise for both overall gains and overall losses. This suggests that surprise

does play a role by shifting attention to the unexpected outcome (e.g., Chen & Rao 2002; Heilman et al., 2002; Noordewier et al., 2016). However, surprise does not amplify the preference for a happy ending specifically for sequences presented with temporal separation, as found in the study of Davis & Bagchi (2018). On the other hand, for pure percentage changes affective evaluations were not influenced by the order, presentation mode, and/or surprise. Therefore, we find no effect of the recency or anchoring as proposed by Davis & Bagchi (2018) for the pure percentage changes. Instead, our research indicates that the overall change is the only governing factor for affective evaluations of pure percentage changes.

4.7.1 Limitations and Future Research

While the above-mentioned findings provide a novel direction in understanding the perception of sequential percentage changes, it remains important to present the methodological limitations of our research. First, while we introduced surprise and unpredictability in our tasks by using different lengths of sequences (i.e., one, two, and three changes), we did not use a measure to evaluate the emotion of surprise. Measurement of surprise requires capturing the emotion while the surprising event occurs (Noordewier et al., 2016). Future research can incorporate measuring surprise in order to get a complete picture of how surprise influences the perception of sequential percentage changes. Second, we induced time pressure to record the responses which could have potentially influenced the estimates as well as the affective evaluations. Time pressure is not only known to impair performance on cognitive tasks (e.g., Roskes et al., 2013; Ganushchak & Schiller, 2009; Keinan et al., 1999) but also has an impact on the affective states of a decision maker (Maule & Hockey, 1993). In general, the presence of the recency effect continues to be an interesting avenue for future research. For example, it is possible that the recency effect in verbal formats (as in our research) can be reduced by presenting graphical information in the end, as the use of visual cues draws more attention and presenting them at the end may reduce the expected recency effect (Hellmann et al., 2017). Moreover, it has been shown that graphical information is likely to be weighted more in comparison with textual information (Lurie & Mason, 2007). Overall, a comparison of the order effect across different presentation formats can be useful in promoting the understanding of sequential percentage changes.

4.8 Conclusions

Decision makers are known to make judgments based on emotions associated with anticipated as well as unexpected future outcomes. While the use of the additive estimation strategy proves to be a useful indicator of how people perceive sequential percentage changes, it remains limited in explaining how people affectively evaluate sequential percentage changes. Normatively, emotions and other psychological processes should play no role in evaluations of percentage changes. However, we find that financial information presented as percentage changes may not always be assessed objectively with straightforward estimation strategies, as they should be. Implicit factors of order and presentation mode additionally influence the evaluations through emotions of anticipation, surprise, and the recency effect. Therefore, it seems imperative to consider the role of such implicit factors in understanding people's preferences, as they are likely to be sensitive to cues that go beyond the use of the additive estimation rule for evaluating sequential percentage changes.

Appendix A

Supplements for Chapter 2

A1.1 Trial selection

For selecting our trials, we first investigated the extent to which the correct multiplicative strategy and the incorrect additive strategy differ in their predictions regarding the overall change for sequences of percentage changes. Therefore, we considered two percentage changes, p , and q in a series without the initial values. Each percentage change (p , q) was expressed as an integer and ranged between -100% and $+100\%$. The two percentages' overall change was simulated as overall gains (i.e., a positive percentage change) and overall losses (i.e., a negative percentage change). We begin by illustrating the mathematical equations for calculating the overall change of sequences of two percentage changes, using the correct multiplicative strategy and the incorrect additive strategy.

A1.1.1 Mathematical Equations

Multiplicative strategy, overall change:

$$[(1+p/100) (1+q/100)] \times 100 - 100$$

$$= p + q + (p \times q/100)$$

Additive strategy, overall change: $p + q$

The error between the two strategies can be calculated by using the formula $p \times q/100$.

Based on the above equations, we can observe that combining the equations of the additive strategy and the error between the two strategies gives us the equation for the correct multiplicative strategy. Furthermore, irrespective of the strategies, the percentage changes can be calculated in

any order (i.e., p first or q first), both orders resulting in the same final change. Figure A1 illustrates the difference in outcomes with the correct multiplicative strategy, the incorrect additive strategy, and the error between two strategies for all possible pairs of percentage changes ranging between -100% and $+100\%$.

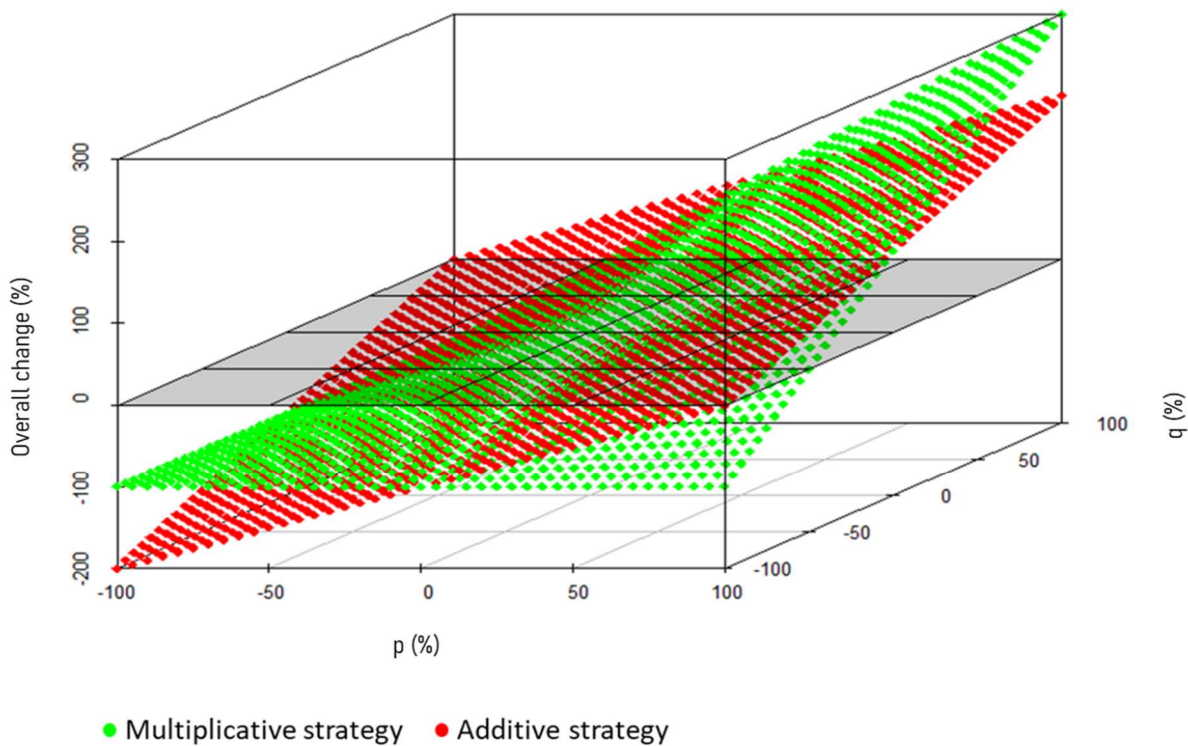


Figure A1: Overall change (%) with the multiplicative and the additive strategy for pairs of percentage changes ranging between -100% and 100% . We find that the error between the two strategies is 0 when at least one of the percentage changes is 0. However, at any other point between -100% and 100% , there are deviations between the two strategies. For most of the percentage pairs between -100% and 100% , both the strategies make similar qualitative predictions regarding overall gains and overall losses. For a small minority of percentage pairs, the two strategies have differing qualitative predictions (i.e., the correct multiplicative strategy predicts an overall loss and the incorrect additive strategy predicts an overall gain).

A1.2 Derivation – 2 Sequential percentage changes

Variable definition:

$I \rightarrow$ Initial value

$I_1 \rightarrow$ Intermittent value 1

$I_2 \rightarrow$ Intermittent value 2

$F \rightarrow$ Final value

$P \rightarrow$ First percentage change

$Q \rightarrow$ Second percentage change

$C \rightarrow$ Cumulative percentage change

Multiplicative strategy

$$I_1 = I + (I \times P/100) = I(1 + P/100)$$

$$\begin{aligned} F &= I_1 + (I_1 \times Q/100) = I(1 + P/100) + I(1 + P/100)(Q/100) = I[1 + P/100 + (1 + P/100)(Q/100)] \\ &= I[1 + P/100 + Q/100 + (P \times Q/100^2)] \end{aligned}$$

Also,

$$F = I + (I \times C/100)$$

$$\Rightarrow I(1 + C/100) = I[1 + P/100 + Q/100 + (P \times Q/100^2)]$$

Cancelling the initial value I out,

$$1 + C/100 = 1 + P/100 + Q/100 + (P \times Q/100^2)$$

Multiplying both LHS and RHS by 100,

$$100 + C = 100 + P + Q + (P \times Q/100)$$

$$\Rightarrow \underline{\underline{C = P + Q + (P \times Q/100)}}$$

Additive strategy

$$C = P + Q$$

The error between the multiplicative strategy and the additive strategy

$$\text{Multiplicative strategy} - \text{Additive strategy} = [P + Q + (P \times Q/100)] - [P + Q]$$

$$= (P \times Q/100)$$

A1.3 Derivation – 3 Sequential percentage changes

Variable definition:

$I \rightarrow$ Initial value

$I_1 \rightarrow$ Intermittent value 1

$I_2 \rightarrow$ Intermittent value 2

$F \rightarrow$ Final value

$P \rightarrow$ First percentage change

$Q \rightarrow$ Second percentage change

$R \rightarrow$ Third percentage change

$C \rightarrow$ Cumulative percentage change

Multiplicative strategy

$$I_1 = I + (I \times P/100) = I (1 + P/100)$$

$$\begin{aligned} I_2 &= I_1 + (I_1 \times Q/100) = I (1 + P/100) + I (1 + P/100) (Q/100) = I [1 + P/100 + (1 + P/100) (Q/100)] \\ &= I [1 + P/100 + Q/100 + (P \times Q/100^2)] \end{aligned}$$

$$\begin{aligned} F &= I_2 + I_2 \times R/100 = I_2 (1 + R/100) = I [1 + P/100 + Q/100 + (P \times Q/100^2)] \times (1 + R/100) \\ &= I [1 + P/100 + Q/100 + (P \times Q/100^2) + R/100 + (P \times R/100^2) + (Q \times R/100^2) + (P \times Q \times R/100^3)] \end{aligned}$$

Also,

$$F = I + (I \times C/100)$$

$$\Rightarrow I (1 + C/100) = I [1 + P/100 + Q/100 + (P \times Q/100^2) + R/100 + (P \times R/100^2) + (Q \times R/100^2) + (P \times Q \times R/100^3)]$$

Cancelling the initial value I out,

$$1 + C/100 = 1 + P/100 + Q/100 + (P \times Q/100^2) + R/100 + (P \times R/100^2) + (Q \times R/100^2) + (P \times Q \times R/100^3)$$

Multiplying both LHS and RHS by 100,

$$100 + C = 100 + P + Q + (P \times Q/100) + R + (P \times R/100) + (Q \times R/100) + (P \times Q \times R/100^2)$$

$$\Rightarrow \underline{C = P + Q + R + (P \times Q/100) + (P \times R/100) + (Q \times R/100) + (P \times Q \times R/100^2)}$$

Additive strategy

$$C = P + Q + R$$

The error between the multiplicative strategy and the additive strategy

$$\text{Multiplicative strategy} - \text{Additive strategy} = [P + Q + R + (P \times Q/100) + (P \times R/100) + (Q \times R/100) + (P \times Q \times R/100^2)] - [P + Q + R]$$

$$= (P \times Q/100) + (P \times R/100) + (Q \times R/100) + (P \times Q \times R/100^2)$$

A2.1 Examples of decision trials

Conflicting trial with pure outcomes (overall gains)

Decoy: +78%, +62%, -54%

Target: +40%, +42%, -22%

Decoy: Multiplicative change = +32.6%, additive change = +86%

Target: Multiplicative change = +55.1%, additive change = +60%

Conflicting trial with pure outcomes (overall losses)

Decoy: +09%, +77%, -91%

Target: +02%, +04%, -34%

Decoy: Multiplicative change = -82.6%, additive change = -5%

Target: Multiplicative change = -30%, additive change = -28%

Conflicting trial with mixed outcomes

Decoy: +60%, +92%, -90%

Target: +11%, +11%, -65%

Decoy: Multiplicative change = -69.3%, additive change = +62%

Target: Multiplicative change = -56.9%, additive change = -43%

Non-conflicting trial

Target: +12%, +58%, -41%

Series 2: +10%, +08%, -26%

Target: Multiplicative change = +4.4%, additive change = +29%

Series 2: Multiplicative change = -12.1%, additive change = -8%

A3.1 Berlin Numeracy Test (Cokely et al., 2012)

- 1) Out of 1,000 people in a small town 500 are members of a choir. Out of these 500 members in a choir 100 are men. Out of the 500 inhabitants that are not in a choir 300 are men. What is the probability that a randomly drawn man is a member of the choir?
Please indicate the probability in percent.

..... %

- 2) Imagine we are throwing a five-sided dice 50 times. On average, out of these 50 throws how many times would this five-sided dice show an odd number (1, 3, or 5)?

..... out of 50 throws

- 3) Imagine we are throwing a loaded dice (6 sides) 70 times. The probability that the dice shows a 6 is twice as high as the probability of each of the other numbers. On average, out of these 70 throws how many times would the dice show the number 6?

..... out of 70 throws

- 4) In a forest 20% of mushrooms are red, 50% brown and 30% white. A red mushroom is poisonous with a probability of 20%. A mushroom that is not red is poisonous with a probability of 5%. What is the probability that a poisonous mushroom in the forest is red?

..... %

Correct answers: 1 = 25; 2 = 30; 3 = 20; 4 = 50.

A3.2 BNT scores distribution

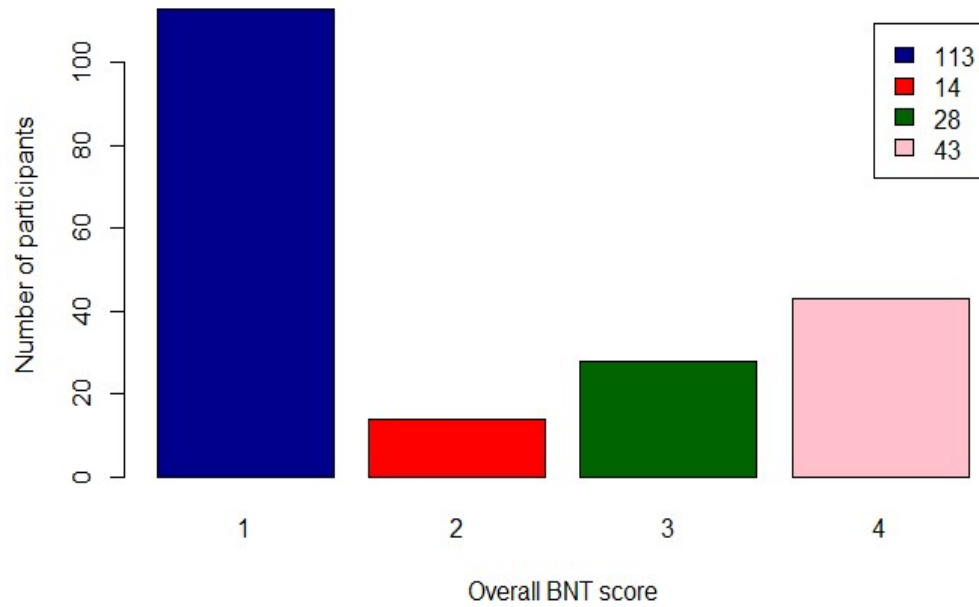


Figure A2: Distribution of the overall BNT scores (n= 198).

Appendix B

Supplements for Chapter 3

B1.1 Study 1, example task: Mixed gain, mathematically equivalent

- Person A discovers that by the end of the week, the value of his investment has increased by 5% (from its original value).
- Person B discovers that the value of his investment has changed twice: After a few days, it has decreased by 25% (from its original value). By the end of the week, the investment's value has increased by 40% (from its intermediate value).

B1.1.1 Measures

Which of the two persons is happier?

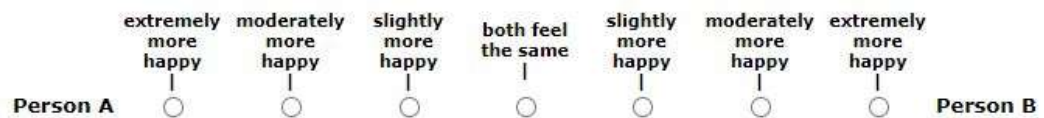


Figure B1: Preference response scale.

Which of the two persons is facing the better financial outcome?

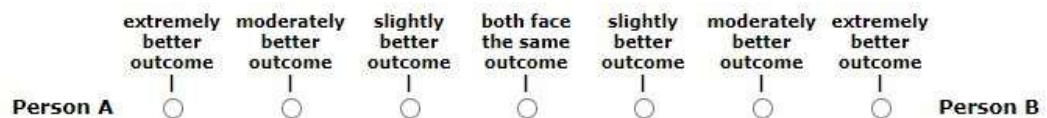


Figure B2: Outcome response scale.

Correct answer: Both face the same outcome

B1.2 Study 2, example task: Mixed gain, additively equivalent

- Person A discovers that by the end of the week, the value of his investment has increased by 15% (from its original value).
- Person B discovers that the value of his investment has changed twice: After a few days, it has decreased by 25% (from its original value). By the end of the week, the investment's value has increased by 40% (from its intermediate value).

B1.2.1 Measures

Both A and B experienced gains, but which of the 2 persons is happier?

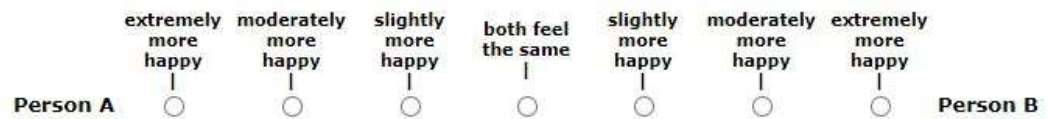


Figure B3: Preference response scale.

Both A and B experienced gains, but which of the 2 persons is facing the better financial outcome?

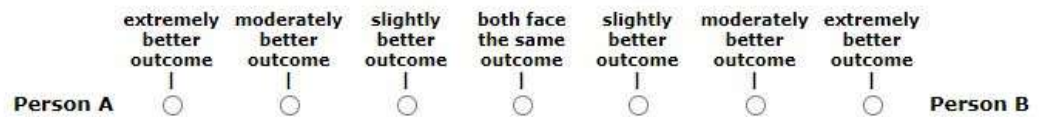


Figure B4: Outcome response scale.

Correct answer: Person A faces the better outcome (i.e., response points 1, 2, 3).

B2.1 Cognitive Reflection Test (Frederick, 2005)

- 1) A TV and a DVD together cost 88 dollars. The TV costs 80 dollars more than the DVD. How much does the DVD cost?

..... Dollars

- 2) If it takes 10 hens 10 days to lay 10 eggs, how long would it take 100 hens to lay 100 eggs?

..... Days

- 3) A computer virus is spreading through a computer system. Every minute, the number of infected files doubles. If it takes 100 minutes for the virus to infect all of the system, how long would it take for the virus to infect half of the system?

..... Minutes

Correct answers: 1 = 4; 2 = 10; 3 = 99

B2.2 Berlin Numeracy Test (Cokely et al., 2012)

- 1) Out of 1,000 people in a small town 500 are members of a choir. Out of these 500 members in a choir 100 are men. Out of the 500 inhabitants that are not in a choir 300 are men. What is the probability that a randomly drawn man is a member of the choir?
Please indicate the probability in percent.

..... %

- 2) Imagine we are throwing a five-sided dice 50 times. On average, out of these 50 throws how many times would this five-sided dice show an odd number (1, 3, or 5)?

..... out of 50 throws

- 5) Imagine we are throwing a loaded dice (6 sides) 70 times. The probability that the dice shows a 6 is twice as high as the probability of each of the other numbers. On average, out of these 70 throws how many times would the dice show the number 6?

..... out of 70 throws

- 3) In a forest 20% of mushrooms are red, 50% brown and 30% white. A red mushroom is poisonous with a probability of 20%. A mushroom that is not red is poisonous with a probability of 5%. What is the probability that a poisonous mushroom in the forest is red?

..... %

Correct answers: 1 = 25; 2 = 30; 3 = 20; 4 = 50

Appendix C

Supplements for Chapter 3

C1.1 Study 1, example task: Mixed gain

C1.1.1 Simultaneous presentation mode, order of percentage changes: Gain-loss

Page 1

Imagine you have **invested a substantial amount** of your money into a short-term fund. You have to cash out your investment after one week and discover that your fund's value has strongly changed during that time. You discover that the value of your investment has **changed twice**.

On the following screen, you will be presented with **the changes of your investment**.

Please note that you will be required to **use both the changes presented** for answering the **subsequent questions**.

Click on 'Continue' to see **the changes**.

Page 2

1st change:

After a few days, the value of your investment has **increased by 40%** (from its original value).

2nd change:

By the end of the week, the value of your investment has **decreased by 25%** (from its

intermediate value).

Think about **how you feel** about **both these changes** of your investment.

Click on 'Continue' to answer some questions.

C1.1.2 Sequential presentation mode, order of percentage changes: Gain-loss

Page 1

Imagine you have **invested a substantial amount** of your money into a short-term fund. You have to cash out your investment after one week and discover that your fund's value has strongly changed during that time. You discover that the value of your investment has **changed twice**.

On the following screens, you will be presented with **the changes of your investment**.

Please note that you will be required to **use both the changes presented** for answering the **subsequent questions**.

Click on 'Continue' to see the **1st change**.

Page 2

1st change:

After a few days, the value of your investment has **increased by 40%** (from its original value).

Think about **how you feel** about this **1st change** of your investment.

Click on 'Continue' to see the **2nd change**.

Page 3

2nd change:

By the end of the week, the value of your investment has **decreased by 25%** (from its intermediate value).

Think about **how you feel** about this **2nd change** of your investment.

Click on 'Continue' to answer some questions.

C1.1.3 Measures

How happy or unhappy do you feel about this investment?

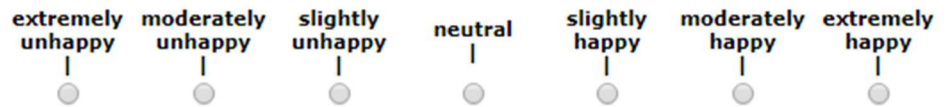


Figure C1: Preference response scale.

Is the overall change a gain or a loss?

- Gain Loss

By how many percent has the investment's value changed overall?

Note: Overall changes with a decimal point should be rounded off to the closest integer. For example: 9.6 = 10.

Also, if you think the overall change is negative, please select "Loss" in the previous question and enter the percent value without a minus (-) sign.

For example: -10% = a loss of 10%.

% (from 0 to 100)

Figure C2: Outcome response scale.

Correct answer: Gain, 5%

C1.2 Study 2, example task: Mixed loss

C1.2.1 Simultaneous presentation mode

Page 1 (Without surprise)

Imagine you have **invested a substantial amount** of your money into a short-term fund. You have to cash out your investment after one week and discover that your fund's value has changed substantially during that time. You discover that the value of your investment has **changed twice**.

On the following screen, you will be presented with **the changes of your investment** and will be **asked for your assessment**.

Click on 'Continue' to see the **next page**.

Page 1 (With surprise)

Imagine you have **invested a substantial amount** of your money into a short-term fund. You have to cash out your investment after one week and discover that your fund's value has **changed** substantially during that time.

On the following screen, you will be presented with **the change(s) of your investment** and will be **asked for your assessment**.

Click on 'Continue' to see the **next page**.

Page 2 (with and without surprise)

Change 1:

The value of your investment has **decreased by 50%**

Change 2:

The value of your investment has **increased by 20%**

Click on 'Continue' to see the **next page**

C1.2.2 Sequential presentation mode

Page 1 (Without surprise)

Imagine you have **invested a substantial amount** of your money into a short-term fund. You have to cash out your investment after one week and discover that your fund's value has changed substantially during that time. You discover that the value of your investment has **changed twice**.

On the following screens, you will be presented with **the changes of your investment** and will be **asked for your assessment**.

Click on 'Continue' to see the **next page**.

Page 1 (With surprise)

Imagine you have **invested a substantial amount** of your money into a short-term fund. You have to cash out your investment after one week and discover that your fund's value has **changed** substantially during that time.

On the following screens, you will be presented with **the change(s) of your investment** and will be **asked for your assessment**.

Click on 'Continue' to see the **next page**.

Page 2 (without surprise)

Change 1:

The value of your investment has **decreased by 50%**.

Page 2 (with surprise)

Change 1:

The value of your investment has **decreased by 50%**.

Page 3 (without surprise)

Change 2:

The value of your investment has **increased by 20%**.

Page 3 (with surprise)

Change 2:

The value of your investment has **increased by 20%**.

Click on 'Continue' to see the **next page**.

C1.2.3 Measures

Time left: **5 seconds**
(not active in example)

How happy or unhappy do you feel about this investment?



Figure C3: Preference response scale.

Time left: **10 seconds**
(not active in example)

Is the overall change a gain or a loss?

- Gain Loss

By how many percent has the investment's value changed overall?

Note: Overall changes with a decimal point should be rounded off to the closest integer. For example: 9.6 = 10.

Also, if you think the overall change is negative, please select "Loss" in the previous question and enter the percent value without a minus (-) sign.

For example: -10% = a loss of 10%.

% (from 0 to 100)

Figure C4: Outcome response scale.

Correct answer: Loss, 40%

C2.1 Cognitive Reflection Test (Frederick, 2005)

- 1) A TV and a DVD together cost 88 dollars. The TV costs 80 dollars more than the DVD. How much does the DVD cost?

..... Dollars

- 2) If it takes 10 hens 10 days to lay 10 eggs, how long would it take 100 hens to lay 100 eggs?

..... Days

- 3) A computer virus is spreading through a computer system. Every minute, the number of infected files doubles. If it takes 100 minutes for the virus to infect all of the system, how long would it take for the virus to infect half of the system?

..... Minutes

Correct answers: 1 = 4; 2 = 10; 3 = 99

C2.2 Berlin Numeracy Test (Cokely et al., 2012)

- 1) Out of 1,000 people in a small town 500 are members of a choir. Out of these 500 members in a choir 100 are men. Out of the 500 inhabitants that are not in a choir 300 are men. What is the probability that a randomly drawn man is a member of the choir?
Please indicate the probability in percent.

..... %

- 2) Imagine we are throwing a five-sided dice 50 times. On average, out of these 50 throws how many times would this five-sided dice show an odd number (1, 3, or 5)?

..... out of 50 throws

- 3) Imagine we are throwing a loaded dice (6 sides) 70 times. The probability that the dice shows a 6 is twice as high as the probability of each of the other numbers. On average, out of these 70 throws how many times would the dice show the number 6?

..... out of 70 throws

- 4) In a forest 20% of mushrooms are red, 50% brown and 30% white. A red mushroom is poisonous with a probability of 20%. A mushroom that is not red is poisonous with a probability of 5%. What is the probability that a poisonous mushroom in the forest is red?

..... %

Correct answers: 1 = 25; 2 = 30; 3 = 20; 4 = 50

List of Contributions

Chapter 1 I, Ruchira Suresh, hereby declare that I am the sole author of the introduction chapter.

Chapter 2 Suresh, R., Gaissmaier, W. & Neth, H. (2020). Sequential percentage changes: Testing the persistency of the erroneous additive strategy as a function of the order of events, the magnitude of losses, and numeracy.

- Idea and study design: RS, WG, HN
- Data collection: RS
- Data analysis: RS
- First draft manuscript: RS
- Revised manuscript and approved final draft: RS, WG, HN

Chapter 3 Suresh, R., Gaissmaier, W. & Neth, H. (2020). Preferences for sequences of percentage changes are more than based on objective outcomes: Effects of order, equivalence, and overall direction of change.

- Idea and study design: RS, WG, HN
- Data collection: RS
- Data analysis: RS
- First draft manuscript: RS
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Chapter 4 Suresh, R., Gaissmaier, W. & Neth, H. (2020). Affective evaluations of sequential percentage changes: Role of anticipation, the recency effect, and surprise.

- Idea and study design: RS, WG, HN

- Data collection: RS
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Suresh, R., Gaissmaier, W. & Neth, H. (2020). Preferences for sequences of percentage changes are more than based on objective outcomes: Effects of order, equivalence, and overall direction of change.

Suresh, R., Gaissmaier, W. & Neth, H. (2020). Affective evaluations of sequential percentage changes: Role of anticipation, the recency effect, and surprise.

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