Chapter 1 – Introduction and Overview of the Thesis

This thesis investigates effects of delay and risk on the perceived value of personal investment returns. The research fulfils theoretical and practical aims. Theoretically, it derives a parameter called $k_i$, which is new to the behavioural and economic literature. The $k_i$ parameter is a property of an investment. The thesis claims that $k_i$ can predict an investment’s appeal to a personal investor. A series of investment simulation experiments test this claim. Further experiments test the effects of delay and probability on the perceived value of investment returns. The results support a model for personal investment decision making based on preferences for delayed and probabilistic rewards. Insights from the research could assist investors to make better decisions. Better decisions are those that the investor would appraise favourably in hindsight.

This chapter commences with an examination of personal investment and savings behaviour, which progresses to issues of self-control. Delay and probability discounting principles governing the perceived value of future and probabilistic rewards are introduced, and their relevance to personal investment decision is shown. The chapter argues that personal investment requires acceptance of delayed reward; may require the acceptance and management of risk; and may require inferences about future investment performance based on historical returns which are an unreliable guide to future performance. Research reported in the thesis examines how investors might respond to these three demands.

**Saving and Investment**

Saving and investment deserve a high priority in behavioural research. Warnings about insufficient personal saving and investment appear in the popular literature (e.g., Lavelle, 1999; Sampson, 1999; Whittaker, 1992) and the technical literature (e.g., Hubbard,
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Skinner, & Zeldes, 1994; Thaler, 1990; Thaler, 1994). The perception of insufficient savings even occurs within the general community, among those to whom the warnings are directed (Angeletos, Laibson, Repetto, Tobacman, & Weinberg, 2001; Laibson, 1998; Laibson, Repetto, & Tobacman, 1998).

Wärneryd (1989) claims that economists rather than psychologists have dominated existing research into savings behaviour, starting from 18th century theorists such as Mandeville and Adam Smith, and their writings on thrift, with strong subsequent representation from 19th century economic thinkers.

Personal investment combines saving with an earnings strategy, both of which require the postponement of consumption (Wärneryd, 1989). When someone invests, they forfeit current expenditure opportunities in exchange for delayed but higher rewards. For people earning typical wages, regular saving at levels recommended to ensure financial independence during retirement demands substantial sacrifice of immediate expenditure (Lavelle, 1999).

Self-control and Investment

The concept of self-control originates early in the Western philosophical tradition. Aristotle referred to akrasia as a disorder of will (Ainslie, 2001) that threatens self-control. Self-control is manifestly a psychological notion, introduced to economics in the 19th century and associated with the ability to defer consumption (Loewenstein, 1992). Frank (1992) interprets reluctance to save in terms of self-control and willpower.

O’Donoghue and Rabin (2000) argue that economists have paid insufficient attention to self-control issues associated with choice over time. Ainslie (1975) refers to self-control when he described behaviour as impulsive if a suboptimal reward is chosen because
“imminent consequences have a greater weight than remote ones” (p. 463). Impulsive behaviour occurs when someone chooses the lesser of two opportunities because the weaker prospect is available sooner than the better alternative.

Shefrin and Thaler (1988) describe the human being as a combination of farsighted planner and myopic doer. The farsighted planner prefers to save, whereas the myopic doer prefers to spend. Saving operates with a long term horizon that maximises benefit over the lifespan, with plans taking precedence over action, whereas spending involves a short term, action-oriented outlook that maximises immediate utility (Gärling, Karlsson, & Selart, 1999). The opposition of these two agencies within the same individual causes internal conflict. Laibson et al. (1998) argue that people’s attempts to limit their immediate expenditure demonstrate their awareness of the gap between their actions (as myopic doers) and their intentions (as farsighted planners).

Read, Loewenstein and Kalyanaraman (1999) distinguish between “vice” and “virtue,” where vice refers to preference for a smaller, immediate reward that carries a large delayed cost, and virtue refers to a preference for a small, immediate cost which eventually brings a large, delayed reward. The myopic doer is prone to vice, whereas the farsighted planner shows virtue.

The notion that human beings possess two, separate decision agencies operating via contrary short term and long term outlooks has been advanced by recent philosophers according to Ainslie (1992). Thaler and Shefrin (1981) argue that the concept of self-control is paradoxical without resorting to a “multiself model of man” (p. 404) who is subject to internal conflict between temporally sensitive motivational states, or as Herrnstein and Prelec (1992) claim, we “act as more than one person, pulling in different directions” (p. 354).
An individual’s degree of self-control has likely implications for their investment behaviour because investment rewards are delayed. Whittaker (1992) observes that compound interest, where capital grows exponentially, requires considerable delay before providing a substantial profit at conventional interest rates. Exponential growth from compound interest rewards the farsighted planner who invests for long terms. Unfortunately, in real life the farsighted planner can submit to the myopic doer who would rather spend than save. Maximising the rewards from investment requires self-control, via the ability to avoid the temptation of low-value, immediate gratification.

**Delay Discounting**

That people must strive to promote their virtuous, farsighted planner tendencies and suppress their myopic doer vices implies that preferences are biased towards immediate or temporally proximate rewards rather than postponed rewards, even though the delayed rewards could be larger. The subjective value of a delayed reward is diminished compared with the same amount available sooner or immediately. The subjective value of the delayed reward is said to be discounted. “Delay discounting” is the perceived reduction in value of a reward that occurs when the reward is postponed. Ainslie (1992) describes this tendency as innate. Raineri and Rachlin (1993) maintain that discounted [subjective] value decreases monotonically with increasing delay. Whether someone prefers a short term prospect to a long term prospect is determined by the rate at which the person delay discounts future rewards. Higher rates of discounting imply a stronger bias towards the short term, meaning greater impatience.

Because investments offer delayed rewards, it follows that delay discounting could affect investment decisions. The current thesis integrates delay discounting with compound
interest growth to make specific predictions about how investment returns will be appraised, and about preferences for investing rather than spending. Chapter 2 of this thesis derives the $k_i$ parameter from the combination of delay discounting at a hyperbolic rate (a widely accepted principle with a strong empirical basis) with exponential growth from compound interest. The $k_i$ parameter supports predictions about investment appraisals. Experiments in Chapter 3 and Chapter 4 test these predictions.

Some theorists associate delay discounting with the principle of diminishing marginal value, which is a foundation of modern economics (Rachlin, 1992) and was recognised by earlier authors such as Bernoulli (1738/1954). Diminishing marginal value holds that possessing larger amounts of a commodity reduces the perceived value of additional amounts of the commodity. Christensen (1989) explains diminishing marginal value in terms of the psychophysiological properties of money. The reduced sensitivity that occurs with sensory processes when amounts are added to ever larger quantities is said also to occur with money. An alternative explanation links delay discounting to diminishing marginal value via physical limitations on consumption rates (Rachlin, 1992). A satiated consumer who is offered yet more food must postpone consumption until appetite returns. The perceived value of the additional food reduces because its consumption is delayed.

Limited consumption rates have practical implications for investment. People may choose to invest a large amount of money because spending it could be inconvenient. Spending large amounts can require planning and careful evaluation of potential big-ticket items, whereas small sums are easy to spend.
Probability Discounting and Investment Risk

Personal investment often involves uncertainty as well as delay. Because returns from many types of investment vary with time, anticipated future rewards may not eventuate or could fall short of expectations. Losses may occur periodically over a long period, especially with investments such as shares.

Variations in investment returns are referred to as “volatility.” Increased volatility is associated with higher investment risk and the potential for a poorer outcome than otherwise would have occurred. A principle which has attained the status of lore in financial circles is that volatility and risk tend to increase when potential returns are higher (e.g., Ganzach, 2000). A trade-off occurs between risk and return, with investors seeking higher returns having to accept increased risk.

As well as preferring earlier rewards to equivalent but delayed rewards, people also prefer certain or highly probable rewards rather than uncertain or less probable rewards (Green, Myerson, & Ostaszewksi, 1999). Researchers refer to the subjective reduction in value with increased uncertainty as “probability discounting” (e.g., Rachlin, Raineri, & Cross, 1991; Rachlin, Brown, & Cross, 2000). Probability discounting leads to risk aversion. Higher rates of probability discounting diminish the perceived value of a probabilistic reward more than lower rates. Chapter 5 and Chapter 6 of the current thesis examine how probability discounting may affect investment decisions in association with delay discounting.

Reducing Risk Through Long Term Investing

If future returns are unpredictable, investing becomes nothing more than a lottery, because attempting to capitalise on random processes amounts to gambling. However, the value of
equities and other volatile investments, while not guaranteed to rise, does tend to increase over the long term, such as periods of more than five years, as shown in Figure 1.1 which graphs the cumulative value for various asset classes for a $10,000 investment in Australia commencing in 1982 and lasting until 1998. Taxation is ignored, but inflation is plotted. Despite short term volatility, over a long term period the value of every investment class increased. Asset classes showing the largest long term increases in value also show the highest short term volatility.

Figure 1.1 Accumulating value of investment for various asset classes

Stock market indicators such as the Dow Jones or All Ordinaries index correspond to Wilkinson and Balasanov’s (1994, p. 797) description of a time series as a combination of components. The first component refers to “location (level or mean).” For investments, the location component would refer to the set point or intrinsic level of an asset’s value. Another component refers to trend, reflecting the long term direction of the time series. Additional, seasonal components reflect cyclical variation, as may occur with resources
stocks (Drury, 1999). Finally, an unsystematic component, unique to each point in time, represents random perturbations.

The trend component and the random perturbations are especially relevant to the current discussion. Both are evident in Figure 1.1. The investment evaluation survey reported in Chapter 7 of this thesis examines how the trend and random components of an investment performance time series influence perceptions of risk and return, and expectations of future performance.

An investor who attempts to employ the random variation component of an investment performance time series to increase short term returns faces substantial risk. Investors should instead attempt to gain from the long term upward trend. This principle argues against attempting to accumulate wealth rapidly through short term, speculative investment in potentially high growth assets. By capitalising on the long term trend component of the time series, the investor avoids the risk associated with the random component.

Especially tempting is to invest in assets with a recent history of superior returns on the assumption that this superiority will be maintained. This post hoc approach to investment selection has the investor falling victim to what Keren and Lewis (1994) describe as a Type II gambler’s fallacy, in which a series of random events is mistakenly regarded as biased and indicative of future events. Sensible investment appraisal involves looking at long term past performance.

The guiding principle for sensible investment is to let time subdue volatility. This principle is illustrated in Figure 1.2 which is based on data used to draw Figure 1.1, and shows the risk of loss for anyone investing in Australian shares and redeeming that investment (i.e., converting it back to cash) after 3 months, 1 year, 2 years and so on until 5 years
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afterwards, for all quarterly intervals during 1982-1998. The obvious conclusion is that longer term investments were associated with greatly reduced risk of a negative return for the specified time period.

Figure 1.2 Risk of loss for 1982-1998 Australian shares per investment interval

Kahneman and Lovallo (1993) argue that excessively short term evaluation encourages maladaptive risk aversion. Figure 1.2 suggests how risk aversion could easily occur in response to short term evaluations of investment returns.

Baz et al. (1999) describe the concept of “time diversification” (p. 273) in relation to investment risk management. Just as financial advisers recommend that investors diversify across assets and funds in order to spread risk, Baz et al. consider long term investment as risk-reducing diversification across time. Long term investment exposes the investor to a large sample of time periods, including both the boom and the bust.
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We have now seen how an investor with a long term as opposed to a short term outlook is doubly rewarded, first by the considerable rewards provided by exponential growth from long term compound interest, and second by the reduction in risk that occurs with extended terms. Investors must be prepared to invest for long terms and even to lose money from time to time in order to make substantial gains. This advice features in popular guides such as Whittaker (1992). However, long term investment is unattractive to myopic doers. Sensible management of personal finance may require people to act in a manner contrary to their natural preference for hastened gratification.

Predicting Future Investment Performance

For investments that lack a fixed rate of return, prospectuses usually warn that past performance has no relationship to future performance. If future returns are predictable, the investment carries no risk from volatility because the value of the investment would be known for any future instance. Losses could always be avoided.

Fama (1965) examined the problem of predicting the future value of shares and found that “the series of price changes has no memory… [and] the past cannot predict the future in any meaningful way” (p. 34). Fama acknowledged that large variations in stock prices precede further large changes, either positive or negative, but this tendency provides no useful information. Overall, Fama concluded that investment profits cannot be increased by referring to historical series of prices. Roberts (1959), citing back to Kendall (1934), provides additional argument that short term movements in stock prices are unpredictable.

Yates, McDaniel, and Brown (1991) examined undergraduate and postgraduate students’ ability to predict movements in share prices. Probabilistic forecasts of price change and company earnings were generally inaccurate, and worse than a purely statistical forecasting
method. Earlier research cited in Yates et al. had found similarly, the conclusion being that equity values are difficult to forecast. Sundali and Atkins (1994) claim that genuine experts in forecasting can outperform overall market trends. Maybe so, but the typical personal investor can hardly be expected to match experts in the field.

Perhaps future performance could be predicted from nonhistorical data such as information about current economic circumstances, government policies, individual companies and their business plans, consumer sentiment surveys and other supposed indicators of future microeconomic or macroeconomic performance. Despite this possibility, it appears that no guaranteed method of predicting investment performance has ever been found. Such a method would have immense economic value in its own right, and would surely achieve instant fame.

Despite the availability of professional advice, investment decisions rest ultimately with the investor. Ironically – in view of above discussion about the unpredictability of investment performance – personal investors often have to rely on historical investment performance data appearing in newspaper business sections, prospectuses and investment performance bulletins. Performance bulletins show results as summarised time series tabulations, or graphical displays such as Figure 1.1. Concealed within the time series are the underlying location, trend, cyclical and random components. To make a worthwhile investment decision, the investor must distinguish the long term trend from the other components. The task of choosing an investment that will perform well in the future, based on historical information about the investment, could be regarded as a form of inductive reasoning according to definitions of induction in Cohen (1989). In the case of investment, a set of historical returns is examined and attempts made to extrapolate these returns to the future. Inductive reasoning is contentious in logic, as philosophers such as Hume
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(1739/1962) have argued, because the past does not necessarily predict the future. With volatile investments, the recent past in particular does not predict the future because random variation can conceal the long term trend.

The investment evaluation survey in Chapter 7 examines how past returns affect finance graduates’ inferences about an investment’s future performance. A pertinent question is whether and how well investors can distinguish long term trends from the random variation in the time series simply by inspecting historical returns.

Implications of the Above Discussion for Personal Investment Decisions

Thus far, discussion about personal investment has shown that it requires:

1. Control of immediate expenditure in the pursuit of future gains. Whether a person chooses to delay gratification could determine whether they invest at all, the amount they invest, and the duration of the investment. Higher rates of delay discounting imply a decreased likelihood of saving and investment.

2. The acceptance and management of risk. Higher rates of probability discounting imply greater risk aversion, and a retreat to low risk, low interest investments such as bank term deposits, with likely lower returns over the long term compared to investments such as shares, which carry higher short term risk.

3. Inferences about future investment performance based on historical returns that may conceal underlying rates of return within random variation, and predict future performance unreliably.

Although a technical literature exists on investment and savings behaviour, and related issues (e.g., Anderson & Settle, 1996; Dahlbäck, 1991; Kroll, Levy, & Rapoport, 1988;
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Lea, Tarpy, & Webley, 1987; Levin, 1998; Stevenson, 1986; Wärneryd, 1989 and studies cited herein from p. 14) surprisingly few authors address the influence of discounting on such behaviour. Delay discounting in itself can only discourage investment, never encourage it. To have preferential appeal over immediate expenditure, an investment’s value must grow at a faster rate than delay discounting reduces its subjective worth. The current thesis compares the growth function from compound interest with the function known to govern delay discounting. The aim is to identify circumstances for which compound interest returns offset delay discounting sufficiently for prospective returns to have preferential appeal over immediate access to the investment principal, so that people would rather invest their money than spend it.

Probability discounting would discourage investors from choosing investments with volatile returns. The conflict between discounting and investment is aggravated by investment risk decreasing with term (see Figure 1.2), although the behavioural economics literature argues for perceived risk increasing with delay (Rachlin et al., 1991). Chapter 5 discusses the relationship between perceived risk and delay in detail.

Central to the forthcoming investigations is the issue of whether the increase in value of a compound interest investment with time exceeds the reduction in the investment’s perceived value from delay discounting, and whether potential returns from compound interest investments at typical interest rates compensate for risk. These issues are virtually unexplored in existing literature. Current knowledge about delay and probability discounting provides a basis for exploring them.

The $k_i$ parameter, mentioned earlier, is derived from current knowledge about delay discounting. The parameter has the potential to predict the perceived worth of an investment according to the compound interest rate of the investment, its term, and the rate...
at which future rewards are discounted. As a result, the thesis shows how current
knowledge of delay discounting behaviour should enable predictions about the
acceptability of compound interest investment returns. A major prediction for the thesis,
based on delay discounting theory and $k_i$, is that long term compound returns at a fixed rate
of interest will compensate better for delay discounting than shorter term returns at the
same interest rate. It follows that long term compound interest returns will have greater
subjective appeal than shorter term returns at the same interest rate, despite delay
discounting. This prediction and others will be tested experimentally in Chapter 3 and
Chapter 4 using methodologies drawn from past discounting studies in order to establish
the likely relevance of discounting theory to investment behaviour. The probability
discounting experiments in Chapter 6 extend the delay discounting experiments to cover
investments with varying probabilities of return.

Discounting Research Methods and Concepts

Numerous scientific studies have examined discounting in humans and other animals,
although rarely in the context of investment. Discounting studies often borrow from
psychophysiological methodologies (Bickel & Marsch, 2001). One example is a titration
exercise in which a stimulus has its amount or intensity adjusted until it is perceived as
equivalent to a second stimulus in a manner resembling the method of limits used in
perception research (Schiffman, 1982).

Researchers who investigate discounting often want to establish the size of delayed or
probabilistic rewards which are equivalent in perceived value to immediate or certain
rewards. A titration exercise can achieve this by adjusting the value of an immediate or
certain reward until its perceived value matches that of a delayed or uncertain reward, so
that subjects register indifference between them. Points of indifference plotted across
delays or degrees of uncertainty give rise to “indifference curves” (Bickel & Marsch, 2001). Indifference curves describe the change in perceived value of a reward with varying delay or probability. These curves will be referred to subsequently as “discount curves.”

Present and Certain Values
Researchers into discounting often measure the value of an immediate or certain reward that is subjectively equivalent to a delayed or probabilistic reward. These values are known respectively as the “present value” or “certain value” of the delayed or probabilistic reward. If the perceived present or certain value of a delayed or probabilistic reward exceeds the perceived value of an alternative reward available now or with certainty, the delayed or uncertain reward is preferred to the immediate or certain reward. If the perceived present or certain values fall below the perceived value of immediate or definite alternatives, the immediate or certain reward is preferred to the postponed or probabilistic reward.

Stability of Preferences Over Time
Prominent in research about discounting is the issue of preference changes over time, or what Laibson (1997) refers to as dynamically inconsistent preferences. Ainslie and Haslam (1992) describe the prototypical experimental paradigm for researching the stability of preferences for long or short term rewards. Two rewards are made available. One is a larger reward available later than the alternative, smaller reward. In a titration exercise the delay to both rewards is then varied by the same, constant value. As the delay to receiving either reward diminishes, subjects tend to reverse their preference from the larger, later reward to the smaller, sooner reward, demonstrating that preferences can change with time. The reversal represents a point of indifference between the smaller, sooner reward and the larger, later reward. When the delay to the smaller, sooner reward equals zero (i.e., the
smaller reward is available immediately) the delay to the larger, later reward only is
titrated, in the manner of Raineri and Rachlin’s (1993) Experiment 1. The magnitude of the immediate reward when preferences reverse indicates the present value of the larger, later reward. The difference between the actual value of a delayed reward and its present value indicates how much the delayed reward has been discounted.

Rachlin et al. (1991) used an expanded version of the preference reversal titration exercise that has featured in many other studies (e.g., Kirby, Petry, & Bickel, 1999; Hesketh, 2000; Hesketh, Watson-Brown, & Whitely, 1998, to name a few). A fixed reward available after a series of varying delays is titrated against a varying reward available immediately, with the delay periods and reward amounts combined factorially. The difference between the values for the immediate reward and the delayed reward indicates the degree of discounting at various delays (Hesketh, 2000). Plotting the decay of a reward’s subjective value with increasing delay reveals the rate at which discounting occurs and the nature of the function governing the rate of decay. The current dissertation will modify the above titration exercises to investigate discounting and compound interest investment growth jointly.

**Existing Research Into Personal Investment Decision Making**

In view of copious research examining delay discounting, and risk and uncertainty in general decision making, including preferences for hypothetical monetary rewards, the literature dedicated to the psychology of personal investment is surprisingly sparse. What follows is a summary of published studies for which investment behaviour is either the primary goal of the research, or secondary to an investigation of broader aspects of economic behaviour.
Some studies of investor behaviour place little emphasis on the relationship between economic theory and behaviour. For example, Anand and Cowton (1993) investigate the influence on investment preferences of factors other than economic utility. East (1993) used Ajzen’s Theory of Planned Behaviour to explain investment decisions.

Other studies do examine investment decisions in relation to economic issues. Stevenson (1986) used hypothetical investment and credit plan scenarios to examine the relationship between preferences, and the delay and probability of a reward. Stevenson found that subjects discounted postponed gains in proportion to delays. Kroll et al. (1988) examined the quality of hypothetical investment portfolio decisions made by statistically aware students. The students selected investments from choices that varied in the mean and standard deviations of returns, along with other parameters. Despite the alleged simplicity of the experimental task, more than a quarter of the chosen portfolios were classified as inefficient. Subjects requested useless, though cost-free information. They demonstrated susceptibility to erroneous sequential dependencies in random data, and gamblers’ fallacies. Results did not auger well for investment decisions based on historical performance data, although Anderson and Settle (1996) criticise Kroll et al.’s studies, saying that tasks presented to subjects were too hard.

Shelley (1994) explored the effect of outcome probability, time and degree of loss and gain in scenarios that were described as lottery evaluation models but actually resembled investment decisions, with the study aiming to reveal individual differences in choices. Subjects were MBA students. Results showed that two thirds of subjects were more influenced by potential losses rather than gains. Only one third combined probabilities in a multiplicative fashion as posited by “conventional theory” (p. 208). Thaler, Tversky, Kahneman, and Schwartz (1997) found that the myopic evaluation horizons and the well-
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documented (e.g., Kahneman & Tversky, 1979, 1984) excessive aversion to losses in relation to gains have the potential to affect investment decisions deleteriously.

Harless and Peterson (1998) cite the persistence of poorly performing investments as threatening the economic efficiency of the market. They found that people evaluate investment funds a lot more critically before placing money in the fund compared with afterwards. Odean (1998), and Shefrin and Statman (1985) cite a common instance of counter-rational investor behaviour in the demonstrated reluctance of investors to sell at a loss, and their over-enthusiasm to sell at a modest profit.

Persistence with poorly performing investments occurred in Kogut and Phillips’ (1994) experiments. In hypothetical scenarios examining students’ willingness to continue investing when the marginal cost of the investment exceeded the expected return, Kogut and Phillips found that subjects attended to sunk costs in the form of money already invested. They continued investing in an attempt to extract a consolation return when they should have bailed out. Soman (2001) found, however, that sunk time was ignored, unlike sunk money costs, an effect that Soman attributed to people’s inability to account for time compared with their ability to account for money.

In one of the relatively few studies to examine genuine investment behaviour as opposed to simulations, Kelly (1995) found insufficient portfolio diversification among personal investors to be widespread. The often low levels of risk diversification ran contrary to predictions from economic theory.

Olsen (1997) refers to desirability bias, which is the tendency to exaggerate the likelihood of desirable outcomes and to underestimate the likelihood of undesirable outcomes.

Various research cited in Olsen (1997) attests to the pervasiveness of excessive optimism,
although some evidence suggests that experts are affected less than non-experts. Olsen found experienced, professional investment managers to exhibit optimism bias, although the degree of bias was not high. If expert investment managers are prone to optimism bias, there seems no reason for immunity among inexperienced investors.

Weinstein (1989) reports that excessive optimism occurs with risks for which the subject lacks personal experience, for hazards with low perceived probability and hazards that are perceived to be under personal control (see also Weinstein, 1980). Whether personal investment risks are perceived as low and under personal control is a matter for research. In this area, individual differences would surely emerge.

Ganzach (2000) examined the relationship between perceived risk and return while distinguishing between familiarity and unfamiliarity of the assets. Participants were MBA students majoring in finance. The task was to evaluate international stock markets. For unfamiliar assets, risk and return ratings correlated -.55, suggesting that perceived risk is associated with lower perceived returns, contrary to the actual relationship between investment risk and long term return. For familiar assets, risk and return correlated highly, at least .86, because subjects recognised the true relationships between these two characteristics of investments. Ganzach also found that correlations between perceived risk and perceived return with unfamiliar assets could be reversed experimentally by reversing whether risk or return judgements were made first or second.

Ganzach’s results attest to the importance of framing effects, which refer to different presentations of fundamentally the same information (Kahneman & Tversky, 1984; Tversky & Kahneman, 1981). Framing changes the reference point against which the prospect is evaluated (Loewenstein, 1988). A substantial literature documents framing effects on decisions (Jones, Frisch, Yurak, & Kim, 1998), although its effects vary (Fagley...
Ganzach’s research suggests that a simple reordering of information can be sufficient to induce a framing effect with investment decisions.

Moore, Kurtzberg, Fox, and Bazerman (1999) tested hypotheses about mutual fund investment decisions. Using simulated investment scenarios based on the performance of real mutual funds, and with a sample of postgraduate business students, Moore et al. found that subjects overestimated their past and future performance in portfolio selection. Subjects expected the market to maintain its current trend rather than regress towards the mean. They were more satisfied with their investment choices in booming rather than depressed markets, suggesting a bias towards evaluating nominal returns rather than returns relative to the market; and they tended excessively to switch between investments in response to poor performance, with a consequent negative effect on portfolio returns.

**Conclusions From Existing Research Into Investment Decision Making**

Much of the research described above reveals tendencies towards economically inefficient investment decisions, manifested as biases (e.g., optimism) and reliance on inappropriate information or irrelevancies, giving rise to framing effects. Investment decisions appear frequently to depart from economically rational ideals, suggesting that the human cognitive apparatus is ill-equipped for such decisions. In short, people perform relatively poorly at investment selection and evaluation.

Two important methodological issues arise from the above-cited research. These issues are the use of hypothetical investment scenarios, and the prevalence of experimentation using students as subjects. Both of these issues apply to the current thesis.
Methodological Considerations for the Current Research

External Validity of Data From Hypothetical Investment Scenarios

The above-cited studies often used hypothetical investment scenarios. Ganzach (2000) and Moore et al. (1999) used real investment performance data, but subjects’ evaluations carried no personal economic consequences. Soman (2001) commenced with hypothetical scenarios but confirmed his results using small rewards. None of the experimental studies involved the substantial amounts of money and extended terms that characterise real investment. Thaler et al. (1997) paid their subjects according to performance, but the amounts paid were insignificant ($5–$35) compared with real investment rewards and losses. Hershey, Walsh, Read, and Chulef’s (1990) subjects made financial recommendations directed towards hypothetical clients. Kelly’s (1995) analysis of large-scale survey data has obvious advantages for external validity, but the passive observational nature of the study precludes experimental control over independent variables, and provides limited scope for causal inferences.

Shelley’s 1994 task presented subjects with a range of investment scenarios. The actual stimulus material consisted of examples such as the following:

This investment option offers you a six in ten chance of gaining $500 and a four in ten chance of losing $900. Whether you win or lose, final payments will be made in one year. The cost of the investment is $100.

Cash flow: The $100 cost is paid immediately.

If the outcome is:

1. A gain – Your investment cost is returned and you receive an additional $500 in one year.
2. A loss – Your investment cost is not returned and you pay an additional $800 in one year.

Shelley (1994, p. 215)
Financial institutions would never present prospects to personal investors in this format. The Shelley (1994) scenarios apply to studies with a mainly theoretical orientation, where results are not intended to generalise to actual investment decisions.

The trade-off between the experimental control available in laboratory studies employing hypothetical scenarios and the potentially greater relevance of community studies relates to the current thesis, which uses scenarios with imaginary financial rewards, risks, sacrifices and investment terms. There is obvious advantage to using real rewards, risk, sacrifices and time commitments. People may not apply their own money to investments in the same way as they respond to hypothetical stimuli. Economists have argued that the weaker incentives that apply in laboratory demonstrations invalidate demonstrations of departures from rationality (Anderson & Settle, 1996), although these two authors cite research supporting the validity of laboratory demonstrations for economic research.

There are obstacles to gathering complete and accurate data about real investment choices from representative samples of volunteers. The data need to be complete, because partial information about investment behaviour ignores the potential influence of other, unrecorded decisions. Confidence in the accuracy of the data could only be achieved by independently auditing people’s financial affairs rather than relying on self-reports. Benzion, Rapoport, and Yagil (1989) argue, citing Loewenstein (1987), that discounting rates are difficult to determine from individual savings behaviour owing to the influence of extraneous variables such as estimated future income and future needs.

Kroll et al. (1998) point out problems with empirical studies that source their data in actual investment portfolios. The problems include the cross-sectional nature of the studies rather than the preferable examination of changes to an individual’s wealth over time, violation of
distributional assumptions with real data, and overemphasis on corporate decisions made by groups rather than individuals.

Kirby (1997) summarises evidence that real rewards may be discounted more severely than hypothetical rewards, possibly because people are less inclined to wait for a real reward than one that is imaginary. Bickel and Marsch (2001) address the question of hypothetical as opposed to real rewards in some detail. They note (from Kirby, 1997) that hypothetical rewards tend to employ larger values than real rewards, so discrepancies between findings from simulations and real-reward studies may be attributable to the different amounts involved. However, they also note that the same mathematical function describes indifference curves in discounting studies that use hypothetical and real rewards, suggesting a fundamental consistency in the results from the two different approaches. Rachlin (2000) agrees.

Methodologies using hypothetical scenarios designed by the researcher allow scope in the form and content of experimental stimuli. For investment decision research, experimental stimuli should present people with choices similar to what they would encounter when making real investment decisions. An advantage of hypothetical scenarios is their capacity to specify the long terms and large amounts of money that feature in personal investments such as superannuation in a way that laboratory studies using trivial quantities of real money invested for short terms, cannot. For examples of the sizeable values featuring in hypothetical scenarios in published research, consider that Rachlin et al. (1991) presented subjects with hypothetical delays of up to 100 years, Raineri and Rachlin (1993) used hypothetical rewards of up to $25 million and delays of 50 years. Green, Fristoe, and Myerson (1994) combined a small hypothetical reward of $20 with a delay of 20 years.
Hypothetical scenarios involving extreme values continue to appear in the discounting literature. Rachlin et al. (2000) studied discounting of hypothetical values ranging from $10 to $10 million, with delays from 1 day to 50 years and probabilities from 1/10 to 1/10,000,000. Greene and Baron (2001) had their sample of mostly students of median age 21 years rate the desirability of amounts up to $2 million. Upper limits for these scenarios are far higher than for any scenarios in the current thesis.

For experimental studies using real money rewards, the relevance of decisions about the investment of several dollars for periods of hours or days to decisions about investing thousands of dollars for many years is questionable. External validity gained by using real money is easily compromised by artificially small investment amounts and terms.

The above arguments collectively demonstrate how the problem of external validity is not readily solved by using either hypothetical rewards or small but real rewards in experiments. Nor does tracking of real investment decisions offer a fully viable alternative. The current thesis approaches the problem by using hypothetical scenarios, but with realistic scenarios, where the amounts of money, investment terms, rates of return and background information resemble genuine, long term investment prospects.

**Analysing Institutional Databases**

An alternative strategy might be to track genuine investment decisions accessible from client records held by financial institutions. However, as noted above, tracking real investments allows limited, if any, control over independent variables. Natural data impose restrictions on research designs. Furthermore, records of financial decisions will be incomplete, leaving no way to interpret a decision in context, unless individuals conduct all their investment transactions with the one institution. An investor could withdraw funds
from an investment because it was time to spend the money, or they may want to invest elsewhere. There is no way to distinguish between the two possibilities without following all of the individual’s subsequent transactions.

Using data from institutional sources raises ethical problems in relation to privacy. For the current thesis, a postal survey of clients from a major investment fund manager was planned and organised to the point of imminent dispatch. The fund manager had earlier agreed to subsidise and distribute the survey to a random sample of clients who would remain anonymous to the researcher. The survey would have included replications of several of the delay discounting investment experiments conducted with undergraduate students and reported below. Scenarios would have been hypothetical, but the sample would most likely have included a wide range of age groups, with all subjects having invested in a managed (i.e., mutual) fund.

The fund manager suddenly withdrew support for the postal survey because of recently strengthened privacy provisions in Australian legislation. Specifically, the Office of the Federal Privacy Commissioner (2001, and embedded links) has enunciated a set of National Privacy Principles (NPPs) for the collection and use of personal information. These provisions cast doubt on the legality of the survey. They limit organisations’ right to collect and utilise personal information. The provision NPP 1.1 requires that organisations only collect personal information necessary for their functions and activities (the “primary purpose”). This provision stops a financial institution from seeking additional information from its clients solely to assist a researcher.
Chapter 1 – Introduction and overview

Use of Student Samples

Many of the above-cited studies use student samples. Sometimes these subjects were undertaking postgraduate degrees in business or finance, which would presumably increase their expertise or least familiarity with financial decision making, and a fair level of numeracy might be assumed. The current dissertation utilised undergraduate psychology students for the discounting experiments. Postgraduate business and finance students were used for the investment evaluation survey.

Whether results from student samples generalise to “real world” investment decisions could depend on the type of scenario presented. Obviously, young undergraduates could not respond meaningfully to investment scenarios targeting people about to retire. For the current thesis, all investment scenarios presented to undergraduates included background information designed for people no older than their 20s. In this way, the scenarios addressed the likely concerns of a young adult investor. Scenarios often examined investment decisions in response to hypothetical windfalls, eliminating any expectation that respondents had saved large amounts from their wages.

It cannot be assumed that undergraduate students have little or no investment experience or expertise, or that they do not save. Wade (2002) cites a market research report suggesting a surprising level of financial literacy among young people. Of those sampled, one in five who were aged from 14 to 21 years reportedly owned shares or had credit cards, superannuation or insurance, and a similar proportion had reportedly saved at least $1,000 over the previous year. A majority of respondents reported an intention to learn more about personal financial management. These findings suggest that investment issues have personal relevance for many young people.
Introduction and overview

The current dissertation seeks to discover whether known principles about discounting generalise to investment decisions. In similar fashion, Hesketh (2000) employs delay discounting principles to interpret career decisions. For investment decision research, controversy over the use of student samples refers to whether undergraduates’ hypothetical investment appraisals generalise to real investments.

What has been found is that delay discounting principles generalise widely. Mathematical functions that approximate delay discounting rates are discussed in detail in Chapter 2. At this stage of the argument, it is important to emphasise that delay discounting functions appear robust across a variety of experimental contexts, including experiments with pigeons (Mazur, 1987), younger and older humans (Green, Fry, & Myerson, 1994), genuine as opposed to hypothetical rewards (Hyten, Madden, & Field, 1994), scenario presentation formats (Rachlin et al., 2000), and nonfinancial scenarios such as vocational choice (Hesketh et al., 1998). Allison and Wood (1991) modelled self-control using simulated investment experiments conducted with rats. If fundamental consistencies are apparent in delay discounting responses across a range of behaviours for humans and other species, we could reasonably expect principles of delay discounting to influence investment decisions, and we could expect undergraduates’ responses to generalise to other adults.

Raineri and Rachlin (1993) defend their use of undergraduates on the basis that the primary interest of the research is the function which best describes behaviour, and that their studies may be judged on the consistency of their results with those of other studies. The current thesis examines whether or not the same principles of discounting behaviour identified in general decision making studies predict investment decisions. To quote from Rachlin and Raineri (1993, p. 93), “…the subjects of these experiments may be conceived
as choosing within the imposed constraints so as to maximise utility. It is a fundamental assumption of behavioural research that an animal cannot but choose what it values most at the time of choice.” Limitations of the methodology for the current dissertation must be acknowledged, along with the robustness of the phenomena under investigation across a wide range of methodologies, scenarios and samples.

Existing research into investment decisions cited above takes little account of discounting principles, and the general discounting literature cited in the next chapter pays little attention to investment. There is a need to integrate the two topics, which the current dissertation achieves. The remainder of the thesis is organised as follows:

Chapter 2 provides a deeper treatment of delay discounting, its associated literature and research, and implications for personal investment decisions. Delay discounting principles provide the theoretical and mathematical basis for deriving the $k_i$ parameter in this chapter, which inspires the first set of investment simulation experiments in Chapter 3. These experiments examine the effect of investment term on the appraisal of compound interest returns, via the $k_i$ parameter. The prediction for these experiments, based on $k_i$ and other demonstrations, is that longer term compound interest returns will have preferential appeal over shorter term returns from a constant rate of interest.

A fundamental hypothesis for the delay discounting component of the thesis is that $k_i$ enables superior prediction of compound interest investment appraisals compared to an alternative and historically dominant model from classical economics. Chapter 4 reports another three investment simulation experiments testing $k_i$ as a generalised predictor of appraisals of compound interest returns. This hypothesis is tested against the traditional, classical economic model which would claim the interest rate as the major predictor of investment appeal.
Chapter 5 provides theoretical background for Chapter 6 experiments which examine the joint effects of delayed and probabilistic compound interest returns on investment appraisals. Existing literature on the subjective value of probabilistic rewards, especially when combined with delay, enables predictions which are tested for the first time using investment scenarios. The experiments evaluate how the amount invested and the investment term influence responses to investment risk.

Chapter 7 considers the practical difficulty of personal investors having to choose investments on the basis of historical returns which report the past performance of an investment as a time series. A survey is reported in which respondents appraise sets of investment returns with historically different interest rates and volatility, infer their underlying properties based on past performance, and rate their worth as future short and long term investment prospects.

Chapter 8 is the general discussion chapter, reviewing evidence presented in the thesis for the primacy of $k_i$ as a predictor of appraisals of compound interest returns, the general relevance of delay and probability discounting principles to investment decisions, and subjects’ ability to appraise investment past performance adaptively. The discussion concludes with generalisations of the $k_i$ rationale beyond investment, for example, to credit and borrowing, and showing how parameters analogous to $k_i$ could be applied to other economic behaviour in which present and future prospects must be compared, such as consumer purchase decisions.
Chapter 2 – Delay Discounting and Investment Decisions

The preference for immediate gratification or reward compared with delayed reward is well established, revealed by numerous laboratory studies and apparent in everyday life. Ainslie and Haslam (1992) describe the devaluation of the future as “pervasive” (p. 59). Kirby (1997) summarises the principle as “the sooner the better” (p. 54). Benzion et al. (1989) offer the economist’s definition of delay discounting as “the ratio of the marginal utility of one unit of consumption in the future to that in the present” (p. 271). The higher the rate of delay discounting, the greater the perceived reduction in the future value of a reward compared with its current value, and the more the future reward must be worth to have preferential appeal over immediate or sooner alternatives.

The concept of delay discounting has been around for some time. Loewenstein (1992) traces its origins to early 19th century economic thought. Psychological concepts were originally invoked to explain the reduction in perceived value of delayed rewards. These concepts gave way to a purely economic approach, only to be revived when economic explanations such as discounted utility were found to predict behaviour inadequately.

Casual observation shows that people sometimes do postpone immediate gratification for expected long term benefit. That people invest at all is proof. The question is not whether people prefer short term reward for higher, long term rewards – people save and they spend – but instead what prompts them to sacrifice immediate for delayed reward. When people consider whether to sacrifice immediate for delayed rewards, they have to compare the immediate or proximate reward with the anticipated delayed reward, while accounting for the delay. Preference for either the expedited or the postponed reward indicates which has the higher perceived value. This chapter and the next two chapters of the thesis examine
how the properties of an investment interact with delay discounting to render delayed investment returns subjectively worthwhile, or not worthwhile.

**Rational Choice and Delay Discounting**

Rational choice entails consistency, ruling out capricious, arbitrary decisions that are interpretable only through ad hoc explanations. Transitivity (i.e., consistent preferences across a range of choices) is a condition for rationality (Edwards, 1954; Lea et al., 1987). If Investment A is preferred to Investment B, and B is preferred to Investment C, transitivity requires a preference for A over C. Delay discounting in itself need not entail inconsistent preferences. Discounting future rewards is sensible because simply delaying a reward rarely, if ever, confers an advantage.

A wider argument could implicate delay discounting with irrationality, even with consistent preferences. Someone who rapidly squanders a large inheritance and then has to live in penury could be described as irrational. However, if big spenders are content with the consequences of their profligacy when the day of reckoning arrives, and in hindsight they accept rather than regret their earlier consumption, and vow that they would do the same again if they had their time over, then no preference reversal has occurred even though the individual has finished in a worse situation than they might otherwise have done. On this basis, spendthrifts are rational so long as their preferences are consistent over time.

The preceding paragraph leads to an important principle for the current research, namely, that no delay discounting theory can prescribe whether or not someone should spend or invest their money, how much or what proportion of their money they should spend or invest, or for how long they should invest. No particular rate of delay discounting can be
objectively described as rational or irrational. The larger and later of two rewards need not always be the sensible choice. One cannot live entirely for tomorrow.

A reasonable expectation of the rational decision maker is consistency in the rate of delay discounting within a given discounting function, so that ever larger rewards would be required to compensate for increasing delay. This principle requires the discounting function to have the property of monotonicity specified by Raineri and Rachlin (1993). If individuals are dissatisfied with the prospect of receiving $100 in a year’s time, they should also be dissatisfied (and even more dissatisfied) with the prospect of receiving $99 in a year, $99 in two years, or $100 in two years.

More obviously, if two different sums of money are offered at the same point in the future, the larger amount should always be preferred because we are never disadvantaged by additional money. Unwanted money is readily discarded. Consequently, when choosing between investments, a higher rate of interest should always be preferred for identical terms, amounts invested and degree of risk. Finally, the economically rational decision maker should exhibit consistency of preferences at any point in time for directly comparable rewards.

Preference Reversals With Time

Delay discounting preference reversals were first mentioned above on p. 15. Allusions to temporary preferences and ambivalent behaviour extend back to classical mythology (Ainslie, 1992; Ainslie & Haslam, 1992). Preference reversals exemplify inconsistency. Rachlin and Raineri (1992) define preference reversals as “discount reversal effects” (p. 93). Anyone whose actions have belied their intentions has demonstrated a discount
Delay discounting preference reversals involve a switch from a previously held, farsighted, long term, “virtuous” position to a myopic, short term priority. A commonly cited example is the change in preference from a larger, later reward to a smaller, sooner reward when the delay to both is reduced, indicating impulsiveness (Ainslie, 1975; Kirby & Herrnstein, 1995; Rachlin & Raineri, 1992). The opposite reversal may occur when subjects initially favour a smaller, sooner reward to a larger, later reward, and then change preference to the larger, later reward when an equal, additional delay is added to both options (Myerson & Green, 1995).

Thaler and Shefrin (1981) interpret preference reversals as a self-control problem (see also Ainslie, 2001 and Rachlin, 2000). Discarding long term prudence for immediate or imminent gratification is historically associated with moral turpitude, because such preference changes find expression in visceral, appetitive, reckless, criminal or opportunistic behaviours. However, myopic self-indulgence need not always win, as in the case of misers who repeatedly postpone immediate gratification (Elster & Loewenstein, 1992) and, with special relevance to the current discussion, long term investors.

The concept of discount preference reversals has not always sat comfortably with economic theory (Ainslie, 1992). The so-called discounted utility model in normative economic theory specifies that delay discounting occurs at a constant, exponential rate (Loewenstein and Elster, 1992a; Wärneryd, 1989). Under this model, discounting occurs at the same rate regardless of delay, that is, a constant fraction is depreciated within equal time intervals (Kirby & Herrnstein, 1995). As Rachlin et al. (1991) have noted, the same function that governs exponential delay discounting also governs compound interest.
investment growth. This principle has more than incidental significance for the current thesis.

Exponential delay discounting ensures that preferences for future outcomes remain consistent across time. Consistent preferences are desirable from a theoretical economic perspective (Loewenstein & Elster, 1992a), and for individuals who plan rationally for their future (Kirby & Herrnstein, 1995). Rachlin and Siegel (1994) note that the normative exponential model for delay discounting is considered rational because it avoids preference reversals with time.

Nevertheless, evidence from personal experience, social history, and a considerable technical literature (such as Ainslie, 1975, through to Loewenstein & Elster, 1992b, Kirby & Herrnstein, 1995, Rachlin, 2000, and Ainslie, 2001) attests to the ubiquity of preference reversals with time. Normative, economic theory’s exclusion of preference changes with time leads Ainslie (1992, p. 14) to claim that “utility theory fails to account for ambivalence.” Preference reversals can occur with exponential discounting, but only if the discount rates differ between reward options (Green & Myerson, 1996).

**Hyperbolic Delay Discounting**

Ainslie (1992) claims that curves describing the reduction in perceived value with increasing delay must intersect for ambivalent behaviour to occur. Because exponential curves with the same discounting rate never cross, discount reversal effects preclude a constant rate of exponential discounting, or perhaps exponential discounting altogether.

Nonexponential discounting was first noted empirically with animals in 1964 and humans in 1981 (Loewenstein & Elster, 1992a). It is consistent with varying rates of delay discounting with time. Ainslie and Haslam (1992, p. 65) account for delay discounting
Delay discounting

preference reversals via Herrnstein’s Matching Law which describes preference as
“proportional to reward rate and amount, and inversely proportional to delay.” By way of
contrast, and according to Kirby (1997, p 54), “normative economic models assume that
delay-discounting rates for future rewards are independent of the amount of, and delay to, a
reward.”

Ainslie and Haslam (1992) explain that Herrnstein’s Matching Law involves an increase in
the rate of discounting with reduced delay. Increased discounting with reduced delay is
consistent with delay discounting functions being hyperbolic rather than exponential.

Ainslie (1992, p. 93) states that “the short-range interest is powerfully motivated by the
proximity of the reward and can be expected to prevail if has not been forestalled” [by an
earlier, binding commitment]. As Laibson (1997, p. 445) observes, “hyperbolic discount
functions are characterized by a relatively high discount rate over short horizons and a
relatively low discount rate over long horizons.” Compared with exponential delay
discounting, hyperbolic delay discounting involves a rate of delay discounting that
diminishes with time (Laibson, 1998).

Ainslie and Haslem (1992) also claim that hyperbolic delay discount functions permit the
intersections with time that are required for preference reversals (see Figure 2.1 below).
These preference reversals cannot occur with exponential functions that characterise
conventional economic models of growth, decay and discounting. A constant rate of
hyperbolic delay discounting allows preference reversals with time because the hyperbolic
discounting function incorporates the changing discount rate with time that is seen relative
to exponential discounting.

Abundant evidence supports the empirical veracity of hyperbolic delay discounting over
the normative exponential model (e.g., Rachlin et al., 1991; Kirby, 1997; Kirby &
Maraković, 1995). Rachlin et al. (2000) claim to know of no empirical delay discounting study involving human or other subjects which favours exponential discounting over hyperbolic. Instead of exponential discounting, the following hyperbolic relationship from Mazur (1987) appears better to describe delay discounting judgments:

Equation 1  Delay discounting hyperbolic function

\[ v_d = \frac{V}{1 + kD} \]  

(1)

where \( V \) is the value of the nondiscounted reward, \( v_d \) is the subjectively diminished value of the postponed reward, \( D \) refers to the delay and \( k \) is a parameter that represents the rate of discounting. Kirby (1997) refers to \( k \) as a “discount rate parameter” (p. 55) to avoid confusion with a simple percentage discount rate. Rachlin and Siegel (1994) describe \( k \) as a constant, no doubt because of its role as a fixed value in the equation, but without the implication that all individuals apply the same value. Individuals who delay discount strongly would apply a higher value of \( k \) to the future reward than individuals who discount less. The discount rate parameter \( k \) provides the foundation for predictions about investment decisions via the derivative \( k_i \) parameter which is hitherto exclusive to this thesis, and features prominently in experiments reported in the next two chapters.

Equation 1 supplies the basis for the canonical illustration of delay discounting preference reversal appearing in Figure 2.1a, which tracks the perceived value (vertical axis) of two hyperbolically discounted rewards, one larger and worth 100 units, the other smaller and worth 75 units, with diminishing delay to their receipt. Perceived value is calculated according to Equation 1, with a value for the discount rate parameter \( k \) of 0.1, and the smaller, sooner reward having a delay of 5 time units less than the delay for the larger,
later reward. A decision maker is expected to choose the reward with the higher perceived value. With diminishing delay, the perceived value of the smaller, sooner reward eventually exceeds the formerly higher perceived value of the larger, later reward, bringing a preference change (in this example, at precisely 10 on the delay scale). The preference reversal represents a comparative over-valuation of the imminent reward.

Hyperbolic delay discounting need not always lead to preference reversals. That is, hyperbolic delay discounting is not sufficient for preference reversals. Whether a preference reversal occurs depends on the values applied to Equation 1. In Figure 2.1a, if $k$ is set to 0.05 or less and all other values remain unchanged, no preference reversal occurs. Similarly, if the value of smaller reward is changed to 50 or less, or the value of the larger

Figure 2.1 Preferences across delay for two rewards of different delay and value, showing difference between hyperbolic and exponential discounting curves
reward is set to 150 or more (i.e., the larger reward is worth at least double the value of the smaller reward) and no other values are changed, the larger reward will be preferred for all values of delay. Finally, if the difference in delay between the two rewards is set to 2.5 or less and nothing else is changed, the larger reward is always preferred. Hyperbolic delay discounting leads to preference reversals for some but not all combinations of reward size, delay and discount rate parameter $k$, just as people’s choices are not always inconsistent. In other words, boundary conditions limit the incidence of preference reversals within the hyperbolic model.

However, with the inset diagram, Figure 2.1b, which incorporates the same parameter values as for Figure 2.1a into the exponential delay discounting formula from Rachlin et al. (1991), no preference reversal occurs regardless of other values applied to the equation. The most that can be achieved is equal perceived value of the two rewards across values of delay.

**Why Hyperbolic Delay Discounting**

The biological adaptiveness of delay discounting is readily explained: Today’s meal provides the energy to obtain tomorrow’s meal. Without today’s meal there may be no meal tomorrow, so today’s meal should be valued at least as highly as tomorrow’s. However, there is no definitive explanation for the prevalence of hyperbolic delay discounting over exponential discounting (Keren & Roelofsma, 1995). Hyperbolic functions are justified from experimental evidence rather than a priori argument, the latter having favoured exponential discounting. The hyperbolic function fits the data better than exponential functions (Green & Myerson, 1996), with the function describing rather than explaining preference reversals. The pertinent question is not so much, “Why hyperbolic delay discounting?” but instead, “Why preference reversals?” To explain preference
reversals we must consider the external contingencies that render them biologically adaptive, for they are not a mathematical necessity, and have no place in the a priori scheme of classical economics.

Preference reversals have been described as ubiquitous in natural settings. Rachlin and Siegel (1994) offer an ecological explanation for hyperbolic discounting: the observation that sharing a commodity with an increasing number of others decreases the value of that commodity hyperbolically. Delaying a reward could be regarded as sharing over time, almost as sharing with oneself, and the associated discounting function could resemble what is applicable to immediate sharing in a social context.

Azfar (1999) proposes a rational model for hyperbolic discounting based on the possibility of misadventure preventing payment of the reward, and uncertainty about the value of future consumption. Rachlin and Raineri (1992) compare hyperbolic discounting models to demonstrations of reversals in perceptual strength in response to physical stimuli, and values of depreciating assets.

Green and Myerson (1996), and Rachlin (2000) attempt to link hyperbolic discounting to rational models of behaviour based on biological imperatives. Cosmides (1989) argues that “the human mind is… a biological system ‘designed’ by the organizing forces of evolution” (p. 188) and goes on to say that the mind is designed for tasks that meet specific challenges from the physical and social environment in which our ancestors lived. The challenges from the physical and social world that reward inconsistent preferences have yet to be specified, although Rachlin and Seigel’s (1994) discussion about the economics of sharing may point in the right direction.
Factors Affecting Delay Discount Rates

Chesson and Vicusi (2000), Loewenstein and Prelec (1992), and Roelofsma and Read (2000) summarise factors known to affect the rate at which delayed rewards are discounted. These factors are additional to the changes in discount rates occurring with time that characterise hyperbolic delay discount functions.

Age affects discounting rates. Green, Fry, et al. (1994) found higher rates of delay discounting for younger compared with older subjects (see also Kirby, 1997). Green, Myerson, Lichtman, Rosen, and Fry (1996) found that people of similar age but different income discounted at varying rates, so that older, low income adults delay discounted at a higher rate than upper income adults.

Researchers have identified gain-loss asymmetry, whereby gains are discounted more than losses (Loewenstein & Prelec, 1992; Prelec & Loewenstein, 1991; Roelofsma & Read, 2000; Thaler, 1981). Shelley (1994) finds to the contrary, that losses are discounted more heavily than gains. Nevertheless, the bulk of opinion seems to favour greater discounting of gains than for losses.

Size of the reward affects delay discount rates. Several studies have found lower rates of delay discounting for larger rewards compared with smaller rewards (e.g., Benzion et al., 1989; Green, Fristoe et al., 1994; Kirby, 1997; Kirby & Maraković, 1995; Kirby et al., 1999; Raineri & Rachlin, 1993). This finding implies that larger investments will be preferred to smaller investments with equivalent terms and percentage returns because the final value of the investment will be discounted less. Returns from larger investments will be worth subjectively more in relation to the initial outlay, and will better compensate for the delay than returns from smaller investments.
Delay discounting

With respect to other factors influencing discounting rates, Roelofsma and Read (2000) report that rewards such as food, which satisfy basic, biological appetites, are discounted more than other, less fundamental rewards. Hesketh et al. (1998) showed that delay discounting rates were less with filled intervals, perhaps because such intervals were perceived to be shorter. Other research has found that various community groups demonstrate different rates of discounting. Kirby et al. (1999) found that heroin addicts discount future rewards more severely than controls. Petry (2001) found that pathological gamblers discounted a hypothetical reward at higher rates than controls, the more so when the pathological gamblers also had a substance abuse disorder. None of the factors described in this paragraph are likely to affect the current research identifiably because the tasks, rewards and participant samples are similar within each experiment.

Delay Preferences for Sequenced Rewards

Loewenstein and Prelec’s (1993) study into preferences for sequential outcomes provides a notable exception to the usual delay discounting “sooner the better” principle. Given the choice between the timing of favourable and unfavourable events, subjects preferred to save the better event until later. Improving situations are preferred to deteriorating situations. Other studies have shown similarly (Chapman, 2000).

Chapman interprets the negative time preference for sequenced rewards (i.e., preference for a postponed higher reward) as a framing effect. Loewenstein and Sicherman (1991) argue that improving rewards are interpreted as gains, and deteriorating rewards as losses. The rewards are aggregated and the sequence treated as a whole. Chapman’s research into preferred sequences of health outcomes found that preferences matched subjects’ expectations about how circumstances would change naturally with time.
Differential appraisal of improving or deteriorating sequences, including negative time preference for sequenced rewards, could affect results for the current series of experiments, with either improving or deteriorating outcomes presented sequentially. Loewenstein’s research cited above enables a specific prediction: Sequences of improving rewards should receive more favourable appraisal than sequences of diminishing rewards. The most obvious form of improvement would be increasing dollar returns, rates of interest and diminishing risk.

**Implications of Delay Discounting for Compound Interest Investments**

Relatively few researchers have considered the effects of hyperbolic delay discounting on investment behaviour. Laibson (1998) shows that hyperbolic discounting describes a wide range of anomalous investment behaviours, including insufficient saving and diminishing savings rates (see also Laibson, 1997). However, Laibson (1997, 1998) explores investment behaviour at a macro level, analysing aggregated, community-wide data. The following theoretical treatment and all subsequent experiments in this thesis examine individuals’ responses to investment propositions.

A basic question is whether people consider investment returns as worth the delay. The interest rate and term should affect the acceptability of returns because these two factors determine the final value of the investment. The discount rate that the investor implicitly applies to the prospective investment should also affect acceptability, because it determines the subjective depreciation of the future reward. This chapter of the thesis will now examine how, in theory, hyperbolic delay discounting could affect people’s appraisals of investment returns. Predictions based on this examination will be tested experimentally in subsequent chapters.
The major incentive for investment must surely be the additional, albeit delayed, expenditure opportunities over and above the immediate value of the principal. However, even though investment returns from a risk-free investment will always be higher than the initial value of the principal, the returns are subject to delay discounting. If an investment increases in objective value at a greater rate than time erodes perceived future value, the discounted value of the investment returns will exceed the immediate value of the principal. Therefore, the investment will have appreciated in value subjectively as well as objectively in relation to the original principal. A decision maker should consider such an investment as acceptable because the higher of two subjective values is always preferable. Conversely, if the discounted value of the future investment returns is less than the value of the initial principal, the investment offers insufficient return to justify the delay. The returns will be rated as unacceptable, that is, not worth the wait.

Exponential delay discounting would subjectively depreciate the future value of the investment according to the same type of function that governs compound interest returns on investments, but not necessarily at the same rate. If the compound interest rate exceeded the exponential delay discounting rate, the subjectively discounted value of the investment would increase with time. The returns would seem worthwhile for any investment term. Conversely, when exponential discounting exceeds investment growth, prospective investment returns will seem inferior to the immediate value of the principal regardless of the term. This would happen when the exponential discount rate exceeds the compound interest rate, in which case a potential investor presumably would rather spend the money immediately or seek a higher return elsewhere.

We shall now consider the situation for hyperbolic delay discounting of compound interest returns, for which predictions based on exponential discounting may not apply. Thus far,
discounting researchers appear to have overlooked this issue. The following theoretical
analysis is unprecedented to the best of the author’s knowledge. The analysis examines
implications of hyperbolic delay discounting applied to prospective compound interest
investments with interest fixed throughout the term. It provides background for the ensuing
series of delay discounting experiments which comprise a major part of this thesis. These
experiments seek empirical support for predictions based on the combination of hyperbolic
delay discounting and exponential growth. The predictions are introduced below.

Figure 2.2 shows hyperbolic depreciation of perceived value at specified rates of the
discount rate parameter \( k \). The downward sloping lines from left to right plot the subjective
depreciation of a reward with initial value 1.0 as it recedes in time. Depreciation of
perceived future value is steepest when delay is short, and decreases with increased delay,
towards the right of the graph. Although discounted values always decline with increased
delay, their \textit{rate} of decline increases as the prospective delay decreases, that is, as the
reward draws imminent. This trend occurs for every value of the discount rate parameter \( k \)
but is more apparent visually with higher values of \( k \).
Hyperbolic delay discounting is at its steepest for short prospective delays, when at the same time compound interest growth in the objective value of the investment is relatively slow. Long terms combine relatively strong investment growth with reduced discounting, whereas short terms combine lower investment growth with relatively steep discounting. As a result, investment earnings would be more likely to overcome the subjective depreciation from delay discounting later during the term compared with earlier. Possible failure of low growth from typical interest rates to over-ride hyperbolic delay discounting early during an investment could render short term investments unattractive compared with longer term investments earning the same rate of interest.

Figure 2.3 examines this situation further. The solid, slightly curved line represents the increase in actual value of an investment earning compound interest at 10% per annum (p.a.) paid yearly. The two broken lines represent the minimum value of the investment that is sufficient to compensate for hyperbolic delay discounting across terms, shown for
two levels of \( k \). These earnings are the amount required to generate decision maker indifference between the immediately available investment principal and higher amounts available after a delay. They are calculated as the reciprocal of the relevant hyperbolic depreciation functions shown in Figure 2.2. It happens that these values increase linearly with time. Although compound interest investment values grow exponentially, the growth required to compensate for delay discounting occurs at a linear rate.

\[
\text{Required earnings} \quad \text{more than} \quad \text{actual earnings}. \quad \text{Short term investment not worthwhile.}
\]

\[
\text{Required earnings} \quad \text{less than} \quad \text{actual earnings}. \quad \text{Returns worthwhile after 1 year.}
\]

\[
\text{Preference reversal}
\]

Figure 2.3  Perceived utility of investment returns for specified levels of return and \( k \) discount rate parameter

In Figure 2.3 the linear functions can intersect the exponential function once, if at all. The implications are as follows: If the value of the discount rate parameter \( k \) equals the compound interest rate (shown above for \( k = 0.10 \)) exponential growth will exceed earnings required to compensate for delay discounting after 1 year. The difference between required and actual earnings will increase for terms longer than 1 year. For someone who
delay discounts hyperbolically at a rate of \( k = 0.10 \), compound interest returns at a rate of 10% p.a. paid yearly would seem subjectively higher than the initial value of the principal for any investment term longer than 1 year. The perceived advantage of the actual returns compared with the initial value of the principal or, equivalently, the returns required to compensate for hyperbolic delay discounting at the rate \( k = 0.10 \), increase with term.

In general, given a choice between the prospective future value of the investment and the immediate value of the principal, people who discount at a \( k \) parameter rate equal to the interest rate would be expected to favour the investment returns over whatever utility the principal offers for an investment term exceeding one unit of time (with \( k \) scaled according to time units for terms and interest rate schedules, and returns paid at the end of each time unit). The attractiveness of the prospective investment returns compared with the initial principal increases with time. Higher interest relative to the \( k \) parameter would further increase the attractiveness of the investment.

The situation differs when the \( k \) parameter applied to the future value of the investment exceeds the compound interest rate. As Figure 2.3 shows, when \( k = 0.15 \) and interest is only 10% p.a. earnings required to compensate for delay are initially greater than the investment return and remain so after 1 year. The gap closes with additional time. When the value for term reaches approximately 8.9 years the linear and exponential growth functions intersect, after which the returns exceed what is needed to offset discounting. Translated into preferences, this arrangement would have potential investors who discount at \( k = 0.15 \) appraising compound interest returns from 10% p.a. paid yearly as insufficient for terms up to 8.9 years. For a term of 8.9 years, indifference would occur between the perceived future value of the investment and the immediate value of the principal. For terms longer than 8.9 years, the actual and the perceived value the investment would more
than compensate for the delay. Given the choice between the immediate value of the principal and the future value of the investment, investors who delay discount hyperbolically would refuse the investment proposition for all terms up to 8.9 years. These investors would prefer immediate expenditure or access to the money, or would seek a higher return. For prospective terms longer than 8.9 years, the investment would be chosen over the immediate value of the principal. Terms longer than 8.9 years would be increasingly attractive compared with the immediate value of the principal, as the gap widens between returns and the amount required to compensate for the delay. The intersection of the exponential growth and hyperbolic discounting functions represents the prospective term at which a preference reversal should occur, from rejection of shorter term investments to acceptance of the investment for longer terms.

It is important to emphasise that the investment preference reversal proposed above represents quite a different situation from the hyperbolic delay discounting preference reversal that is the subject of existing theory and research. Unlike the type of preference reversal discussed in the literature and exemplified in Figure 2.1a, which involves only hyperbolic discount functions, the proposed new variety of preference reversal occurs when exponential growth from compound interest combines with a hyperbolic rate of decay. Preference reversals examined in much of this thesis refer to this second type of scenario, which is hitherto unexplored in the literature. The $k_i$ parameter, soon to be developed in this thesis, contributes to predictions about preference reversals that may occur when compound interest returns are delay discounted hyperbolically.

Figure 2.4 generalises Figure 2.3 to a wider and continuous range of $k$ values while retaining the 10% compound interest rate, although now interest is paid continuously. The height of the plotted surface shows the difference between returns from exponential growth
and the linear increase in value needed to compensate for hyperbolic delay discounting at various rates. Light shading towards the upper left indicates returns more than sufficient to compensate for hyperbolic delay discounting. Dark shading at the lower right indicates returns less than sufficient to offset discounting. The curved boundary between the white and dark grey shading represents the point of indifference between the value of the immediately available principal and the perceived value of prospective returns.

\[
\text{Function} = \text{Euler}^{0.1\times\text{delay}}-(1+k\times\text{delay})
\]

Figure 2.4 Generalised perceived utility of investment returns for values of \(k\) hyperbolic discount rate parameter and delay

Returns are always sufficient regardless of term when values for the discount rate parameter \(k\) applied to the investment are less than the 10% interest rate used to create the graph. With increasing rates of discounting, the points at which returns more than compensate for discounting recede in time. The investment returns will overtake required returns eventually, but with high rates of discounting a comparatively long term is needed. Holding the discount rate constant, higher rates of interest (not shown) would bring the
indifference point forward in time. Lower interest rates would postpone the time at which a preference reversal would occur.

Figure 2.5 plots the contrasting situation for exponential delay discounting, showing the difference between the exponentially discounted compound interest returns and the immediate value of the principal across values of delay and the exponential discounting analogue of the $k$ parameter.

![Figure 2.5 Generalised perceived utility of investment returns for $k$ exponential discount rate parameter](image)

When the discount rate parameter is less than the interest rate (10% in this instance) the subjective value of the compound returns net after exponential discounting gradually increases with time. When the exponential delay discounting rate equals the compound interest rate, the discounted value of the investment returns always matches the immediate value of the principal, leading to indifference between investment returns and the principal.
Delay discounting

for any term. When the exponential discounting rate exceeds the rate of return, net
perceived value of future returns diminishes with time, an effect that does not occur at all
with hyperbolic delay discounting as shown earlier in Figure 2.4.

The depreciation of subjective value with time that occurs for comparatively high rates of
exponential discounting would discourage investment, especially long term investment,
precisely the opposite to what should occur with hyperbolic delay discounting, which
biases preferences towards longer term investment. When the exponential delay
discounting rate greatly exceeds the 10% interest rate in Figure 2.5, perceived value of the
discounted investment returns diminishes sharply with increased term, which is inimical to
long term investment. Varying the interest rate in the function used to draw Figure 2.5
would show that higher interest reduces the tendency for future returns to depreciate with
time, and increases the appreciation in perceived value with time that occurs when the
interest rate exceeds the exponential discounting rate. A rate of interest much lower than
the discounting rate increases the sharp decline in perceived value that occurs with longer
terms. With exponential delay discounting at a constant rate, the perceived value of future
rewards from compound interest investment remains either higher, lower or equal to than
the immediate value of the principle for any term. A change in sign for the difference
between the immediate value of the principal and the discounted value of future rewards
never occurs with changes in term. A change in sign can happen when the rate of
hypermolic delay discounting exceeds the compound interest rate.

The only imaginable reason for a term-related preference reversal when exponential
discounting is combined with compound interest growth arises from the increasing
discrepancy between actual rewards and rewards required to compensate from discounting.
Increasing the term magnifies any disparity between actual and required returns. Investors
could be insensitive to a slight difference between required and actual returns that may occur with short terms, only to become increasingly responsive to the larger differences between actual and required rewards brought by longer terms. Exponential discounting at low rates could lead to preference changes favouring long term investment, although Figure 2.5 suggests that this effect could be weak when interest rates are low. Exponential discounting at high rates would send preferences away from long term investment, this being a strong effect when interest rates are low.

The main conclusion from the above comparison between hyperbolic and exponential delay discounting of compound interest returns is that hyperbolic delay discounting enables preference reversals, though in one direction, a switch from preferring immediate access to the principal, to preferring the larger delayed rewards with increasing term. With hyperbolic discounting, the widening disparity between the actual value of compound returns and the amount required to compensate for delay serves always to increase the subjective appeal of the longer term investment. Longer investment terms, higher interest rates and lower discount rates would all boost the appeal of long term investments for a hyperbolic delay discounter, as the growth from compound interest increasingly outpaces subjective depreciation from delay discounting. There is a preference reversal because there is a perceived value reversal.

With exponential delay discounting, the perceived value of compound interest returns is superior, inferior or identical to the immediate value of the principal throughout any term. Only the degree of superiority or inferiority increases with time. Whereas higher rates of hyperbolic delay discounting merely postpone the time when compound interest returns overtake subjective depreciation, rates of exponential delay discounting much higher than the interest rate would destroy the appeal of long term investment.
Mathematical Demonstration Relating Hyperbolic Delay Discounting to Compound Interest Investment Growth

This section introduce the new parameter $k_i$, which combines hyperbolic delay discounting with exponential growth from compound interest to enable predictions about how investors will appraise compound interest investment returns depending on the investment term, the interest rate, and the rate at which the investor delay discounts hyperbolically.

Calculating the $k_i$ Parameter

Begin with Equation 1 on p. 36, this being the well-known formula for the perceived present value of a delayed reward which is discounted hyperbolically at the rate $k$.

Commencing with an initial investment of amount $v_i$, interest rate $r$ and final return $v_r$ after delay $D$, it happens that $v_r = v_i (1 + r)^D$. For an investor to show indifference between a sum of money available now ($v_i$) and its future, discounted value at the end of an investment term ($v_d$), $v_i$ must equal $v_d$.

Therefore:

$$v_d = v_i = \frac{v_r}{1 + kD} = \frac{v_i(1 + r)^D}{1 + kD}$$

and

$$1 + kD = (1 + r)^D$$

Rearranging the terms we obtain:

Equation 2 $k_i$ calculated from return and term

$$k_i = \frac{(1 + r)^D - 1}{D}$$ (2)
Chapter 2 – Delay discounting

The term $k_i$ (“$k$ for an investment”) in Equation 2 is the rate of hyperbolic delay discounting that precisely neutralises the appreciation of an investment with the compound interest rate and term used to calculate $k_i$. The $k_i$ parameter derives from the interest rate and term, yet it represents the personal rate of hyperbolic discounting an investor applies when they show indifference between an immediately available sum and the future value of that sum invested for the period $D$ at compound interest rate $r$. Henceforth, the $k_i$ parameter will be distinguished from the discount rate parameter, “$k$,” which indicates the rate of hyperbolic delay discounting that an individual applies to a delayed reward.

An alternative formula for $k_i$ derived by rearranging the terms in Equation 1 is:

Equation 3  Alternative formula for $k_i$ based on amount invested and discounted value of returns

$$k_i = \frac{V}{V_d} - 1$$

In Equation 3, $V_d$ refers to the discounted value of the future investment returns as they are perceived now (i.e., their present value) and $V$ stands for the investment’s actual value at the end of term $D$. Equation 3 has the advantage of allowing any interest payment regime, not only compound interest, because the equation relies on actual returns rather than interest rates. When identifying the value of $k_i$ associated with indifference between the value of the principal at the outset of the investment and the investment’s actual value at maturity, $V_d$ takes the value of 1 and $V$ is expressed as the ratio of initial principal to actual value of the investment at the end of the term (so if the investment doubles in value, $V = 2$).
In past research, Kirby has presented tables of values for the discount parameter \( k \), for which immediate and delayed rewards are of equal subjective value (e.g., Kirby & Maraković, 1996; Kirby et al., 1999). Although equivalent to \( k_i \), these values were not used for predicting responses to compound interest investment scenarios, which is the contribution and theme for much of this thesis.

**\( k_i \) as a Property of the Investment**

Aside from the two examples from Kirby mentioned above, the literature presents the discount rate parameter \( k \) from Equation 1 as a property of the individual who discounts hyperbolically. The value of \( k \) denotes an individual’s rate of hyperbolic discounting. In contrast, Equation 2 and Equation 3 present \( k_i \) as a property of the investment. In one sense, values of \( k \) should always apply to individuals because only organisms discount. As a property of an investment, \( k_i \) has a functional or interpretative significance. It denotes the hyperbolic delay discounting rate required for indifference between the discounted value of the future returns and the initial amount for a specified term and compound interest rate (Equation 2) or, alternatively, the rate of hyperbolic delay discounting required for an investment’s future returns to have a specified present value (Equation 3).

Properties of the investment (specifically the compound interest rate and term) together with an individual’s subjective appraisal of the investment’s returns enable inferences about the rate of discounting applied to the investment. If someone accepts prospective investment returns as worthwhile, they are applying a personal rate of \( k \) to the prospective returns which is less than the value of \( k_i \) for the investment. If the prospective returns are rejected as insufficient to compensate for the delay, the individual is applying a personal value of \( k \) exceeding \( k_i \) for the investment.
Chapter 2 – Delay discounting

The $k_i$ parameter enables predictions about the combination of interest rate and term that an individual who discounts hyperbolically will accept as worthwhile, or will reject. Someone who delay discounts hyperbolically at less than the rate of $k_i$ will accept the respective combination of interest and term as worthwhile because the investment’s actual value after delay $D$ will have appreciated by a greater amount than it has subjectively depreciated. Someone who discounts at a higher rate than $k_i$ would not consider the investment worthwhile because its perceived value will have depreciated through delay discounting by more than its actual value has increased. Therefore, $k_i$ can identify combinations of compound interest rate and term that will prove acceptable or unacceptable to hyperbolic discounters whose personal rate of discounting is known.

Demonstrations Involving $k_i$

Table 2.1 provides examples of future values of hypothetical investments for various units of term ranging from 1 to 10 (e.g., years) along with the associated $k_i$ values displayed with enough decimal places to reveal increments. The investment value for Time = 0 refers to the starting value of the investment, set arbitrarily to 1 (e.g., $1). Table 2.1 maps values of $k_i$ against exponential growth at 1%, 5%, 10%, 15% and 20% compound interest per unit time paid at the end of each unit (e.g., per annum paid yearly). The “value” column shows investment growth as multiples of the investment’s initial value. For example, $1 invested at 5% p.a. compound interest is worth $1.16 after 3 years. The values for $k_i$ at each level of interest rate and term show the rate parameter $k$ that an individual who delay discounts hyperbolically would apply to the investment for that individual to consider the investment returns as subjectively comparable to the immediate value of the principal. Each value of $k_i$ refers only to its respective combination of term and interest rate.
Table 2.1 Future investment value coefficients and corresponding values of $k_i$ for compound interest investments

<table>
<thead>
<tr>
<th>Time</th>
<th>Value $k_i$</th>
<th>Value $k_i$</th>
<th>Value $k_i$</th>
<th>Value $k_i$</th>
<th>Value $k_i$</th>
<th>Value $k_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1</td>
<td>1.01 0.0100</td>
<td>1.05 0.050</td>
<td>1.10 0.100</td>
<td>1.15 0.15</td>
<td>1.20 0.20</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.02 0.0105</td>
<td>1.10 0.051</td>
<td>1.21 0.105</td>
<td>1.32 0.16</td>
<td>1.44 0.22</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.03 0.0110</td>
<td>1.16 0.053</td>
<td>1.33 0.110</td>
<td>1.52 0.17</td>
<td>1.73 0.24</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1.04 0.0115</td>
<td>1.22 0.054</td>
<td>1.46 0.116</td>
<td>1.75 0.19</td>
<td>2.07 0.27</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1.05 0.0120</td>
<td>1.28 0.055</td>
<td>1.61 0.122</td>
<td>2.01 0.20</td>
<td>2.49 0.30</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1.06 0.0125</td>
<td>1.34 0.057</td>
<td>1.77 0.129</td>
<td>2.31 0.22</td>
<td>2.99 0.33</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1.07 0.0131</td>
<td>1.41 0.058</td>
<td>1.95 0.136</td>
<td>2.66 0.24</td>
<td>3.58 0.37</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1.08 0.0136</td>
<td>1.48 0.060</td>
<td>2.14 0.143</td>
<td>3.06 0.26</td>
<td>4.30 0.41</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1.09 0.0141</td>
<td>1.55 0.061</td>
<td>2.36 0.151</td>
<td>3.52 0.28</td>
<td>5.16 0.46</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1.10 0.0146</td>
<td>1.63 0.063</td>
<td>2.59 0.159</td>
<td>4.05 0.30</td>
<td>6.19 0.52</td>
<td></td>
</tr>
</tbody>
</table>

For example, at 10% p.a. interest an investment will have increased in value by a factor of 1.61 after 5 years and 2.59 after 10 years. To show indifference between the initial principal (1.0) and these prospective returns at the specified delays, investors would have to discount hyperbolically at the corresponding rates of 0.122 and 0.159. If they were to discount hyperbolically at rates less than these values of $k_i$ they should consider the respective combination of term and interest rate as subjectively higher than the initial value of the investment, meaning that the investment has subjectively appreciated in value with time, net after discounting. The prospective returns for the investment would be appraised favourably. If an investor discounts at a higher rate of $k$ than the respective $k_i$ values, he or
she would perceive the investment as depreciating subjectively with time compared with the initial value of the investment. The prospective investment returns would be appraised as less than worthwhile for the delay.

These predictions apply only to prospective investment returns and not to appraisals of returns when the investment matures, because prospective returns are subject to delay, and therefore delay discounting. At the time of maturity the returns are available immediately, and so are not subject to delay discounting.

Table 2.1 provides additional insights:

• When the value for time (i.e., delay) equals 1 unit, $k_i$ equals the percentage return.

• Values of $k_i$ increase with time and percentage return. From this observation it follows that longer term investments should be rated as more attractive prospects than shorter term investments because higher rates of hyperbolic delay discounting are required to render them subjectively equivalent to the initial value of the investment. This prediction assumes fixed interest rates and constant rates of hyperbolic delay discounting, and again refers only to prospective returns which are available after a delay equal to the investment term. The prediction of increased attractiveness to hyperbolic delay discounters of longer term compound interest investments provides the basis for experiments in Chapter 3.

• Increases in the value of $k_i$ with percentage rate and time are non-linear. Values of $k_i$ accelerate with time and interest rate, consistent with the effects of compounding.

Table 2.1 can be used to infer the acceptability of investment returns based on appraisals of other returns. For example, if an investor is satisfied with tripling the value of their
investment after 8 years, but is dissatisfied with a lesser return for the same period, it could be inferred from Table 2.1 that this investor implicitly delay discounts the prospective returns at rate of $k$ approximately equal to 0.26, sufficient to negate a 15% compound return over the 8-year period. If the same investor consistently discounts at a rate of $k = 0.26$ for all investment scenarios, no term shorter than 8 years at 15% will be acceptable because $k_i$ values corresponding to terms of 7 or fewer years are less than 0.26. However, the same investor applying a discount rate of 0.26 would accept a 4-year investment at 20% p.a., for which $k_i = 0.27$, even though the investment only doubles in value rather than triples. The smaller increase in value is offset by the shorter delay. The absolute value of the return alone does not govern the acceptability of an investment, but the return balanced against the delay does.

Table 2.1 shows that lesser rates of return are acceptable for investors providing the term is longer. In reverse, a higher interest rate is required to compensate for shorter terms. This is equivalent to saying that the higher objective returns provided by longer term compound interest do compensate for additional discounting from the extra delay. Inflation does not negate this principle because it serves only to reduce the investment’s effective return.

The above discussion has shown how $k_i$ enables predictions about the acceptability of compound interest investments, assuming that the personal rate of the discount parameter $k$ applied by the individual investor remains constant for that investor. Taxation and other real world factors are ignored but would have to be taken into account when attempting to generalise to real investment decisions. Note, however, that Moore et al. (1999) found a bias towards evaluating only nominal returns, suggesting that people do not adjust adequately for ancillary factors.
**Possible Effect of Reduced Rate of Delay Discounting From Larger Rewards on Predictions From $k_i$**

On page 40 it was reported that larger rewards are delay discounted at lower rates than smaller rewards. Reduced discounting means that the investor applies a lower personal rate of the discount rate parameter $k$ to the investments. For a given rate of compound interest and term, the perceived value of returns from larger investments would seem superior compared with returns from smaller investments simply because they are discounted at lower rates. As a result, investments with lower associated $k_i$ values will be acceptable with larger investment amounts. As well, because they are discounted at lower rates compared with smaller investments, larger investments will bring forward the time when actual returns more than compensate for discounting.

The next chapter reports on experiments testing the hypothesis that exponential growth from compound interest investments eventually compensates for subjective depreciation from hyperbolic delay discounting of future rewards. The experiments utilise combinations of term and interest rate typical of everyday investing. In common with all discounting experiments in this dissertation, participants were offered hypothetical investment scenarios presented as binary-choice tasks on a computer. In Chapter 3, participants decided whether investment returns were worthwhile in relation to the delay. Longer investment terms should be associated with significantly increased likelihood that an investment return will be perceived as worthwhile. A Type 1 error rate of .05 serves as the criterion for statistical significance throughout this thesis.
Chapter 3 – Delay Discounting Investment Experiments

Investigating Term Effects

Chapter 2 argued that longer term investments of the same amount at the same interest rate should be increasingly favourable to an investor who delay discounts hyperbolically. On the other hand, an investor who delay discounts exponentially may perceive no advantage from an increased term. When they discount at high rates, exponential discounters may perceive a disadvantage with longer terms. Hyperbolic delay discounters never see a disadvantage with longer term compound interest, no matter how high their rate of discounting, and regardless of the interest rate.

The three experiments in this chapter test the principle that longer term compound interest returns are appraised more favourably than compound returns from shorter terms, which is consistent with any rate of hyperbolic delay discounting, but will occur with exponential discounting only under the restrictive assumption that the individual discounts at a rate lower than the interest rate. The first two experiments examine various combinations of investment amount, interest rate and term. The third experiment introduces taxation and inflation as a practical consideration.

Existing research has already demonstrated the primacy of the hyperbolic discounting model over the exponential model embraced by classical economics (Rachlin et al., 2000), so the main aim of the following experiments is not to compare the hyperbolic and exponential delay discounting models. Predictions from exponential discounting will receive some, though secondary, consideration. The experiments seek evidence that compound interest investment appraisals are consistent with the hyperbolic delay discounting model and predictions from the $k_i$ parameter. Finding that returns from longer
terms are perceived more favourably than shorter term returns will suggest that prospective returns are delay discounted hyperbolically, and that appraisals of prospective returns are predictable from the hyperbolic model. The finding that longer term investment returns are perceived more favourably than shorter term returns at the same interest rate has important practical significance. It will imply that people are fundamentally amenable to long term investment, at least when they have compared short and long term returns.
**Experiment 1: Increased Attractiveness of Longer Term Investments**

Experiment 1 tests whether increasing the term of a prospective compound interest investment increases the attractiveness of the returns, which can be expected if the returns are delay discounted hyperbolically. Compound interest returns accelerate with term, while the slope of the hyperbolic delay discounting function diminishes with delay, allowing the exponential and hyperbolic functions to intersect. The intersection marks a preference reversal point beyond which longer term investment returns will be perceived as increasingly favourable compared with the initial value of the investment. In other words, the present value of prospective compound returns is more likely to exceed the initial value of the amount invested when terms are longer.

Experimental participants were presented with a series of immediately available hypothetical rewards in the form of imaginary windfalls they were said to have received. For each of 25 investment scenarios they chose between spending the windfall within a reasonably short time, or investing the entire windfall at no risk to provide a larger but delayed reward. The fundamental choice was between a smaller, immediate reward and a larger, later reward. Unlike the rewards in Figure 2.1 and typical experiments in discounting research, the objective value of the delayed rewards increased with delay according to a specified (in this case, exponential growth) function.

If the perceived value of the discounted future returns from the investment option were to exceed the value of the windfall, a participant would forego immediate access to the windfall in pursuit of the investment returns. He or she would invest rather than spend the windfall. Alternatively, if the perceived, immediate value of the windfall exceeded the perceived value of the investment returns after delay discounting, the participant would
retain immediate access to the windfall with a view to spending it, because the investment returns would have failed to compensate for the delay.

Because longer term compound interest returns should increasingly compensate for hyperbolic delay discounting, an increased willingness to choose longer term investments in preference to spending the windfall was predicted, and would support the hyperbolic delay discounting model. At least some participants who chose to spend rather than invest for a shorter term were expected to change their preference to investment when the prospective term increased. Fewer participants, if any, were expected to change preference from investing to spending as prospective terms increased, because to do so would defend the exponential discounting model which hitherto has received scant, if any, empirical support. A constant preference for the investment or the windfall alternative across terms supports the exponential discounting model. Unchanging preference across terms could also result from a delay discounting preference reversal point beyond the range of terms offered in this experiment.

To summarise, constant preferences across terms do not distinguish either way between hyperbolic and exponential delay discounting. Preference changes in favour of longer terms support hyperbolic delay discounting but do not refute exponential delay discounting because, by chance, all participants could delay discount exponentially at a lower rate than the 10% p.a. interest featuring in the experiment. A preference reversal favouring shorter terms strongly supports exponential discounting and finds against hyperbolic delay discounting.

The prediction from hyperbolic delay discounting (that longer terms will be more attractive than shorter terms) assumes a constant rate of interest, a constant rate of hyperbolic delay discounting and participants being informed of the final, gross returns of the investment so
they know the magnitude of the delayed reward. In addition, participants were expected to report greater willingness to invest rather than spend larger sums of money compared with smaller sums, owing to reduced discounting of larger amounts.

**Method**

**Participants**

Participants were 90 first year psychology students (22 males and 68 females) of mean age 21 years ($SD = 6.45$). They received course credit for their involvement.

**Design and procedure**

Participants received hypothetical background information stating that they had recently received a windfall and had to decide whether to invest the entire amount for a fixed term with all interest reinvested, or instead to spend the entire sum. They were asked to imagine themselves as aged in their late 20s. This suggestion was included to reduce disparate responding from participants across a wide range of age groups, for whom the scenarios might have had age-specific relevance. Specifying the hypothetical age was intended to provide consistency in imagined lifestyle circumstances across participants of varying age. For the younger students, stipulating an age in their 20s would imply greater financial security than is likely for their student years, with less likely reliance on the immediate expenditure of the windfall for mere survival. (In the current thesis, background information specifying participants’ personal circumstances and some other minor aspects of the experiments were varied between experiments to prevent any incidental feature affecting every experiment. Most experimental instructions advised participants to imagine themselves as financially secure, or words to that effect, so that postponement of expenditure would be considered feasible.)
Chapter 3 – Attractiveness of longer term investments

Participants were asked to ignore issues such as taxation and inflation. Raineri and Rachlin’s (1993) participants seemed not to account for inflation, apparently without being asked to ignore it. See Experiment 3 below for a study which does incorporate inflation and taxation.

The binary decision to invest or to spend the windfall served as the dependent measure for analysis. In the computerised presentation, each scenario showed a single windfall amount along with the spending or investment alternatives. Compound interest returns were shown for the investment option. Participants made their selection, after which the screen cleared and the next scenario appeared. Instructions and the first item for the ascending order condition appear below. The final paragraph of the instructions (“To indicate your decision…”) was common to all experiments in this dissertation that were presented on computer, and will be omitted for subsequent experiments.

Imagine you are in your late 20s and thinking about whether to invest or spend a sum of money you have unexpectedly inherited from a distant relative. Any money you do invest will be “locked up” so you can’t spend it for the duration of the investment, and any interest you earn will be reinvested, so you can’t spend the interest either. You manage to find an investment that will earn 10% per annum over many years. It remains for you to decide whether to invest now, or spend the money any way you like.

Soon you will be presented with a series of choices for quickly spending certain amounts of money, or investing the money over various periods. The amount you would receive at the end of the investment term is also shown. It includes the sum that you originally invested plus all interest earned. Ignore issues such as taxes, fees and charges.

To indicate your decision, use the Up and Down arrow keys to move from Option A to Option B in the decision window. When you have highlighted your preferred response, press Enter to continue. If you are unsure about what to do or have any questions, please ask the researcher before you continue. When you have finished reading, press any key.

Assume you have two options for a large sum of money.

Option A would be immediate investment of the entire amount.
Option B would be rapid expenditure of the entire amount.

Which investment option would you prefer, Option A or Option B?

Option A
Invest $1,000 for 1 year and receive $1,100

Option B
Spend $1,000 within a month, any way you wish
Windfalls of $1,000, $2,000, $3,000, $4,000 and $5,000 were presented in successive investment scenarios, factorially combined with investment terms ranging from 1 year to 5 years in 1-year increments. Earnings were calculated on the basis of 10% p.a. interest paid quarterly. Quarterly interest increased the final payouts compared with annual interest, lifting the attractiveness of the investment. The $1,000 to $5,000 windfall values were chosen because these amounts would represent meaningful and attractive amounts of money to a student on a modest income. Although an older investor might only consider investing far larger sums, such as tens of thousands of dollars, it was important not to overwhelm participants with a vast windfall which in real life would have major lifestyle implications. The choice of 1 to 5-years terms was intended to provide a comprehensible time period which spanned a range of investment terms from short to medium duration. Shorter terms than 1 year would provide only small returns from 10% p.a. interest, whilst terms longer than 5 years could represent such a long period that participants could find it difficult to imagine their circumstances so far into the future – but see Experiment 2 for responses to long term investments.

The windfall expenditure option required participants to spend the windfall within a month. They were given a month to spend the windfall because immediately spending up to $5,000 could seem inconvenient. Severely limited consumption time is unrealistic, and could have greatly diminished the marginal value of the larger windfalls. It would have turned the experiment into something like the movie Brewster’s Millions in which a fellow has to spend a fortune in a short time. However, a moderate time limit on expenditure was imposed to ensure some sense of imperative for expenditure, and to avoid perceived overlap between the expenditure option and the 1-year investment term.
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Factorial combination of the five windfall amounts with the five levels of term gave 25 scenarios, each scenario consisting of one level of windfall combined with a term value. Investment payouts included the principal. Payouts were rounded to the nearest $10. See Table 3.2 below for investment scenarios and payouts.

Items were presented in two between-groups counterbalanced orders. The ascending order commenced with a $1,000 windfall and a 1-year investment term, incrementing by year (2, 3, 4 and 5) followed by amount ($2000 to $5,000) with n = 44. The same scenarios were presented in reverse order for the descending sequence with n = 46.

Because each experiment lasted only a few to several minutes within a half-hour testing session, most participants participated in one or two other studies. This regime applied to all computer task experiments in this dissertation. To reduce the likelihood of systematic contamination between experiments, participants mostly undertook experiments with dissimilar scenarios and items. They were allocated to experiments randomly; and experiments were presented in unsystematically varying orders. One possible advantage of participation in multiple experiments is the increased general familiarity with the task, facilitating comprehension.

Results

Preference reversal patterns

Table 3.1 shows the percentage of participants choosing the specified sequences of responses with increasing investment term within windfall amounts. For example, the pattern “spend then invest” represents a single change in preference from spending the windfall to investing it with increasing term, within a level of windfall amount. The “spend then invest” response pattern is the only preference change consistent with hyperbolic
delay discounting. Uniform responses indicate that all returns for a given windfall amount were either acceptable or unacceptable after discounting, regardless of term. As noted earlier, uniform responding (“always invest” or “always spend”) could indicate a hyperbolic delay discounting preference reversal point outside the experimental range, that is, at a term greater than 5 years or less than 1 year, or it could indicate exponential discounting.

For $2,000 to $5,000 windfalls, the predicted preference reversal from spending to investing with increased term was more common than other individual patterns, although constant responding across terms predominated. For the $1,000 windfall, the most common preference reversal was from short term investing to spending rather than investing for a longer term – contrary to expectations from hyperbolic delay discounting, although compatible with exponential discounting at a higher rate than the 10% p.a. interest earned. With increasing windfall, the percentage of respondents choosing always to invest for each of the five terms increased, whilst the percentage who chose always to spend declined, suggesting increased attractiveness of investing larger windfalls.
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Table 3.1 Percentage response patterns for increasing term – Experiment 1

<table>
<thead>
<tr>
<th>Pattern with increasing term</th>
<th>Windfall amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1,000</td>
</tr>
<tr>
<td>Always spend</td>
<td>50%</td>
</tr>
<tr>
<td>Always invest</td>
<td>24%</td>
</tr>
<tr>
<td>Spend then invest*</td>
<td>4%</td>
</tr>
<tr>
<td>Invest then spend</td>
<td>12%</td>
</tr>
<tr>
<td>Invest-spend-invest</td>
<td>4%</td>
</tr>
<tr>
<td>Spend-invest-spend</td>
<td>4%</td>
</tr>
<tr>
<td>Other</td>
<td>0%</td>
</tr>
</tbody>
</table>

* The only preference reversal pattern consistent with hyperbolic delay discounting.

Factorial analysis of preferences

For each combination of windfall and investment term the percentage of respondents who preferred the investment to the spending alternative is shown in Table 3.2.

Table 3.2 shows an increased tendency to invest rather than spend for longer terms when the windfalls equalled $2,000 or more, but not for $1,000 windfalls. Decisions to invest were more likely for larger compared with smaller windfalls. Increased attractiveness of the investment option for the $2,000 and higher windfalls matches predictions from hyperbolic delay discounting, and is consistent with the predominant preference reversal pattern shown in Table 3.1. The reverse effect for $1,000 runs contrary to predictions from hyperbolic delay discounting.
Table 3.2  Investment payouts and percent choosing to invest – Experiment 1

<table>
<thead>
<tr>
<th>Amount</th>
<th>1 year</th>
<th>2 years</th>
<th>3 years</th>
<th>4 years</th>
<th>5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1,000</td>
<td>$1100</td>
<td>$1220</td>
<td>$1340</td>
<td>$1480</td>
<td>$1640</td>
</tr>
<tr>
<td></td>
<td>41%</td>
<td>37%</td>
<td>34%</td>
<td>33%</td>
<td>34%</td>
</tr>
<tr>
<td>$2,000</td>
<td>$2210</td>
<td>$2440</td>
<td>$2690</td>
<td>$2970</td>
<td>$3280</td>
</tr>
<tr>
<td></td>
<td>48%</td>
<td>50%</td>
<td>47%</td>
<td>57%</td>
<td>69%</td>
</tr>
<tr>
<td>$3,000</td>
<td>$3310</td>
<td>$3660</td>
<td>$4030</td>
<td>$4450</td>
<td>$4920</td>
</tr>
<tr>
<td></td>
<td>57%</td>
<td>60%</td>
<td>67%</td>
<td>72%</td>
<td>71%</td>
</tr>
<tr>
<td>$4,000</td>
<td>$4420</td>
<td>$4870</td>
<td>$5380</td>
<td>$5940</td>
<td>$6550</td>
</tr>
<tr>
<td></td>
<td>59%</td>
<td>66%</td>
<td>81%</td>
<td>74%</td>
<td>71%</td>
</tr>
<tr>
<td>$5,000</td>
<td>$5520</td>
<td>$6090</td>
<td>$6720</td>
<td>$7420</td>
<td>$8190</td>
</tr>
<tr>
<td></td>
<td>65%</td>
<td>78%</td>
<td>78%</td>
<td>88%</td>
<td>90%</td>
</tr>
</tbody>
</table>

The descriptive interpretation of Table 3.2 is supported by a 3-way ANOVA. Order of presentation served as a single between-groups factor. Windfall amount and term for the investment option served as repeat factors. In the following presentation, Wilks’ lambda and multivariate $p$ values are given where $df$ for the effect $> 1$; otherwise probabilities refer to univariate tests. This policy for presenting mixed model ANOVA results applies throughout this dissertation, and follows from Tabachnick and Fidell (2001).

The main effect for investment term was significant, $\Lambda(4, 85) = .88, p = .0234$. The linear trend for investment term $F(1, 88) = 10.91, p = .0014$, was significant. Quadratic $[F(1, 88) = 0.27, p = .6044]$ and cubic $[F(1, 88) = 0.01, p = .9346]$ trends were not significant. Longer investment terms were significantly associated with increased preference for investment instead of spending, with participants switching from spending to investing at a consistent rate with time, as the linear trend reveals. This finding supports
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the principal hypothesis for the experiment, namely that longer terms would render the investments more attractive.

The significant main effect for windfall amount, $\Lambda(4, 85) = .43, p < .0001$, reinforces the descriptive observation that larger windfalls encouraged decisions to invest. Linear $[F(1, 88) = 98.09, p < .0001]$, quadratic $[F(1, 88) = 6.89, p = .0102]$ and cubic $[F(1, 88) = 4.33, p = .0404]$ trends were all significant, with Table 3.2 suggesting a general increase in preferences for investment of larger windfalls.

The interaction between windfall amount and investment term was also significant, $\Lambda(16, 73) = .56, p < .0001$, showing that the effect of term varied across windfall amounts. Helmert contrasts for windfall amount were tested with the linear trend for term, yielding one significant, interpretable and relevant interaction, $F(1, 88) = 30.51, p < .0001$. Figure 3.1 illustrates this result, showing that longer terms were associated with reduced inclination to invest $1,000, compared with increased preference for investing amounts from $2,000 to $5,000.

![Figure 3.1](image)

Figure 3.1 Windfall amount by investment term interaction contrast – Experiment 1
None of the remaining interactions for Helmert contrasts with amount and linear trends for investment duration were significant \( p \geq .0875 \). The predicted increase in attractiveness of longer term investments applied only to windfalls from $2,000 to $5,000, and not the $1,000 windfall.

For the presentation order effect, ascending order participants preferred to invest for a mean of 75% of items, compared with a mean of 48% for the descending order group, \( F(1, 88) = 20.83, p < .0001 \). Presenting scenarios with increasing windfall amounts, terms and payouts increased preferences for investment.

An alternative ANOVA omitting 13 participants who always chose to invest, and 3 who always chose to spend for all 25 items, (i.e., analysing only results for which preference reversals occurred) gave findings that were descriptively similar and substantively identical to the above analysis.

**Discussion**

The predicted increase in preference for the investment option for scenarios with longer terms occurred, but only for the $2,000 to $5,000 windfalls and not the $1,000 windfall. The result for the $2,000 to $5,000 windfalls is consistent with participants discounting the investment returns hyperbolically. A nonsignificant main effect for term would have supported exponential discounting over the hyperbolic model, or suggested that preference reversal points lay outside the range of terms and investment amounts presented in the experiment (e.g., terms less than 1 year, or longer than 5 years).

The diminishing attractiveness of longer terms that occurred for the $1,000 investments runs contrary to the hyperbolic model. The result suggests a cut-off for amounts that are
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considered worth investing, with $1,000 apparently too trivial an amount to invest for well over half of participants, and especially for longer terms. It was as if $1,000 was allocated to a separate, “petty cash” mental account in the sense of Thaler (1990, 1999), and was earmarked for spending.

With regard to the second hypothesis referring to investment amounts, larger windfalls were considered more worthy of investment than smaller windfalls, as expected from reduced delay discounting of the larger rewards provided by larger investments. This finding is also consistent with diminishing marginal value for immediate expenditure of large amounts.

The increased preference for the investment option when payouts increased with successive items in the ascending order condition is consistent with participants preferring a sequence of improving outcomes compared with deteriorating outcomes, as identified in other discounting research such as Loewenstein and Prelec (1993).

It might be said that a participant may not consider the returns from larger investments worthwhile but invests anyway because expenditure of the windfall is inconvenient. However, a decision to invest for any reason shows that the invested windfall and associated returns are worth subjectively more in the future than expenditure of the windfall is worth now. The objection that immediate expenditure was merely inconvenient fails to address why longer terms strengthened the appeal of investment. Inconvenience associated with immediate expenditure cannot account for the significant term main effect. Even the 1-year investment term postponed expenditure considerably compared with having to spend the windfall within a month.
However, the 1-month limit for immediate expenditure may have especially encouraged investment decisions for large windfalls because worthwhile expenditure of $5,000 within a month could be onerous. Perceived inconvenience of immediate expenditure may account for the significant amount main effect. Experiment 2 meets this objection by allowing participants anything up to several months to spend their albeit larger windfalls. The longer and inexact time limit for the spending the windfall should provide sufficient flexibility to minimise diminished marginal value of large windfalls for a realistic scenario.

It could be argued (persuasively) that Experiment 1 confounds payout with term. Because final returns increased with term and payout, any increased preference for longer terms could have occurred solely because of reduced discounting of the larger payouts from longer terms rather than the combination of hyperbolic delay discounting and exponential growth.

The confound between term and final payout presents a genuine difficulty for the current experiment (along with Experiment 2 and Experiment 3) because higher yields for longer terms are an inevitable feature of compound interest investments. Experiment 6 avoids the problem by fixing the final payout. Data from the first three experiments are worthwhile despite the confound because their scenarios resemble a conventional investment proposition, that is, the opportunity to invest a specified amount of money for a specified term and interest rate to earn a readily calculable payout. If reduced discounting of larger rewards from longer terms operated consistently across investment amounts, preference reversals away from longer term investments of the $1,000 windfalls would not have occurred.

Just as importantly, the statistical procedure for the 3-way ANOVA controls for the different main effects and interactions by employing “effective hypothesis” sums of
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squares (Statsoft Inc., 2003) which tested the term effect independently (i.e., over and above) any effect attributable to windfall amount. In practice, the effective hypothesis sums of squares gave identical results to the traditional Type III sums of squares which control for effects of equal and lower order, and are orthogonal to higher order effects. Because final payouts are proportional to windfall amounts, any differences between payouts attributable to windfall size are fully accounted for by the windfall main effect, leaving only compound interest growth to contribute to the term effect after controlling for all other main effects.

Experiment 1 supported the prediction that longer term compound interest investments would more attractive than shorter term investments, an effect attributable to hyperbolic delay discounting of compound interest growth. The next experiment examines the attractiveness of longer term investing for a wider range of terms, windfall amounts and across varying interest rates.
Experiment 2: Attractiveness of Large, Long Term Investments With Varying Interest Rates

To establish whether results from the first experiment generalise to a wider range of scenarios, Experiment 2 replicates the general design and procedure for Experiment 1 while expanding the range of investment amounts and terms, and testing a range of interest rates. Consistent with Experiment 1, longer terms and larger windfalls should be associated with increased willingness to invest. Higher interest obviously should encourage investment decisions.

Experiment 2 adds yet another effect to Experiment 1. In the retail investment market it would be rare for potential investors to be told in advance how much money they would receive from a compound interest investment. Banks and other institutions offering fixed interest investments usually provide only the annual percentage return because the amount invested, and therefore the payout, will vary among customers. Unlike Experiment 1, in which the exit value of the investment was stated, genuine investors must estimate or calculate the long term return, or just assume an adequate payout. Empirical research has found that people tend to underestimate loan durations (Lewis & van Venrooij, 1995; Overton & MacFadyen, 1998; Ranyard & Craig, 1993). If the same psychological principles influence estimates of loan amortisation and investment growth, naïve subjects prone to underestimating how long it takes to amortise a debt may also underestimate the time an investment takes to reach a particular value. An investor who underestimates compound interest returns would more likely spend a windfall than invest it, compared with someone who knows the final return.

To examine this possibility, scenarios in Experiment 2 were presented twice: the first time showing only the principal, interest rate and term; and a second time with final payout
information provided in the manner of Experiment 1. Payout information is expected to increase decisions to invest – assuming that compound interest returns or the time needed to reach an investment goal are underestimated.

Method

Participants

First year psychology students (47 females and 13 males) participated for course credit. Mean age for the entire sample was 19.32 years, with \(SD = 4.12\).

Design and procedure

Experiment 2 used the same computerised task as Experiment 1, with the following factors and levels:

1. Windfall amount – $1,000, $4,000, $7,000 and $10,000.

2. Investment term – 5, 10, 15 and 20 years, that is, commencing at the highest value used in Experiment 1 and incrementing up to a genuinely long term.

3. Interest rate – 5%, 10% and 15% p.a. paid annually, rather than the quarterly interest in Experiment 1. Annual interest produced low payouts for the 5% interest level, as a contrast to the substantial payouts from 15% p.a. for 20 years, and simply to introduce variation in the interest payment schedule between experiments.

The above conditions were combined factorially, giving 48 investment scenarios. Background information given to participants was almost identical to that of Experiment 1, with additional advice that various interest rates would be presented. Half of participants
received the scenarios in ascending order, with time, windfall amount and interest rate incremented in that order, from slowest to fastest with successive items. The remaining half of participants received scenarios in the opposite, descending order. For both presentation orders, payout information was withheld for the first presentation of the 48 scenarios and presented (rounded to the nearest dollar) during the repeat presentation of otherwise identical scenarios. For each scenario, participants chose between investing the entire windfall at the specified interest rate and for the specified term, or spending the entire windfall within several months. The longer period allowed for the spending option compared with Experiment 1 offered a more reasonable time for expenditure in order to minimise diminished marginal value of the larger payouts while keeping the time limit well below the minimum investment term. Instructions and the first scenario for the ascending order with payout information condition are as follows:

Imagine you are in your mid 20s and thinking about whether to invest or spend a large sum of money you have unexpectedly received. You could have won a competition or gained an inheritance from a distant relative. If you decide to invest, the money will be “locked up” for the duration of the investment, and any interest you earn will be reinvested so you can’t spend the interest either. You manage to find an investment that will pay the same rate of compound interest over many years. Now you have to decide whether to invest for a fixed term, or keep the money at call and earning almost no interest, because you intend to spend the money fairly soon on anything you like.

Soon you will be given choices for spending or investing. Various combinations of money amount, investment term and interest rate will be shown. Ignore issues such as taxes, fees and charges. Assume that inflation will remain low and therefore can be ignored.

Assume you have received $1,000 and have two options.

Option A: Spend the money within several months on whatever you want.
Option B: Invest the money for 5 years at 5% per annum interest.

Which option do you prefer, Option A or Option B?

Option A
Spend $1,000 within several months

Option B
Invest $1,000 for 5 years at 5% per annum and receive $1,276
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Results

Preference reversal patterns

All participants changed preference at least once throughout the 96 scenarios, but for the 48 items featuring investment payout information one participant always chose to invest. Table 3.3 shows the individual response patterns, defined as per Experiment 1 – see p. 68. Showing the payout appears to encourage decisions to invest when the windfall is large, and to discourage investment for smaller windfalls, especially at the 5% p.a. interest rate, and less so for higher interest.

Table 3.3 Response patterns for increasing term – Experiment 2

<table>
<thead>
<tr>
<th>N = 60 per cell</th>
<th>Windfall amount and whether payout shown</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1,000</td>
</tr>
<tr>
<td>Interest rate and pattern</td>
<td>Not shown</td>
</tr>
<tr>
<td>5% p.a. Always spend</td>
<td>45%</td>
</tr>
<tr>
<td>Always invest</td>
<td>13%</td>
</tr>
<tr>
<td>Spend then invest*</td>
<td>10%</td>
</tr>
<tr>
<td>Invest then spend</td>
<td>27%</td>
</tr>
<tr>
<td>Invest-spend-invest</td>
<td>2%</td>
</tr>
<tr>
<td>Spend-invest-spend</td>
<td>2%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
</tr>
</tbody>
</table>
**Experiment 2**

<table>
<thead>
<tr>
<th>Interest rate and pattern</th>
<th>Windfall amount and whether payout shown</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1,000</td>
<td>$4,000</td>
</tr>
<tr>
<td>10% p.a.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always spend</td>
<td>42%</td>
<td>50%</td>
</tr>
<tr>
<td>Always invest</td>
<td>17%</td>
<td>15%</td>
</tr>
<tr>
<td>Spend then invest*</td>
<td>5%</td>
<td>20%</td>
</tr>
<tr>
<td>Invest then spend</td>
<td>28%</td>
<td>10%</td>
</tr>
<tr>
<td>Invest-spend-invest</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Spend-invest-spend</td>
<td>8%</td>
<td>5%</td>
</tr>
<tr>
<td>Other</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>15% p.a.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Always spend</td>
<td>37%</td>
<td>27%</td>
</tr>
<tr>
<td>Always invest</td>
<td>27%</td>
<td>30%</td>
</tr>
<tr>
<td>Spend then invest*</td>
<td>3%</td>
<td>27%</td>
</tr>
<tr>
<td>Invest then spend</td>
<td>25%</td>
<td>13%</td>
</tr>
<tr>
<td>Invest-spend-invest</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>Spend-invest-spend</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
<td>0%</td>
</tr>
</tbody>
</table>

* The only preference reversal consistent with hyperbolic delay discounting.

The preference reversal predicted from hyperbolic delay discounting, that is, switching from expenditure to investment with increasing term, occurred much more often when payouts were displayed than when payouts were concealed. For the payout nondisplay condition, switching from investment to spending with longer terms predominated, the opposite pattern to that expected if compound interest future returns are delay discounted hyperbolically. In the subsequent payout-display condition, the predicted preference
reversal pattern predominated, consistent with hyperbolic discounting of compound interest returns.

**Factorial analysis of responses**

A 5-way ANOVA was conducted with presentation order (ascending or descending) a between-groups factor, and term, windfall, interest and information level as repeat factors. Main effects for repeat factors are shown in Figure 3.2.

![Factorial analysis of responses](image)

Figure 3.2 Main effects – Experiment 2

Figure 3.2 shows that:

a) Presenting the investments’ final values encouraged decisions to invest, $F(1, 58) = 5.39, p = .0238$.

b) Higher interest encouraged decisions to invest, $\Lambda(2, 57) = .35, p < .0001$. 

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c) Participants were more willing to invest larger windfalls compared with smaller amounts, $\Lambda(3, 56) = .31, p < .0001$.

d) Longer terms discouraged investment, $\Lambda(3, 56) = .74, p = .0007$. Therefore, choices ran contrary to predictions, with longer investments apparently having less appeal than shorter investments. These data include responses for items when payouts were not shown, so participants were not given future monetary values to discount. The long prospective terms alone may have provided sufficient disincentive to invest, this effect being a gross indicator of delay discounting.

Showing payout information interacted significantly with preferences over the range of terms, $F(1, 58) = 5.39, p = .0238$. Figure 3.3 shows this interaction, demonstrating that the declining appeal of long term investments for the payout nondisplay condition swamped a slight increase across terms for the displayed payout items. Fewer participants chose to invest for the 5-year term when the payout was shown compared with payout nondisplay. The reverse occurred for 15 and 20-year terms.

For the items that included payout information, neither the linear [$F(1, 58) = 1.79, p = .1862$], or quadratic [$F(1, 58) = 2.40, p = .1268$], nor the cubic [$F(1, 58) = 3.88, p = .0536$] trends were significant, implying that the investments’ appeal was effectively constant across terms. This flat response profile indicates delay discounting, because the enhanced returns of 15 and 20-year terms failed to induce a net change of preference in favour of investment. For the 15% p.a. condition, investment decisions were already at a high level, reducing the opportunity to recruit additional investors. Figure 3.3 does show a significant [$F(1, 58) = 5.57, p = .0217$] if slight rise in participants choosing to invest for 10-year terms compared with 5-year terms for the payout display condition, but for investments of
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10 years or more, delay discounting almost exactly negated higher returns from the longer delay.

![Graph showing investment preferences](image)

Figure 3.3  Investment preferences for term and payout display conditions – Experiment 2

For the main effect of presentation order, ascending term, windfall amount and interest rate gave significantly more decisions to invest ($M = 66\%$) compared with incrementing downwards ($M = 48\%$). This result matches Experiment 1. Presenting short term, low interest investments of small amounts prior to the long term, high interest investments of large amounts (the latter providing much higher absolute dollar returns) tended to encourage decisions to invest.

Discussion

The general conclusion from Experiment 2 is that the substantial financial returns offered by 15 and 20-year investments, even at high interest, failed to persuade additional participants to forego immediate expenditure. This finding strongly suggests delay
Experiment 2

discounting, but not hyperbolic delay discounting. Preference for investment increased for
the 10-year term compared with the 5-year term for the payout display condition, but the
10-year term may represent a time period beyond which hyperbolic discounting predictions
no longer apply to compound interest scenarios. Descriptive results from response pattern
analysis are slightly more favourable to the hypothesis of increased investment
attractiveness with longer term than ANOVA results comparing sets of scenarios.

Increased attractiveness of longer term compound interest assumes a hyperbolic
discounting rate that does not increase with delay. It may be that extreme discounting
occurs for terms beyond 10 years, or even 5 years. Raineri and Rachlin (1993) suggest that
25 and 50-year delays could exceed undergraduate students’ “subjective time horizons”
(p. 83). Experiment 2 results suggest that hyperbolic delay discounting predictions about
investment behaviour have limited value when terms exceed 10-years. Subsequent
experiments in the current dissertation restrict terms to 10-years or less (in the manner of
Raineri & Rachlin, 1993), with terms longer than 5 years mostly avoided.

Scenarios without payout information revealed declining enthusiasm for long term
investment, suggesting that long term investments expressed as combinations of term and
interest rate have low appeal in the absence of payout information. In practice, short term
interest rate information could be all that many investors receive. As a result, widespread
reluctance towards substantial, long term saving seems hardly surprising.

Showing the investment payouts encouraged investing with the longer term, high interest
scenarios, and spending for the shorter term, low interest scenarios. This finding suggests
that participants overestimated short term, low interest returns and underestimated long
term, high interest returns. They appeared generally unable to estimate compound interest
returns across varying levels of interest and term. A practical implication of this finding is
that presenting long term compound interest returns in personal investment promotional literature could encourage people to invest money they might otherwise spend. As noted in Chapter 1, mutual fund prospectuses and advertising often present histories of investment returns. Aside from their reporting obligations, fund managers may believe that gross returns from long term investments will be appealing. Experiment 2 helps to justify this belief.

Increased enthusiasm for investing the larger sized windfalls found in the current experiment matches results for Experiment 1, and again may indicate reduced delay discounting of larger rewards, possibly combined with perceived inconvenience of spending large amounts immediately. The apparent reluctance to invest relatively small amounts of money such as $1,000 that was demonstrated in Experiment 1 and Experiment 2 offers a challenge to financial advisers who consider that people often save inadequately. Smaller windfalls are more likely to occur in everyday life than large ones. Many of us rarely have to choose between spending or investing a large sum of money, yet investing small amounts can provide substantial payoffs over a long period, the very strategy which many participants in the present study resisted. It may be that financial advisers and the investment industry have to promote the concept that investing small amounts can offer long term advantages. The low favourability of the $1,000 windfall in both experiments prompted the use of larger amounts (≥ $2,000) in future experiments involving discretional investment in the current dissertation, to ensure that all amounts of money would be considered potentially worthy for investment by a large proportion of participants.

Both experiments so far have demonstrated the importance of information context on decisions. Presenting the scenarios in ascending order of term, investment amount and interest rate tended to promote the decision to invest. Presenting the large, long term
investments with high dollar returns before the more modest investments probably made
the smaller returns appear trifling by comparison, and not worth the wait. Commencing
with modest, short term returns would make the subsequent larger dollar returns appear
generous, encouraging participants to switch from spending to investing.

The Experiment 2 payout display condition results did not support the proposition that
compound interest returns from extended term investments are delay discounted
hyperbolically. Both Experiment 1 and Experiment 2 demonstrated the predicted increase
in investment preference for larger windfalls, the more so for Experiment 2 with its greater
range of dollar amounts. Experiment 3 examines appraisals of net rather than gross returns.
Experiment 3: Attractiveness of Returns Adjusted for Inflation and Taxation

Results from Experiment 1 and Experiment 2 may seem inapplicable to genuine investing because neither experiment accounts for inflation and taxation. Presenting returns net after tax and adjusted for inflation could increase the external validity of the experiments. Henceforth, values adjusted for taxation and inflation will be described simply as “adjusted” as opposed to “unadjusted” gross returns.

Table 3.4 shows the effect of a fixed level of inflation and taxation on $k_i$ values for a range of percentage returns. The three columns on the left, with 5%, 10% and 15% p.a. returns, show $k_i$ values for terms of 1 to 10 years without adjusting for taxation and inflation. To the right, columns for 5% to 25% show $k_i$ values with returns adjusted for 30% tax on earnings and a low but not negligible rate of 3.5% p.a. for inflation. The formula used to adjust for taxation and inflation is:

Equation 4  Inflation and taxation adjustment formula

$$V_D = V_0 \left[ \frac{(1 + R(1 - t))}{1 + i} \right]^D$$

where $V_D$ is the value of investment principal $V_0$ after delay $D$, $R$ is the interest rate, $i$ is the inflation rate and $t$ is the marginal tax rate.

Table 2.1 (p. 57) showed that unadjusted $k_i$ values increase for longer terms. In Table 3.4, all unadjusted $k_i$ values are positive, implying that all depicted returns would all have positive utility compared to the immediate value of the investment principal for someone who does not delay discount at all.
Table 3.4 Values for $k_i$ adjusted for inflation and taxation

<table>
<thead>
<tr>
<th>Percent per annum compound return paid yearly</th>
<th>5%</th>
<th>10%</th>
<th>15%</th>
<th>2%</th>
<th>4%</th>
<th>5%</th>
<th>5.72%</th>
<th>10%</th>
<th>15%</th>
<th>20%</th>
<th>25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years</td>
<td>$k_i$ values unadjusted</td>
<td>$k_i$ values adjusted for 30% tax and 3.5% p.a. inflation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>.050</td>
<td>.100</td>
<td>.150</td>
<td>-.020</td>
<td>-.007</td>
<td>.000</td>
<td>.005</td>
<td>.034</td>
<td>.068</td>
<td>.101</td>
<td>.135</td>
</tr>
<tr>
<td>2</td>
<td>.051</td>
<td>.105</td>
<td>.161</td>
<td>-.020</td>
<td>-.007</td>
<td>.000</td>
<td>.005</td>
<td>.034</td>
<td>.070</td>
<td>.107</td>
<td>.144</td>
</tr>
<tr>
<td>3</td>
<td>.053</td>
<td>.110</td>
<td>.174</td>
<td>-.020</td>
<td>-.007</td>
<td>.000</td>
<td>.005</td>
<td>.035</td>
<td>.072</td>
<td>.112</td>
<td>.154</td>
</tr>
<tr>
<td>4</td>
<td>.054</td>
<td>.116</td>
<td>.187</td>
<td>-.020</td>
<td>-.007</td>
<td>.000</td>
<td>.005</td>
<td>.036</td>
<td>.075</td>
<td>.118</td>
<td>.165</td>
</tr>
<tr>
<td>5</td>
<td>.055</td>
<td>.122</td>
<td>.202</td>
<td>-.019</td>
<td>-.007</td>
<td>.000</td>
<td>.005</td>
<td>.036</td>
<td>.077</td>
<td>.124</td>
<td>.177</td>
</tr>
<tr>
<td>6</td>
<td>.057</td>
<td>.129</td>
<td>.219</td>
<td>-.019</td>
<td>-.007</td>
<td>.000</td>
<td>.005</td>
<td>.037</td>
<td>.080</td>
<td>.131</td>
<td>.190</td>
</tr>
<tr>
<td>7</td>
<td>.058</td>
<td>.136</td>
<td>.237</td>
<td>-.019</td>
<td>-.007</td>
<td>.000</td>
<td>.005</td>
<td>.037</td>
<td>.083</td>
<td>.138</td>
<td>.204</td>
</tr>
<tr>
<td>8</td>
<td>.060</td>
<td>.143</td>
<td>.257</td>
<td>-.019</td>
<td>-.007</td>
<td>.000</td>
<td>.005</td>
<td>.038</td>
<td>.086</td>
<td>.146</td>
<td>.220</td>
</tr>
<tr>
<td>9</td>
<td>.061</td>
<td>.151</td>
<td>.280</td>
<td>-.019</td>
<td>-.007</td>
<td>.000</td>
<td>.005</td>
<td>.039</td>
<td>.089</td>
<td>.154</td>
<td>.237</td>
</tr>
<tr>
<td>10</td>
<td>.063</td>
<td>.159</td>
<td>.305</td>
<td>-.019</td>
<td>-.007</td>
<td>.000</td>
<td>.005</td>
<td>.039</td>
<td>.092</td>
<td>.163</td>
<td>.256</td>
</tr>
</tbody>
</table>

Within a limited range of percentage returns (in Table 3.4: from 4.00 to 5.72% p.a. compound paid yearly), $k_i$ values for adjusted returns remain effectively constant across terms, indicating that the present value of the hyperbolically delay discounted return after tax and inflation will not change with time. Within this range of interest rates, the subjective value of the investments would remain constant regardless of the delay. It is easy to imagine returns from these very low (almost zero) $k_i$ investments being rejected because the investor’s own, personal rate of $k$ will be higher than $k_i$ if the investor delay discounts appreciably.

At 30% tax and 3.5% p.a. inflation, investment returns below 5% p.a. show negative $k_i$ values, indicating that the perceived value of all net investment returns would be lower
than the perceived value of the immediately available principal. Any investor, including imaginary people who do not discount at all, would consider these investment returns as having lower subjective value than the immediate value of the principal. However, even the negative $k_i$ values increase with time when the percentage return is low enough for changes to be apparent. As in Table 2.1, it appears that longer investment terms always provide $k_i$ values that are no lower than $k_i$ for shorter term investments, even after adjusting for taxation and inflation. Increased attractiveness of longer term investment still holds after adjustment for taxation and inflation, even if longer terms only reduce unattractiveness. In general, the perceived value of an investment improves with time when a constant rate of hyperbolic delay discounting is applied to the prospective returns.

The much lower $k_i$ values for the adjusted returns in Table 3.4 compared with unadjusted returns would make the net returns subjectively unattractive compared with gross returns. Given the choice between investing and spending windfalls with payout information provided, fewer people would be expected to choose the investment option when returns are adjusted for tax and inflation compared with unadjusted, gross returns. The practical implication of Table 3.4 is that adjusting returns for conventional rates of taxation and inflation will render the investment comparatively unattractive. In principle, longer terms should compensate for hyperbolic delay discounting even after adjustment for taxation and inflation because longer terms have larger $k_i$ values than shorter terms. However, increments to $k_i$ values are so much smaller when returns are adjusted for taxation and inflation compared with unadjusted returns (see Table 2.1) that the perceived increase in subjective value of adjusted returns longer terms could be very slight, and perhaps insufficient to affect decisions except at very high interest.
Experiment 3 replicates the methodology of Experiment 1, and Experiment 2 except that the returns are adjusted for tax and inflation. The experiment was a 3 x 4 x 4 factorial design, with the following within-groups factors and levels:

1. Windfall amount – $2,000, $5,000 and $8,000. Windfalls of $1,000 were not used because the first two experiments found them to be unappealing for investment.

2. Interest rate – 10%, 15%, 20% and 25% p.a. compound interest paid yearly. Lower interest rates were avoided because their $k_i$ values hardly increase with time, and therefore could only contribute an unnoticeable effect. Yearly interest facilitated the use of Equation 4 for generating items.

3. Investment term – 2, 4, 6 and 8 years. These values were chosen to avoid very short terms such as 1 year, and longer terms which Experiment 2 showed could generate idiosyncratic responses.

Presentation order was an additional, between-groups factor serving to counterbalance order effects.

**Predictions for Experiment 3**

1. Longer term investments will be increasingly attractive compared with shorter term investments, assuming that a constant rate of hyperbolic discounting is applied to future returns. However, the term effect is likely to be attenuated if not nullified in comparison with the first two experiments, for which no adjustments for taxation and inflation were made.
Chapter 3 – Attractiveness of longer term investments

2. Higher interest obviously will render the investment option more attractive than lower interest.

3. Larger windfalls should be more attractive for investment than smaller windfalls because of reduced discounting for larger amounts compared with smaller amounts.

Method

Participants
Data were collected from 62 undergraduate psychology students participating for course credit, 43 (69%) of whom were female. Mean age was 19.15 years with SD = 2.35.

Design and procedure
The same computerised task and similar scenarios were used as for the first two experiments. Participants were offered a hypothetical windfall along with an investment term and final payout information, always net after 30% tax and 3.5% inflation. They chose whether to invest the windfall or, for the alternative option, to spend the entire amount or leave some or all of it at-call but earning zero interest. The spending option allowed keeping the windfall at-call in order to reduce the effects of diminishing marginal utility because participants no longer had to spend the full amount of the windfall quickly. They could retain immediate access to the money, although without additional financial reward. Interest rates for the investment options were not shown. The ascending order condition cycled upwards through term, interest rate and windfall amount in that order (incrementing fastest to slowest). The ascending order condition consisted of 32 participants. The descending order condition (n = 30) received the same items presented in
reverse order. On-screen instructions to participants and the first scenario in the forward order follow:

Imagine you have just received an unexpected windfall. You could invest all of the money. If you do, you can’t spend any of it throughout the investment term. All interest is reinvested, so you can’t spend the interest either.

Alternatively, you could spend some of the money and leave what’s left in an at-call account earning zero interest. With this option you can enjoy the money when you want, but you won’t earn interest.

Soon you will make choices for investing various amounts of money, or alternatively spending the money or leaving it in a zero-interest at-call account, but available to spend.

For the investment options, the amount of money you would receive at the end is shown. It includes all of the money you invest, plus all interest. These amounts are adjusted for taxation and inflation so they show the future spending power in today’s dollars that you would have at the end of the investment.

Various amounts of windfall and investment term will be shown. Interest rates will vary but they are not shown. Assume there is no risk to your money with any investment option. Also assume you are financially secure, with adequate income and no debts.

Assume you have two options for a $2,000 windfall.

Option A: Spend the $2,000 or keep it at-call.
Option B: Invest the entire $2,000 for 2 years.

Which investment option would you prefer, Option A or Option B?

Option A
Spend all or part of the $2,000, keeping any remaining money in an at-call account earning zero interest.

Option B
Invest the $2,000 for 2 years. After 2 years you receive the spending power of $2,138.

Results

Preference reversal patterns

Table 3.5 shows the patterns of switching for the two response options (spending and investing) as investment term increased. For example, “All spend” indicates that participants chose to spend rather than invest for the 2, 4, 6 and 8-year terms with the specified combination of investment principal and interest rate. “Spend, invest” indicates participants who switched from a spending response to an investment response as term increased within a 2 to 8-year series.
### Table 3.5  
Response patterns – Experiment 3

<table>
<thead>
<tr>
<th>N = 62</th>
<th>$2,000 windfall</th>
<th>10% p.a.</th>
<th>15% p.a.</th>
<th>20% p.a.</th>
<th>25% p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>All spend</td>
<td>58%</td>
<td>42%</td>
<td>32%</td>
<td>53%</td>
<td></td>
</tr>
<tr>
<td>All invest</td>
<td>15%</td>
<td>23%</td>
<td>32%</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Spend, invest*</td>
<td>5%</td>
<td>10%</td>
<td>16%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Invest, spend</td>
<td>19%</td>
<td>21%</td>
<td>19%</td>
<td>23%</td>
<td></td>
</tr>
<tr>
<td>Spend, invest, spend</td>
<td>0%</td>
<td>3%</td>
<td>0%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Invest, spend, invest</td>
<td>2%</td>
<td>2%</td>
<td>0%</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$5,000 windfall</th>
<th>10% p.a.</th>
<th>15% p.a.</th>
<th>20% p.a.</th>
<th>25% p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>All spend</td>
<td>26%</td>
<td>15%</td>
<td>45%</td>
<td>8%</td>
</tr>
<tr>
<td>All invest</td>
<td>32%</td>
<td>50%</td>
<td>19%</td>
<td>53%</td>
</tr>
<tr>
<td>Spend, invest*</td>
<td>15%</td>
<td>8%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Invest, spend</td>
<td>23%</td>
<td>21%</td>
<td>15%</td>
<td>21%</td>
</tr>
<tr>
<td>Spend, invest, spend</td>
<td>5%</td>
<td>2%</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Invest, spend, invest</td>
<td>0%</td>
<td>2%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>Other</td>
<td>0%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Decisions always to invest or always to spend commonly occurred within a series. These response patterns are consistent with increments to $k_i$ values being too small in the inflation and taxation adjusted scenarios to elicit a change in response. Where preference reversals did occur, the predicted pattern of spending for the shorter term and investing for the longer term rarely predominated. The alternative reversal, from investing for short terms to spending instead of investing for longer terms often predominated despite this switch running contrary to predictions based on constant rates of hyperbolic discounting of adjusted compound interest returns. These patterns provide little if any support for the notion that hyperbolic discounting predicts patterns of investment decisions when scenarios are adjusted for moderate rates of inflation and taxation.

*Factorial analysis of responses*

A 4-way ANOVA with presentation order the between-groups factor and investment amount, percentage return and term the repeat factors examined responses combined across participants. Figure 3.4 illustrates main effect results.
Figure 3.4 shows that:

a) The ascending order condition chose to invest for more scenarios than the descending order condition, $F(1, 60) = 18.72, p = .0001$.

b) Increasing percentage return rendered the investment options more attractive, $\Lambda(3, 58) = .72, p = .0002$, which is unsurprising.

c) Increasing windfall amount was associated with increased willingness to invest rather than spend, $\Lambda(2, 59) = .38, p < .0001$. 
d) The important trend for investment term was not significant, $\Lambda(3, 58) = 0.96, p = 0.5312$. Longer term investments were no more attractive, and descriptively were less attractive than shorter term investments.

The amount by term interaction is illustrated in Figure 3.5. Although this interaction was significant, $\Lambda(6, 55) = 0.74, p = 0.0079$, descriptively the trend for investment term never demonstrates the predicted increase in willingness to invest for longer terms regardless of the windfall amount. The appeal of $2,000 investments seems to have diminished with time.

![Figure 3.5](image)

Figure 3.5  Investment amount by term interaction – Experiment 3

**Discussion**

The prediction of increased willingness to invest for longer terms, based on hyperbolic delay discounting of compound interest growth, did not occur when returns were presented as “today’s dollars,” adjusted for taxation and inflation. However, this result is plausible even with hyperbolic delay discounting because $k_i$ values associated with the adjusted
returns incremented only slightly with increased term. The additional net value provided by longer terms may have been too slight for subjective importance. Translated into real investment decisions, the above results would have long term investments showing no additional appeal over short term investment alternatives at the same rate of interest when net returns are displayed after 3.5% inflation and a 30% marginal taxation rate.

An element of the current experiment which could have affected results was the allowance for indefinite parking of the windfall in an at-call account, albeit with zero interest. This feature may have increased the attractiveness of the so-called spending option compared with earlier experiments for which the windfall, if spent, had to be spent fairly quickly. The increased convenience of the spend-or-park option compared with earlier experiments with a time limit for spending may have militated against investing. Leaving money at-call is a genuine possibility with real windfalls. This aspect of the current experiment reflects the choices people have when they suddenly receive a substantial amount of money. However, permission to park the windfall at-call cannot account for the inability of longer term investments to attract more respondents, whereas the relative uniformity of $k_i$ across terms for adjusted returns readily explains this finding.

Participants were more willing to invest larger than smaller windfalls, presumably because of reduced discounting of larger rewards. Not surprisingly, increased percentage return was associated with increased willingness to invest rather than spend the hypothetical windfalls. Increased popularity of the investment option for the ascending order condition is consistent with the previous two experiments. Greater preference for investing with the ascending order condition compared with investments in descending order also matches findings from the first two experiments, and from Loewenstein and Prelec (1993).
The main conclusion from the current experiment is that adjusting investment returns for reasonable rates of taxation and inflation can diminish if not eliminate the increased attractiveness of longer term returns predicted from the combined effects of hyperbolic delay discounting and compound interest growth. Experiment 3 suggests that investments with moderate terms, credible interest rates, and returns adjusted for plausible rates of taxation and inflation do not grow sufficiently to offset delay discounting. Delay discounting would readily explain people’s reluctance to invest, to the extent that they realise how taxation and inflation reduce the value of net investment returns compared with gross returns. Unless the investor delay discounts at a very low rate, net returns, which indicate future spending power, are not worth the wait.
Summary of Chapter 3

The above three experiments tested the principal hypothesis developed in Chapter 2, which maintained that longer term investments will be more attractive than shorter term investments earning the same rate of compound interest because long term exponential growth is better able to compensate for hyperbolic delay discounting than short term growth. It was also predicted that returns from larger investments would be more attractive than smaller investment returns at the same rate of interest owing to reduced delay discounting of larger rewards, and possibly also the inconvenience of quickly spending large amounts. This second hypothesis was supported without controversy.

A summary of delay discounting results arising from investment term effects, and relevant to the first hypothesis, follows:

- Experiment 1 found that longer terms were more attractive to potential investors than shorter terms, consistent with hyperbolic delay discounting of compound interest returns. Increased attractiveness was measured by the increased willingness to spend rather than invest a hypothetical windfall. The majority of preference reversals conformed to the predicted pattern of changing from spending to investing the windfall when terms increased. These results applied to investments of $2,000 to $5,000 for 1 to 5 years with 10% p.a. interest, but not the $1,000 investments. It appears that participants did not consider the $1,000 as worth investing, especially for longer terms.

- Experiment 2 replicated the design of Experiment 1, with additions such as terms extending to 20 years; first providing scenarios without payout information, then again with payouts; interest rates of 5%, 10% and 15% p.a., and larger windfall...
amounts to a maximum of $10,000. The term effect ran contrary to predictions, probably because the protracted terms exceeded the student participants’ time horizons. The students appeared to discount returns from extended terms very strongly. Showing investment payouts increased willingness to invest for 10 to 20-year terms, but had the opposite effect for the shortest (5-year) terms. Some participants reacted as if they overestimated the 5-year returns and underestimated longer term returns. Hyperbolic delay discounting may apply only to a restricted range of investment amounts (e.g., ≥ $2,000 – see also Experiment 1) and terms (≤ 10 years), possibly because larger amounts and terms are difficult to comprehend. Amounts smaller than $2,000 were regarded as too trivial to invest and may as well be spent. Responses to very long term investments did indicate delay discounting per se, but not hyperbolic delay discounting at a constant rate.

- Experiment 3 resembled the first two experiments, with returns adjusted for moderate rates of taxation and inflation. A theoretical demonstration showed that the prediction of increased attractiveness of longer terms should apply to adjusted returns above a threshold rate of interest, but increments to \( k_i \) were so slight that the predicted effects of hyperbolic delay discounting of compound interest returns were likely to be attenuated. This was indeed the case, with no significant effect of term on willingness to invest, even though interest rates for the experiment were kept high to maintain the appeal of the investments. Adjustment for 30% taxation and 3.5% inflation flattened investment net growth to the extent that longer investment terms had no incremental appeal, contrary to the result with gross returns in Experiment 1. This result has practical implications because it suggests that presenting net returns from long term investments adjusted for a typical taxation rate and reasonably low
Chapter 3 – Attractiveness of longer term investments

inflation will not encourage people to invest, even when interest rates are high. Low interest rates coupled with high inflation and taxation could ensure that adjusted returns have negative appeal even for people who discount at low rates. For realistic investment scenarios, many people may not consider net returns worth the wait.
Chapter 4 – Delay Discounting Experiments Using $k_i$ to Predict Appraisals of Compound Interest Returns

This chapter continues the investigation of hyperbolic delay discounting of compound investment returns. The previous chapter tested the hypothesis that longer term investments will have increased appeal compared with shorter term investments. Because investment growth from compound interest accelerates with time while reduction in subjective value from hyperbolic delay discounting decelerates, longer investment terms would better compensate for delay discounting. Preferences would change from spending to investing as prospective terms increase. The development of this prediction utilised the $k_i$ parameter, which represents the rate of hyperbolic delay discounting exactly compensating for compound interest growth at a specified interest rate and term. If an investor delay discounts at a lower rate than $k_i$, investment returns will have subjectively appreciated with time, and therefore should appear worth the wait. If the investor delay discounts at a rate higher than $k_i$, the investment will have subjectively depreciated with time despite growth in actual value. The returns will probably not seem worthwhile.

Chapter 3 experiments tested whether investments with higher $k_i$ values have additional appeal compared with lower $k_i$ investments under conditions where $k_i$ was increased by lengthening the investment term – see Table 2.1. With its emphasis on investment term, Chapter 3 represents a special case of using $k_i$ to predict preferences for investing or spending a windfall. Using investment term indirectly to manipulate $k_i$ facilitated investment simulations resembling real world situations, such as whether to invest or spend a windfall, and targeted the practical issue of long term investment and its appeal.
Chapter 4 – The $k_i$ parameter as a predictor of investment choice

The next three experiments explore the $k_i$ parameter as a direct predictor of investment choice, and not only via its relationship with investment term. In the following experiments, some scenarios will have higher $k_i$ associated with shorter terms, unlike the Chapter 3 experiments where higher $k_i$ investments had longer terms at the same rate of interest. The basic hypothesis remains that $k_i$ will predict investment appraisals, dominating even that most obvious source of value – the interest rate. Moreover, investments having equal $k_i$ values should have equal subjective appeal regardless of their other properties, assuming that future rewards are delay discounted hyperbolically at a constant rate. The sensitivity of investment appraisals to $k_i$ will be compared with the normative model of exponential delay discounting in the expectation that $k_i$, with its hyperbolic delay discounting foundation, will better predict responses than the exponential model, consistent with other discounting research. The final delay discounting experiment in this series breaks the link between investment term and returns by fixing payouts at a single value, thereby removing the confound between delay and returns that occurs with more conventionally stated investment scenarios such as those in Chapter 3.

The experiments reported below involve $k_i$ directly as a design factor. This strategy necessitated a departure from the “spend or invest a windfall” scenarios used in Chapter 3. Other experimental designs were needed to test the generality of predictions based on $k_i$. The experimental designs often involve comparisons between pairs of investments, with participants recording their preferred of the two scenarios. Nevertheless, every experiment placed the scenarios within a plausible investment context and imposed the canonical dilemma of whether to choose a smaller, sooner reward or a larger, later reward. This dilemma is fundamental to delay discounting research, and to everyday life.
Experiment 4: Preference for Investments With Higher $k_i$

This experiment offers a straightforward test of whether prospective compound interest returns are delay discounted hyperbolically. It tests whether investments with higher $k_i$ values will be preferred to investments with lower $k_i$ irrespective of the term. The experiment seeks a preference reversal within a series of hypothetical investment scenarios, and makes a specific prediction about the location in the series at which the preference reversal will occur. The preference reversal location is predicted from $k_i$, as described below. Preference reversals occurring at the expected location in the series will serve as evidence that compound interest returns are delay discounted hyperbolically.

Consider Table 4.1, which shows gross returns on 2-year and 5-year compound interest investments of $10,000. Values for $k_i$ are shown to the left of each return. As $k_i$ increases, the underlying compound interest rate (shown as % p.a.) increases, because the term is held constant within each column.

Table 4.1 Pairs of investments with 2 and 5-year terms with reversed orders of $k_i$ – Experiment 4

<table>
<thead>
<tr>
<th>$k_i$</th>
<th>2-year term</th>
<th>5-year term</th>
<th>$k_i$</th>
<th>Return</th>
<th>% p.a.</th>
<th>Return</th>
<th>% p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.31</td>
<td>14,542</td>
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Chapter 4 – The $k_i$ parameter as a predictor of investment choice

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<th>$k_i$</th>
<th>2-year term</th>
<th>% p.a.</th>
<th>5-year term</th>
<th>% p.a.</th>
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</table>
For each term, \( k_i \) runs in opposite directions for successive rows. Returns and \( k_i \) decrease for successive rows of the 2-year term and increase for the 5-year term. The 5-year term always pays a higher final return than the 2-year term, so there is always extra gain for extra delay. With successive rows down the table, the payout advantage of the 5-year term increases compared with the 2-year term. The question is whether the extra gain for the 5-year term is sufficient to make it preferable to the 2-year term.

Decision-makers who delay discount hyperbolically should prefer the investment with the higher \( k_i \). When evaluating successive rows down the table they should begin by preferring the 2-year term to the 5-year term, preferring to receive $14,542 after 2 years rather than $15,000 after 5 years. Below the double underline on the table, the higher \( k_i \) value shifts to the 5-year investments. The 5-year term should be preferred to the 2-year term below the double line.

The prediction for Experiment 4 is that participants presented with successive 2-year and 5-year investments as shown in Table 4.1 should change preference between terms (to whichever has the higher \( k_i \)) at the hyperbolic delay discounting point of indifference, where \( k_i \) changes from 0.20 to 0.21 in the table. If this prediction is upheld, the experiment provides evidence that compound interest returns are delay discounted hyperbolically, using a different experimental design from the Chapter 3 experiments reported above.

The experiment also enables comparison between the hyperbolic delay discounting model as applied to compound interest returns, and the normative exponential discounting model of classical economics. A strict interpretation of Figure 2.5 (see p. 50) and associated discussion implies that the exponential discounting model has the interest rate alone and not \( k_i \) (which includes a term parameter) predicting the subjective value of prospective investment returns. When an individual discounts exponentially at a lower rate than the
compound interest rate, returns for any term should appear subjectively superior to the immediate value of the principal; and when an individual discounts exponentially at a rate higher than the interest rate, the investment subjectively depreciates for all terms. Extending the term only magnifies and does not reverse the discrepancies between the perceived value of future returns and the immediate value of the principal. Assuming experimental participants’ sensitivity to all discrepancies between subjective value of the prospective returns and immediate value of the principal, they would choose investments solely on the basis of interest rates without reference to term, if they delay discount exponentially. In Table 4.1 the broken line indicates the predicted preference reversal point for exponential delay discounters by marking the point at which the higher interest rate switches between the 2 and 5-year terms.

The experiment below identifies preference reversal points for a sample of undergraduate participants and examines whether the mean preference reversal occurs closer to that predicted for hyperbolic or for exponential delay discounting. The prediction, based on the apparent ubiquity of hyperbolic delay discounting, is that investment preferences will follow the \( k_i \) parameter rather than the interest rate.

**Method**

**Participants**

Sixty-one undergraduate psychology students participating for course credit were tested, of whom 50 (82\%) were female, 7 male and 4 with gender and age not matched to experimental data. Mean age was 18.88 years (\( SD = 2.20 \), \( N = 57 \)).
**Design and procedure**

In a computerised binary-choice task, the 31 successive investment pairs from Table 4.1 were presented one pair at a time. Dollar returns and not percentage returns were shown.

For each pair of investments within a presentation, participants recorded whether they preferred the 2-year or the 5-year investment. The order of presentation was counterbalanced on a between-groups basis. Thirty-two participants received scenarios in forward order with increasing $k_i$ for 5-year investments, and 29 in reverse order with decreasing $k_i$ for 5-year investments. Participants were not obliged to change preference. They could have changed preference from the higher to the lower $k_i$ had they wanted, and multiple preference changes were permitted. Experimental instructions and the first pair of investments for the forward order condition from Table 4.1 are shown below.

Imagine you have received a $10,000 windfall. You may have won a competition or received an inheritance from a distant relative. You decide to invest the entire $10,000. One option is to invest for 2 years. Alternatively you could invest for 5 years. The 5-year investment will always be worth more at the end than the 2-year investment, but you have to wait longer for the extra money.

Soon you will make a series of choices for investing $10,000 for 2 years or 5 years. You will see how much money you would receive at the end of the 2-year investment and the alternative 5-year investment. Money you receive includes the $10,000 you invest.

You are asked to choose between the 2-year investment and 5-year investment. Assume the $10,000 you invest will be “locked up” so you can’t spend it for the duration of the investment. After the investment you can do whatever you like with the money. Ignore issues such as taxation, fees and charges, and inflation. Assume no risk to your investment – you cannot lose money.

Assume that you have two options for investing $10,000.

- **Option A** is a 2-year investment.
  - Invest $10,000 for 2 years and receive $14,542

- **Option B** is a 5-year investment.
  - Invest $10,000 for 5 years and receive $15,000
Chapter 4 – The $k_i$ parameter as a predictor of investment choice

Results

Recall that only one switch within the series should occur, with participants expected to change preferences from the 2-year investment to the 5-year investment (forward order) or the 5-year investment to the 2-year investment (reverse order). Fifty-one participants (84%) performed the requisite single switch, with no participants switching once in a direction contrary to predictions. Two participants (3%) chose the 5-year investment throughout, not switching at all; no participants chose 2-year investments exclusively; 2 participants switched twice; 3 (5%) switched three times; 1 (2%) switched four times and 2 switched five times.

The next analysis includes only participants who switched once in the expected direction. The analysis identifies the point within the sequence of scenarios at which respondents tended to switch. Preferences were predicted always to favour the investment with the higher $k_i$ value. This prediction required them to switch from the 2-year investment at the 11th row pair of investments in Table 4.1 to the 5-year investment at the 12th row; or from the 5-year to the 2-year investment at the same location for items presented in reverse order. Figure 4.1 shows actual responses as the percentage choosing the 5-year term. The solid vertical line in the graph represents the predicted switch point for hyperbolic delay discounting, where higher $k_i$ changes between the 2 and 5-year investments. To the left of the switch point, $k_i$ for the 2-year investment exceeds $k_i$ for the 5-year investment, so the 2-year investment should always be chosen (0% choosing the 5-year investment). To the right of the predicted switch point, $k_i$ for the 5-year investment exceeds the 2-year $k_i$, so the 5-year investment should always be chosen.
Figure 4.1 Preference for 5-year investment pair by values of $k_i$ – Experiment 4

The broken line represents the location in the series where the higher interest rate changes from the 2-year to the 5-year investment. If participants delay discounted prospective returns exponentially, they would change their preference at this location rather than the solid vertical line.

As shown in Figure 4.1, preferences for the 5-year investments increased as their $k_i$ values increased relative to $k_i$ for the 2-year investment. A sharp increase in perceived favourability of the 5-year investment is apparent prior to the point at which 5-year $k_i$ values exceed $k_i$ values for the 2-year investment. From left to right in the graph, preference reversals accumulate before the hyperbolic delay discounting prediction line, and are 70% complete by that location. Relatively few additional preference reversals occur near the broken line representing the exponential discounting preference reversal point. The hyperbolic delay discounting preference reversal prediction appears to follow actual preferences better than the exponential delay discounting prediction.
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Figure 4.2 shows the percentage of participants responding consistently with predictions based on hyperbolic delay discounting of compound interest returns. These participants chose the investment with the higher $k_i$. When differences between $k_i$ values for the 2 and 5-year investments were at their greatest, at the extremes of the horizontal axis, most or all participants chose the predicted investment. Predictions were least accurate for 2-year investments where $k_i$ was marginally higher than for the corresponding 5-year investment. This result applies both to the forward and reverse order investments, but especially for the forward order. The results show that many of the forward order participants switched preferences to the 5-year investment just before the predicted point. Many of the reverse order participants switched just after the predicted point – recall that presentation of reverse order items runs from right to left on the graph. Clearly, there is variation between participants in the point at which they switched, although descriptively the predicted point where pairs of $k_i$ values converged seems to represent a pivotal zone in the data.

![Graph showing consistency of choices with predictions from hyperbolic delay discounting of compound interest returns – Experiment 4](image)

Figure 4.2 Consistency of choices with predictions from hyperbolic delay discounting of compound interest returns – Experiment 4
For each participant, the mean of the two $k_i$ values for the 2-year investment before and after their preference change were used to estimate $k_i$ for that participant’s preference reversal. The mean $k_i$ of these estimates across all participants was 0.209 ($SD = 0.08$), when the predicted value based on hyperbolic delay discounting of compound returns would have been 0.205. Therefore, predicted and actual mean values were close and within the 95% confidence interval for the mean, which ranged from 0.19 to 0.23. The predicted switch location for exponential delay discounting, based on interest rate alone, lies outside the 95% confidence interval. Mean preference changes converged on the point predicted by hyperbolic delay discounting of compound interest returns, and not on exponential delay discounting.

Forward order participants, on average, switched at a 2-year $k_i$ of 0.24 ($SD = 0.05$), slightly higher than the corresponding $k_i$ for the 5-year investment. Reverse order participants on average switched at $k_i = 0.18$ ($SD = 0.09$). Taking into account order of presentation, each group tended to switch a few items prior to the predicted switching point. The difference in switching points between forward and reverse groups was significant, $t(36.35) = 2.67, p = .0111$. This result suggests that participants changed their preferences when underlying $k_i$ values became so close as to be indistinguishable, which must have occurred a few items prior to the $k_i$ values’ point true of equality.

**Discussion**

Results for Experiment 4 support the hypothesis that investments with higher $k_i$ values are preferred to investments with lower $k_i$ values regardless of the term and the difference between payouts. Participants did not always choose the shorter term, and did not always choose the higher payout from the longer term. Interest rate alone predicted preference
reversals less well than $k_i$. Participants apparently accounted for the investment term and
not just the interest rate when choosing their preferred investment, consistent with
hyperbolic delay discounting of compound interest returns rather than exponential
discounting. The tendency for participants to prefer the 5-year investment when its $k_i$ value
is just slightly lower than for the corresponding 2-year investment could be attributed to a
reduced rate of discounting for the higher future reward, which would bias responses
towards the larger reward despite the longer delay. Figure 4.2 suggests a bias towards the
larger reward, evidenced by its prevailing into the 2-year preference zone.

Investments with equal $k_i$ values appear to have equal subjective value because for the
entire sample the mean point of indifference between the 2-year and 5-year terms
corresponded to the point of equality between 2-year and 5-year $k_i$ values, even though
investments at that point earned different rates of interest and had different terms.

Experiment 6 further explores the issue of subjective equality of returns from investments
having the same $k_i$ value. According to the current experiment, the hyperbolic delay
discounting model appears well to predict comparisons between compound interest
investments, and predicts preferences better than the normative exponential model.
Experiment 5: Comparison of the Hyperbolic Delay Discounting Model With the Normative Exponential Discounting Model

This experiment examines the predictability of investment decisions based on $k_i$. The basis for Experiment 5 is the now familiar prediction that people should prefer investments with higher $k_i$ values. The previous experiment found in favour of this prediction. The aim of the current experiment is again to test whether $k_i$ and the hyperbolic delay discounting model predict the appraisal of investment returns better than an alternative, normative exponential delay discounting model. The experiment also allows testing of Chapter 3 predictions, namely that returns from longer term investments will be more attractive than for shorter investments at the same interest rate, again because of hyperbolic delay discounting; and that returns from larger investments will be more attractive than from smaller investments at the same interest rating, because of reduced discounting of larger rewards.

The experiment presented participants with a range of investment scenarios where there was some overlap in $k_i$ values across different rates of interest. Specifically, when compound interest paid yearly ranges from 5% p.a. to 14% p.a. and terms range from 1 to 10 years, it happens that $k_i$ values for the 10-year return can exceed $k_i$ for a shorter term although the shorter term interest rate is higher. A larger value for $k_i$ should make the longer term, lower interest investment more attractive than a shorter term, higher interest investment, even though the latter may appear superficially attractive because of the reduced delay and higher rate of return. Of course, this prediction assumes hyperbolic delay discounting of the returns.

Higher $k_i$ for a longer term, lower interest investment compared with shorter term, higher interest alternatives can happen because the longer term of the lower interest investment
Chapter 4 – The $k_i$ parameter as a predictor of investment choice

makes better use of compounding than the shorter term, higher interest investment. More money is earned per unit time with the longer term despite lower interest. The additional return per unit time boosts $k_i$.

The upper half of Table 4.2 shows returns from specified rates of compound interest paid yearly for 1 to 10-year terms. The lower half of Table 4.2 shows the associated $k_i$ values. Within each level of interest (column of investments) longer terms have higher $k_i$ values. Underlined $k_i$ values are less than or equal to $k_i$ for the 10-year investment for the preceding column (to the left) which pays 1% p.a. less interest. For example, at 5% p.a. for 10 years the associated $k_i$ is 0.063. All $k_i$ values for terms up to 2 years at 6% are less than 0.063. If someone who delay discounts at a constant hyperbolic rate were to consider the $629 return from a 10-year $1,000 investment at 5% p.a. as sufficient reward for the delay, they would also accept the returns from all of the other investments where the interest rate is at least 6% and the term at least 3 years because all combinations of interest and term of $\geq 6\%$ and $\geq 3$ years have $k_i$ values $> 0.063$. Conversely, anyone who considers the return from 5% p.a. and 10 years as inadequate should also reject investments up to 2 years at 6% p.a. Other predictions of acceptability of various combinations of term and interest rate can be readily adduced from the table according to the principle that hyperbolic delay discounters will prefer investments with higher $k_i$ values to investments with lower $k_i$. 
Table 4.2 Returns from a $1,000 investment, and associated $k_i$ values for combinations of interest and term

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<th>5%</th>
<th>6%</th>
<th>7%</th>
<th>8%</th>
<th>9%</th>
<th>10%</th>
<th>11%</th>
<th>12%</th>
<th>13%</th>
<th>14%</th>
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<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
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<td>14%</td>
<td>15%</td>
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$k_i$ associated with each return:

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<td>0.151</td>
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<tr>
<td>10</td>
<td>0.063</td>
<td>0.079</td>
<td>0.097</td>
<td>0.116</td>
<td>0.137</td>
<td>0.159</td>
<td>0.184</td>
<td>0.211</td>
<td>0.239</td>
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</tbody>
</table>
Chapter 4 – The $k_i$ parameter as a predictor of investment choice

One problem with using Table 4.2 to predict acceptability of combinations of term and interest rate is that $k_i$ values change only slightly from year to year within a level of interest. The changes may be less than the just noticeable difference. If participants do not respond as predicted, it could be because the investments with similar rates of interest have indistinguishable $k_i$ values. In other words, returns per unit time could be too close to permit discrimination. This issue has practical implications, because the combinations of investment amount, interest rate and term shown in the table are realistic. Including lower rates of return, for example, down to 1% p.a. in the scenarios, would aggravate the problem because increments to $k_i$ with each year diminish with reduced interest. Overall, this issue indicates that the current experiment is conservative with its predictions. If $k_i$ predicts the acceptability of the investments, it is despite the relatively small increments to $k_i$ for adjacent scenarios. Very high rates of interest, up to 20% p.a. or more, would provide larger increments to $k_i$ across years, but interest rates at such a level are probably unsustainable over the long term in genuine investments without the considerable risk typically associated with high returns.

Because inflation and taxation are not taken into account in the current scenarios, $k_i$ values differ among the scenarios more than they would if net returns were shown. If participants fail to distinguish between the scenarios according to predictions based on gross returns, they would not distinguish between inflation and taxation-adjusted scenarios. If responses to the current experiment do match predictions based on $k_i$, the findings nevertheless may not transfer to net gains after inflation and taxation owing to the finer increments to $k_i$.

Evidence that investments with higher $k_i$ are preferred to investments with lower $k_i$ across a wide range of terms and interest rates supports the notion that investment returns are delay
discounted hyperbolically, especially if hyperbolic delay discounting predicts responses better than the normative exponential discounting model.

**Method**

**Participants**

These were undergraduate psychology students participating for course credit, consisting of 20 males and 41 females with mean age 19.48 years ($SD = 2.28$).

**Design and procedure**

Scenarios were presented as a repeated measures design with two factors, these being interest rate p.a. (5%-14% compound paid yearly) and term (1 to 10 years) as per Table 4.2. All participants received all 100 investment scenarios.

Two between-groups factors were employed, these being the amount invested ($1,000 or $10,000), and forward or reverse presentation order, described below. The $10,000 investments multiply the principal and the payout by a factor of 10, whilst the associated $k_i$ values remain unchanged. However, reduced discounting of larger rewards could be expected, making returns from $10,000 investments generally more attractive than the $1,000 investments with the same term and interest rate. Eighteen participants received the $1,000 scenarios in ascending order, 13 received $10,000 scenarios in ascending order, 15 received $1,000 scenarios in descending order and 15 received $10,000 scenarios in descending order.

A $1,000 investment was used even though Experiment 1 suggested that investing this amount is unattractive, at least to students. This was less of an issue for the current experiment, with its lack of emphasis on immediate expenditure. Participants merely
appraised the returns as worthwhile or not worthwhile. The advantage of a $1,000
investment for the current experiment is the ease with which participants could compare
returns with the amount invested. The $10,000 investment provided an element of
generalisation to the scenarios, in case responses to the $1,000 principal happened to be
idiosyncratic. The $10,000 investment also enabled easy mental calculation of the return
on investment, and allowed researcher comparisons with the $1,000 investment to
determine whether the amount invested significantly affected preferences.

The forward order scenarios commenced at 14% p.a. with term incremented upwards,
starting at 1 year. That is, investment terms increased within decreasing levels of interest.
The reverse order condition commenced at 5% p.a. with terms decremented, commencing
from 10 years. That is, terms decreased within increasing levels of interest. This ordering
distributed the returns early and late in the presentation more evenly than would occur with
ascending interest coupled with ascending terms and the reverse (descending) alternative.
The more even distribution of returns with successive items was intended to reduce order
effects.

The experimental task was a binary-choice computer task similar to that used for previous
experiments. For each combination of interest rate and term the current experiment sought
appraisals of whether profits were “too low” or “acceptable,” which is a conceptually
similar response proposition to the first three experiments, but without an action (spend or
invest) tied to the decision.

Profits (gross final return minus principal) were shown rather than final returns, because
the returns in particular were being appraised, and to add diversity to the experiments.
Predictions from hyperbolic delay discounting should hold across a range of scenario
varieties to have practical significance. Showing participants the profits also facilitated
appraisal of the return on investment. Interest rates were not shown, to ensure that participants could evaluate only the profits.

Experimental instructions with the first item from the forward order condition and $1,000 principal appear below.

Imagine you are thinking about how to invest $1,000 which you have unexpectedly received. You are willing to invest the money for up to 10 years. But you want an investment that earns enough to justify locking up your money for a while. Otherwise, you may as well spend the money or find a different investment that pays a better return.

Soon you will see investments ranging from 1 to 10 years in duration. Each scenario shows how much profit you would make. You have to decide whether each investment provides a profit which is worth the wait. Profit does not include the $1,000 you invest at the outset. Please ignore taxation, fees, charges and inflation. You get to keep all the profit. Assume no risk to your investment. No matter what, you cannot lose money.

Consider the following scenario:
Invest $1,000 for 1 year and make $140 profit
Is this an acceptable profit from a 1 year investment?

Choose your answer from Option A or Option B below.
Option A
No, the profit is too low.
Option B
Yes, $140 is an acceptable profit from a 1 year investment of $1,000.

Results

Summary of preferences for combinations of interest rate and term

Table 4.3 shows the percentage of participants who considered the profits as worthwhile.

Every combination of term and interest rate is shown.
Percentages of participants accepting the returns ranged from less than 20% for the short and especially medium term, low-interest investments, to more than 70% for the high interest investments. Some participants rejected even highly favourable returns, suggesting unrealistic expectations of genuine investment returns, especially given that returns were presented without adjustment for taxation and inflation, and participants were asked to ignore these issues.

Acceptance of investments was sometimes higher for 1 and 2-year investments compared with 9 and 10-year investments paying 1% p.a. lower interest, even though the 9 and 10-year investments had higher $k_i$ values. This result is contrary to expectations based on hyperbolic delay discounting, which would have acceptance of investments corresponding closely to $k_i$. The finding cannot be attributed to diminished discounting of larger rewards,
which would tend to favour the 9 and 10-year investments over the 1 and 2-year investments paying 1% p.a. more interest. Subsequent analysis explores beyond this descriptive impression.

**Predictions based on \( k_i \)**

For a hyperbolic delay discounting person to accept or reject investment profits consistently, \( k_i \) values associated with rejected investments would have to be lower than \( k_i \) for acceptable investments. On average, the entire sample of 61 participants accepted the returns from 43% of scenarios and rejected 57% (\( SD = 27\% \)). A dependent \( t \) test found that the mean value of \( k_i \) for accepted investments was 0.15 (\( SD = 0.03 \), \( N = 59 \) because 2 participants rejected all investments), a value significantly higher \([t(58) = 12.01, \ p < .0001]\) than the mean \( k_i \) for rejected investments of 0.10 (\( SD = 0.02 \)). This finding is consistent with the prediction that investments with acceptable returns would have higher \( k_i \) than investments whose returns were rated as too low and, therefore, that the investment profits were delay discounted hyperbolically.

The above dependent \( t \) test finds a gross difference in \( k_i \) for accepted and rejected investment profits. Consistent responding would additionally require that all accepted investments have higher \( k_i \) than all rejected investments. This means that the highest \( k_i \) for rejected investments should be lower than the lowest \( k_i \) for accepted investments. However, this criterion is unreasonably strict. The lowest \( k_i \) accepted and the highest \( k_i \) rejected comprise only 2 of the 100 responses from each participant. Such a small sample of items could easily be idiosyncratic. For this reason the analysis will concentrate on mean \( k_i \) of investments accepted and mean \( k_i \) rejected, which together include all 100 scenarios for each participant.
Chapter 4 – The $k_i$ parameter as a predictor of investment choice

The midpoint between the mean $k_i$ accepted and the mean $k_i$ rejected could also serve to estimate each participant’s discount rate parameter applied to the investments. In general, though, results from the midpoint value of $k_i$ were substantively the same as results for mean $k_i$ accepted and mean $k_i$ rejected. Mean $k_i$ for accepted and rejected investments also provides a stricter criterion than the midpoint compromise value, and was adopted for the following analysis.

For consistent decisions among people who delay discount hyperbolically, investments with $k_i$ higher than the mean $k_i$ for rejected investments should be accepted. Investments with $k_i$ lower than the mean $k_i$ for accepted investments value should be rejected. These two principles provide four possible types of response for each scenario.

1. Acceptance consistent with other responses. This will happen when the investment is accepted and its $k_i$ is higher than the mean $k_i$ of rejected investments.

2. Rejection consistent with other responses. This will happen when the investment is rejected, and its $k_i$ is lower than the mean $k_i$ of accepted investments.

3. Acceptance inconsistent with other responses. This occurs when the investment is accepted even though its $k_i$ is lower than or equal to the mean $k_i$ of rejected investments.

4. Rejection inconsistent with other responses. This occurs when the investment is rejected despite its $k_i$ being higher than or equal to the mean $k_i$ of accepted investments.

The above scheme can be interpreted in terms of sensitivity and specificity analysis often used in medical diagnosis or epidemiological research (e.g., Christie, Gordon, & Heller,
For the current purpose, sensitivity is defined as correct acceptance of an investment because the investment has a $k_i$ value which is higher than the participant’s mean $k_i$ rejected. Specificity refers to correctly rejecting an investment because the investment has a $k_i$ value lower than the mean $k_i$ accepted. Incorrectly accepting an investment corresponds to a false positive. Incorrectly rejecting an investment qualifies as a miss.

Table 4.4 shows mean sensitivities calculated according to mean $k_i$ for rejected investments and mean $k_i$ for accepted investments. They are shown as the percentage of participants accepting the investment when its $k_i$ is greater than the mean $k_i$ that the participant had rejected in other investments. Higher percentages indicate greater sensitivity, that is, greater ability to predict the acceptance of an investment return when responses to other investments suggest it will be accepted. Incorrectly rejected investments (i.e., investments that should have been accepted, according to responses to other investments, but were not accepted) contribute to the percentage base and the sample size (N) in the table.

Table 4.4 Mean sensitivity based on mean $k_i$ accepted and mean $k_i$ rejected – Experiment 5

<table>
<thead>
<tr>
<th>Term</th>
<th>Interest rate p.a.</th>
<th>5%</th>
<th>6%</th>
<th>7%</th>
<th>8%</th>
<th>9%</th>
<th>10%</th>
<th>11%</th>
<th>12%</th>
<th>13%</th>
<th>14%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>Sensitivity N</td>
<td>–</td>
<td>–</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>97%</td>
<td>91%</td>
</tr>
<tr>
<td>2 years</td>
<td>Sensitivity N</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>9</td>
<td>18</td>
<td>21</td>
<td>28</td>
<td>36</td>
<td>44</td>
</tr>
<tr>
<td>3 years</td>
<td>Sensitivity N</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>10</td>
<td>21</td>
<td>27</td>
<td>32</td>
<td>42</td>
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<tr>
<td>4 years</td>
<td>Sensitivity N</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>25</td>
<td>30</td>
<td>42</td>
<td>45</td>
<td>49</td>
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</tbody>
</table>
Chapter 4 – The $k_i$ parameter as a predictor of investment choice

<table>
<thead>
<tr>
<th>Term</th>
<th>Sensitivity</th>
<th>5%</th>
<th>6%</th>
<th>7%</th>
<th>8%</th>
<th>9%</th>
<th>10%</th>
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<tbody>
<tr>
<td>5 years</td>
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<td>2</td>
<td>7</td>
<td>8</td>
<td>19</td>
<td>33</td>
<td>42</td>
<td>48</td>
<td>49</td>
<td>54</td>
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<tr>
<td>6 years</td>
<td>N</td>
<td>0</td>
<td>4</td>
<td>7</td>
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<td>34</td>
<td>43</td>
<td>52</td>
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<td>7 years</td>
<td>N</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>14</td>
<td>30</td>
<td>39</td>
<td>45</td>
<td>52</td>
<td>56</td>
<td>59</td>
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<tr>
<td>8 years</td>
<td>N</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>17</td>
<td>31</td>
<td>43</td>
<td>45</td>
<td>56</td>
<td>57</td>
<td>59</td>
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<tr>
<td>9 years</td>
<td>N</td>
<td>1</td>
<td>5</td>
<td>9</td>
<td>22</td>
<td>36</td>
<td>39</td>
<td>50</td>
<td>57</td>
<td>58</td>
<td>59</td>
</tr>
<tr>
<td>10 years</td>
<td>N</td>
<td>1</td>
<td>5</td>
<td>10</td>
<td>26</td>
<td>33</td>
<td>42</td>
<td>54</td>
<td>58</td>
<td>59</td>
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</table>

Relatively few participants contribute to the results for short terms and low interest rates because relatively few participants, if any, had accepted any of the investments at such low levels of $k_i$. As term and interest rate increased, more participants had accepted at least one investment, enabling more comparisons with other decisions for investments with longer terms and even higher interest.

For example, 4 participants correctly accepted the 1-year 7% p.a. investment. These four represents 100% of eligible participants, because no participants incorrectly rejected the investment. All of the 40 participants who rejected the 1-year 7% p.a. investment did so correctly, because for these participants $k_i$ for the 1-year 7% p.a. investment was lower than the mean $k_i$ of investments they accepted. The remaining 17 participants who accepted the 1-year 7% p.a. investment did so incorrectly, and their results contribute to the forthcoming specificity table.
The small sample size for sensitivity towards the 1-year 7% p.a. investment is unsurprising because this investment is relatively unattractive, so participants rejected it. The 1-year 7% p.a. investment is easily rejected correctly, because its low $k_i$ will almost certainly be less than the mean $k_i$ of accepted investments. Of the 21 participants who did accept the 1-year 7% p.a. investment, most did so incorrectly because its very low $k_i$ is likely (and was) lower than the mean $k_i$ of rejected investments. Therefore, few participants remained to accept the 1-year 7% p.a. investment correctly. These 4 participants tended to accept most of the other investments, even with those with low interest and short terms, so their mean $k_i$ for rejected investments was very low indeed, and lower than $k_i$ for the 1-year 7% p.a. investment. These participants tolerated low investment returns.

Nearly all participants contributed to sensitivity results for the 10-year 14% p.a. investment, for which 44 participants correctly accepted returns. These 44 participants comprised 75% of the valid sample of 59 participants. The other 15 participants (25%) incorrectly rejected the 10-year 14% p.a. investment. Two other participants did not contribute to the 10-year 14% result because they rejected all 100 investments, and therefore could not correctly accept nor incorrectly reject an investment according to operational definitions. Compared with the short term, low interest investments, reduced sensitivity should be expected from the long term, high interest investments because incorrect rejection is a distinct possibility. The large $k_i$ for long term, high interest investments will typically be larger than the mean $k_i$ for rejected investments, so the 10-year, 14% p.a. investment should usually be accepted. Most participants did accept such attractive investment, and correctly, but those participants who rejected it demonstrated inconsistency with their other responses, because $k_i$ for the 10-year, 14% p.a. investment was higher than the mean $k_i$ for other investments they accepted. Results for the 98 other combinations of term and interest can be interpreted in similar fashion.
Chapter 4 – The $k_i$ parameter as a predictor of investment choice

Sensitivities in Table 4.4 are all quite high, although sample sizes are either small or non-existent at low interest rates. The mean sensitivity is 88% ($SD = 12$) and the mean sample size 27 ($SD = 21$). The conclusion from this table is that the slight chance of acceptance of a low interest, short term investment can be predicted with high accuracy. If responses to a wide range of other investments predict that a participant will accept low interest and a short term, then almost certainly the participant will accept such an investment even though it is not especially attractive. Although long term, high interest investments are attractive and likely to be accepted, actually predicting the acceptance of these investments from responses to other investments is not as accurate as it is with shorter term investments paying low interest. Overall, though, acceptance of investments is highly predictable from $k_i$ and responses to other investments.

Table 4.5 shows specificities based on mean $k_i$ values of accepted and rejected investments. Recall that specificity refers to the ability to predict rejection of an investment when other responses suggest that the participant will reject it. An investment was rejected correctly if its $k_i$ value was lower than the mean $k_i$ of accepted investments, and accepted incorrectly if its $k_i$ value was less than or equal to the mean $k_i$ of rejected investments.

<table>
<thead>
<tr>
<th>Interest rate p.a.</th>
<th>5%</th>
<th>6%</th>
<th>7%</th>
<th>8%</th>
<th>9%</th>
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<th>11%</th>
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<th>12%</th>
<th>14%</th>
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<td><strong>Term</strong></td>
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<tr>
<td>1 year</td>
<td>Specificity</td>
<td>81%</td>
<td>76%</td>
<td>69%</td>
<td>75%</td>
<td>76%</td>
<td>68%</td>
<td>79%</td>
<td>81%</td>
<td>96%</td>
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<tr>
<td></td>
<td>N</td>
<td>59</td>
<td>59</td>
<td>55</td>
<td>53</td>
<td>50</td>
<td>41</td>
<td>38</td>
<td>31</td>
<td>23</td>
</tr>
<tr>
<td>2 years</td>
<td>Specificity</td>
<td>71%</td>
<td>79%</td>
<td>74%</td>
<td>79%</td>
<td>78%</td>
<td>84%</td>
<td>88%</td>
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<td>100%</td>
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<tr>
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<td>N</td>
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<td>58</td>
<td>54</td>
<td>52</td>
<td>49</td>
<td>38</td>
<td>32</td>
<td>27</td>
<td>17</td>
</tr>
<tr>
<td>3 years</td>
<td>Specificity</td>
<td>85%</td>
<td>83%</td>
<td>79%</td>
<td>81%</td>
<td>92%</td>
<td>91%</td>
<td>97%</td>
<td>100%</td>
<td>100%</td>
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</table>
The mean specificity is 90% (SD = 9) and the mean sample size 32 (SD = 21). Specificities are all quite high, often exceeding 80% with reasonably large sample sizes, and reaching 100%, but only with small sample sizes. Specificity increased with increasing interest rate and term. In the unlikely event that a high interest, long term investment should be rejected because it has a lower \( k_i \) than the mean \( k_i \) of accepted investments, then almost certainly it will be rejected. The high specificities (and sensitivities shown earlier) are consistent with hyperbolic delay discounting and the notion that investment decisions (in this case rejection of investment returns) can be predicted from \( k_i \) and appraisals of other investment profits.

One factor likely to influence specificity results is decreased discounting of larger rewards, which would render longer term and higher interest investments more favourable, and therefore less likely to be rejected. This effect could increase the number of acceptances.
that were inconsistent with other responses, and therefore reduce specificities for higher interest and longer term investments.

Figure 4.3 shows the ROC (received operating characteristic) curve, which plots false positives (rate of acceptance for investments with a $k_i$ value less than or equal to the mean $k_i$ of rejected investments) against sensitivity (acceptance of investments with $k_i$ values higher than the mean $k_i$ of rejected investments).

![ROC Curve](image)

Figure 4.3 ROC based on mean $k_i$ of accepted and rejected and rejected investments – Experiment 5

Each data point represents an investment scenario. The ROC curve is the plotted line summarising the data points (circles) in the graph. This line was fitted according to a distance-weighted least squares criterion, which maximises flexibility compared to a function with few parameters. Sensitivities are generally high and the false positive rate low. This result suggests a high level of discrimination among investments based on acceptance and rejection of other investments. Overall, participants’ investment appraisals...
were internally consistent, with hyperbolic delay discounting defining the criterion for consistency.

The value of $d'$ (a measure of discriminability independent of response bias – see Schiffman, 1982) for the above ROC curve is given by the difference between the mean hit rate (88.03%) minus the mean false positive rate (10.19%) divided by the $SD$ of the false positive rate (9.47%) to give a value of 8.22. Subsequent analysis will refer to this value again.

The next analysis compares predictions from $k_i$ with predictions from the normative exponential delay discounting function, against which the hyperbolic discounting function has been compared in other discounting research (see p. 35 and Experiment 4 above). The value of $d'$ for the hyperbolic delay discounting ROC will be compared to $d'$ derived from exponential discounting to determine whether hyperbolic delay discounting predicts acceptance or rejection of investment profits better or worse than the normative economic model. If hyperbolic delay discounting predicts investment decisions better than exponential delay discounting, the value of $d'$ for hyperbolic delay discounting will exceed the corresponding $d'$ from the ROC curve based on exponential discounting.

Predictions based on exponential delay discounting

Predicting consistency among responses with an exponential delay discounting model is straightforward. A strict interpretation of Figure 2.5 on p. 50 maintains that an exponential discounter who accepts an investment with a given combination of interest rate and term would accept all other investments at the same interest rate, regardless of term, and all other investments with higher interest rates, again regardless of term. Figure 2.5 has the interest rate alone predicting acceptance or rejection of investments when investment
returns are delay discounted hyperbolically. The criterion for consistency in the current experiment is based on mean interest rates accepted and mean interest rates rejected. According to this principle:

- Investments with an interest rate higher than the mean interest rate rejected should be accepted.
- Investments with an interest rate lower than the mean interest rate accepted should be rejected.

The exponential delay discounting criterion severely restricts permissible responses because all investments with the same interest rate should either be accepted or rejected, with no switching permitted with varying terms.

According to mean interest rates accepted and rejected and the exponential delay discounting criterion, sensitivity for the current data averaged at 84% (SD = 14) while for hyperbolic delay discounting the mean sensitivity was 88% (SD = 12) with N = 93 items. A dependent t test using items as cases found sensitivity to be significantly better for the hyperbolic discounting model compared with exponential discounting, t(92) = 5.25, p < .0001.

Compared with exponential discounting, the hyperbolic delay discounting model provided superior ability to predict the acceptance of other investments from the characteristics of rejected investments. Investments should be accepted because they are perceived as better than investments that were rejected. A hyperbolic delay discounting model conforms better to this type of decision than exponential delay discounting.

Specificities hardly differed between the two models, averaging across items at 88% (SD = 10) for exponential discounting and 90% (SD = 10) for hyperbolic delay discounting with
N = 95 items. Despite the small effect size the difference was significant, t(94) = 3.43, p = .0009. Therefore, the hyperbolic delay discounting model also provided higher specificity than exponential discounting, although the difference is trivial.

Figure 4.4 presents the ROC based on exponential discounting and again fitted according to distance-weighted least squares. The ROC fits the vertical left and horizontal top of the chart less well than the hyperbolic delay discounting ROC in Figure 4.3, suggesting superior predictability of responses for the hyperbolic compared with the exponential delay discounting rate parameters.

The value of $d'$ for the Figure 4.4 ROC is given by the difference between the mean hit rate (84.4%) minus the mean false positive rate (11.6%) divided by the SD of the false positive rate (10.4%) to give a value of 7.00. This value of $d'$ is lower than the value of 8.22 from the hyperbolic delay discounting ROC, again suggesting superior prediction from hyperbolic delay discounting compared with exponential delay discounting.
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![Graph showing ROC based on mean exponential discount rate parameter – Experiment 5](image)

Figure 4.4 ROC based on mean exponential discount rate parameter – Experiment 5

**Effects of investment amount and term**

A mixed model factorial ANOVA examined the effect of design features of the experiment on investment decisions. Hyperbolic delay discounting would predict increasing preference for longer term investments compared with shorter terms, although reduced discounting of larger rewards provided by longer terms would encourage the same result. If reduced discounting of larger rewards affected results, greater acceptance of payouts from $10,000 investments would be expected compared with $1,000 investments.

Figure 4.5 shows the main effects of investment amount and term.
Figure 4.5  Main effects of investment amount and term – Experiment 5

The following interpretations refer to Figure 4.5:

a) Profits from $10,000 investments appear more acceptable than profits from $1,000 investments, although the effect was not significant, $F(1, 57) = 3.42, p = .0696.$

b) Only a slight increase in the rate of acceptance with longer investment terms is evident. The associated $p$ value marginally exceeded the critical value by multivariate test, $\Lambda(9, 49) = .73, p < .0564$, but was significant for the corresponding univariate test, $F(9, 513) = 2.73, p = .0041$. The linear trend was significant, $F(1,57) = 4.20, p = .0449$ but the quadratic trend was not $F(1, 57) = 0.84, p = .3636$, indicating a consistent though slight rise in acceptance of investment with increased term.
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Discussion

The most important conclusion from this experiment is that the hyperbolic delay discounting model predicts investment appraisal based on other investment choices quite well, especially for unlikely choices such as acceptance of low-return investments and rejection of high-return investments.

At worst, it could be said that predicting the acceptance and rejection of investments from $k_i$ is no great feat because $k_i$ correlates with the interest rate. Discovering that people consistently prefer investments with high $k_i$ could be no more profound than saying they prefer high returns to lower returns. In response to this criticism, it can be pointed out that the sensitivity and specificity analysis achieved the highest predictability with the least likely choices, namely acceptance of low-return investments and rejection of high-return investments. However, there is no need to rely solely on this argument to support the case for $k_i$ as a predictor of investment choice. The crucial finding is that the hyperbolic model provides superior prediction of investment appraisal based on appraisals of other investments compared with the normative exponential delay discounting model which relies on the interest rate alone to predict appraisals.

Other support for hyperbolic discounting as a predictor of investment appraisals came with the weak though significant trend favouring higher acceptance of investments with increasing term. Returns from the $10,000 investment appeared to be more acceptable than returns from $1,000 investments, but were not significantly more acceptable. Unlike the current experiment, Experiments 1 and 2 did find significant effects for investment amount, and with smaller increments ($1,000 and $3,000) compared with the $9,000 increment in the current experiment. The reason why the large increment to investment amount failed to influence responses is open to speculation. The answer may reside with
the incidental features of the experimental methodologies. The first two experiments asked participants to choose between investing or spending, whereas the current experiment only sought an appraisal without a behavioural intention. Another possibility is that Experiment 5 presented profits rather than final returns. Any of these differences in methodology could conceivably affect responses.

The nonsignificant effect of investment amount suggests that reduced discounting of larger profits did not occur to an extent that influenced responses in the current experiment. This finding, though nonsignificant, is important because the additional returns from longer terms were not so great as the factor of 10 which applied to the levels of investment amount. Given that the effect of investment amount was not significant, it follows that any increased preference for longer term investments is not readily attributable to reduced discounting of larger rewards for the current experiment.

In summary, the fundamental prediction for this experiment was for higher $k_i$ to be associated with increasing attractiveness of the investment returns. The following lines of evidence support this principle:

- The mean $k_i$ for acceptable investments was significantly higher than mean $k_i$ for investments with unacceptable returns.

- Sensitivity and specificity for the prediction of investment acceptability was significantly higher for a hyperbolic delay discounting model compared with exponential discounting.
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- The value of $d'$ was higher for the hyperbolic discounting model than the normative exponential model. Predictive accuracy based on hyperbolic delay discounting was marginally higher than for exponential delay discounting.

In further analysis:

- Profits from longer term investments were rated as acceptable significantly more often than shorter term profits. The finding is consistent with hyperbolic delay discounting of investment profits, although descriptively the effect was slight.

- Mean acceptability of profits from longer and shorter term investments did not differ significantly, suggesting that reduced discounting of larger rewards did not influence results of this experiment.

Thus far, the weight of evidence argues in favour of the idea that investment returns are delay discounted hyperbolically, and that patterns of investment appraisals are consistent with this mode of discounting. The next experiment continues the evaluation of $k_i$ as a predictor of investment appraisals.
Experiment 6: Attractiveness of Investments With Equal $k_i$ and Fixed Payout With Factorial Manipulation of Term

The $k_i$ parameter supports another prediction about how hyperbolic delay discounters would evaluate prospective investment returns. Investments with the same $k_i$ value should have equal appeal to a hyperbolic delay discounter regardless of differences in term. This prediction assumes a constant rate of hyperbolic discounting across different terms. The difference in terms makes this prediction important, because if two investments with the same $k_i$ have the same term they will also have the same interest rate, and therefore will be identical investment propositions.

Invariance of the discounting rate with delay is fundamental to hyperbolic delay discounting because the hyperbolic discounting function itself incorporates changes in the rate of discounting with time compared with normative exponential discounting. If the rate of hyperbolic discounting changes with delay, the hyperbolic delay discounting function inadequately describes perceived future value in the same way that the exponential model proved inadequate. If future returns from investments with the same $k_i$ are perceived as subjectively equal in value regardless of term differences, it suggests that a constant rate of hyperbolic delay discounting is applied to the returns, leading to predictable investment decisions once the individual’s personal discounting rate applied to prospective investment returns is known.

Experiment 6 tests the prediction that investments with the same $k_i$ yet with different terms provide subjectively equivalent returns. The experiment also addresses the methodological difficulty that occurs when compound interest returns increase with term. Increased appeal of longer term returns could happen because of reduced discounting of larger rewards rather than the combination of hyperbolic delay discounting and exponential growth. The
current experiment asked participants to compare pairs of investments, each having the same $k_i$ value, and with all final payouts fixed at the one value. The scenarios varied the initial investment amount and the term. Each scenario asked participants to choose between a larger, shorter investment ranging in term from 2 to 5 years and a smaller investment with a term 1 to 4 years longer than the shorter investment. Both investments had final payouts of $10,000 including the principal. With the payout held constant for all terms, changes in delay discounting rates attributable to payout differences cannot affect perceived values of the future investment reward.

The dilemma for participants was whether to invest a larger amount and sacrifice immediate expenditure opportunities in order to reach the $10,000 goal more quickly, or to retain immediate access to more money but take longer to reach the payout goal.

Table 4.6 shows the scenarios for the factorial combination of shorter term (2 to 5 years), additional duration of longer term (1 to 4 years) and $k_i$ (0.05 to 0.25), which serve as design factors for the current experiment. The dollar amount on the left of each pair is the principal for the larger, shorter investment, with its term shown in the column heading. The dollar value on the right of each pair shows the smaller, longer investment amount, with its term on the row heading. In every example, the two investments have equal $k_i$ values. Equation 3 will verify these scenarios.
Table 4.6  Investment amounts, terms and $k_i$ for investment pairs – Experiment 6

<table>
<thead>
<tr>
<th>$k_i$ &amp; duration of longer term</th>
<th>Duration of shorter term</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 years</td>
</tr>
<tr>
<td>$k_i = 0.05$</td>
<td></td>
</tr>
<tr>
<td>Shorter + 1 year</td>
<td>$9,091 or $8,696$</td>
</tr>
<tr>
<td>Shorter + 2 years</td>
<td>$9,091 or $8,333$</td>
</tr>
<tr>
<td>Shorter + 3 years</td>
<td>$9,091 or $8,000$</td>
</tr>
<tr>
<td>Shorter + 4 years</td>
<td>$9,091 or $7,692$</td>
</tr>
<tr>
<td>$k_i = 0.15$</td>
<td></td>
</tr>
<tr>
<td>Shorter + 1 year</td>
<td>$7,692 or $6,897$</td>
</tr>
<tr>
<td>Shorter + 2 years</td>
<td>$7,692 or $6,250$</td>
</tr>
<tr>
<td>Shorter + 3 years</td>
<td>$7,692 or $5,714$</td>
</tr>
<tr>
<td>Shorter + 4 years</td>
<td>$7,692 or $5,263$</td>
</tr>
<tr>
<td>$k_i = 0.25$</td>
<td></td>
</tr>
<tr>
<td>Shorter + 1 year</td>
<td>$6,667 or $5,714$</td>
</tr>
<tr>
<td>Shorter + 2 years</td>
<td>$6,667 or $5,000$</td>
</tr>
<tr>
<td>Shorter + 3 years</td>
<td>$6,667 or $4,444$</td>
</tr>
<tr>
<td>Shorter + 4 years</td>
<td>$6,667 or $4,000$</td>
</tr>
</tbody>
</table>

For the first scenario, at the top left of the table, participants chose between investing $9,091 for 2 years or $8,696 for (2+1) = 3 years. Either way, the investor finishes with $10,000. Because both of these investments have the same $k_i$ of 0.05, they should be subjectively equivalent in perceived value for someone who discounts hyperbolically at a constant rate regardless of the amount invested and term. The decision about whether to invest for the longer or shorter period becomes arbitrary for a hyperbolic delay discounter.
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If the investments within a pair truly are subjectively equal, it will be in spite of a financial incentive to choose the smaller, longer investment, and the contrary, temporal incentive to choose the shorter, larger investment. For every combination of shorter term and additional term, Table 4.7 shows how much extra must be invested when choosing the larger, shorter investment to expedite the $10,000 reward. Additions to the investment are shown in dollars and as the percentage increase in the amount invested. For example, when the investment pairs have a $k_i$ value of 0.05, then to shorten a 3-year investment to 2 years an additional $395, that is, 5% extra, must be invested. The spending opportunities forfeited represent the price of reducing the term, in effect, the price of time. Table 4.7 shows that larger reductions in term are more expensive than smaller reductions, especially when both terms are relatively short and $k_i$ is relatively large.

Table 4.7 Additional dollar and percentage cost to choose the larger, shorter investment – Experiment 6

<table>
<thead>
<tr>
<th>$k_i$ &amp; duration of longer term</th>
<th>Duration of shorter term</th>
<th>2 years</th>
<th>3 years</th>
<th>4 years</th>
<th>5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$k_i = 0.05$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shorter + 1 year</td>
<td>$395$</td>
<td>5%</td>
<td>$363$</td>
<td>4%</td>
<td>$333$</td>
</tr>
<tr>
<td>Shorter + 2 years</td>
<td>$758$</td>
<td>9%</td>
<td>$696$</td>
<td>9%</td>
<td>$641$</td>
</tr>
<tr>
<td>Shorter + 3 years</td>
<td>$1,091$</td>
<td>14%</td>
<td>$1,004$</td>
<td>13%</td>
<td>$926$</td>
</tr>
<tr>
<td>Shorter + 4 years</td>
<td>$1,399$</td>
<td>18%</td>
<td>$1,289$</td>
<td>17%</td>
<td>$1,190$</td>
</tr>
<tr>
<td>$k_i = 0.15$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shorter + 1 year</td>
<td>$795$</td>
<td>12%</td>
<td>$647$</td>
<td>10%</td>
<td>$536$</td>
</tr>
<tr>
<td>Shorter + 2 years</td>
<td>$1,442$</td>
<td>23%</td>
<td>$1,183$</td>
<td>21%</td>
<td>$987$</td>
</tr>
<tr>
<td>Shorter + 3 years</td>
<td>$1,978$</td>
<td>35%</td>
<td>$1,634$</td>
<td>31%</td>
<td>$1,372$</td>
</tr>
<tr>
<td>Shorter + 4 years</td>
<td>$2,429$</td>
<td>46%</td>
<td>$2,019$</td>
<td>41%</td>
<td>$1,705$</td>
</tr>
<tr>
<td>$k_i$ &amp; duration of longer term</td>
<td>2 years</td>
<td>3 years</td>
<td>4 years</td>
<td>5 years</td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>$k_i = 0.25$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shorter + 1 year</td>
<td>$953$</td>
<td>$714$</td>
<td>$556$</td>
<td>$444$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17%</td>
<td>14%</td>
<td>13%</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>Shorter + 2 years</td>
<td>$1,667$</td>
<td>$1,270$</td>
<td>$1,000$</td>
<td>$808$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>33%</td>
<td>29%</td>
<td>25%</td>
<td>22%</td>
<td></td>
</tr>
<tr>
<td>Shorter + 3 years</td>
<td>$2,223$</td>
<td>$1,714$</td>
<td>$1,364$</td>
<td>$1,111$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>43%</td>
<td>38%</td>
<td>33%</td>
<td></td>
</tr>
<tr>
<td>Shorter + 4 years</td>
<td>$2,667$</td>
<td>$2,078$</td>
<td>$1,667$</td>
<td>$1,367$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>67%</td>
<td>57%</td>
<td>50%</td>
<td>44%</td>
<td></td>
</tr>
</tbody>
</table>

If future rewards are discounted hyperbolically at a constant rate across terms, there should be no bias in preferences either towards the shorter or longer of the two investments. “No bias” implies that the shorter and longer investment will each be chosen about equally, on average for 50% of scenarios. Absence of bias should prevail for all levels of duration for the shorter term, all levels of additional duration of longer term, and all levels of $k_i$, because each pair of investments should be subjectively equivalent across all design factors. Any bias towards either the longer or shorter term investment, or significant effects for the term factors or the $k_i$ factor would suggest a changing rate of discounting across time beyond that accounted for by the hyperbolic delay discounting model.

**Method**

*Participants*

Data were collected from 59 undergraduate psychology students, 39 (67%) of whom were female. The mean age for the entire sample was 19.03 years with $SD = 1.84$ years.
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Design and procedure

In a binary-choice computer task similar to that used for previous experiments, participants chose between the shorter or longer investments for each of the 48 scenarios in Table 4.6. There was no mention of a windfall; participants were implicitly using their own cash from existing reserves. The design was fully repeated measures except for the presentation order counterbalancing condition, for which 29 participants received items in ascending order of extra years for the longer term nested within ascending years of shorter term, nested in turn within ascending order of $k_i$. The other 30 participants received items in reverse order, featuring decrements rather than increments to factor levels. Interest rates and $k_i$ were not shown or mentioned. The instructions and the first item for the ascending order condition are given below.

Imagine you are financially secure, earning good money, have no debts and no major expenses coming up. You have spare cash, and decide to increase this amount to $10,000 through investing. Soon you will see options for investing various amounts of money for various periods of time. You can invest a larger amount of money for a shorter time or a smaller amount of money for a longer time. All of the investments are worth $10,000 at the end. If you choose the larger, shorter investment, you will reach your $10,000 goal sooner, but you will have more of your money tied up. If you choose the smaller investment, less of your money is tied up, but you have to wait longer to reach $10,000. The $10,000 you finish with includes all the money you invest plus all interest.

None of the investment options carries any risk – you can never lose money. Whatever you invest and any interest earned will be “locked up” throughout the investment so you can’t get to the money until the investment ends. Ignore issues such as taxes, inflation and fees, and any other issue that isn’t mentioned.

Assume you have two investment options from which to choose.

Option A invests a larger amount for a shorter time.
Option B invests a smaller amount for a longer time.

Which option would you prefer, Option A or Option B?

Option A
Invest $9,091 for 2 years and receive $10,000

Option B
Invest $8,696 for 3 years and receive $10,000
Results

Table 4.8 shows the percentage of participants who chose the larger and shorter of the two investments, sacrificing expenditure opportunities in order to expedite the $10,000 final payout. Responses are shown for each level of $k_i$ and investment term.

Table 4.8 Percent choosing larger, shorter investment for levels of $k_i$ and investment term

<table>
<thead>
<tr>
<th>N = 59</th>
<th>Duration of shorter term</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 years</td>
</tr>
<tr>
<td>$k_i$ and duration of longer term</td>
<td></td>
</tr>
<tr>
<td>$k_i = 0.05$</td>
<td></td>
</tr>
<tr>
<td>Shorter + 1 year</td>
<td>61%</td>
</tr>
<tr>
<td>Shorter + 2 years</td>
<td>66%</td>
</tr>
<tr>
<td>Shorter + 3 years</td>
<td>71%</td>
</tr>
<tr>
<td>Shorter + 4 years</td>
<td>77%</td>
</tr>
<tr>
<td>$k_i = 0.15$</td>
<td></td>
</tr>
<tr>
<td>Shorter + 1 year</td>
<td>59%</td>
</tr>
<tr>
<td>Shorter + 2 years</td>
<td>73%</td>
</tr>
<tr>
<td>Shorter + 3 years</td>
<td>65%</td>
</tr>
<tr>
<td>Shorter + 4 years</td>
<td>73%</td>
</tr>
<tr>
<td>$k_i = 0.25$</td>
<td></td>
</tr>
<tr>
<td>Shorter + 1 year</td>
<td>63%</td>
</tr>
<tr>
<td>Shorter + 2 years</td>
<td>73%</td>
</tr>
<tr>
<td>Shorter + 3 years</td>
<td>78%</td>
</tr>
<tr>
<td>Shorter + 4 years</td>
<td>83%</td>
</tr>
</tbody>
</table>

On average, the larger, shorter investment was chosen for 80% of the scenarios ($SD = 20\%$), indicating a strong bias towards the larger, shorter investment. The 95% confidence
interval for investment preferences covers the range 75% to 85% of participants choosing the larger, shorter investment, so the null hypothesis of no bias towards to either the larger, shorter or smaller, longer investment is rejected. Fifteen of the sample (25%) chose the larger, shorter investment for every one of the 48 scenarios. No participant exclusively chose the smaller, longer investment. The bias towards the shorter investment occurred despite its $k_i$ value equalling that of the longer investment within each scenario.

The relationship between presentation order, $k_i$, duration of the shorter investment and the additional years of term for the longer investment were tested via a 4-way ANOVA. In accordance with predictions, the main effect for $k_i$ was not significant, $\Lambda(2, 56) = 1.00, p = .9562$. Because investments in each pair should have been equally worthwhile subjectively, there was no a priori reason for preferences to vary across levels of $k_i$, and they did not. For the $k_i = 0.05$ and $k_i = 0.15$ scenarios, the larger, shorter investment was chosen for $M = 80\%$ of items, whilst for the $k_i = 0.25$ scenarios, the larger, shorter investment was preferred for $M = 81\%$ of items. Increasing $k_i$ would have made both investments in a pair more attractive because it raises the underlying interest rate. The nonsignificant $k_i$ main effect suggests that raising $k_i$ by equal amounts for the longer and shorter investments boosted each investment’s attractiveness equally.

The $k_i$ factor interacted with the duration of the shorter term, $\Lambda(6, 52) = 0.78, p = .351$, and the main effect of the shorter term itself was significant $\Lambda(3, 55) = 0.66, p < .0001$. Figure 4.6 illustrates the main effect of the shorter investment term and the $k_i$ by shorter term interaction.
As the shorter term increased, respondents increasingly chose the shorter of the two terms (Figure 4.6a). The linear, quadratic and cubic trends for the shorter term factor were all significant ($p \leq .0025$). Descriptively, increased enthusiasm for the shorter term investment levels approaches a ceiling with increasing length of the shorter term. The $k_i$ by shorter term interaction appears unsystematic (Figure 4.6b), although each level of $k_i$ tends roughly to follow the trend that occurs for the shorter term.

The diminished appeal of the shorter term traces its higher cost as the shorter term becomes even shorter – see Table 4.7. If each investment pair was delay discounted at a constant hyperbolic rate across all term levels, the constant $k_i$ parameter would have precisely compensated for the change in costs relative to delay. Instead, reducing the delay to both investment payouts failed to compensate for the increased cost of the choosing the
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shorter investment. Participants showed increasing sensitivity to the higher cost of the shorter investment the shorter it became.

The difference between the longer and shorter investment terms did not affect preferences $\Lambda(3, 55) = 0.88$, $p = .0761$. The difference between the two investment terms did not interact significantly with any other factor ($p \geq .1160$).

**Discussion**

Twenty-five percent of participants always chose the shorter investment even though the longer investment should have been equally attractive. On average, 80% of decisions favoured the shorter investment. Absence of bias towards either investment would have divided preferences equally between the two investments. The shorter term investment often had higher subjective value than the longer term investment, despite the two investments having the same $k_i$ value.

Preference for the shorter term investment increased as both investment terms increased, but remained constant with variation to the difference between the two terms. Expediting the $10,000$ payout was usually perceived as worth additional, upfront cost, but varying the number of years by which the payout was expedited apparently was compensated exactly by concomitant changes to the additional, upfront cost based on $k_i$. The absence of a significant effect for the difference between terms suggests insensitivity to the degree of disparity between terms, and associated costs derived from $k_i$. This insensitivity nevertheless resides within an overall preference for shorter terms.

An explanation for the bias towards the larger, shorter investment is warranted. With the payout held constant at $10,000$, there was no smaller, sooner reward to compare with a
larger, later reward. There were only sooner or later rewards available with different upfront costs, with discounting alone responsible for delay differences in the perceived value of the payout. With no trade-off available between objective reward size and delay between the pairs of investments in the experiment, the only strategy participants perceived as worthwhile, according to the data, was to reduce the delay, which favours the shorter term over the longer term. Delay became a commodity participants could trade against an upfront cost. Participants demonstrated sensitivity to this cost because higher upfront costs diminished the appeal of the shorter investment. They accepted the cost of the shorter investment more when the cost was lower (see Table 4.7).

The dominant preference for the shorter investment certainly indicates delay discounting, but not hyperbolic delay discounting at a constant rate across terms. The current experiment controls for hyperbolic delay discounting by adjusting investment amounts, using $k_i$ to negate subjective differences between delayed rewards for a hyperbolic delay discounter. The perceived value of investment payouts after delay discounting should have been equal for investments with the same $k_i$ values, assuming constant rates of hyperbolic delay discounting.

The hyperbolic delay discounting model does not account for diminishing appeal of the shorter investment when its costs were raised by further reduction of its term compared with the longer term investment. Findings from the current experiment suggest that the hyperbolic delay discounting model may not explain some aspects of investment behaviour. Earlier experiments in this thesis found the hyperbolic delay discounting model to predict choices where set amounts were invested to achieve payouts which varied with delay. In the current experiment, the investment amount rather than the investment payout varied with delay. Scenarios in the current experiment resembled practical situations where
the investor aims to reach a specified financial goal. In such instances, a degree of impatience may occur beyond that predicted by the hyperbolic delay discounting model.
Summary of Chapter 4

Three experiments tested the principal hypothesis that $k_i$ predicts appraisals to compound interest investment returns. Consequences from this hypothesis are that higher $k_i$ investments have more appeal than lower $k_i$ investments; and that returns from investments with the same $k_i$ value are perceived as subjectively equivalent regardless of term and interest rate. Empirical support for these hypotheses from various experimental designs suggests that compound interest returns from hypothetical, prospective investments are delay discounted hyperbolically at a constant rate for prospective delays.

A summary of experimental findings follows:

- Experiment 4 relied on two values for investment term (2 years and 5 years) to test whether investments with higher $k_i$ are more appealing than lower $k_i$ scenarios regardless of term. Results were remarkably close to the prediction, even allowing for reduced discounting of larger rewards. Results argued strongly for $k_i$ as a predictor of the appeal of investment returns.

- Experiment 5 compared the hyperbolic and exponential delay discounting models when applied to investment appraisals. Participants evaluated compound interest returns from various combinations of interest rate, principal and term, including longer term investments that a hyperbolic delay discounter would prefer to shorter term, higher interest investments that would better please an exponential discounter. Response patterns were examined using sensitivity and specificity analysis, and ROC curves derived from signal detection theory. The analysis found that $k_i$ and its associated hyperbolic delay discounting model predicted appraisals reasonably well, and better than the normative exponential model. Evidence for reduced delay
discounting of larger payouts from larger investment amounts was notably absent from results for this experiment.

- Experiment 6 tested whether investments with equal $k_i$ values are equally attractive. Participants chose between pairs of shorter term investments and longer term investments, with each investment offering a fixed $10,000 payout. The shorter investment imposed a higher upfront cost in the form a larger principal compared with the longer investment, yet both investments had the same $k_i$ value, implying subjective equality for a hyperbolic delay discounter. The fixed value of the final payout eliminated reduced discounting of larger investment returns that could affect other investment scenarios. Preferences for the shorter or longer of two investments remained the same across levels of $k_i$, regardless of the difference in term between the two investments, consistent with the hyperbolic discounting model. A strong, general preference for the shorter of the two investments suggested a willingness to expedite a reward at some initial, temporary cost. Willingness to invest more money to expedite the payout tended to diminish with increasing upfront cost and reduced delay to both investments. This latter finding suggests an additional degree of impatience beyond what $k_i$ and the hyperbolic delay discounting model predict. This effect may occur when upfront investment amounts rather than investment payouts vary according to the investment’s duration.
Chapter 5 – Probability Discounting and Investment Decisions

The research next examines how probability discounting may affect investment appraisals. Because investments involve delayed returns, delay discounting effects will be explored alongside probability discounting.

Probability discounting was first introduced in the current dissertation on p. 6 where it was defined as the perceived reduction in the value of a reward as the likelihood of receiving it diminishes. People who probability discount at higher rates subjectively penalise a probabilistic reward more than people who discount at lower rates. Therefore, people who discount probabilistic rewards at low rates will tolerate higher risk compared with those who discount at high rates. The relevance of probability discounting to investment decisions derives from the fact that many investments offer uncertain returns, this being described as investment risk. Because investment risk and return are correlated, investors seeking higher returns have to accept the undesirable possibility of suboptimal returns, or even losing money. In addition to the risk-return association, increasing the term reduces investment risk (see Figure 1.2 on p. 9). However, risk conventionally increases with delay (see below), as does subjective depreciation from delay discounting.

Probability appears to receive less attention in the discounting literature than delay. An April 2002 search of English language articles using the key words “discount or discounting” combined with “time or delay” yielded 173 articles, whereas “probability or risk” and “discount or discounting” found 87 articles. However, decision making under uncertainty has a long-standing literature in its own right, although this literature seldom explicitly refers to probability discounting.
Chapter 5 – Probability discounting

Relationship Between Probability and Delay

Researchers who study discounting are well aware that probability discounting and delay discounting are linked (e.g., Rachlin et al., 1991) and not just in relation to personal investment. Time and probability may seem like distinct concepts, but the literature often argues for a theoretical connection. Rachlin, Logue, Gibbon, and Frankel (1986) suggest no less than functional equivalence for probability and delay discounting (see also Mazur & Romano, 1992). Rachlin et al.’s alleged equivalence between delay discounting and probability discounting would have naïve investors perceiving greater risk of a suboptimal outcome with an extended term, simply because term equates to risk.

Two theoretical arguments associate probability with delay discounting. The first claims that long delayed rewards are less likely to be paid at all compared with sooner rewards, owing to the possibility of misadventure. As Rachlin et al. (1991) explain, “…promises of delayed reward are rarely given or, if given, broken…. Longer delays correspond to lower probabilities” (p. 233). For example, a book is less likely to be returned if lent to someone over a long period rather than a short period. The other argument states that low probabilities of reward are intrinsically associated with long delays because we usually have to wait longer for a low probability event than a high probability event (Rachlin, 1990; Rachlin & Siegel, 1994).

Whichever argument is correct – or perhaps the matter is unresolvable because time and probability are confounded (Rachlin et al., 2000) – the precedence of delay and probability discounting is not crucial to the current discussion. The main point is that probability and delay are often related in the literature, both conceptually and empirically, so that increased delay is associated with lower probability of a reward. In addition, trade-offs might be expected between delay and probability. High likelihood of a reward may compensate for a
long wait for its acquisition. Imminent receipt of a reward may compensate for low probability.

**Economic Theory of Rational Decision Making Under Uncertainty**

Theories of risky choice originated more than 250 years ago with Bernoulli (1738/1954; also discussed in Kahneman & Tversky, 1984). Bernoulli argued that a reward paid with certainty is regarded as worth its full amount. When not paid at all the reward is subjectively worth nothing. As the probability of a reward increases it gains in subjective value (or “utility”), but people vary in the extent to which utility increases for higher probabilities. Bernoulli noted that most people are risk averse towards probabilistic gains. They prefer a certain gain to a probabilistic gain that is worth marginally more than what is strictly necessary to offset the risk. The certain reward is chosen even though the probabilistic reward is a better prospect despite the risk. Risk seeking individuals would tend to avoid smaller, certain rewards, preferring larger, probabilistic rewards that are worth less than their expected value.

Central to theory of decision under risk is the notion of expected utility. Bernoulli defines the expected value or utility of a proposition as the product of its amount and its probability. This formula provides the certain value of a risky reward, that is, the value of a reward paid with certainty that is subjectively equivalent to an alternative reward with a specified probability of payment. The probabilistic reward must have higher objective value than a subjectively equivalent certain reward in order to compensate for risk.

The formula for expected utility provides the basis for economically rational decisions. As such, it is a normative prescription: People *should* appraise a range of outcomes with equal expected utilities as subjectively equal, regardless of the probabilities associated with each
Chapter 5 – Probability discounting

outcome. Choices between prospects should depend only on the value of payoffs and rewards, and not on incidental effects such as framing (Kahneman & Tversky, 1984). One dollar paid with certainty should have equal subjective value to a 10% chance of receiving $10 and a 1% chance of receiving $100.

Threats to the proposition of economically rational decisions emerge from Kahneman and Tversky’s numerous observations suggesting that human performance varies with predictions from a rational calculus. Carlin (1992) notes that empirical violations of rationality emerged experimentally as early as 1953 via the work of Allais. Laibson and Zeckhauser (1998) describe economic rationality as an “analytically elegant and normatively sanguine theoretical edifice” (p. 7), but “Tversky and his collaborators show that economic rationality is systematically violated, and the decision-making errors are both widespread and predictable” (p. 9).

Violations to rationality in human behaviour are ubiquitous in everyday life. The persistence of casinos, lotteries, the tote and other opportunities for people to lose more money than they gain shows that people either fail to evaluate options accurately, or prefer to finish out of pocket at least some of the time.

Prospect Theory

This influential theory, advanced by Kahneman and Tversky (1979), arose in response to empirical violations of expected utility theory. Although Kahneman and Tversky describe numerous empirical distortions or biases in judgements leading to departures from expected utility theory predictions, the two most important for the current dissertation are:

1. The certainty effect, in which people are said to prefer definite (i.e., nonprobabilistic) outcomes excessively over probabilistic outcomes. Reduction of a sure gain to a
probabilistic one is penalised more than an equal but further reduction in the probability of an already uncertain gain. Implications of the certainty effect for personal investors could include excessive preference for capital guaranteed investments compared with other investments yielding probabilistic returns.

2. The reflection effect, in which the certainty effect is reversed for losses, and decision makers become risk seeking. Whilst the certainty effect biases decision makers towards certain gain rather than a larger, uncertain gain, the reflection effect has decision makers prefer an uncertain loss to a smaller, certain loss. Tversky and Kahneman (1979) summarise the reflection effect such that “certainty increases the aversiveness of losses as well as the desirability of gains” (p. 269). The reflection effect is possibly demonstrated in the reluctance to sell at a loss, as mentioned earlier with Odean (1998), and Shefrin and Statman (1985).

Another Prospect Theory principle is that people view outcomes in terms of amounts gained or lost rather than final worth. This principle would have investors more concerned with the amount of money they can make (or lose) rather than the total in their pockets at the end. Prospect Theory accommodates diminishing marginal utility, whereby earning one’s first million would provide a greater sense of achievement than the second million. Losing two million would provide less than double the pain of losing one million.
Chapter 5 – Probability discounting

Figure 5.1 schematically plots the perceived value (utility) of different levels of gains and losses, based on Kahneman and Tversky (1984), with labelling from Schaubroeck and Davis (1994, p. 60). The horizontal axis plots gains and losses rather than the actual amount held, consistent with Prospect Theory’s claim “that the carriers of value or utility are changes of wealth, rather than final asset positions that include current wealth” (Kahneman & Tversky, 1979, p. 273). Note also that with increasing gain and loss, the relative value of further increments or decrements decreases (i.e., marginal utility declines). Furthermore, increasing gains are discounted at a greater rate than increased losses, which is the reflection effect.

**Decision Weights for Probabilistic Outcomes**

Tversky and Kahneman (1981) claim that a weighting function is applied to the probabilistic outcomes so that low probabilities are overweighted (evaluated as more likely than their actual probabilities), and high and moderate probabilities are underweighted (regarded as less probable than they actually are). The actual probabilities are underestimated for most of the probability range. Only very low probabilities are overestimated, and then considerably. The weighting function would easily accommodate behaviours such as the purchase of lottery tickets, for which the slight probability of winning is vastly overestimated. Similarly, people buy insurance because they overestimate the low probability of loss (Kahneman & Tversky, 1984).
Eliminating investment risk would increase the appeal of an investment compared with an equal reduction in risk from a higher to a lower, nonzero value. Again, this tendency would have investors favouring capital guaranteed investments over merely capital stable or higher risk investments to an extent which does not account for the likely opportunity cost associated with the lower interest rate.

Criticism of Prospect Theory

Prospect Theory has numerous critics. Rachlin (1990) questions the relevance of Prospect Theory to the examination of successive events by claiming that Prospect Theory relates only to one-off payments. Rachlin cites research in which preferences change with repeated exposure to the same contingencies, findings that Prospect Theory would be unable to accommodate. Prospect Theory would apply to personal investment if such investment were seen as a single, fixed commitment with a final payoff at the end rather than a series of sequential returns.

Still on the issue of single or multiple outcomes, Keren and Wagenaar (1987) show that predictions from utility theory do hold for repeated gambles. Violations of utility theory were restricted to single-instance scenarios. People’s judgements about investments may depend on whether the investment is perceived or presented as one scenario, such as a fixed term bank deposit, or a succession of payments and payoffs, as commonly occurs for investments lasting many years. Forthcoming experiments in Chapter 6 present investment returns as single payouts, whereas Chapter 7 presents investments as a series of annual returns.

Gigerenzer and Hoffrage (1995) show that an alternative representation of posterior probabilities in the form of so-called frequency formats greatly facilitates inferences,
allegedly because such formats resemble how information is gained in natural settings. The implications are that decision biases may be a consequence of how information is presented (i.e., framing) rather than the mind’s inability to reason effectively.

**Reward Size and Probability Discounting**

On p. 40 it was noted that delay discounting is generally lower for larger than smaller rewards. Green et al. (1999) report a contrary effect for probabilistic rewards, namely that increasing reward size brings greater discounting. Risk is increasingly penalised where larger amounts are involved. This effect could influence the current research. Subjects could be less risk averse when appraising investments with higher returns than if risk aversion depended only on the level of risk itself.

Greater probability discounting for larger rewards, as opposed to reduced delay discounting for larger rewards, suggests that different processes underwrite delay and probability discounting despite the theoretical link between time and probability. Green et al. (1999) found that people tend to seek risk with small rewards and avoid risk with larger rewards. Küberger, Schulte-Mecklenbeck, and Perner (1999) mention the same in their meta-analysis. Rachlin et al.’s (2000) experiments, which used a different methodology than the usual choice procedures, also found a reverse amount effect for probability discounting – with greater discounting for higher amounts, consistent with Green et al. and opposite to the reward effect for delay discounting.

Rachlin et al. (2000) speculatively attribute increased probability discounting for larger amounts to people’s inability to plan for the receipt of an uncertain reward, which in turn lowers subjective value. Predictable rewards, which are only subject to delay discounting, can be planned for, whereas probabilistic rewards may not arrive at all, so preparatory
action should be limited. Green et al. (1999) offer a different explanation for the reverse amount effect in probability discounting: that probabilistic rewards offer the possibility of nonpayment, which is disappointing, and all the more so if the reward is larger, leading to greater discounting. Delayed but certain rewards will always be received eventually, so the possibility of greater disappointment associated with larger rewards does not arise.

**Hyperbolic Probability Discounting**

Chapter 2 discussed preference reversals with time as a counter-rational delay discounting phenomenon. Anomalous decision biases associated with probability discounting are discussed above. Prelec and Loewenstein (1991) argue for a remarkable resemblance between delay discounting anomalies and probability discounting anomalies. Each type of anomalous decision for delay discounting has its probability discounting equivalent. For example, excessive preference for immediate rewards resembles the certainty effect for probabilistic rewards.

Rachlin et al. (1991) demonstrate another fundamental connection between delay and probability discounting: the hyperbolic discount function. Probabilistic rewards are discounted hyperbolically, as are delayed rewards. Rachlin et al. (1991) propose the Equation 5 formula below for hyperbolic probability discounting. The formula shows the extent to which risk diminishes the perceived value of a probabilistic reward.

**Equation 5** Probability discounting hyperbolic function

\[ v_p = \frac{pV}{p + h(1 - p)} \]

where \( v_p \) is the perceived value of the reward after probability discounting, \( V \) is the value of the reward if paid with certainty, \( h \) refers to a parameter indicating the degree of
 discounting and p the probability of the reward. The parameter h is the probability
discounting equivalent of the delay discount rate parameter k. Just as values for k can be
calculated for combinations of interest rate and delay, so too could h values be calculated
for combinations of investment return and probability of payment. As with the k parameter, h is a property of the investment, and it enables statements about how an
investor will respond to investments with returns of known probability, according to the
investor’s personal rate of probability discounting, h, applied to the scenario.

Table 5.1 shows h values for investments of $1 at 10% p.a. compound interest paid yearly
for terms of 1 to 15 years, and various probabilities that the returns will be paid at all,
ranging from 90% chance of payment down to 10%. Each value for h is the rate of
hyperbolic probability discounting that reduces the perceived value of the prospective
investment return to the equivalent of the certain, initial value of the investment, namely
$1. An investor who probability discounts at the rate h will perceive growth in the value of
the investment with time to be neutralised exactly by the risk in not receiving payment. For
an investment to increase subjectively in spite of risk, the investor must probability
discount hyperbolically at a rate lower than h for the specified combination of compound
interest and payment probability. For example, an investor who probability discounts at the
rate h = 10.29 will be just satisfied with a 90% chance of receiving an investment return of
more than $2.14 from an 8-year investment and a 10% chance of receiving nothing. This
analysis ignores delay discounting. An investment would need a value higher than $2.14 to
please an investor who discounts probability hyperbolically at a rate of h = 10.29 in order
to compensate for delay discounting as well as probability discounting.
Table 5.1 Probability discounting parameter $h_i$ for combinations of term and payment probability

<table>
<thead>
<tr>
<th>Term</th>
<th>Compound return</th>
<th>Probability of payment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90%</td>
<td>70%</td>
</tr>
<tr>
<td>0</td>
<td>$1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1</td>
<td>$1.10</td>
<td>0.90</td>
</tr>
<tr>
<td>2</td>
<td>$1.21</td>
<td>1.89</td>
</tr>
<tr>
<td>3</td>
<td>$1.33</td>
<td>2.98</td>
</tr>
<tr>
<td>4</td>
<td>$1.46</td>
<td>4.18</td>
</tr>
<tr>
<td>5</td>
<td>$1.61</td>
<td>5.49</td>
</tr>
<tr>
<td>6</td>
<td>$1.77</td>
<td>6.94</td>
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<td>8.54</td>
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<tr>
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<td>$2.36</td>
<td>12.22</td>
</tr>
<tr>
<td>10</td>
<td>$2.59</td>
<td>14.34</td>
</tr>
</tbody>
</table>

As with $k_i$ values, $h_i$ increases with term. As the value of the investment increases with time, a higher rate of probability discounting is needed to depreciate the investment’s final, subjective value back to $1. When term = 0 the value of $h_i$ must be zero regardless of payment probability because the final value of the investment is $1 after a zero term; therefore a zero rate of discounting is required to depreciate the investment back to its starting value. The $h_i$ parameter increases as the chances of payment increase. This is because high likelihood of payment increases the expected utility of the investment, so greater discounting is required to reduce the subjective value of the highly probable return back to $1 than to depreciate an unlikely return with its low expected utility.
Chapter 5 – Probability discounting

Having the value of $h_i$ increase with term implies that compound interest growth will offset the reduction in perceived value associated with hyperbolic probability discounting when the term is sufficiently long. Hyperbolic probability discounting of compound interest would operate alongside hyperbolic delay discounting to increase the perceived, prospective value of an investment with increasing delay.

The $h_i$ parameter has mainly a theoretical interest. Operationalising $h_i$ experimentally to show that longer terms for compound interest investments increasingly compensate for probability discounting introduces methodological problems. Effects attributable to $h_i$ will also be attributable to $k_i$ because the probabilistic returns are also delayed. The important principle from $h_i$ is that hyperbolic probability discounting should augment the increase in perceived value of prospective compound returns that hyperbolic delay discounting confers with increasing delay. The three experiments in Chapter 6 guard against confounding delay discounting with probability discounting by ensuring equal terms for pairs of investments in every binary-choice scenario. The investment pairs differ only in the size of the investment returns and their probability, offering the choice between a smaller, certain return and a larger, probabilistic reward. Because both rewards have equal delay, participants could only compare rewards in relation to their probability. Trade-offs occur between the size of the reward and the likelihood of receiving it, not when it is received.

The alleged biases associated with hyperbolic probability discounting compared with normative probability discounting are illustrated in Figure 5.2, which subtracts expected utility (the product of reward size and probability) from probability discounted hyperbolically across values of $h$ and probability. Values above zero (light shading) indicate hyperbolically discounted values that are higher than the normative prescription based on expected utility. Values less than zero (dark shading) indicate a subjective value
from hyperbolic delay discounting which is lower than the normative value from expected utility. Low values of $h$ indicate a risk seeking disposition, because risk is not discounted appreciably, whereas high values of $h$ represent risk averseness.

Figure 5.2 Difference between perceived values for hyperbolic and linear probability discounting functions

Consistent with Rachlin et al. (1991), Figure 5.2 shows that biases affect intermediate probabilities rather than near certainty or extreme unlikelihood. Risk averse persons ($h > 1$) undervalue high probabilities in the $p = 0.4$ to 0.8 range compared with normative expectations, as revealed by negative difference scores. Risk seeking individuals overvalue low probabilities in the 0.2 to 0.6 range. Risk seekers overvalue more than the risk averse tend to undervalue.
Chapter 5 – Probability discounting

If most people are risk averse towards moderate to high probabilities, as Prospect Theory claims, the implication for personal investment is that most people would avoid investments that carry only a small to moderate risk unless these investments carry the inducement of potentially high rewards. A slight increase in risk compared with certainty could deter a risk averse investor unless substantial compensatory reward was foreseeable.

Probability Discounting Combined With Delay

Notwithstanding arguments for a theoretical connection between probability and delay (e.g., Rachlin et al., 1986) the discounting literature is far from replete with studies about how probability and delay interact as separate variables. Recall from Green et al. (1999) – see p. 160 above – that contrary reward size effects suggest separate processes for delay and probability discounting. Rewards that are both delayed and probabilistic would combine these two processes, and a net effect would emerge.

Jones and Johnson (1973) found that people exposed to a hypothetical therapeutic drug scenario showed a greater willingness to accept risk if the consequences were delayed than if they were proximate. This result suggests that risk itself is discounted with delay. The implications for investment decisions are complicated because delay discounting of risk, which would enhance the appeal of a probabilistic reward, would be combined with delay discounting, which reduces appeal. The net outcome is difficult to predict a priori – unless the reward is a compound interest return, in which case subjective appeal would increase with time both from delay discounting of risk, and the ability of compound interest to offset delay discounting. Perhaps the most important issue to arise from Jones and Johnson (1973) is the interaction between delay and probability. More recently, Onculer (2000) found that uncertainty increased delay discounting rates whilst delay reduces probability
Probability discounting

discounting. Uncertainty makes people more impatient whereas delay makes them more risk tolerant. The latter finding again suggests that risk is delay discounted.

Keren and Roelofsma (1995) explored the relationship between probability and delay discounting experimentally. Consistent with Prelec and Loewenstein (1991) they note theoretical similarities between the certainty effect and overvaluation of immediate rewards. Their experiments measured the effect of delay on preferences for probabilistic rewards, and the effect of manipulations to the probability of delayed rewards. They found that reducing a reward’s probability weakens delay discounting for imminent rewards but not remote rewards. With remote rewards the greater preference for the later but higher of two rewards remained approximately the same across levels of probability. A second experiment found that gambles with higher probability but lower expected value than an alternative gamble were more attractive when offered immediately than when delayed. In other words, delay reduces the certainty effect. Coincidentally, a reduction in the certainty effect with delay is adaptive for investors, because genuine (as opposed to perceived) investment risk diminishes with longer terms – see Figure 1.2 on p. 9.

Keren and Roelofsma interpret these results in terms of external uncertainty and internal uncertainty. External uncertainty is an attribute of the world and reflects the probabilistic nature of a reward per se. Internal uncertainty resides within the individual, and refers to the possibility that the individual may not be available to collect a reward. Internal uncertainty can be eliminated only by immediate consumption; therefore it relates to the uncertainty associated with delay discounting. External uncertainty refers to payoff contingencies, which are independent of delay. Only by offering a definite reward immediately can both types of uncertainty be removed, which enhances the appeal of immediate consumption. This is not possible with investments because the reward is
always delayed. Delaying a certain reward introduces internal uncertainty and dilutes the certainty effect associated with a definite reward. Therefore, for longer prospective terms we would expect less in the way of risk aversion and more attention paid to the size of the payout, which is a desirable emphasis for investors. With shorter terms, for which internal uncertainty is reduced, more attention to the external probabilistic features of the investment is expected and, consequently, a greater likelihood of risk averseness.

**Summary of Probability Discounting Effects**

This chapter discusses probability discounting effects that may influence appraisals of investments with uncertain outcomes. These effects manifest as biases in relation to normative prescriptions for rational decision making. The effects are:

- **The certainty effect,** which excessively values definite rewards over probabilistic rewards, which could bias investors towards fixed interest when probabilistic returns have higher expected utility.

- **The reflection effect,** which biases investors towards riskier but potentially higher losses rather than certain or less risky, smaller losses with better expected utility. Faced with the prospect of certain loss, investors may take unwise risks to avoid it.

- **Greater discounting of gains than losses,** which biases people towards risk aversion and excessively conservative investment decisions.

- **Overvaluation of low probability rewards,** especially for risk seeking individuals, again encouraging undesirably conservative investment.
• Undervaluation of moderate to high probability rewards, especially for risk averse individuals. These individuals would avoid moderate levels of risk that are nevertheless worthwhile.

• A reverse amount effect for probability discounting, in which higher rewards are subject to greater probability discounting than lower rewards, encouraging conservative investments where large amounts of money are involved.

• Reduced bias in the form of the certainty effect (risk aversion) when terms are longer, manifesting as increased tolerance to risk with long term investment. This tendency has the potential to improve investment decisions, because genuine investment risk also diminishes with longer terms.

Three experiments in the next chapter examine how probability discounting affects hypothetical investment decisions. Whereas the experiments in Chapter 3 and Chapter 4 examine the perceived value of money as it changes with time, the Chapter 6 experiments examine how the perceived value of investment risk changes with time. Other issues, such as reward size, are examined as well. Given what is currently known about probability discounting and decision under risk as described above, the following hypotheses are proposed:

• Risk aversion towards investment gains can be expected. Subjects will prefer safe investments with lower expected utility than risky investments offering a high chance of better returns that compensate for the risk.

• Greater probability discounting of larger rewards should magnify risk aversion for larger investment amounts.
Chapter 5 – Probability discounting

- Longer investment terms could be associated with increased risk tolerance, consistent with Jones and Johnson’s (1973) research, and Keren and Roelofsma’s (1995) research. This effect would amount to delay discounting of risk. Chapter 6 experiments examine delay discounting of risk rather than delay discounting of value.
Chapter 6 – Experiments With Probabilistic Investment Returns

Experiment 7: Choosing Between Guaranteed 5% p.a. or Higher Percentage Return With Risk of Loss

This experiment simulates the choices long term investors confront when seeking higher than bank interest returns. Fixed interest cash investments offered by banks typically pay mediocre although definite returns. Alternatively, the investor may seek higher returns, but with the risk of an even poorer return than bank interest, and possible loss of capital.

The experiment offered participants the choice between investing at a guaranteed 5% p.a. compound interest, and alternative investments offering potentially higher interest with the risk of zero interest or negative returns. The size of the potential loss was not specified, but loss of all investment capital was not ruled out. The indeterminate risk reflects the dilemma investors face in the share market, where actual returns cannot be predicted but will probably be higher than fixed interest returns over the long term, yet could be low or nothing, with capital loss a possibility. Aside from the ecological validity of the items, a methodological advantage of the design is the lack of ostensible confound between investment term and compound returns because participants saw only the interest rate, and not the returns. The unspecified suboptimal returns for the risk investments are ecologically valid. However, they prevent the calculation of a definite value for expected utility which, in turn, makes it harder to evaluate responses against normative criteria. The analysis deals with this problem conservatively, by evaluating responses against the worst possible outcome, that is, zero interest and total capital loss.

The following hypotheses are proposed. The hypotheses are based on predictions listed at the end of Chapter 5 – see p. 169.
Participants will demonstrate risk aversion, often preferring the guaranteed 5% p.a. investment when the risk investment offered a better prospect even when the worst possible outcome was total loss. Experiment 2 findings suggested that participants underestimate compound returns based on percentages alone. This tendency, along with risk aversion at moderate to high likelihood of a satisfactory return, would render participants especially liable to choose the guaranteed 5% p.a. investment even when the risk investment has the better expected utility.

Higher risk aversion will be demonstrated for larger investments owing to increased probability discounting.

Risk aversion may diminish for the longer terms, consistent with some research mentioned in Chapter 5.

**Method**

*Design and procedure*

The design was a 5-way ANOVA with the following within-subjects factors, plus a between-subjects presentation order condition:

1. Investment term: 5 years and 10 years. The 10-year investment term corresponded to the longest meaningful term identified in Experiment 2. The 5-year term corresponds to the minimum term commonly recommended for equities investments or mutual fund investments with high equities exposure.

2. Amount invested: $1,000 and $10,000. The large difference between investment amounts was chosen to magnify the effect of this variable. The upper value of $10,000 is a meaningful amount, though not extraordinarily large. Experiment 1
participants generally preferred to spend rather than invest $1,000. Spending was not an option in the current experiment, which instead explored how participants preferred to invest, either conservatively or more aggressively.

3. Interest rate for the risk investments: 10%, 15%, 20%, 25% p.a. compound. The maximum value of 25% p.a. for 10 years would be an exceptional return in real life, and should tempt even risk averse individuals.

4. Level of risk was shown as a percentage likelihood of the investment earning the higher interest rate, with values of 90% down to 30% in 10% increments. Higher percentages represented lower risk. Piloting showed that below 30% likelihood of the higher return, almost all participants rejected the higher risk investment regardless of the return, so higher risk items were omitted to shorten the task to 112 items. Investments with less than 30% perceived chance of a worthwhile return can hardly be described as mainstream. Percentage likelihood of an outcome is a standard form of presentation in Kahneman and Tversky’s Prospect Theory research, and derivative research by others. It was assumed that participants would comprehend percentage likelihood of returns in an ordinal sense, even if they were not fully conversant with the meaning of percentage likelihood in terms of Pascalian probability. See also p. 267 of the General Discussion for further treatment of this issue.

The likelihood of future returns is rarely if ever specified quantitatively for genuine investments, even if it were known. Percentage likelihood was intended to convey a sense of varying risk whilst enabling expected utilities to be calculated. These utilities, which are the product of risk and final return, are presented for $1,000 investments in Table 6.1 for the 5 and 10-year returns, and the 10% to 25% p.a. interest rates, paid yearly. Returns for
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the 5% p.a. investments are also shown, which can be compared with expected utilities from the risk investments. The 100% percent likelihood of higher return examples show the returns that would accrue in the absence of risk, although participants were not presented with these options.

Table 6.1  Expected utilities of $1,000 investment final returns – Experiment 7

<table>
<thead>
<tr>
<th>Likelihood of higher return</th>
<th>10% p.a.</th>
<th>15% p.a.</th>
<th>20% p.a.</th>
<th>25% p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% (not presented)</td>
<td>$1,611</td>
<td>$2,011</td>
<td>$2,488</td>
<td>$3,052</td>
</tr>
<tr>
<td>90%</td>
<td>$1,449</td>
<td>$1,810</td>
<td>$2,239</td>
<td>$2,747</td>
</tr>
<tr>
<td>80%</td>
<td>$1,288</td>
<td>$1,609</td>
<td>$1,991</td>
<td>$2,441</td>
</tr>
<tr>
<td>70%</td>
<td>$1,127</td>
<td>$1,408</td>
<td>$1,742</td>
<td>$2,136</td>
</tr>
<tr>
<td>60%</td>
<td>$966</td>
<td>$1,207</td>
<td>$1,493</td>
<td>$1,831</td>
</tr>
<tr>
<td>50%</td>
<td>$805</td>
<td>$1,006</td>
<td>$1,244</td>
<td>$1,526</td>
</tr>
<tr>
<td>40%</td>
<td>$644</td>
<td>$805</td>
<td>$995</td>
<td>$1,221</td>
</tr>
<tr>
<td>30%</td>
<td>$483</td>
<td>$603</td>
<td>$746</td>
<td>$916</td>
</tr>
</tbody>
</table>
10-year return from 5% p.a. = $1,629

<table>
<thead>
<tr>
<th>Likelihood of higher return</th>
<th>10% p.a.</th>
<th>15% p.a.</th>
<th>20% p.a.</th>
<th>25% p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% (not presented)</td>
<td>$2,594</td>
<td>$4,046</td>
<td>$6,192</td>
<td>$9,313</td>
</tr>
<tr>
<td>90%</td>
<td>$2,334</td>
<td>$3,641</td>
<td>$5,573</td>
<td>$8,382</td>
</tr>
<tr>
<td>80%</td>
<td>$2,075</td>
<td>$3,236</td>
<td>$4,953</td>
<td>$7,451</td>
</tr>
<tr>
<td>70%</td>
<td>$1,816</td>
<td>$2,832</td>
<td>$4,334</td>
<td>$6,519</td>
</tr>
<tr>
<td>60%</td>
<td>$1,556</td>
<td>$2,427</td>
<td>$3,715</td>
<td>$5,588</td>
</tr>
<tr>
<td>50%</td>
<td>$1,297</td>
<td>$2,023</td>
<td>$3,096</td>
<td>$4,657</td>
</tr>
<tr>
<td>40%</td>
<td>$1,037</td>
<td>$1,618</td>
<td>$2,477</td>
<td>$3,725</td>
</tr>
<tr>
<td>30%</td>
<td>$778</td>
<td>$1,214</td>
<td>$1,858</td>
<td>$2,794</td>
</tr>
</tbody>
</table>

The shaded areas within the table show combinations for which the risk option offers superior expected utility than the safe 5% p.a. investment, assuming the worst case scenario of zero interest and total capital loss. If suboptimal returns are better than zero, the risk investments offer better expected utility than shown in the table. Therefore, the shaded areas in the table show the scenarios for which the risk option should be chosen. Nevertheless, a tendency to choose the safe investment incorrectly is expected because of presumed risk aversion. As well, participants are expected to choose the safe investment correctly, for the unshaded scenarios, again because of risk aversion. In the actual experiment, participants were presented with the potential interest rates alone, and not utility values, as is the case in genuine investments.

Scenarios were presented in order of ascending risk, interest, term and amount invested in that order using the same computerised presentation as for earlier experiments. For a
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separate, between-groups condition the opposite order of presentation was employed.

Instructions and the first item for the ascending order group appear below.

Imagine that you are in your late 20s and thinking about how to invest a recent windfall. Any money you do invest will be “locked up,” so you can’t get to it for the duration of the investment. You manage to find a “capital-guaranteed” investment that always earns 5% per annum. This investment is perfectly safe – you cannot lose money with it. You have to decide whether to put your money in the safe investment, or alternative investments that usually earn more than 5%, but could also earn less than 5% per annum, or even lose money. The alternative investments therefore involve risk, whilst the 5% per annum investment carries no risk.

Soon you will be presented with a series of choices for investing amounts of money in the safe, 5% per annum investment, or investments that usually earn more than 5% every year, but could earn nothing, or lose money. Ignore extraneous issues such as taxation, fees and charges.

Assume that you have two options for investing $1,000.

Option A typically earns higher interest but carries risk.
Option B is perfectly safe, but typically earns lower interest.

Which investment option would you prefer, Option A or Option B?

Option A
Invest $1,000 for 5 years with 90% chance of 10% per annum and 10% chance of less than 5% per annum

Option B
Invest $1,000 for 5 years and earn 5% per annum

Participants

These consisted of 95 psychology undergraduates: 63 were females, 12 males and 20 for whom gender and age records were lost, but can be assumed as similar to those with known biodata. Mean age was 19.49 years ($SD = 4.28, N = 75$). For the ascending order condition, data were collected from 30 participants. For the reverse order condition, data were inadvertently collected from more participants, 65 in all.

Results

One participant from the ascending condition chose the capital-guaranteed investment on every occasion. This response pattern indicates high aversion to risk, which could well describe this participant’s preferences. Problems with computerised data collection led to
one missing response from each of 15 descending order participants, who consequently were also omitted from the analysis, reducing the oversupply of descending order participants. For each presentation order group the percentage of participants choosing the risk option is shown for all 112 items in Appendix A.

Preference reversal patterns

Table 6.2 shows patterns of responses for increasing risk within levels of investment amount, term and risk option interest rate. Results are shown as the percentage of respondents who chose the specified response pattern. A pattern was deemed incoherent if the participant accepted a higher level of risk and rejected a lower level of risk anywhere within the 7 items belonging to a combination of interest rate, term and investment amount. Multiple preference changes within a set, or a single switch from the safe investment to the risk option for increasing risk within a set were therefore classified as incoherent. These incoherent responses indicate a preference for risk without any compensating advantage.

The predicted preference change from the risk option to the safe investment with increasing risk predominated greatly over other preference reversals and uniform responses within a set. Each type of incoherent pattern comprised a small minority of responses. Henceforth, analyses will exclude the 7 participants returning more than two sets with an incoherent response pattern, so that subsequent analysis includes data containing mostly coherent patterns. A small number of incoherent patterns (such as two) could represent occasional inadvertence, but larger numbers could indicate persistent carelessness or misunderstanding of the items. Excluding participants with many incoherent responses was intended to restrict the sample to those who demonstrably understood the task and responded carefully.
Table 6.2  Response patterns with increasing risk – Experiment 7

<table>
<thead>
<tr>
<th>Pattern</th>
<th>All safe 5% p.a.</th>
<th>All risk investments</th>
<th>Risk then safe</th>
<th>Safe then risk*</th>
<th>Safe, risk, safe*</th>
<th>Risk, safe, risk*</th>
<th>Other*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1,000 invested for 5 years</td>
<td>$10,000 invested for 5 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10% p.a.</td>
<td>13%</td>
<td>6%</td>
<td>76%</td>
<td>1%</td>
<td>3%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>15% p.a.</td>
<td>4%</td>
<td>0%</td>
<td>75%</td>
<td>0%</td>
<td>4%</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>20% p.a.</td>
<td>3%</td>
<td>16%</td>
<td>66%</td>
<td>0%</td>
<td>6%</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>25% p.a.</td>
<td>1%</td>
<td>13%</td>
<td>86%</td>
<td>0%</td>
<td>3%</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>$1,000 invested for 10 years</td>
<td>$10,000 invested for 10 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10% p.a.</td>
<td>5%</td>
<td>5%</td>
<td>88%</td>
<td>0%</td>
<td>1%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>15% p.a.</td>
<td>3%</td>
<td>14%</td>
<td>86%</td>
<td>0%</td>
<td>1%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>20% p.a.</td>
<td>1%</td>
<td>9%</td>
<td>80%</td>
<td>0%</td>
<td>9%</td>
<td>9%</td>
<td>26%</td>
</tr>
<tr>
<td>25% p.a.</td>
<td>1%</td>
<td>1%</td>
<td>86%</td>
<td>0%</td>
<td>1%</td>
<td>9%</td>
<td>79%</td>
</tr>
<tr>
<td>* Incoherent pattern: prefers riskier option to safer option within same set.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Factorial analysis of responses

Table 6.2 suggests increased acceptance of risk with longer terms (predicted) and higher interest rates for the risk option (normatively sensible). These impressions were tested more systematically in a 5-way mixed model ANOVA. The mean percentage of participants choosing the investment option associated with risk (i.e., the noncapital-guaranteed investment) is shown for each level of every main effect in Table 6.3. A higher
mean percentage indicates higher risk acceptance, that is, more participants choosing the probabilistic return rather than the smaller, guaranteed return.

Table 6.3 Preference for investment risk for factor main effects – Experiment 7

<table>
<thead>
<tr>
<th>Order of presentation</th>
<th>Term of investment</th>
<th>Dollars invested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascending risk ......</td>
<td>5 years ............</td>
<td>53%</td>
</tr>
<tr>
<td>Descending risk ....</td>
<td>10 years ...........</td>
<td>55%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interest for risk option</th>
<th>Risk (i.e., 100 minus likelihood of higher return)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>Preferring risk</td>
</tr>
<tr>
<td>10% ................</td>
<td>45%</td>
</tr>
<tr>
<td>15% ................</td>
<td>51%</td>
</tr>
<tr>
<td>20% ................</td>
<td>58%</td>
</tr>
<tr>
<td>25% ................</td>
<td>62%</td>
</tr>
</tbody>
</table>

N = 73

Conclusions from Table 6.3 and associated significance tests are as follows:

- Presenting scenarios in descending order of risk (from higher risk to lower risk) rendered the risk investment more attractive than ascending order of risk, $F(1, 71) = 5.60, p = .0207.$

- Although descriptively the risk investment was chosen slightly more often with longer terms than shorter terms, the difference was not significant, $F(1, 71) = 3.91, p = .0519.$

- The $10,000 investment option was invested more conservatively (i.e., favouring the safe investment) than the $1,000 option, $F(1, 71) = 8.05, p = .0059$, although again the difference was small.
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- Higher rates of interest encouraged preferences for the risk option, $\Lambda(3, 69) = .34$, $p < .0001$, which is sensible because higher interest compensates for risk.

- Preference for the riskier investment option was high when risk was only 10% to 30%, but dropped markedly at 40% to 50%, reaching almost the minimum at 70% risk. The risk main effect was significant $\Lambda(6, 66) = .05$, $p < .0001$.

The term by risk interaction is important despite its nonsignificance $\Lambda(6, 66) = .89$, $p = .2488$). Figure 6.1 shows that acceptance of the risk option was almost unrelated to whether prospective investments had long or short terms across every level of risk.

Figure 6.1  Risk by term interaction – Experiment 7

The term by amount interaction was also nonsignificant, $\Lambda(1, 71) = 1.00$, $p = .9148$, so the slightly higher aversion towards risk that occurred for larger investment amount was effectively constant across 5 and 10-year terms.
Risk aversion and risk seeking

This analysis examines the normative correctness of responses. A response is risk averse if the investment is rejected when its expected utility exceeds the return from the guaranteed 5% p.a. option. A response is risk seeking when it is accepted even though its expected utility is less than for the guaranteed 5% p.a. option. Expected utility is calculated according to the worst possible outcome for the risk option, which is zero interest and total loss of capital.

Table 6.4 shows the percentage of respondents providing risk averse or risk seeking choices. Low levels of risk (e.g., 10%) represent high probability (90%) of a reward, whereas high risk (e.g., 70%) represents low probability of a reward (30%). Risk averse responses are shaded and tend to occur at low levels of risk, whereas unshaded responses are risk seeking and occur at higher levels of risk, based on Table 6.1. The same subject inclusion conditions applied as for the above 5-way ANOVA and for the same reason.

High levels of risk aversion are evident for the 10-year investment returns, especially for high interest prospects. Risk seeking is also evident, especially for moderate levels of risk and lower interest.
### Table 6.4 Percent respondents risk averse and risk seeking – Experiment 7

<table>
<thead>
<tr>
<th>Risk</th>
<th>10% p.a.</th>
<th>15% p.a.</th>
<th>20% p.a.</th>
<th>25% p.a.</th>
<th>10% p.a.</th>
<th>15% p.a.</th>
<th>20% p.a.</th>
<th>25% p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>18%</td>
<td>16%</td>
<td>10%</td>
<td>2%</td>
<td>7%</td>
<td>4%</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>20%</td>
<td>18%</td>
<td>12%</td>
<td>6%</td>
<td>3%</td>
<td>17%</td>
<td>12%</td>
<td>11%</td>
<td>8%</td>
</tr>
<tr>
<td>30%</td>
<td>69%</td>
<td>19%</td>
<td>15%</td>
<td>6%</td>
<td>70%</td>
<td>24%</td>
<td>23%</td>
<td>13%</td>
</tr>
<tr>
<td>40%</td>
<td>41%</td>
<td>60%</td>
<td>35%</td>
<td>25%</td>
<td>47%</td>
<td>53%</td>
<td>39%</td>
<td>32%</td>
</tr>
<tr>
<td>50%</td>
<td>25%</td>
<td>34%</td>
<td>47%</td>
<td>50%</td>
<td>12%</td>
<td>21%</td>
<td>32%</td>
<td>64%</td>
</tr>
<tr>
<td>60%</td>
<td>5%</td>
<td>14%</td>
<td>26%</td>
<td>25%</td>
<td>1%</td>
<td>6%</td>
<td>9%</td>
<td>16%</td>
</tr>
<tr>
<td>70%</td>
<td>5%</td>
<td>7%</td>
<td>18%</td>
<td>12%</td>
<td>3%</td>
<td>2%</td>
<td>3%</td>
<td>6%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk</th>
<th>10% p.a.</th>
<th>15% p.a.</th>
<th>20% p.a.</th>
<th>25% p.a.</th>
<th>10% p.a.</th>
<th>15% p.a.</th>
<th>20% p.a.</th>
<th>25% p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>8%</td>
<td>5%</td>
<td>2%</td>
<td>2%</td>
<td>5%</td>
<td>4%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>20%</td>
<td>10%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>18%</td>
<td>13%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>30%</td>
<td>25%</td>
<td>19%</td>
<td>10%</td>
<td>6%</td>
<td>32%</td>
<td>22%</td>
<td>21%</td>
<td>14%</td>
</tr>
<tr>
<td>40%</td>
<td>50%</td>
<td>41%</td>
<td>35%</td>
<td>28%</td>
<td>39%</td>
<td>52%</td>
<td>45%</td>
<td>30%</td>
</tr>
<tr>
<td>50%</td>
<td>27%</td>
<td>65%</td>
<td>56%</td>
<td>54%</td>
<td>10%</td>
<td>78%</td>
<td>69%</td>
<td>51%</td>
</tr>
<tr>
<td>60%</td>
<td>8%</td>
<td>11%</td>
<td>78%</td>
<td>74%</td>
<td>4%</td>
<td>4%</td>
<td>84%</td>
<td>70%</td>
</tr>
<tr>
<td>70%</td>
<td>3%</td>
<td>5%</td>
<td>83%</td>
<td>89%</td>
<td>4%</td>
<td>1%</td>
<td>87%</td>
<td>77%</td>
</tr>
</tbody>
</table>

Shading indicates risk averse response. Unshaded is risk seeking.

### Discussion

The change in preference from the risk option to the safe investment with increasing risk greatly predominated among preference changes. This pattern indicates internally coherent responding. Changing one’s preference to the higher interest with risk investment occurred at uneven rates with increasing risk. Participants generally deserted the risk option when
risk was 40% or more, leading to high rates of risk aversion where the normatively superior high interest with risk investment was avoided.

The substantively equivalent risk tolerance for the 5-year and 10-year investments suggests equal probability discounting rates across terms, contrary to the prediction that shorter terms would have experienced greater probability discounting and consequent susceptibility to risk aversion (based on Jones & Johnson, 1973; and Keren & Roelofsma, 1995). Increased probability discounting of supposed larger rewards from longer terms could have negated any reduction in probability discounting rates. The more conservative (i.e., risk averse) investment choices for the $10,000 amount compared with $1,000 suggest increased probability discounting for larger rewards, consistent with predictions, although the net effect of investment amount in terms of participant numbers (n = 3, which is 4% of the analysed sample) was slight.

The nonsignificant term result and the nonsignificant term by risk interaction are maladaptive for genuine investment choices because the same levels of risk applied for longer and shorter term investments, yet the longer term investments offered higher growth prospects from compound interest, which at least partly offset the risk – see Table 6.1. For the experimental participants, higher prospective returns from the 10-year investment failed to compensate for risk as they should have done. Presumably the participants underestimated compound returns and the 10-year terms’ advantage, or longer terms were delay discounted to the extent that they had no perceived advantage, similar to the payout nondisplay condition in Experiment 2 – see Figure 3.3, p. 84.

Translated into genuine investment behaviour, the risk aversion results in Table 6.4 imply an excessive wariness towards moderate to high risk investments that could pay high interest. In protecting themselves against risk, investors could forfeit worthwhile returns.
The tendency towards risk aversion found in the current experiment is consistent with Prospect Theory.

Although the current experiment found high levels of risk aversion for many scenarios, the design and analysis were biased against detecting risk aversion. Total loss and zero interest were the worst outcome for these investments, but not the only adverse outcome. Experimental instructions allowed for adverse outcomes up to but not including 5% p.a. Falsely rejecting normatively superior investments in the current experiment definitely represents risk aversion, and quite excessive risk aversion because of failure to consider the possibility of better than the worst possible outcome.

Risk seeking also occurred. As shown in Figure 5.2 on p. 165, whether an individual overvalues or undervalues risk depends on the level of risk and the individual’s personal rate of hyperbolic probability discounting. Although the current experiment did not measure risk seeking entirely accurately because of the indeterminate reward, a tendency towards risk seeking was demonstrated at intermediate risk. Therefore, both risk evaluation biases – risk seeking and risk aversion – that Figure 5.2 illustrates are also evident in the current experimental findings. This observation suggests considerable individual variation in probability discounting rates, the implication being that responses to risk investments in real life will differ greatly among individuals. Where some people discount uncertain rewards severely and others discount only slightly, there will be people who will accept moderate risk in pursuit of a return offering only 5-10% p.a. more than a safe investment, and others who will reject moderate risk when the expected payoff is much higher than a guaranteed return.

Without investment payout information, participants may have responded according to a subjective impression of risk. This subjective impression could vary nonlinearily with
actual risk. The normative correctness of this response pattern is indeterminate from the current experiment because the risk option payout was not specified. The value of the current experiment lies with the authenticity of its scenarios. Participants evaluated combinations of term, guaranteed interest rate, and indeterminate but potentially better returns. This information resembles what is typically available for genuine investments.

To summarise the current experiment, risk aversion was expected, and occurred. Risk aversion manifested as excessive preference for low but guaranteed returns. Risk aversion was strongest for moderate to high risk, that is, for combinations of long term and high interest which offered superior expected utility to the guaranteed low interest alternative despite the high risk.

The predicted higher acceptance of risk with longer term investments, which would have indicated delay discounting of risk, did not occur. Participants’ presumed underestimation of long term compound interest returns could have maintained risk aversion for the more protracted investment. The slightly increased risk aversion found towards the larger investments may indicate increased probability discounting of larger investments that was noted in the probability discounting literature and predicted for this experiment.

Results from the current experiment suggest that investors will commonly avoid investments offering anything more than low levels of risk even if the potential for high interest should render the risk investment attractive. They would fail to acknowledge protection from risk that long term compound interest may offer. The next two experiments interpret responses to risk more precisely, by specifying exact payouts.
Experiment 8: Choosing Between Guaranteed 5% p.a. or Higher Profit With Risk of Zero Profit

In the previous experiment, participants chose between investing at 5% p.a. with no risk, or choosing a higher percentage return with the danger that the better return may not eventuate. The probabilistic rewards were indeterminate. Nor were dollar values for potential payouts shown. Participants only saw the percentage return. The items were externally valid insofar as they gave the same information that is commonly available for genuine investments. However, without exactly specifying reward size, Experiment 7 could not precisely evaluate the normative correctness of decisions.

The current experiment resembles Experiment 7 but has the following differences:

- Outcomes for risk investments are quantified precisely. The investment either earns the higher return (compared with the guaranteed lower return) or it earns nothing, but this time the investment can never lose money. This feature makes it easy to calculate expected utilities simply by multiplying return by probability. Utility for the risk option can be compared with the lower, definite return, allowing the specification of a normatively correct response. For example, a 50% chance of earning $1,000 should be valued higher than a definite $400 return. Whether participants respond accordingly can be tested. Kahneman and Tversky’s work, and results from the previous experiment suggest that they will not. Instead, risk aversion is expected. Risk aversion would be demonstrated as an exaggerated preference for smaller, guaranteed returns compared with the normative rule.

- The actual profit is provided, not just the percentage return. Participants evaluated rewards expressed in dollar values. Profits did not include capital invested.
Experiment 8

Participants again chose between a guaranteed, low return 5% p.a. investment or a higher return investment with variable risk of no return, but with no chance of losing initial capital. A single value only ($1,000) for the investment amount features in this experiment, facilitating mental calculation of percentage profits by participants if desired.

Opposing effects identified in previous research and mentioned in Chapter 5 could influence responses to the scenarios. These effects derive from the positive association between investment term and payout that occurs with compound interest. Effects that could increase the attractiveness of risk investments with longer terms are:

- Reduced probability discounting of longer term investments because of delay discounting of risk, as per Jones and Johnson (1973), and Keren and Roelofsma, (1995). According to this principle, increasing the term alone helps to offset risk.

- Reduced delay discounting of larger rewards provided by longer term compound interest. The higher subjective value conferred by reduced delay discounting would help to offset risk. Results for the Chapter 3 experiments suggest that larger investments enhance the perceived value of longer term, compound interest investments in a manner consistent with reduced rates of delay discounting, although Experiment 5 found no such evidence. The current experiment resembles Experiment 5 in that profits only are shown.

Effects that could diminish the appeal of longer term investments are the following:

- Larger rewards such as those provided by longer term compound interest experiencing increased probability discounting, which reduces subjective value and tolerance to risk – as noted in Chapter 5. Whereas delay discounting provides a
subjective advantage for longer terms, probability discounting would steer preferences away from longer terms by reducing the perceived value of larger rewards, and thus their ability to compensate for risk. Experiment 7 found a slight but significant effect for investment amount in a direction consistent with increasing probability discounting of larger rewards.

- Larger rewards are subject to diminishing marginal utility, which would decrease their incremental subjective value and consequently erode their ability to offset risk. Results from Chapter 3, for which larger amounts of money were more attractive for investment than smaller amounts, suggest that decreased delay discounting of larger rewards more than compensates for diminishing marginal utility of compound interest returns although, again, Experiment 5 found no significant effect for investment amount. Although diminishing marginal utility has the potential for influence, results thus far suggest it has no predominant influence on appraisals of investment profits.

The forthcoming experiment tests which of these contrary sets of influences predominates for investment scenarios with uncertain profits. This aim is achieved by examining whether risk tolerance is greater for longer or shorter terms for investments where compound interest profits increase with term. If risk tolerance is higher for longer terms, it would suggest the dominance of delay discounting of risk, reduced delay discounting of larger rewards, or both. Risk tolerance decreasing for longer terms would suggest the dominant influence of increased probability discounting of larger rewards, diminishing marginal utility of larger rewards, or both. These sets of contrary tendencies could also cancel out, giving a net null effect for term. The experiment embodies the logic of a two-tailed
significance test, whereby either of two means (in this case, mean acceptance of a longer
term or a shorter term risky prospect) could be the higher, or no difference may occur.

Method

Participants

Data were collected from 53 undergraduate university students. Seven participants (13%) were male, and 46 (87%) female. Mean age was 18.43 years (SD = 0.93).

Design

The design was a 3-way repeated measures factorial with the following factors and levels:

1. Higher return than 5% p.a. for the investment risk-option – 10%, 15%, 20% p.a.

2. Term – 2, 4, 6, 8 years.

3. Risk – 90% down to 10% chance of higher return, in 10% increments. Risk was presented to participants as the chances of making the higher return. Therefore, high values (e.g., 90%) indicated low risk.

Table 6.5 shows profits on the $1,000 investment for each combination of interest and term with compound returns paid yearly. The table also shows for each interest rate the maximum risk that is allowed before the 5% p.a. guaranteed return becomes normatively preferable. The table shows that levels of tolerable risk increase only slightly with higher terms, and more substantially with high rates of interest. Higher interest offers much greater protection against risk than longer terms.
Table 6.5 Profits and acceptable risk thresholds for Experiment 8 items

<table>
<thead>
<tr>
<th>Interest rate</th>
<th>5%</th>
<th>10%</th>
<th>15%</th>
<th>20%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Term</strong></td>
<td>Profit</td>
<td>Profit</td>
<td>Max. risk</td>
<td>Profit</td>
</tr>
<tr>
<td>2 years</td>
<td>$103</td>
<td>$210</td>
<td>51%</td>
<td>$323</td>
</tr>
<tr>
<td>4 years</td>
<td>$216</td>
<td>$464</td>
<td>53%</td>
<td>$749</td>
</tr>
<tr>
<td>6 years</td>
<td>$340</td>
<td>$772</td>
<td>56%</td>
<td>$1,313</td>
</tr>
<tr>
<td>8 years</td>
<td>$477</td>
<td>$1,144</td>
<td>58%</td>
<td>$2,059</td>
</tr>
</tbody>
</table>

Items were presented in counterbalanced order, with the ascending order between-groups condition (n = 24) incrementing risk followed by term and interest rate. The descending order condition (n = 29) presented items in the opposite sequence, decrementing all factors.

The binary-choice computerised presentation used for previous experiments was employed. Instructions and the first item for the ascending order group were:

Imagine you are in your late 20s and thinking about how to invest a recent windfall. You find an investment that will always earn 5% per annum (p.a.). Alternatively, you could choose another investment that may pay more than 5%, but could also earn nothing. You have to decide whether to invest in the guaranteed 5% p.a. investment, or the higher return investment that may instead pay 0%. All money invested is “locked up” for the duration of the investment, and all interest is reinvested, so you cannot get to your money until the investment finishes. Soon you will choose between investments that will always pay 5% p.a., or alternative investments that could pay more than 5% every year but may instead earn nothing. The scenarios show the amount you invest and the profit you would make from each investment. Always assume the return of your original windfall is guaranteed. You cannot lose the sum of money you invest. The worst that can happen is you make no profit. Ignore taxation, fees, charges and inflation.

You are being asked to choose between an investment with a guaranteed return and other investments that can earn more, but could earn nothing. Regardless of which investment you choose, you will always get back the money you invested. When you are given your two options, please focus only on information provided in the options. Each investment option always refers to one, single deposit of money into the investment for a fixed period of time.

Assume that you have two options for investing $1,000.

Option A always earns 5% per annum
Option B can earn 10% per annum, but may earn nothing
Which investment option would you prefer, Option A or Option B?

Option A
Invest $1,000 for 2 years and make $103 profit

Option B
Invest $1,000 for 2 years with a 90% chance of $210 profit and a 10% chance of making $0

Results

The percentage of respondents choosing the higher return with risk option is shown for every combination of experimental factors in Appendix A.

Preference reversal patterns

All participants returned a variety of responses, choosing the risk investment and the safe investment at least once for the 108 items. Table 6.6 shows response patterns, indicating the percentage of participants with uniform response patterns and preference reversals, if any, within levels of term and interest rate. Where preference reversals occurred, the coherent pattern of choosing the risk option at low levels of risk and switching to the safe option at higher risk greatly predominated over other patterns. Uniform responses, where the risk or the safe investment was always chosen for sequences of 9 items along the risk continuum, happened occasionally.
Table 6.6 Response patterns within levels of term and interest rate – Experiment 8

<table>
<thead>
<tr>
<th>Pattern with increasing risk</th>
<th>10% p.a. potential return for risk option</th>
<th>2 years</th>
<th>4 years</th>
<th>6 years</th>
<th>8 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe 5% throughout</td>
<td></td>
<td>8%</td>
<td>4%</td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>Risk option throughout</td>
<td></td>
<td>8%</td>
<td>4%</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>Risk option, switch to safe</td>
<td></td>
<td>75%</td>
<td>79%</td>
<td>85%</td>
<td>85%</td>
</tr>
<tr>
<td>Safe option, switch to risk*</td>
<td></td>
<td>0%</td>
<td>4%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>Safe, risk, safe*</td>
<td></td>
<td>4%</td>
<td>2%</td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td>Risk, safe, risk*</td>
<td></td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Other pattern*</td>
<td></td>
<td>4%</td>
<td>6%</td>
<td>2%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pattern with increasing risk</th>
<th>15% p.a. potential return for risk option</th>
<th>2 years</th>
<th>4 years</th>
<th>6 years</th>
<th>8 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe 5% throughout</td>
<td></td>
<td>4%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Risk option throughout</td>
<td></td>
<td>9%</td>
<td>8%</td>
<td>9%</td>
<td>6%</td>
</tr>
<tr>
<td>Risk option, switch to safe</td>
<td></td>
<td>79%</td>
<td>85%</td>
<td>83%</td>
<td>87%</td>
</tr>
<tr>
<td>Safe option, switch to risk*</td>
<td></td>
<td>4%</td>
<td>4%</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>Safe, risk, safe*</td>
<td></td>
<td>2%</td>
<td>0%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>Risk, safe, risk*</td>
<td></td>
<td>0%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Other pattern*</td>
<td></td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pattern with increasing risk</th>
<th>20% p.a. potential return for risk option</th>
<th>2 years</th>
<th>4 years</th>
<th>6 years</th>
<th>8 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe 5% throughout</td>
<td></td>
<td>4%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Risk option throughout</td>
<td></td>
<td>11%</td>
<td>19%</td>
<td>11%</td>
<td>15%</td>
</tr>
<tr>
<td>Risk option, switch to safe</td>
<td></td>
<td>77%</td>
<td>75%</td>
<td>83%</td>
<td>72%</td>
</tr>
<tr>
<td>Safe option, switch to risk*</td>
<td></td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Safe, risk, safe*</td>
<td></td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Risk, safe, risk*</td>
<td></td>
<td>2%</td>
<td>2%</td>
<td>0%</td>
<td>8%</td>
</tr>
<tr>
<td>Other pattern*</td>
<td></td>
<td>6%</td>
<td>2%</td>
<td>4%</td>
<td>4%</td>
</tr>
</tbody>
</table>

* Incoherent pattern: prefers riskier option to safer option within same set.
Factorial analysis of responses

A 4-way ANOVA evaluated the effects of presentation order, interest rate for the risk option, term and risk. The 5 participants who provided three or more incoherent response patterns (preferring high risk to low risk within a level of interest and term) were excluded. This exclusion reduced the sample size to 22 for the ascending order group and 26 for the descending order group.

The term main effect was not significant, $\Lambda(3, 44) = .95, p = .5072$. The trend, illustrated in Figure 6.2a, shows only a slight increase in participants choosing the higher return with increased term. Nor did term interact significantly with interest rate, $\Lambda(6, 41) = .82, p = .1872$; risk, $\Lambda(24, 23) = .43, p = .2711$; or presentation order, $\Lambda(3, 44) = .96, p = .6217$. Collectively, these tests show that risk tolerance did not vary with term. Participants were no more or less likely to choose the risk investment with changing levels of term.

Figure 6.2b shows the significant main effect of risk option interest rate, $\Lambda(2, 45) = .56, p < .0001$. More respondents chose the risk option as its interest rate increased.

The percentage of respondents choosing the risk option declined significantly, $\Lambda(8, 39) = .04, p < .0001$, as the risk increased, although at a nonuniform rate. The same doubly inflected function occurred is seen in Figure 6.2c and in Figure 6.1 for Experiment 7. The sharpest rate of decline occurred at intermediate levels on the risk scale.
Normative correctness of decisions

Data were recoded to reflect the consistency of decisions with the expected utility of profits. Expected utility was calculated as the profit from the risk option multiplied by the risk. Where the expected utility of the risk investment exceeds the guaranteed profit of the 5% p.a. safe investment option, subjects should choose the risk option. Not to do so would indicate risk aversion according to a normative criterion. Conversely, to choose the risk option when its expected utility is less than the 5% p.a. safe investment would demonstrate risk seeking. The recoding classified responses in four ways:

1. Correctly choosing the higher return with risk option.

2. Correctly choosing the 5% p.a. safe option.
3. Incorrectly choosing the higher return with risk option (risk seeking).

4. Incorrectly choosing the 5% p.a. safe profit option (risk averseness).

Normatively correct and incorrect responses were counted for the same 48 participants as per the ANOVA above. Figure 6.3 shows the percentage of participants who were risk averse and risk seeking for each combination of risk, investment term and interest rate for the risk option. Risk averseness was a typical and often predominant response to intermediate risk, and was especially common for high interest coupled with high risk. Risk averseness occurred significantly more often than risk seeking, even after controlling for the different number of items for which risk averseness (77 items) and risk seeking (31 items) could occur. Risk averse responses occurred for $M = 34\%$ of applicable scenarios ($SD = 23\%$), whereas risk seeking occurred for $M = 13\%$ (SD = 19\%) of applicable scenarios, $t(47) = 3.81, p = .0004$.

Risk aversion correlated strongly ($r = -.65, p < .0001$) with risk seeking. Participants who made more of the risk averse errors made fewer risk seeking errors. Likewise, risk seeking errors were associated with fewer risk averseness errors. This finding suggests that participants who made risk seeking errors and participants who made risk averseness errors were two different groups rather than the same participants making more of both types of normative error than other participants.
Discussion

Experiment 8 examined responses to investment profits offered with increasing risk and with varying rates of interest and term. The absence of term effects on risk tolerance for
this experiment and the absence of term effects for Experiment 7 are examples of where general principles of discounting summarised in Chapter 5 appear to lack a dominant influence on investment appraisals, whether the risk involved the entire investment amount including the principal (Experiment 7), or just the profits, as in the current investment. Instead, effects having contrary influences may have cancelled each other, or not operated detectably.

Recall from Chapter 5 that the certainty effect is said to reduce with increased delay, so risk tolerance should increase for longer investment terms. Theoretical content in Table 5.1 also argued from a hyperbolic probability discounting standpoint that longer term returns from compound interest investments will partly compensate for risk. Acting against increased risk tolerance for longer delayed rewards could be the higher probability discounting associated with larger rewards from longer terms, and diminishing marginal utility. Together with any delay discounting of risk, reduced delay discounting of larger rewards could have nullified any contrary change to probability discounting rates, the net result being the absence of a significant term effect. The almost flat trend for investment term (Figure 6.2a) could be justified normatively on grounds that larger returns from longer terms offered little additional protection against risk (Table 6.5).

As with Experiment 7, risk aversion featured prominently in responses for the current experiment, especially for long term, high-interest-with-risk investments which paid sufficient profit to compensate for the increased risk. Risk aversion was especially noticeable at moderate risk, consistent with high rates of hyperbolic probability discounting. Because subjects knew the profits, and the investment amount of $1,000 facilitated mental calculation of expected utilities if the formula were known, the result suggests that participants were not attempting to apply, or could not accurately apply the
normative economic principle of evaluating utility as the product of outcome and risk. Few if any participants may have known the expected utility formula and its application.

Consistent with Experiment 7, a precipitous decline in the number of participants preferring the risk investment occurred at intermediate levels of risk (Figure 6.2c). Figure 6.3, showing risk averse and risk seeking responses, substantiates this interpretation, with large proportions of participants opting for the safe investment even when the risk investment offered higher utility. Participants preferred guaranteed small profits to a low risk of receiving no profit at all. This finding is consistent with the risk averseness towards gains alleged in Prospect Theory, and with high rates of hyperbolic probability discounting among some participants. Participants should have been influenced by risk, return and term, but instead they were mostly influenced by risk. Risk aversion among people who probability discount hyperbolically at high rates is also demonstrated in the theoretical graph, Figure 5.2, for levels of risk similar to those in the current experiment.

Although risk aversion was a common response, participants were sensitive to reward size. They were sensitive to the considerable protection against risk offered by higher interest, as evidenced by the main effect for percentage return. Figure 6.2b shows that higher interest returns were increasingly acceptable for the risk option. The result is normatively reasonable according to Table 6.5, which showed that higher interest offered worthwhile protection against risk.

The negative correlation between the risk averse and risk seeking errors suggests a systematic bias towards either acceptance or rejection of risk, rather than just a propensity among some participants to make both types of error. The correlation suggests individual differences in relation to this bias. Individual differences in risk tolerance and varying propensity towards risk seeking or risk averse errors reflect individual differences in
probability discounting rates, as illustrated in Figure 5.2. The findings reflect everyday experience, in that some investors avoid worthwhile risks whereas others chase high returns while paying insufficient attention to risk.

Translated into genuine investment decisions, Experiment 8 results would have investors avoiding anything more than a slight degree of risk, and resisting prospective returns that are nevertheless worth moderate to high levels of risk. Higher rates of compound interest would compensate for risk, increasing the acceptability of probabilistic returns. Investment term would not influence risk aversion.

The next experiment further investigates effects of risk, return and delay on investment appraisals, this time by breaking the link between term and payout. The same levels of profit are offered regardless of investment term, so return and delay are no longer confounded as they are in a compound interest scenario. The confounding of return and delay is a consequence of the compound interest scenarios rather than an experimental design oversight. Experiment 9 examines delay and reward independently by factorially combining term and profit instead of using compound interest. It therefore becomes possible to separate increased probability discounting of larger returns from reduced probability discounting with longer delays, and reduced delay discounting of larger returns. These various and contrary influences cannot be distinguished with compound interest returns. In combination, they appear to nullify the effect of term on decisions.
Experiment 9: Choosing Between Guaranteed Lower Return or Higher Return With Risk for Factorial Combinations of Payout With Term, Risk and Amount

This experiment builds on the previous two experiments which examined the relationship between an investment’s perceived utility, and its term and level of risk.

Kahneman and Tversky’s (1979) certainty effect was observed in both experiments. A high proportion of participants (up to 90%) demonstrated risk aversion by choosing a guaranteed, low rate of return instead of prospective higher returns accompanied by risk, even when the risk option offered higher expected utility. However, patterns of risk aversion may have been influenced by the characteristics of compound interest investments, which offer higher returns for the longer delays. The positive association between reward size and delay that happens with compound interest confounds the contrary effects to probability and delay discounting that may occur with varying investment terms.

A significant effect of investment term on risk tolerance would indicate that the perceived value of a risk varies with time. Jones and Johnson (1973), and Keren and Roelofsma (1995) found evidence of reduced probability discounting with time. The certainty effect reduces with delay, that is, subjective risk is delay discounted. This effect would having risk tolerance increasing for longer terms. Decreased discounting of larger delayed rewards could only amplify this effect.

The lack of a general term effect in Experiment 7 and Experiment 8 could have been a consequence of increased probability discounting, possibly combined with diminishing marginal utility, for the larger rewards from longer term compound interest. These additional effects may have cancelled any reduction of perceived risk with increasing delay.
Experiment 9 resembles Experiment 8 except that the same dollar values for profit are offered for each term. This design separates profit from delay which, in a compound interest investment, are inevitably confounded. Term effects are examined independently of reward size. Another feature of the experiment is that for each level of investment risk (defined as the chance of zero profit), participants were offered at least one profit amount that was normatively worth the risk, and at least one profit amount that was not worth the risk. Risk aversion and risk seeking can be detected for every level of risk.

Predictions, based on existing research and theory discussed in Chapter 5 but so far unsupported by Experiment 7 and Experiment 8 in the current dissertation, are for:

- Higher risk tolerance for longer terms because of reduced probability discounting of further delayed rewards. Participants will be more likely to accept risk investments, including those not normatively worthwhile, when the term is longer.

- Reduced risk tolerance for larger profits because of higher probability discounting, which could be exacerbated by diminishing marginal utility. Participants would be more likely to reject risk investments, including those that are normatively worthwhile, as the size of the prospective profit increases.

A possibility for simultaneous, contrary influences on investment appraisals nevertheless remains. Because investment scenarios necessarily involve delayed rewards, reduced delay discounting of larger rewards could mask increased probability discounting of larger rewards. It is impossible to eliminate delay discounting effects from the design without providing instantaneous rewards, which would obviate the investment context. Any demonstration of higher risk aversion with larger returns will be all the more convincing because such effects must outweigh the contrary influence of reduced delay discounting of
larger returns. The design for the current experiment does remove the confound between
reward and delay affecting the previous two experiments which involved compound
interest, but the current design with its fixed-return investment scenarios still cannot
eliminate delay and its influence on perceived value.

The design includes a second impediment towards demonstrating increased probability
discounting of larger rewards. In the experimental scenarios, larger profits are associated
with higher expected utility. This arrangement need not be the case because expected
utility depends on risk as well as profit, but was instituted in the current experiment when
devising normatively worthwhile investments for every level of risk. Larger profits in the
current experiment will increasingly compensate for higher levels of risk – see Table 6.7
below. In order to manifest in the results, reduced tolerance to risk caused by increased
probability discounting of larger profits must prevail over increasing compensation for
risk, as well as reduced delay discounting.

Two investment amounts are included in the design even though this factor has no bearing
on profits. If participants are sensitive to rates of return rather than absolute return, an
effect for investment amount could be identified. Participants who want increasing
compensation for a larger amount invested could be more risk tolerant as they pursue the
larger profit in spite of risk. Participants who want their profit guaranteed in response to
the substantial immediate sacrifice of a large investment could be more risk averse than
participants with smaller investments. The experiment can detect either increasing risk
tolerance or increasing risk aversion with a larger investment amount.
Method

Participants
Data were collected from 59 undergraduate university students, 45 (76%) of whom were female. Mean age was 18.76 years ($SD = 2.11$).

Design and procedure
Participants chose between a guaranteed low profit of $500, or a higher profit with the risk of zero profit. Only the profits were subject to risk because return of all capital was guaranteed throughout the experiment. The design was a 4-way repeated measures factorial with the following factors and levels:

1. Risk – a 90%, 70%, 50%, 30% and 10% chance of a higher profit against the alternative of zero profit.

2. Higher profit value – $526, $667, $909, $1429, $3333 and $10,000. These values correspond to utilities from levels of risk higher by 5% than the actual levels of risk featuring in the scenarios. The profit values were calculated as $500 divided by a specified level of chance that the higher return will be received. Levels of chance used were those from the risk levels shown above plus 5%, with results rounded to the nearest whole dollar. For example:

- $526 = \frac{500}{95\%}$. Compared with anything less than a 95% chance of receiving $526, receiving $500 with certainty is normatively superior. A 90% or lower chance of receiving $526 is normatively worse than definitely receiving $500. At all levels of risk featuring in the scenarios, the certain $500 option should be chosen over the probabilistic $526.$
Chapter 6 – Experiments with probabilistic investment returns

- $667 = $500 ÷ 75\%. A 90\% chance of receiving $667 is normatively superior than definitely receiving $500 but a 70\% chance of receiving $500 is normatively superior to a 70\% chance of receiving $667. For all scenario risk levels greater than a 10\% chance of not receiving the higher return, participants should choose the certain $500 over the probabilistic $667.

And so on, down to:

- $10,000 = $500 divided by 5\%. A 10\% chance of receiving $10,000 is normatively better than $500 with certainty. The $10,000 probabilistic reward should always be chosen over the definite $500, because a 10\% chance of receiving the higher profit is highest level of risk used in the scenarios.

In summary, $500 with certainty has a higher expected utility than a:

- 90\% or lower chance of $526
- 70\% or lower chance of $667
- 50\% or lower chance of $909
- 30\% or lower chance of $1,429
- 10\% or lower chance of $3,333.

However, $500 with certainty has less utility than a:

- 90\% chance of $667
- 70\% or higher chance of $909
- 50\% or higher chance of $1,429
• 30% or higher chance of $3,333

• 10% or higher chance of $10,000.

The above values enable every level of risk to have at least one probabilistic profit that is normatively better than the safe alternative, and at least one probabilistic profit that is normatively worse. A 90% chance of receiving the $526 profit is normatively worse than the safe $500, but all higher profit levels are normatively worthwhile. At 10% chance of receiving the $10,000 profit is normatively better than $500 guaranteed, but all lower profits are worse.

The next two factors were:

3. Investment terms = 2 years or 5 years.

4. Investment amount = $1,000 or $5,000.

The full range of experimental items (120) provides for poor returns ($500 profit on $5,000 after 5 years) up to very high returns characteristic of speculative investments ($10,000 profit on $1,000 after 2 years). In this regard, the scenarios cover a wide range of investment outcomes.

Table 6.7 shows expected utility for each combination of higher profit and probability for its receipt. Unshaded regions indicate where the $500 certain profit option has higher expected utility than the risk option, and should be chosen. Not to choose it would be risk seeking. Shaded areas identify combinations for profit and risk that are normatively preferable to the certain $500, so the higher profit with risk option should be chosen, otherwise the response is risk averse. Higher profits are associated with greatly increased
expected utility for every level of risk. The bordered cells show levels of profit that would compensate for risk that is higher by 15% than the risk level in the respective column. The bordered items contribute to the analysis of profit amount and risk tolerance that is described in the Results.

Table 6.7 Expected utilities for combinations of probabilistic profit and risk – Experiment 9

<table>
<thead>
<tr>
<th>Higher profit</th>
<th>90%</th>
<th>70%</th>
<th>50%</th>
<th>30%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>$526</td>
<td>$473</td>
<td>$368</td>
<td>$263</td>
<td>$158</td>
<td>$53</td>
</tr>
<tr>
<td>$667</td>
<td>$600</td>
<td>$467</td>
<td>$334</td>
<td>$200</td>
<td>$67</td>
</tr>
<tr>
<td>$909</td>
<td>$818</td>
<td>$636</td>
<td>$455</td>
<td>$273</td>
<td>$91</td>
</tr>
<tr>
<td>$1,429</td>
<td>$1,286</td>
<td>$1,000</td>
<td>$715</td>
<td>$429</td>
<td>$143</td>
</tr>
<tr>
<td>$3,333</td>
<td>$3,000</td>
<td>$2,333</td>
<td>$1,667</td>
<td>$1,000</td>
<td>$333</td>
</tr>
<tr>
<td>$10,000</td>
<td>$9,000</td>
<td>$7,000</td>
<td>$5,000</td>
<td>$3,000</td>
<td>$1,000</td>
</tr>
</tbody>
</table>

Shaded regions indicate risk aversion if $500 guaranteed profit chosen.
Bordered cells feature in specific analysis – see Results.

Order of presentation of items was counterbalanced on a between-groups basis. Ascending order participants (n = 30) were presented with items incremented upwards, with risk the most rapidly changing, followed by term, level of return for the risk option, and then the amount invested. Descending order participants (n = 29) received the same items in the opposite order, from highest to lowest values.
A similar computerised task to that used in previous experiments was employed.

Instructions given to participants and the first item for the ascending order group were:

Imagine you are in your late 20s and thinking about how to invest a recent windfall. You find an investment that will always earn the same rate of interest. Alternatively, you could choose another investment that potentially offers higher returns but could also earn nothing. You have to decide whether to invest in the investment with a low return that is guaranteed, or the higher return investment that may instead pay nothing. All money invested is “locked up” for the duration of the investment, and all interest is reinvested, so you cannot get to your money until the investment finishes.

Soon you will choose between investments that always pay a relatively low return, or alternative investments that could pay more but may instead earn nothing. The scenarios show the profit you would make from each investment. Always assume the return of your original capital is guaranteed. You cannot lose the sum of money you invest. The worst that can happen is you make no profit. Ignore taxation, fees, charges and inflation.

Finally, when you are given your two options, please focus only on information provided in the options. Each investment option always refers to one, single deposit of money into the investment for a fixed period of time.

Assume that you have two options for a 2 year investment of $1,000

Option A will always pay you a small profit
Option B can earn higher profit, but may earn nothing

Which investment option would you prefer, Option A or Option B?

Option A
Invest $1,000 for 2 years and make $500 profit

Option B
Invest $1,000 for 2 years with 90% chance of $526 profit and 10% chance of making $0

Results

Percentages of participants choosing the risk-option are shown for every combination of order, investment amount, profit, term and risk in Appendix A.

Response patterns

Table 6.8 shows the percentage of participants choosing the nominated response patterns with increasing risk. For example, “Risk option; switch to certain $500” indicates that at the lowest level of risk (10% chance of $0 return if the higher interest option is chosen) the participant chose the higher return, but as risk increased a single switch to the certain payment of $500 was chosen and maintained for the other items within a level of term and
amount. Constant responding (always choosing the safe option or the risk option) or a single switch from the risk option to the safe option represents a coherent response pattern irrespective of normative correctness. Switching from the safe to the risk option with increasing risk, or any instance of multiple switching within a series, constitutes an incoherent response pattern. In such cases, the respondent prefers a higher level of risk than they previously rejected: The higher risk is chosen without additional, compensatory reward.

Table 6.8  
Response patterns for combinations of risk, amount invested and term – Experiment 9

<table>
<thead>
<tr>
<th>Risk option profit = $526. Never the correct choice at any risk level in the current experiment.</th>
<th>N = 59</th>
<th>Investment amount and term</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$1,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>Pattern with increasing risk</td>
<td>2 years</td>
<td>5 years</td>
</tr>
<tr>
<td>Always choose certain $500 profit</td>
<td>64%</td>
<td>58%</td>
</tr>
<tr>
<td>Always choose higher return with risk</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>Risk option; switch to certain $500</td>
<td>27%</td>
<td>39%</td>
</tr>
<tr>
<td>Certain $500; switch to risk*</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Certain $500; switch to risk; then to certain $500*</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>Risk option; switch to certain $500; then to risk*</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Other pattern*</td>
<td>3%</td>
<td>2%</td>
</tr>
</tbody>
</table>

| Risk option profit = $667. Correct choice when 90% chance of receipt (≤ 10% risk of $0). | |
|-----------------------------------------------------------------|---------|-----------------------------|
|                                                                 | $1,000  | $5,000                     |
| Pattern with increasing risk                                     | 2 years | 5 years | 2 years | 5 years |
| Always choose certain $500 profit                                | 17%     | 29%     | 31%     | 39%     |
| Always choose higher return with risk                            | 2%      | 0%      | 3%      | 5%      |
| Risk option; switch to certain $500                              | 76%     | 68%     | 64%     | 54%     |
| Certain $500; switch to risk*                                    | 0%      | 0%      | 0%      | 0%      |
| Certain $500; switch to risk; then to certain $500*              | 5%      | 3%      | 0%      | 2%      |
| Risk option; switch to certain $500; then to risk*              | 0%      | 0%      | 2%      | 0%      |
| Other pattern*                                                  | 0%      | 0%      | 0%      | 0%      |
Experiment 9

<table>
<thead>
<tr>
<th>N = 59</th>
<th>Investment amount and term</th>
</tr>
</thead>
</table>

Risk option profit = $909. Correct choice when 70% chance of receipt or higher (≤ 30% risk of $0).

<table>
<thead>
<tr>
<th>$1,000</th>
<th>$5,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern with increasing risk</td>
<td>2 years</td>
</tr>
<tr>
<td>Always choose certain $500 profit</td>
<td>2%</td>
</tr>
<tr>
<td>Always choose higher return with risk</td>
<td>3%</td>
</tr>
<tr>
<td>Risk option; switch to certain $500</td>
<td>85%</td>
</tr>
<tr>
<td>Certain $500; switch to risk*</td>
<td>0%</td>
</tr>
<tr>
<td>Certain $500; switch to risk; then to certain $500*</td>
<td>3%</td>
</tr>
<tr>
<td>Risk option; switch to certain $500; then to risk*</td>
<td>5%</td>
</tr>
<tr>
<td>Other pattern*</td>
<td>2%</td>
</tr>
</tbody>
</table>

Risk option profit = $1,429. Correct choice when 50% chance of receipt or higher (≤ 50% risk of $0).

<table>
<thead>
<tr>
<th>$1,000</th>
<th>$5,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern with increasing risk</td>
<td>2 years</td>
</tr>
<tr>
<td>Always choose certain $500 profit</td>
<td>0%</td>
</tr>
<tr>
<td>Always choose higher return with risk</td>
<td>7%</td>
</tr>
<tr>
<td>Risk option; switch to certain $500</td>
<td>88%</td>
</tr>
<tr>
<td>Certain $500; switch to risk*</td>
<td>0%</td>
</tr>
<tr>
<td>Certain $500; switch to risk; then to certain $500*</td>
<td>2%</td>
</tr>
<tr>
<td>Risk option; switch to certain $500; then to risk*</td>
<td>2%</td>
</tr>
<tr>
<td>Other pattern*</td>
<td>2%</td>
</tr>
</tbody>
</table>

Risk option profit = $3,333. Correct choice when 30% chance of receipt or higher (≤ 70% risk of $0).

<table>
<thead>
<tr>
<th>$1,000</th>
<th>$5,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pattern with increasing risk</td>
<td>2 years</td>
</tr>
<tr>
<td>Always choose certain $500 profit</td>
<td>2%</td>
</tr>
<tr>
<td>Always choose higher return with risk</td>
<td>17%</td>
</tr>
<tr>
<td>Risk option; switch to certain $500</td>
<td>81%</td>
</tr>
<tr>
<td>Certain $500; switch to risk*</td>
<td>0%</td>
</tr>
<tr>
<td>Certain $500; switch to risk; then to certain $500*</td>
<td>0%</td>
</tr>
<tr>
<td>Risk option; switch to certain $500; then to risk*</td>
<td>0%</td>
</tr>
<tr>
<td>Other pattern*</td>
<td>0%</td>
</tr>
</tbody>
</table>
Coherent response patterns greatly predominated. When the risk option provided a relatively low payment, participants typically chose the safe option throughout or, less often, a single switch from the risk option to the safe option with increasing risk. More switching occurred as the potential profit from the risk option increased. For high profits a substantial proportion chose the risk option regardless of the level of risk, although the single switch from the risk option to the safe $500 still predominated.

**Effect of investment characteristics on preferences**

The relationships between preferences for the risk option or the guaranteed $500 profit and the level of risk, risk option profit, investment amount and term were examined using a 4-way repeated measures ANOVA which included presentation order as an additional, between-groups factor. Consistent with the previous two experiments, only participants who returned two or fewer incoherent response patterns were included, in all, 27 each for the ascending and descending order groups.
Figure 6.4 graphs the significant within-subjects main effects, showing the mean percentage of respondents choosing the risk option.

As the risk option profit increased, a higher percentage of participants chose the risk option, $\Lambda(5, 48) = .17, p < .0001$, Figure 6.4a, which is sensible because the higher profits increasingly compensate for risk. The linear and quadratic trends were significant, $p \leq .0001$. Descriptively the linear trend summarises the effect reasonably well. The high expected utilities at the upper end of the profit scale (see Table 6.7) failed to entice at least 25% of participants to accept the risk option. On average, only 75% of participants preferred the $10,000 risk option profit to the $500 safe option even though the $10,000 profit was always preferable, regardless of risk. The appeal of high value risk investments should have been further enhanced by reduced delay discounting of larger rewards.
Chapter 6 – Experiments with probabilistic investment returns

Increased probability discounting, possibly along with diminishing marginal utility, may have attenuated the appeal of larger rewards. This issue is explored in further analysis below, which examines the effect of profit amount on risk tolerance.

On average, participants perceived the risk option as less favourable for the 5-year term compared with the 2-year term, $F(1, 52) = 13.25, p = .0006$, Figure 6.4b. The mean percentage difference amounts to approximately 2 of the 54 participants, so the effect is slight. The trend runs contrary to one of the major predictions for this experiment, that of higher risk tolerance for longer term rewards, based on the principle that subjective risk is delay discounted.

With increasing risk, fewer participants were attracted to the higher return with risk, as would obviously be expected, $\Lambda(4, 49) = .06, p < .0001$, Figure 6.4c. The linear and cubic trends were significant, $p < .0001$. More participants were recruited to the guaranteed-return investment at intermediate risk levels (30% to 70%) than at high and low risk levels. Descriptively, the doubly inflected risk main effect is not so marked as it was in the previous two experiments.

The main effect of investment amount was not significant, $F(1, 52) = 0.45, p = .5049$. For both the $1,000 and $5,000 investment amounts the higher profit with risk option was chosen for $M = 47\%$ items. The risk option was chosen significantly more often for the ascending order condition ($M = 51\%$) compared with the descending order condition ($M = 43\%$), with $F(1, 52) = 5.51, p = .0227$.

A second, major prediction was for greater probability discounting of larger rewards, which would appear as diminishing risk tolerance with higher profits. The issue was addressed by examining the combined profit-risk trend when risk is increased sufficiently
to compensate for the higher expected utility of larger profits. This strategy considerably reduced the higher expected utility associated with larger profits that occurs when all scenarios are analysed. Increasing compensation for risk from larger profits could over-ride increased probability discounting. The next analysis concentrates on items selected so that profit and risk increase in tandem, thereby holding expected utility almost constant.

Responses to the four items bordered in Table 6.7 are analysed. For these scenarios, the risk investment profit compensates normatively for a level of risk higher by 15% than the actual level of risk, so the risk option rewards of $667, $909, $1,429, $3,333 should always be chosen over the guaranteed $500 reward. The expected utility of these items does increase with risk, but increases in profit greatly exceed increases in utility. If expected utility alone guided appraisals, higher risk would seem increasingly favourable for these four scenarios because with higher risk the probabilistic rewards increasingly exceed the minimum required to compensate for the risk. Contrary to this effect, increased probability discounting of larger rewards could reduce preferences for the risk option at higher profit levels.

The four items served as repeated measures for an ANOVA conducted using the same 54 participants as the previous analysis, with investment amount, term, profit-risk combination, and presentation order the other factors. The term, $F(1, 52) = 24.11, p < .0001$, and the profit-risk, $\Lambda(3, 50) = .60, p < .0001$, main effects were significant. The term main effect reflects the result for all 120 scenarios (Figure 6.4b), though more strongly, with the risk option preferred more for shorter terms ($M = 74\%$ preferring the risk option) than longer terms ($M = 51\%$ choosing risk), contrary to the principle that risk is delay discounted.
The main effect for profit-risk is the important finding for this analysis. The mean percentage of respondents choosing the risk option for each level of risk and profit is shown in Table 6.9 for the 2 and 5-year terms, and combined terms.

Table 6.9 Preferences for higher rewards that compensate for risk

<table>
<thead>
<tr>
<th>Profit and risk for risk option (expected utility)</th>
<th>2-year term</th>
<th>5-year term</th>
<th>Combined terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>90% chance of $667 ($600)</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
</tr>
<tr>
<td>70% chance of $909 ($636)</td>
<td>67%</td>
<td>55%</td>
<td>61%</td>
</tr>
<tr>
<td>50% chance $1,429 ($715)</td>
<td>81%</td>
<td>42%</td>
<td>61%</td>
</tr>
<tr>
<td>30% chance of $3,333 ($1,000)</td>
<td>74%</td>
<td>31%</td>
<td>53%</td>
</tr>
</tbody>
</table>

N = 54

For combined terms the linear trend for risk was significant, $F(1, 52) = 26.14, p = .0001$. This trend indicates diminishing enthusiasm for the risk option with increasing profit even with the larger profit offering increasingly better compensation (expected utility) for the associated risk. This finding upholds the hypothesis for this analysis.

Enthusiasm for the risk option with increasing risk and profit varied across levels of term, with the profit-risk by term interaction significant, $\Lambda(3, 50) = .64, p = .0001$. For the 2-year term, preference for the risk option was erratic across profit-risk combinations, with only the cubic trend significant, $F(1, 52) = 7.33, p = .0092$. The cubic trend indicates substantive change across levels of term, but not consistent change representing a systematic relationship between risk tolerance, and risk, profit or utility. The trend for 5-year investments does suggest a systematic relationship, with the guaranteed $500 profit increasingly preferred to higher profit and risk. The linear trend for the 5-year investments
was significant $F(1, 52), 59.58, p < .0001$. The trend for 5-year investment doubtless underlies the systematic combined-terms results. Higher profits combined with higher risk were increasingly penalised subjectively even though the profits more than compensated for risk, but only for the 5-year investments and not the 2-year investments.

**Normative correctness of responses**

Figure 6.5 shows the mean percentage of participants making the normatively *incorrect* choice for the interaction between risk and risk option potential profit for all scenarios. Grey-column items indicate risk averseness. Black columns indicate risk seeking.

![Graphs showing normative correctness of responses](image)

**Figure 6.5** Risk averseness and risk seeking across profit levels – Experiment 9
For much of the risk range, participants apparently did not realise or were not persuaded by the normative superiority of high returns compared with the $500 alternative. When high profits were combined with high risk, a majority of participants were risk averse, avoiding the normatively worthwhile risk investment.

As well, participants often failed to identify the safe $500 option as the better prospect. Approximately 40% of participants were risk seeking, this result occurring where risk option profits were low or moderate, and risk correspondingly low or moderate, yet insufficient to compensate for risk. Results for Figure 6.5 resemble Figure 6.3 from Experiment 8. Risk averseness is especially pronounced at high profit combinations.

Risk aversion correlated -.50 with risk seeking, \( p = .0001 \). As with Experiment 8, participants who demonstrated risk aversion were protected against risk seeking, and risk seeking protected against risk aversion.

**Discussion**

No evidence was found for delay discounting of risk. The predicted increase in willingness to choose the risk investment for longer terms did not occur. Unlike Experiment 8, in the current experiment similar levels of risk tolerance for long and short term investments cannot be attributed to increased probability discounting of larger rewards from long term compound interest cancelling any reduction in probability discounting associated with the longer term. In the current experiment, delay was independent of reward size. The term result is consistent with Experiment 8 but inconsistent with expectations from literature such as Jones and Johnson (1973), and Keren and Roelofsma (1995).
Despite percentage returns being 5 times better for the $1,000 investment compared with the $5,000 investment, the amount invested did not affect risk tolerance. Respondents evidently attended only to the net profit values and not to the investment amount. They may simply have ignored the investment amount, and considered the profits and risk independently of the temporary cost of gaining the profits.

That risk seeking occurred in the current experiment and Experiment 8 is inconsistent with the Prospect Theory principle (Kahneman & Tversky, 1984) that people are risk averse towards gains. Prospect Theory has people risk seeking towards losses, but neither the current nor the previous experiment presented participants with the chance of loss. Zero profit was the worst possible outcome with the risk investment. Therefore, little if any risk seeking would be expected. However, hyperbolic probability discounting readily accommodates risk seeking as illustrated in Figure 5.2, which shows that risk seeking can occur towards gains when people who probability discount hyperbolically at a low rate are presented with prospects within the risk range for the current set of experiments.

Evidence for increased probability discounting of larger rewards was sought by comparing preferences for four scenarios where the risk option profits were boosted at least sufficiently to compensate for risk. Reduced appeal for the risk investment when profits were larger occurred despite any reduction in delay discounting of larger profits that may have operated. However, reduced appeal for the larger investments occurred only for the 5-year terms, and not the 2-year terms. Diminishing appeal of the larger, probabilistic profit is consistent with increased probability discounting of larger rewards identified in previous research described in Chapter 5 (e.g., Green et al., 1999). The restriction of this effect to the 5-year investments is unexpected from theory discussed in Chapter 5.
An issue concerning increased probability discounting of larger profits in the current experiment is the strong relationship between reward size and risk with the four scenarios that contributed to this analysis. Participants may have responded mainly to the increased risk rather than the increased reward. Experimental findings therefore do not incontrovertibly demonstrate higher probability discounting of larger rewards. (The analysis does not show that the certain value of a $10,000 reward is less than 10 times the certain value of a $1,000 reward at a given level of risk.) However, the analysis was forced to associate risk with reward size because to examine these two factors independently merely replicates Figure 6.4a and Figure 6.4c, which demonstrated the more prosaic principle that reward per se and risk per se affect the appeal of an investment. Of greater interest to researchers of investment behaviour is the extent to which reward compensates for risk, given that risk and reward are closely related in genuine investments. Scenarios for this analysis were chosen to nullify risk indirectly, via reward size, and according to a normative criterion. Higher probability discounting of larger rewards, possibly along with diminishing marginal utility, could have reduced the subjective value of larger rewards so that they compensated for proportionate levels of risk less well than smaller rewards.

The greater appeal of risk-option profits presented in ascending order of magnitude compared with descending order scenarios reflects the preference for improving returns noted in earlier experiments, and is consistent with Loewenstein and Prelec (1993).

The occurrence of both risk seeking and risk aversion, with the moderately strong negative correlation between each, suggests individual differences in risk tolerance among participants, consistent with results from Experiment 8. These results reflect common knowledge that some investors are risk averse, whereas others tolerate risk.
The practical implication from the findings for the current experiment is that larger potential profits will attract investors, but not necessarily enough to overcome subjective appraisals of high risk. Normatively maladaptive risk aversion seen in Figure 6.5 is the consequence. Apparently, it requires substantial over-compensation to persuade investors to accept a high level of risk when a small but guaranteed alternative profit is available. Translated into investment behaviour, some investors will be sufficiently risk averse to reject high prospective profits coupled with high risk even when they should be accepted on normative grounds. Other investors will be sufficiently risk seeking to accept the prospect of relatively low profits available at low risk when a guaranteed but even lower profit would be normatively superior.
**Summary of Chapter 6**

Risk aversion towards investment returns that were normatively worthwhile was a common finding in this set of three experiments, which examined preferences for guaranteed returns compared with probabilistic, higher returns. Sizeable proportions (often a majority, and up to 90%) of participants preferred a guaranteed low return to the chance of a higher return with the risk of a zero return or loss, even though the risk option offered higher expected utility. Risk aversion occurred most often when potentially high returns were combined with high risk. It rarely occurred at low levels of risk. These findings applied for Experiment 7, which presented participants with combinations of risk, term and compound interest rate with the possibility of total loss, but without showing actual dollar returns; Experiment 8, which did show compound interest profits, with the risk of no profit; and Experiment 9, where profits were fixed rather than linked to terms. Risk aversion is consistent with Prospect Theory and associated research which has consistently shown in various contexts that individuals tend towards risk aversion with gains. Risk aversion is similarly consistent with some experimental participants discounting probabilistic returns hyperbolically at high rates. Risk seeking also occurred, which is consistent with other participants discounting probabilistic returns hyperbolically at low rates.

Another major prediction was that risk tolerance would increase for longer term investments, but no evidence was found for this proposition. With Experiment 7 and Experiment 8, increased probability discounting of the larger returns associated with longer term compound interest could have nullified any reduced probability discounting of longer terms. Experiment 9 rendered profits independent of amount invested and term, and found risk aversion to increase with the longer term, although only slightly.
Experiment 9 found evidence for increased risk aversion for higher rewards for a set of scenarios where profits more than compensated for increasing risk. The increased risk aversion with combinations of higher profit and risk is consistent with increased probability discounting of the larger profits, although not a definitive demonstration. Increased risk aversion towards higher rewards occurred only for the 5-year term and not for the 2-year term investments.

Participants showed little if any consistent application of expected utilities to their appraisals, presumably because of unfamiliarity with utility theory and the associated formula, and their tendencies towards risk aversion or risk seeking. Instead, it appears that the perception of risk exerts the major influence on investment appraisals. Investment returns, which were presented in three different ways across the experiments, were a secondary consideration. Participants did switch their preference to the risk option as potential profits associated with that option increased, although not commensurately with the large profits on offer.

If these findings generalised to real investment decisions, the popularity of low but fixed interest investments such as bank term deposits is assured for many investors, even when investors are informed that the investments involving some risk are likely pay much higher returns than their low-return but safe alternatives. Only if the perceived risk is low, in the order of an 80-90% chance of a substantially higher return than bank interest, and the prospective returns very high, would probabilistic returns appeal to a large majority of investors. On the other hand, there is another set of investors who will accept the possibility returns which are not justified, even with a comparatively low level of risk.
Chapter 7 – Evaluating Investments’ Past Returns

Chapter 1 argued that personal investment imposes three demands. First is the sacrifice of immediate expenditure for higher but delayed expenditure opportunities. This issue was examined in Chapter 2 through to Chapter 4, which explored delay discounting effects on investment appraisals. Second, investors must decide whether higher, delayed returns are worth the risk. Chapter 5 and Chapter 6 explored this topic. The third demand is the choice of an investment from the many available. For other than fixed interest investments, choices may have to rely on past performance to indicate future performance. Chapter 1 maintained that using past performance to indicate future performance requires inductive inference, that is, generalising from existing facts. The current chapter explores how prospective investments are evaluated when past returns are presented as a time series.

A Series of Investment Returns

Investment prospectuses often show past investment performance as a series of returns across intervals of time. Investors have to detect an underlying rate of return from a set of returns, concealed as it is within random variation. The underlying rate of return would be used to infer future returns. In the absence of inside market knowledge, the long term rate of return may be the only available indicator of future performance, even though prospectuses often advise that past performance does not predict the future.

Table 7.1 shows what may confront an investor comparing investment fund historical returns. Past performance is presented for “multifund single sector investment options” for international and Australian share funds with a “higher risk profile” and complete histories from the AMP December quarter 2002 bulletin p. 14. Per annum returns are shown across
various terms. Performance varies considerably within and between funds. The deplorable results for all funds doubtless reflect stock market conditions at the time of compilation.

Table 7.1  Historical investment performance (% p.a.) from a managed fund bulletin

<table>
<thead>
<tr>
<th>Fund</th>
<th>3 months</th>
<th>6 months</th>
<th>1 year</th>
<th>3 years</th>
<th>5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMP International Share</td>
<td>1.3%</td>
<td>-16.7%</td>
<td>-30.8%</td>
<td>-16.5%</td>
<td>-3.1%</td>
</tr>
<tr>
<td>BT International Share</td>
<td>0.0%</td>
<td>-17.5%</td>
<td>-31.8%</td>
<td>-17.0%</td>
<td>-2.6%</td>
</tr>
<tr>
<td>Dresdner RCM International Equities</td>
<td>0.5%</td>
<td>-12.1%</td>
<td>-30.1%</td>
<td>-15.7%</td>
<td>3.8%</td>
</tr>
<tr>
<td>Lazard Freres Global Equities</td>
<td>4.5%</td>
<td>-10.4%</td>
<td>-24.0%</td>
<td>-10.1%</td>
<td>-0.4%</td>
</tr>
<tr>
<td>AMP Australian Share</td>
<td>2.7%</td>
<td>-4.1%</td>
<td>-7.8%</td>
<td>3.5%</td>
<td>7.8%</td>
</tr>
<tr>
<td>Colonial First State Australian Share</td>
<td>2.0%</td>
<td>-6.1%</td>
<td>-13.8%</td>
<td>-0.9%</td>
<td>5.4%</td>
</tr>
<tr>
<td>Macquarie Australian Enhanced Equities</td>
<td>1.4%</td>
<td>-6.4%</td>
<td>-11.1%</td>
<td>-0.2%</td>
<td>5.3%</td>
</tr>
<tr>
<td>ING Australian Share</td>
<td>1.9%</td>
<td>-5.6%</td>
<td>-9.6%</td>
<td>1.1%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Perpetual Industrial Share</td>
<td>1.0%</td>
<td>-4.2%</td>
<td>-2.0%</td>
<td>6.7%</td>
<td>8.2%</td>
</tr>
</tbody>
</table>

Table 7.2 uses fabricated scenarios to demonstrate further the difficulty of comparing series of past returns. The table shows annual percentage returns from hypothetical 10-year investments. Year 1 represents the first year of the investment, Year 2 the second year, and so on down to Year 10, the final year. Returns were generated randomly, yet with fixed distributional parameters. The final row of the table shows the dollar value at the end of the 10-year term, principal included, of a hypothetical $1,000 invested at the outset with compound interest paid yearly.
## Table 7.2 Yearly percent p.a. from hypothetical 10-year investments generated from random numbers

<table>
<thead>
<tr>
<th>Year</th>
<th>Randomly ordered returns</th>
<th>Sequenced returns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Different random returns</td>
<td>Improving</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.2%</td>
</tr>
<tr>
<td>1</td>
<td>10.8%</td>
<td>4.5%</td>
</tr>
<tr>
<td>2</td>
<td>14.4%</td>
<td>11.9%</td>
</tr>
<tr>
<td>3</td>
<td>4.8%</td>
<td>10.4%</td>
</tr>
<tr>
<td>4</td>
<td>11.9%</td>
<td>3.9%</td>
</tr>
<tr>
<td>5</td>
<td>9.9%</td>
<td>7.1%</td>
</tr>
<tr>
<td>6</td>
<td>4.1%</td>
<td>16.5%</td>
</tr>
<tr>
<td>7</td>
<td>15.2%</td>
<td>18.2%</td>
</tr>
<tr>
<td>8</td>
<td>1.1%</td>
<td>12.4%</td>
</tr>
<tr>
<td>9</td>
<td>14.5%</td>
<td>10.5%</td>
</tr>
<tr>
<td>10</td>
<td>13.4%</td>
<td>4.6%</td>
</tr>
<tr>
<td></td>
<td>Final value in dollars</td>
<td>$2,569</td>
</tr>
</tbody>
</table>

Investments in the two left-most columns show a mean return of 10% p.a. paid yearly with $SD = 5$, representing a moderate return with low volatility. Different sets of random numbers were used to generate these two columns of returns. Final values of the two investments differ only slightly. Ideally, an investor should identify these two sets of percentage returns as offering equivalent outcomes. The third investment also pays a mean of 10% p.a. but its higher volatility, including occasional losses, reduces the final payout, showing how volatility can cost the investor. Ideally, an investor should recognise and
avoid investments with higher volatility than other investments offering the same, mean percentage return over time.

The fourth investment has a 15% p.a. mean return along with high volatility, leading to intermittent losses. If these returns generalised to the future, the fourth investment would offer a superior long term prospect to the low (and high) volatility 10% p.a. investments despite intermittent negative returns. Volatility may cost the investor, but generally high returns over a long term can compensate for intermittent losses.

The last two investments (right-most columns of Table 7.2) have identical percentage returns. They differ only in their sequence of the returns. For the improving returns, the five lowest percentages have been randomly allocated to the first 5 years. The five highest percentages are allocated to the final 5 years. Deteriorating returns exchange results with improving returns for the early and recent set of 5 years. Final payouts are nevertheless identical for the improving and deteriorating returns owing to the commutative law of mathematics. Percentage returns are fundamentally coefficients that can be reordered without affecting the product.

The two right-most investments in Table 7.2 with sequenced returns have a slightly higher final payout compared with the fourth investment, even though returns from all three of these investments have the same underlying distribution ($M = 15, SD = 25$). This is because the fourth investment has different values of percentage return, which differentially affects the final payout, as occurred to a slight extent with the first two investments in the left-most columns. A future investment that paid returns with the same mean and standard deviation as it did in the past could nevertheless provide a different final payout over the same term because of random variation in the actual values of the ongoing returns.
Table 7.2 has implications for investment decisions. To decide sensibly for the future, investors must at least be able to:

1. Distinguish higher returns from lower returns and recognise fundamentally equal returns through the random “noise” of volatility.
2. Distinguish high from low volatility.
3. Recognise the negative effect of volatility on returns.
4. Recognise that the sequence of returns alone has no effect on outcomes.

It is reasonable to ask whether people can succeed with these tasks. Harvey (1988) examined subjects’ ability to forecast values based on a time series using nonanalytical means and found performance to be good, suggesting that subjects acquired an internal representation of the series. Even so, the lack of comprehensive research about how ostensible characteristics of investment past performance affects appraisals, together with the large amounts of money at stake with investment decisions, shows that this issue warrants further investigation.

**Aims of the Investment Evaluation Survey**

The survey reported examines whether subjects appraise series of investment returns consistently with criteria for accurate appraisal listed above. It tests whether subjects can distinguish different levels of return across levels of volatility; whether they can distinguish high from low volatility with different rates of return; their ability to identify the best-performing investment in terms of final dollar payout; and whether the sequence of returns affects appraisals when sequencing has no effect on the final payout. Subjects’ appraisals reveal perceived prospective value based on actual retrospective value.
The general methodology was a survey presenting mature aged, postgraduate finance students with simulated investment returns, of which Table 7.1 includes examples. Investment simulations were randomly generated, but with fixed parameters. Participants rated the investments according to subjective impressions of earnings, risk, and worthiness as future short or long term investments. Unlike the earlier experiments in this thesis, subjects evaluated sets of multiple, past returns rather than prospective investments with a single combination of term and payout.

The scope of the survey was broader than the topics under investigation in the current thesis, with its emphasis on reward delay. The wider investigation compared different ways of presenting investment returns, such as average, and annualised returns, and dollar value histories, introduced as a between-subjects effect with the aim of identifying ways of presenting investment performance that minimise biased appraisal, as described further in the Method section. Bidewell (2001) summarises the full survey’s findings. Briefly, it was found that returns presented as yearly percentages (as per Table 7.2) provided useful sensitivity to risk, whilst $1,000 investment histories provided the best sensitivity to differing levels of return. Maladaptive appraisals occurred, such as preference for high volatility over low volatility for improving returns expressed as mean and annualised percentages. These problems were attributed to framing effects.

Survey analysis and results reported in this chapter were conducted specifically for the thesis, and involved a subsample of respondents. The analysis concentrates on respondents who appraised successive yearly returns presented as separate, per annum percentages, as in Table 7.2. Cumulative returns presented as mean and annualised percentages, and changing values of a $1,000 investment were omitted because these presentations conceal the separate values that comprise the investment performance time series. Comparing
responses to different investment presentations involved detailed analysis beyond the scope of this chapter, and not relevant to delay and probability discounting.

**Theoretical Background to the Survey**

The theoretical work most relevant to the current discussion begins with Simon’s concept of bounded rationality, as described in Tisdell (1996), which proposes a limited cognitive capacity for processing, storing and retrieving information. These limitations restrict calculation and problem solving ability. For example, it is unrealistic to expect people to estimate the final dollar values shown in Table 7.2 from the percentage returns. (A separate, “investment estimation” survey was piloted for the current thesis using a sample of adult laypersons. Participants attempted to estimate compound interest returns from varying rates of interest, term and amount invested. They found the task so difficult, and even aversive, that hardly any completed surveys were returned, leading to the survey’s abandonment. Estimates from the returned surveys were grossly inaccurate.)

Moreover, decision makers are alleged to have limited capacity for choice. Decision options may be too numerous for an individual to evaluate, requiring a compromise on perfect rationality and selection of the best-appearing option from a restricted set. *Satisficing* is the term given to this type of compromise. The obvious questions for the current study are what makes an investment the “best-appearing,” and whether the best appearing investment truly is the best.

**Heuristics and Biases in Decision Making**

Tversky and Kahneman (1974) showed “that people rely on a limited number of heuristic principles which reduce the complex tasks of assessing probabilities and predicting values to simpler judgmental operations” (p. 1124). Tversky and Kahneman noted that heuristics
Investment evaluation survey

may serve people adequately in many situations, but can lead to predictable errors in the form of judgement biases. These errors allegedly demonstrate the flawed nature of economists’ rationality postulate (Laibson & Zeckhauser, 1988).

The notion that judgemental heuristics may influence investment decisions now finds its way into the popular press, for example, Sampson (2003), which mentions Kahneman and Tversky’s work in behavioural economics leading to Kahneman’s Nobel award (Smith, 2003). Sampson discusses judgemental heuristics and biases, and how aversion to loss, framing and the perception of systematic patterns in random sequences could damage people’s ability to process and respond to financial information adaptively. Sampson’s article claims that heuristics and biases compromise investment decisions.

The heuristics most likely to affect investment appraisals include representativeness, which, according to Kahneman and Tversky (1974) can lead to fallacies associated with chance events, such as gamblers’ fallacies. Kroll et al. (1988) argue that the representativeness heuristic encourages financial decision-makers to perceive order where only randomness exists, and that this tendency can and does lead to suboptimal investment choices. Table 7.3 shows hypothetical sequences of returns that suggest unsystematic and systematic performance returns. An analogous version appears in Tversky and Kahneman (1974). The three investments paying $M = 15\%$ p.a. with $SD = 25$ (i.e., the three right-most columns) in Table 7.2 are another example.
Table 7.3  Apparently random and nonrandom hypothetical investment returns

<table>
<thead>
<tr>
<th>Appearance</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random</td>
<td>Good</td>
<td>Poor</td>
<td>Poor</td>
<td>Good</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Systematic</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
</tbody>
</table>

Returns for the upper row of Table 7.3 appear random because high and low returns are interspersed. The apparently systematic returns on the second row could imply that a previously poor investment has recovered and will offer good returns in the future, yet both sequences have identical frequency distributions. Neither row has superior returns to the other, and both distributions are equally likely on the basis of chance.

With the *adjustment and anchoring* heuristic, judgements rely excessively on starting values. An example from Tversky and Kahneman (1974) is the typically higher result estimated for the answer to $8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1$ and its reverse: $1 \times 2 \times 3 \times 4 \times 5 \times 6 \times 7 \times 8$, when the answer is the same regardless of multiplication order. Sequencing of returns may influence impressions about investment performance even though rearranging a set of multipliers leaves their product unchanged. If early investment returns influence appraisals disproportionately, investors would incorrectly assume a higher final dollar value for the deteriorating returns in Table 7.2 compared with improving returns.

**Possible Discounting Effects on Investment Performance Appraisals**

Returns that are more distant in time, that is, occurring early during an investment could be discounted. This tendency amounts to delay discounting of the past. The intertemporal choice literature occasionally refers to the subjective value of past rewards and events (e.g., Rachlin & Raineri, 1992; Elster & Loewenstein, 1992). If past returns were delay
discounted retrospectively, the higher returns that occurred late during an improving returns investment in Table 7.2, and the lower returns occurring late during a deteriorating returns investment would carry more salience than the earlier returns. On this basis, recent high returns from an improving investment would render it more subjectively favourable than deteriorating investment returns, consistent with Loewenstein and Prelec’s (1993) research into future prospects which found that people prefer improving sequences to deteriorating sequences. Note that the prediction based on Loewenstein and Prelec (1993) is opposite to the above-mentioned prediction from the adjustment and anchoring heuristic.

Probability discounting diminishes the subjective value of a reward with increasing risk. Research discussed in Chapter 5, such as Jones and Johnson (1973), and Keren and Roelofsma (1995) found that delay diminishes probability discounting, enhancing the appeal of longer delayed rewards with the same risk as shorter delayed rewards, that is, producing higher risk tolerance with longer delays. Chapter 6 experiments found no evidence that investment risk tolerance increases with term. However, if delay discounting of risk were to influence the subjective value of prospective investments as per the literature, investment risk could be perceived as more important for short term investments than long term investments. General knowledge that investment risk diminishes with increased term could reinforce this tendency. As a result, investors could rate the worthiness of a future investment as higher when the prospective term is long than when it is short. On the other hand, if trends follow those for the Chapter 6 experiments, the perceived worthiness of future investments will not vary with term.
Chapter 7 – Evaluating investment’s past returns

Investment Evaluation Survey Method

The sample and design reported below refer to the full survey, not just the subjects, factors and conditions contributing to the Results and Discussion in this thesis.

Participants

Participants consisted of 110 postgraduate finance and management students attending the graduate school of management at a large university in Sydney, Australia. The number of students was the maximum the school could provide. Surveys were distributed in class time by arrangement with lecturers. Students who declined to participate were free to leave for half an hour, but almost all elected to participate.

Design

The survey was a self-completion pencil and paper exercise. Investment scenarios were presented as historical returns for a 10-year investment commencing in 1990 and finishing in 1999. The survey was run in late 2000.

Between-subjects factors

Three fixed, between-subjects factors were employed. These factors partly defined the investment scenarios. Bolded terms will henceforth refer to the respective factor.

1. Random number set – 4 levels. This factor partly defined the investment scenarios. Investment scenarios were generated from four independents sets of random numbers. This strategy gave variety to the investment scenarios.
2. **Format** of investment performance history – 4 levels. These were:

⇒ Annual percentage returns, showing the percentage return for each year. This is the only format contributing to the Results and Discussion.

⇒ Mean percentage returns: the mean compound percentage return for previous years, commencing with the most recent, final year of the investment, and successively including previous years all the way up to the full 10 years of the investment.

⇒ Annualised percentage returns: the cumulative percentage based on a standard formula that corrects for compounding.

⇒ Change in dollar value of investments: the value of a $1,000 investment is recorded for each of the 10 years of the investment term. Annual returns are reinvested.

3. **Order** of presentation. Half of the surveys presented scenarios in reverse order to the other half. Orders were arbitrarily defined as “forward” and “reverse.”

The three between-subjects factors were factorially combined, giving 32 versions of the survey. The different survey versions were randomly distributed to participants.

Within each survey version the investment scenarios were presented in a quasi-random sequence with the restriction that pairs of consecutive scenarios had to have different levels of mean annual percentage return or volatility. The same sequences of scenarios applied to all versions of the surveys (i.e., consistently across the four random number sets).
Chapter 7 – Evaluating investment’s past returns

Within-subjects factors

Four repeated measures factors further defined the investment scenarios.

1. **Mean annual percentage returns** for the 10-year period, with three levels: 5%, 10% and 15% p.a.

2. **Volatility** for investment return, with three levels: $SD = 0$ (a constant rate of interest), $SD = 5$ and $SD = 25$, with higher $SD = higher$ volatility. Zero volatility is especially obvious in a series because interest rates have the same value from year to year, whereas even low volatility investments show some variation.

3. **Sequence** of high and low returns, consisting of three levels:

   ⇒ Annual returns randomly distributed across the 10-year term according to the survey set (between-subjects variable).

   ⇒ Returns improving across the 10-year term. The 10 annual returns were categorised into five highest and five lowest. The five lowest returns were randomly allocated to the first 5 years of the investment, and the remaining five highest returns randomly allocated to the most recent 5 years.

   ⇒ Returns worsening with time (“deteriorating”). The five highest annual percentage returns were randomly allocated to the first 5 years and the five highest returns randomly allocated to the last 5 years of the 10-year term. Random order of allocation was the same as for improving returns.

The sequencing factor gave rise to scenarios resembling Table 7.2 on p. 224, and for which that table gives examples. See Appendix B for the complete set of yearly percentage scenarios listed in forward order.
Each within-subjects factor was factorially combined with the other repeats, with the exception of the $SD = 0$ (fixed interest) level of volatility, for which varying sequences of return could not apply. The 21 investment scenarios devised for each questionnaire, included three levels of return by two levels of volatility by three levels of return order, plus the three levels of return with zero volatility. Table 7.4 shows descriptive statistics for the item sets per level of interest and volatility for other than fixed interest. Sequence is omitted from the table because it has no effect on payouts. The table Ns refer to the random number sets. Table entries show payouts from hypothetical $1,000 investments, which relate to earnings; and the number of negative returns within the 10-year investment term, which relates to the risk of losing money. Payouts include the $1,000 invested.

Table 7.4 Descriptive statistics for investment evaluation survey item properties

<table>
<thead>
<tr>
<th>Interest % p.a.</th>
<th>Volatility</th>
<th>Final value of $1,000 investment</th>
<th>No. negative returns in 10-year term</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>5 0</td>
<td></td>
<td>$1,629$</td>
<td>0</td>
</tr>
<tr>
<td>5 5</td>
<td></td>
<td>$1,612$</td>
<td>0</td>
</tr>
<tr>
<td>5 25</td>
<td></td>
<td>$1,249$</td>
<td>28</td>
</tr>
<tr>
<td>10 0</td>
<td></td>
<td>$2,594$</td>
<td>0</td>
</tr>
<tr>
<td>10 5</td>
<td></td>
<td>$2,570$</td>
<td>0</td>
</tr>
<tr>
<td>10 25</td>
<td></td>
<td>$2,039$</td>
<td>39</td>
</tr>
<tr>
<td>15 0</td>
<td></td>
<td>$4,046$</td>
<td>0</td>
</tr>
<tr>
<td>15 5</td>
<td></td>
<td>$4,011$</td>
<td>0</td>
</tr>
<tr>
<td>15 25</td>
<td></td>
<td>$3,248$</td>
<td>54</td>
</tr>
</tbody>
</table>

Table 7.4 shows the increasing value of the 10-year return with higher interest, and the increasing number of negative returns with higher volatility. Higher volatility reduces...
Chapter 7 – Evaluating investment’s past returns

payouts within a given level of interest. Higher interest compensates for higher volatility. These scenarios justify higher perceived earnings and lower perceived risk with higher interest; and lower perceived earnings and higher perceived risk with higher volatility.

Dependent variables

Four dependent variables were assigned to each scenario, consisting of ratings for:

1. Investment earnings – 6-point scale with anchors Very poor, Poor, Fair, Good, Very good and Excellent.
2. “Risk of losing money at any time” – 6-point scale with anchors Very low risk, Low risk, Moderate risk, High risk, Very high risk, Extreme risk.
3. Attractiveness of future investment for 3 years or less (i.e., a short term investment) – 6-point scale with anchors Very poor, Poor, Fair, Good, Very good and Excellent.
4. Attractiveness of future investment for 10 years or more (i.e., a long term investment) – 6-point scale with anchors Very poor, Poor, Fair, Good, Very good and Excellent.

When the analysis compares rating scale responses for 3 and 10-year investments, an additional, binary within-subjects prospective term factor is created from these two dependent variables.
A supplementary section to the survey examined the following self-reported financial and associated behaviours:

- Number of types of personal investments currently held, choosing from: term deposits, bonds, investment property, shares or tradeable commodities, but not personal superannuation, which is compulsory for most employees.

- Personal propensity to spend or save, choosing from *Definitely save, Save, Spend* and *Definitely spend*.

- Personal priority towards risk or return when investing a large amount of money, coded as a binary response with options *Avoiding the risk of losing money, even if it means a lower return*, and *Achieving a high return, even if it involves the risk of losing money*.

- Frequency of personal gambling or betting, coded *Once a year or less, A few times a year, Several times a year, At least monthly, At least fortnightly, At least weekly*.

- Degree of interest in personal investment, coded *Not at all interested, Slightly interested, Moderately interested and Very interested*.

**Investment Evaluation Survey Results**

The analysis commences with a sample description, then explores how investment characteristics affected appraisals of yearly percentage returns. Two analyses of investment characteristics are presented because a full factorial design was not possible with all 21 scenarios without duplicating the fixed interest results to fill the three levels of the sequencing factor. The first analysis includes only randomly ordered returns but does
include fixed interest scenarios. The second analysis omits fixed interest scenarios but examines the sequencing factor, which is a time-related issue. Only effects relevant to the general topic area of this thesis are discussed in detail, with the emphasis on issues of time and risk. Appendix C presents descriptive statistics for the rating scale responses.

**Sample description**

Sixty-nine males and 40 females participated, with one respondent not reporting gender. Sample ages ranged from 22 to 51 years with $M = 30.16$, $SD = 7.01$, $Mdn = 27$. The mode = 25 years (17% of sample). Three respondents did not report their age. The mean age for males was 31.06 years and for females 28.65 years, but these means were not significantly different, $t(105) = 1.74$, $p = .0852$. All surveys were filled out within half an hour, with most requiring approximately 20 minutes.

Twenty three participants appraised yearly percentage returns. These subjects’ results are presented below. Of the participants who appraised other return formats (and whose results are omitted from this analysis), 48 examined mean percentage returns, 30 appraised annualised returns and 32 examined $1,000$ investment histories.

**Fixed interest and random returns analysis**

The effects of earnings and volatility on the perceived future worth of short and long term prospective investments were examined via a 5-way ANOVA. The random number set used to generate the scenarios, and the scenario presentation order served as between-subjects factors. Interest rate, volatility and prospective term were repeat factors. The single dependent variable was the perceived worthiness of the scenario for a future investment rated on the 6-point scale.
Neither the presentation order \([F(1, 14) = 0.45, p = .5148]\), the scenario set factor \([F(3, 14) = 1.03, p = .4077]\) nor any of their interactions, \(p \geq .0859\), were significant, leaving only the within-subjects factors to explore. Figure 7.1 illustrates their joint effects.

Figure 7.1  Term, interest rate and volatility effects on perceived attractiveness for fixed interest and random returns

The term factor \(\Lambda(1, 14) = .97, p = .5016\) was not significant, showing that the perceived attractiveness of the 3-year and 10-year future investments was effectively equal. The mean rating for 3-year prospective investments was 3.36 \((SD = 1.59)\) while for 10-year prospective investments \(M = 3.45\) \((SD = 2.14)\). Both means lie between Fair and Good on the 6-point rating scale. Recall that ratings for 3 and 10-year terms refer to identical scenario information.

Not surprisingly, higher interest significantly increased the perceived attractiveness of future investments, \(\Lambda(2, 13) = .23, p = .0001\), and in a way that interacted significantly
with prospective term, $\Lambda(2, 13) = .59, p = .0318$. Follow-up polynomial contrasts found that 10-year prospective terms became increasingly the more attractive compared with 3-year terms, $F(1, 14) = 7.78, p = .0145$, at a linear rate with higher interest. The interest rate quadratic trend did not interact significantly with term, $F(1, 14) = 0.05, p = .8333$.

Higher volatility rendered future investments less attractive $\Lambda(2, 13) = .26, p = .0002$. Volatility did not interact significantly with term, $\Lambda(2, 13) = .93, p = .6376$. Despite the apparent divergence of 3 and 10-year terms with increasing interest and high volatility (Figure 7.1c) the term by volatility by interest rate interaction was not significant, $\Lambda(4, 11) = .87, p = .8017$.

Figure 7.2 shows the effects of interest rate and volatility on perceived earnings. A 4-way ANOVA was conducted with volatility and interest as within-subjects effects, and with set and order controlled as between-subjects factors. Perceived earnings increased significantly with actual interest, $\Lambda(2, 14) = .13, p < .0001$ and decreased with higher volatility, $\Lambda(2, 14) = .38, p < .0012$. Volatility interacted significantly with interest, $\Lambda(4, 12) = .37, p < .0125$. The significant linear, $F(1, 15) = 33.79, p < .0001$, and quadratic, $F(1, 15) = 5.25, p = .0368$, interest rate trends for the $SD = 25$ volatility condition indicate that respondents
could distinguish between interest rates even when they were concealed within a high level of random variation.

The interest rate linear trend comparing combined zero and low volatility with higher volatility was significant, $F(1, 15) = 23.72, p = .0002$. This trend follows the divergence between combined zero and low volatility, and high volatility with increasing interest apparent in Figure 7.2. The interest rate quadratic trend for this volatility contrast, and linear and quadratic trends across interest for the difference between zero and low volatility were all nonsignificant, $p \geq .3857$. Overall, these follow-up tests show that perceived earnings increased at a faster rate with higher interest for low and zero volatility investments compared with high volatility investments. High volatility attenuated the increase in perceived earnings with higher actual interest.

The obvious question is whether the perceived earnings trends correspond to actual earnings. Comparing the investment final values in Table 7.4 shows that perceived and actual earnings trends do correspond. As Table 7.4 will attest, when interest rates increase from 5% p.a. to 10% p.a., combined zero and low volatility scenarios increase in value by $M = $171 more than the increase for high volatility investments. When interest rates increase from 10% p.a. to 15% p.a., zero and low volatility scenarios increase by $M = $238 more than the increase for high volatility investments. With the current scenarios, higher interest is more rewarding with lower or zero volatility than with high volatility. Perceived earnings follow this trend.
Chapter 7 – Evaluating investment’s past returns

Figure 7.3 shows the relationship between interest rates and volatility, and the perceived chance (risk) of losing money at any time. A 4-way ANOVA examined the effects of volatility and interest, controlling for set and order as between-subjects effects. Perceived risk clearly and significantly increased with actual risk, Λ(2, 12) = .08, p < .0001. Perceived risk also decreased with higher interest, Λ(2, 12) = .43, p < .0066, but volatility and interest rates did not interact significantly to affect perceived risk, Λ(4, 10) = .64, p < .3030. Table 7.4 shows that higher interest reduces actual risk of losing money (i.e., achieving a negative return in any one year), so the perceived reduction in risk with higher interest is justified.

Sequenced returns analysis

As noted earlier, sequencing of returns from high to low during initial or later years of the 10-year investment applies only to variable interest rates, and not fixed interest. In the following analysis, ways in which sequencing of returns affects the numerical properties of the investment scenarios will be examined before the rating scale responses. Characteristics of sequenced returns can then be compared with rating scale responses.

Table 7.5 shows mean item values expressed as percentage returns for the first and second half of the investments for random, improving and deteriorating returns. Improving returns
place superior values late in the investment, whereas deteriorating returns place them early. Random returns distribute high and low returns evenly across the term.

Table 7.5 Mean percent p.a. for return sequences

<table>
<thead>
<tr>
<th>Sequence</th>
<th>M 1–5 years</th>
<th>M 6–10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random</td>
<td>9.97%</td>
<td>10.03%</td>
</tr>
<tr>
<td>Improving</td>
<td>-1.90%</td>
<td>21.90%</td>
</tr>
<tr>
<td>Deteriorating</td>
<td>21.90%</td>
<td>-1.90%</td>
</tr>
</tbody>
</table>

N = 24 items per condition

A 6-way ANOVA evaluated the scenarios’ perceived worthiness for future investment, with presentation order and random number set as between-subject factors, and interest rate, volatility (two levels), sequence and 3 and 10-year term ratings the within-subjects factors. Figure 7.4 shows mean ratings for all combinations of within-subjects factors. Higher ratings indicate superior attractiveness for future investment for the specified term.

As occurred with fixed interest and random returns, the term main effect was not significant, $F(1, 13) = 2.46, p = .1410$, so the duration of the prospective term had no influence on the attractiveness of future investments. Higher rates of past interest made future investment prospective more attractive, $\Lambda(2, 12) = .13, p < .0001$, and higher past volatility made future investments less attractive, $F(1, 13) = 23.96, p = .0003$.

The sequencing factor was significant $\Lambda(2, 12) = .43, p = .0064$. For random returns, $M = 3.00$ on the 6-point rating scale ($SD = 1.90$), for improving returns $M = 3.91$ ($SD = 2.76$) and for deteriorating returns $M = 3.04$ ($SD = 1.60$). Figure 7.4 suggests that improving returns were perceived as more attractive for future investment than random or
deteriorating returns. Follow-up contrasts support this interpretation, with improving returns rated significantly higher than random and deteriorating returns combined $F(1, 13) = 15.75, p = .0016$. Attractiveness of random returns was effectively the same as for deteriorating returns $F(1, 13) = .30, p = .5910$. A history of improving returns boosts the perceived worthiness of a future investment.

![Interest, volatility, sequence and prospective term mean ratings for perceived attractiveness of future investment](image)

**Figure 7.4** Interest, volatility, sequence and prospective term mean ratings for perceived attractiveness of future investment
Effects of interest rate, volatility and sequence on earnings ratings were tested using a 5-way ANOVA, controlling for order and set. Figure 7.5 presents mean earnings ratings for combinations of within-subjects factors. Again, the sequence $[\Lambda(2, 14) = .48, p = .0058]$, interest rate, $[\Lambda(2, 14) = .17, p < .0001]$, and volatility $[F(1, 15) = 15.53, p = .0013]$ main effects were all significant, and equivalent in direction with the same main effects on prospective investment ratings. Concentrating on the sequencing effect, follow-up contrasts found mean perceived earnings to be higher for improving sequences compared with random and deteriorating combined, $F(1, 15) = 14.66, p = .0016$. Random and deteriorating returns did not differ, $F(1, 15) = 0.99, p = .3349$. In Figure 7.5 the difference between improving returns and other sequences appears greater for the high volatility condition than for the lower volatility condition, and the associated interaction was significant, $F(1, 15) = 14.90, p = .0015$. 

![Figure 7.5](image_url)
In summary, compared with random returns, improving returns boost perceived earnings, especially with high volatility, but deteriorating returns do not diminish perceived earnings.

The main effect of the sequencing factor on perceived chance of losing money (risk) was just short of significance, $\Lambda(2, 12) = .61, p = .0501$. The trend, shown in Figure 7.6, suggests that improving returns were perceived as less risky than random or deteriorating returns. A significant follow-up contrast suggests this was so, $F(1, 13) = 8.41, p = .0124$.

![Figure 7.6 Interest, volatility and sequence interaction on perceived risk](image)

As occurred with earnings, the perceived risk comparison between random and deteriorating returns was not significant, $F(1, 13) < 0.01, p = .9812$. Volatility interacted with the sequencing effect on perceived risk, $\Lambda(2, 12) = .55, p = .0281$, although in this instance the comparison between random and deteriorating returns was significant, $F(1, 13) = 6.01, p = .0291$, and not the comparison between improving and other sequences.
Investment evaluation survey

\[ F(1, 13) = 3.37, p = .0894. \] Figure 7.6 suggests that higher volatility eliminated the perceived additional risk with deteriorating returns compared with random returns.

Sequencing interacted with interest rate on perceived risk, with the linear trend for interest interacting significantly with the comparison between improving and other returns,

\[ F(1, 13) = 12.68, p = .0035. \] Figure 7.6 suggests that the higher perceived risk of random and deteriorating returns compared with improving returns diminishes with higher interest. The linear trend for interest rate did not interact significantly with the difference between random and deteriorating returns, \( F(1, 13) = 0.54, p = .4739. \) Quadratic trends for interest did not interact significantly with improving compared with other returns, nor random compared with deteriorating returns, \( p \geq .2342, \) and the sequence by return by volatility interaction was not significant, \( \Lambda(4, 10) = .89, p = .8608. \)

**Correlations between ratings**

Table 7.6 shows mean correlations between ratings for perceived earnings and risk, and ratings for perceived attractiveness of 3 and 10-year investments. The small sample size for these correlations renders their interpretation tentative, and requiring substantiation with larger samples. With \( N = 21, \) the threshold value for a significant value of \( r = .43 \) for a two-tailed test at \( p = .05 \) (Hopkins & Glass, 1978), so only comparatively large correlations will be significant. Nonsignificance of lower correlations could be attributed to low statistical power rather than the absence of population effects.

Notwithstanding the limitations of this analysis, on average, higher earnings were moderately (and significantly at \( p < .05 \)) associated with higher future investment ratings. The mean correlation for 10-year investments was significantly higher than for 3-year investments, \( p = .0210, \) so that, on average, the relationship between perceived earnings
and perceived attractiveness of future investments was stronger for 10-year investments than 3-year investments. Minimum and maximum correlations reveal considerable variation in the size of correlations between perceived earnings and future investment ratings among difference investment scenarios.

Table 7.6 Perceived earnings and risk correlated with attractiveness for future investment

<table>
<thead>
<tr>
<th>Future term</th>
<th>Earnings</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>3-years</td>
<td>.51</td>
<td>.18</td>
</tr>
<tr>
<td>10-years</td>
<td>.69</td>
<td>.11</td>
</tr>
</tbody>
</table>

N = 9 correlations per cell from 21-22 participants.

Higher perceived risk on average correlated weakly with perceived attractiveness of 3 and 10-year investments, with no significant difference in mean correlations between the prospective terms, $p = .7434$. A wide range of correlations between perceived risk and future investment ratings is again evident across the scenarios.

On average, perceived earnings rating correlated -.27 with perceived risk ($SD = 0.22$, range = -.57 to .06, N = 9 correlations) indicating that earnings were perceived to diminish with higher risk. The relationship was not strong and was insufficient for significance, although it varied considerably across scenarios. The mean correlation closely matched the correlation of $r = -.29$ between the final dollar value of the investment and the volatility ($SD$ of returns) for the investment, showing that perceptions of earnings and risk were almost the same as for actual earnings and volatility. However, the correlation between final dollar payouts and the number of negative returns within a series was much higher at
-0.52. If negative returns are the criterion for risk, the actual relationship between risk and return is much stronger than the perceived relationship.

**Discussion**

The investment evaluation survey examined subjective appraisals of past investment performance in relation to interest rate, volatility and the sequence of returns. The potential difficulty of evaluating past performances from returns with random fluctuation could have investors resorting to heuristical strategies which simplify the decision process, at the risk of cognitive biases. Early in Chapter 7 it was argued that investors choosing on the basis of past returns should ideally be able to distinguish between high and low past returns despite volatility; distinguish high from low volatility; account for the negative effect of volatility on returns; and ignore the sequence of returns within a series. Having examined subjective appraisals of investment scenarios, we may now ask whether the sample of business graduates could accomplish these tasks.

Survey results suggest that they could. Participants distinguished between 5% p.a. increments in return, and variation in returns of $SD = 0$, 5 and 25, representing zero, low and high volatility. Higher volatility was associated with lower returns, as it should be, and participants correctly interpreted the effect on returns of interest combined with volatility.

Prospective term had no overall effect on the perceived worth of a prospective investment. However, interest rates separated the ratings across prospective terms, with 10-year terms being perceived as more attractive compared with 3-year terms as interest rates increased. Possible awareness of the substantial rewards from long term compound interest at high rates may account for this pattern of responses. The higher correlation between perceived earnings and the attractiveness of future investment for longer terms supports the notion
that longer terms increase the perceived importance of earnings. Participants may have recognised that a long term investment involves greater commitment and higher opportunity cost if returns are suboptimal, so high returns become all the more important for protracted investments. Participants disliked high volatility equally for long and short prospective terms even though, conventionally, investment risk decreases for longer terms, and longer terms would permit greater delay discounting of risk, if that were to occur at all.

The sequencing of returns gave rise to several significant effects, although it should not have done because the percentage values throughout the 10-year performance history and the value of the final payouts were identical for all sequences. In theoretical background material in Chapter 7, the adjustment and anchoring heuristic was identified as a potential source of bias leading investors to underestimate returns from an improving series, and to overestimate returns from a deteriorating series compared with an unordered series of otherwise identical returns.

Conversely, retrospective delay discounting of past returns (if that happens) and the known tendency for people to prefer improving sequences to deteriorating sequences of outcomes could render improving sequences of returns more attractive than deteriorating sequences – a prediction opposite to that from the anchoring and adjustment heuristic. Either way, survey participants might erroneously associate the sequence of returns with the final payout.

The survey results found that preferences tended to favour improving returns compared to random returns or returns that deteriorated with time. Improving returns were erroneously associated with higher earnings, lower risk of losing money, and perceived superiority of future investments. These effects are consistent with Loewenstein and Prelec’s (1993) research in which subjects favoured improving outcomes to deteriorating outcomes, and
also to the separate notion of delay discounting in retrospect, with returns from the distant past exerting a smaller influence on appraisals than recent returns. Sequencing effects ran contrary to the direction predicted from the anchoring and adjustment heuristic, suggesting that temporal aspects of the returns influenced appraisals. Neither the heuristical nor the temporal bias would have facilitated investment appraisals. Why the improving returns should be appraised as superior while deteriorating returns were perceived as no worse than random returns is unexplained, and perhaps best resolved by further studies examining whether, or under what conditions, this finding generalises.

The sequencing factor affected perceived risk as well as perceived earnings and attractiveness of future investment. This result would have occurred because improving returns featured fewer losses in the more recent years although, again, the ordering of intermittent losses did not influence final payouts for the current scenarios. In the analysis of perceived risk, random returns emerged as subjectively less risky than deteriorating returns, an instance where participants did discriminate between these two sequences. Sequencing also influenced the effect of interest rates on perceived risk. It appears that sequencing extends its influence across multiple features of investment returns, without justification in the current scenarios.

Correlations between perceived earnings and risk matched the actual relationship between earnings and volatility, suggesting accurate appraisal of the investment characteristics. However, the definition of risk in the survey was “the chance of losing money at any time,” so negative returns arguably should serve as the criterion for risk, in which case participants tended to underestimate the relationship between risk and dollar return for these scenarios.
The investment evaluation survey methodology has potential for elaboration. Samples could include lay investors rather than only business school graduates. Subjects could estimate the actual rate of percentage returns and volatility rather than just offer a subjective appraisal, although pilot studies for the current thesis suggest that this task could be excessively onerous, especially for people unfamiliar with finance.

Survey participants could discriminate between 5% p.a. increments to interest rates at all levels of volatility. A worthwhile question is whether they could discriminate between 1% p.a. increments, and under what degree of volatility (fixed interest rates being always discriminable), and with what minimum number of returns in the series. Relevant studies could establish limits to the discriminability of interest rate differences at varying levels of volatility, and varying interest rates – recall from Figure 7.2 how perceived increase in earnings levelled off with higher interest in the high volatility condition. High interest combined with high volatility appears to reduce decision makers’ ability to discriminate interest rates. Further discussion in the next chapter proposes additional methodological innovations for future research exploring these issues.
Chapter 8 – General discussion

This thesis adds to existing knowledge about how the subjective valuation of delayed and probabilistic rewards could influence investment decisions. As Chapter 1 argues, personal investment requires the postponement of immediate gratification, and the acceptance and management of risk in the pursuit of higher reward. Investment decisions may also require inferences about future investment performance based on past performance. For each of these three demands (risk, delay and inference) the thesis employed relevant theory from more general decision making literature to inform predictions about investment appraisals. Personal investment can be regarded as a special case to which general theories about preferences for delayed and probabilistic rewards, and judgement under uncertainty, should and do apply.

Delay Discounting Experiments

The delay discounting literature was recruited to predict responses to compound interest returns from varying investment amounts and terms. Chapter 2 introduced the $k_i$ parameter, which indicates the rate of hyperbolic delay discounting required to achieve subjective equivalence between the immediate value of a reward and its perceived future value when invested at a constant rate of compound interest. Theoretical demonstrations showed that exponential growth from compound interest should more than compensate for subjective depreciation from delay discounting, given a sufficient term. Consistent with this prediction, longer terms at the same rate of interest were more attractive than shorter terms (Experiment 1).

A second, more inclusive hypothesis proposed that investments with higher $k_i$ values should have preferential appeal independently of their term. Preferences for a 2-year
investment and an alternative 5-year investment paying a higher return followed the value of \( k_i \) (Experiment 4). Subjects changed preferences from the shorter to the longer investment, or vice versa, so that they chose the higher \( k_i \) regardless of the term.

Experiment 4 strongly supported \( k_i \) as a predictor of a compound interest investment’s appeal, and with it the importance of hyperbolic delay discounting in the evaluation of investment payouts.

Experiment 5 took the prediction of preferential appeal for the higher \( k_i \) further, using a novel application of sensitivity and specificity analysis to show that preferences followed \( k_i \) across a wide range of scenarios. Sensitivity and specificity analysis showed that \( k_i \) predicted appraisals better than an alternative, exponential delay discounting model.

Experiment 5 supports the proposition that \( k_i \) enables specific predictions about choices between compound interest returns from various combinations of interest rate and term.

Experiment 6 examined whether investments with the same \( k_i \) have equal subjective value regardless of term, as they should, assuming a constant rate of hyperbolic delay discounting with time. Experiment 6 eliminated the confound between investment term and compound interest returns which would normally render longer term investments more attractive because of reduced discounting of larger rewards. Again consistent with the hyperbolic delay discounting model and the \( k_i \) parameter as a predictor of investment choice, Experiment 6 found that preferences for the longer or shorter of two investments remained constant across levels of \( k_i \) irrespective of term.
Limitations of the Hyperbolic Delay Discounting Model for Investment Appraisals

Investment Payout Information

Experiment 2 and Experiment 3 examined whether predictions from hyperbolic delay discounting of compound interest returns generalised across disparate conditions. Experiment 2 found increasing reluctance to invest rather than spend for longer terms when payout information was suppressed, doubtless because participants could not estimate the payout. Conversely, presenting payout information suppressed willingness to invest for shorter terms, suggesting a tendency to overestimate short term compound interest payouts in the absence of payout information. It appears that predictions from hyperbolic delay discounting hold only when investment payout information is provided, and that presenting only interest rate and term inadequately substitutes for payout information.

The finding that people change their preferences when presented with payout information implies that investment decisions made solely on the basis of prospective interest rates and terms may differ from what might have been chosen had final dollar values of the investment been evaluated. In practice, investors should calculate or at least estimate what an investment will finally be worth when they decide how to invest, instead of relying on interest rate and term combinations. Relying on guesswork or naïve estimations of investment payouts could have people choosing investments they would consider unsatisfactory if the precise values of payouts were known in advance. Payout information showing gross returns renders long term investment more attractive, but can render short term investment less attractive – see Figure 3.3, p. 84.
Chapter 8 – General discussion

Limited Time Horizons

Experiment 2 found no increase in the appeal of longer term investments beyond 10-year terms when payout information was presented, and increasing reluctance to invest for longer terms beyond the experimental minimum of 5 years when payout information was suppressed. In short, Experiment 2 found limits to the investment durations for which hyperbolic delay discounting predicts appraisals. For the displayed payout condition, the inability of long term compound interest to enthuse participants despite the substantial rewards suggests that other than a constant rate of hyperbolic delay discounting occurred for these scenarios. Beyond a 10-year term, a sharply increasing rate of discounting must have been applied for the observed negation of compound returns to happen. Results for Experiment 2 suggest that a constant rate of hyperbolic delay discounting applies to a limited range of terms, which in turn limits the predictability of investment choices based on the $k_i$ parameter. The apparent 10-year upper limit for the predictability of investment choice from $k_i$ nevertheless covers a useful range, relevant for many conventional investments, but not for protracted investments such as superannuation commenced early during working life.

Other delay discounting research has examined far longer periods than 10 years, such as 100 years, as well as short periods, such as 1 day, and disparate amounts of hypothetical money (e.g., Rachlin et al., 1991; Rachlin et al., 2000; see also p. 23 above). Rachlin et al. (1991) found that present values of rewards delayed from 1 week to 50 years conformed to the hyperbolic model, although Raineri and Rachlin (1993) refer to a subjective time horizon of from 25 to 50 years. It is open to speculation as to why hyperbolic delay discounting for hypothetical investments has limited explanatory power for extended delays compared with rewards presented outside of an investment scenario. Characteristics of experimental participants are an unlikely explanation because Rachlin’s research also
utilised undergraduates. The use of investment scenarios may limit the appeal of extended delays owing to lifestyle and planning considerations associated with investment. An individual of any age may be able to foresee their circumstances for the next 5 to 10 years, but beyond that range their uncertainty may dissuade them from committing funds to investments for such periods, regardless of the rate of return.

Fixed investment terms were stipulated for all discounting experiments in the current dissertation, with invested funds described as “locked up.” Fixed terms enabled precise specification of the delay. However, they impose an artificial restriction compared with genuine investment possibilities. Some people may maintain a bank term deposit with a 1-year fixed term for a period of many years. The total duration of the investment could be 12, 15 or even 20 years, but at the end of each 1-year term the investor has access to their money. The maximum delay is no more than 1 year at any time, and the delay diminishes annually to zero. If investing for a series of 1-year terms with the option of pulling out at any time were allowed for experiments in the current thesis, the imposition of extended delay would have been eliminated. Time horizons may not have applied to the extent that they did in the actual findings.

Genuine investments exist where the rewards are inaccessible for many years or even decades, superannuation for young persons being an example. Experimental participants’ reluctance to embrace very long term investment exemplifies the wider community problem of insufficient long term savings as alleged in popular and technical literature (see p. 1 above) and would help to justify compulsory superannuation. If high rates of return cannot persuade young people to invest for more than a few years, voluntary commitment to a 35-year superannuation plan would be unlikely, despite any long term advantage.
A general theory of delay discounting should account for time horizons, acknowledging that constant rates of hyperbolic delay discounting are not maintained indefinitely. Otherwise, time horizons, even if pervasive, amount to no more than a convenient post hoc explanation for why hyperbolic delay discounting fails to predict decisions covering extended periods. A general theory of delay discounting would predict the circumstances under which a constant rate of hyperbolic delay discounting applies and when time horizons will interfere. Such a theory would better account for practical considerations in decision making, such as stages of life and limits to foreseeable circumstances, compared with the simpler but restrictive assumption that delay discounting occurs at a constant rate regardless of delay. A general theory of delay discounting should also account for situational specifics and decision context, such as investment per se, as opposed to other types of delayed reward.

It is tempting to generalise the hyperbolic delay discounting model simply by adding parameters to the discounting function. Additional parameters would modify present values to account for time horizons, and to accommodate situational specifics beyond delay duration and discounting rates. Adding parameters to fit data better with an extant model has precedents extending a long way back in the history of science. It was applied to Ptolemaic cosmological theory before Copernicus (Larrabee, 1945) and in the 19th century, with the so-called Lorentz and Fitzgerald contraction prior to relativity theory (Wilson, 1965). In both cases, it served briefly to forestall the demise of prevailing but doomed theories. The disadvantage of added parameters is a reduction in the model’s parsimony. Ideally, modifications to the delay discounting function should provide a conceptual advance rather than merely improving the empirical fit of the model to data. Physicists probably tolerate boundary conditions less readily than behavioural researchers.
because the former seek universal laws, whereas behavioural scientists acknowledge the genuine possibility of context-dependent phenomena.

Interestingly, Newtonian mechanics exemplify a coherent theoretical system with boundary conditions because the Newtonian system accurately models large scale physical phenomena, but fails at the subatomic level. In similar fashion, hyperbolic discounting models may describe behaviour adequately and usefully within specifiable limits, while serving inadequately for extreme situations.

Experiment 6 revealed an additional behavioural tendency that appears to be superimposed on the hyperbolic delay discounting model. Subjects were apparently prepared to pay an additional, upfront cost to expedite an investment payout where, according to the hyperbolic model, they should have been indifferent between the longer and shorter terms. This tendency appeared in the special situation where investment payouts were held constant and the amounts invested varied with term.

*Taxation and Inflation*

Experiment 3 found that adjustment for taxation and inflation demolished the increased attractiveness of longer term investment predicted from hyperbolic delay discounting found in Experiment 1 and, to a lesser extent, in Experiment 2. Attenuation of increases to $k_i$ parameters with longer terms for investment returns adjusted for tax and inflation predicted this effect – see Table 3.4 on p. 89 – so the result is actually consistent with predictions from $k_i$. A practical implication is that gross rather than net returns should be presented to encourage investment. According to Experiment 3, presenting returns adjusted for typical rates of tax and inflation would provide little incentive to invest. Given the effects of taxation and inflation on investors’ future spending power, the pursuit of tax-
effective investments and returns that greatly exceed the inflation rate would emerge as major priorities among knowledgeable investors. Because of delay discounting, taxation and inflation could serve as major barriers to investment for many people. People will not invest unless the perceived, as opposed to the monetary, value of an investment increases with time. Investments earning typical interest under to low to moderate inflation, with returns taxed at typical rates, may barely keep pace with delay discounting. Population data on delay discounting rates applied to large sums of money (e.g., several thousand dollars) over delays of a few to several years could, in combination with the $k_i$ parameter, indicate the rates of interest required to compensate for delay discounting both for gross and net returns. These data would indicate the general acceptability of investment returns under various conditions.

**Regular Savings Plans to Control Immediate Expenditure**

Paying small amounts regularly into an investment fund is a common strategy. Regular savings plans complicate the testing of delay discounting principles in relation to investment behaviour because investors are no longer offered a choice between two simple alternatives, one with a short term benefit and the other with a larger but delayed benefit. Instead, they must evaluate a succession of small, future investments. These investment contributions would be delay discounted. Investing $100 per month over 12 months would seem a subjectively lower investment than a single, immediate investment of $1,200, but the single, lump sum investment pays more in the end.

Experiment 1 and Experiment 2 found participants reluctant to invest amounts of $1,000 which could otherwise have been spent. On p. 85 it was argued that this reluctance militates generally against investment. There is also a contrary, practical view. Whereas small amounts, such as $100 per month, might be considered too trivial to invest, these
amounts could be small enough not to be missed if they were invested, so they might as well be invested. The availability of regular payments into mutual fund investments suggests that some people adopt this strategy.

The decision to invest future sums of money using a savings plan demonstrates precommitment (Thaler & Shefrin, 1981), whereby the investor chooses to limit future options. Of course, the investor can revoke the decision, for example, by reducing voluntary superannuation contributions. Precommitment attempts to maintain self-control even when the commitment is nonbinding. Precommitment to a savings plan could be interpreted as delay discounting operating at intermediate range. The investor must discount the medium term expenditure opportunities to a value below the longer term outcome. Like any nonbinding agreement, the intended savings plan is subject to a preference reversal when the ongoing temptation to spend exceeds the perceived value of delayed rewards.

Savings plans at best provide a semblance of control (see discussion below on complex ambivalence) although the semblance may be sufficient to garner adherents. When people precommit to regular savings plans or long term investments which disallow early withdrawal, it suggests a recognition of limits to self-control. Loss of flexibility is the price people are willing pay for binding precommitment.

Rachlin (2000) distinguishes between strict, binding commitment to a long term, high value objective, and nonbinding commitment, which allows a preference reversal that revokes the original intention. Scenarios in the current dissertation bound participants to their initial decision. With most investments, even bank term deposits, the investor can withdraw funds at short notice, perhaps with a penalty. Access to the short term, low value reward is therefore perpetual and, with it, the temptation to spend. Rachlin (2000)
describes continuously available temptation as complex ambivalence. Future research into financial decision making could incorporate complex ambivalence, allowing for preference reversals that rescind earlier decisions made during the experiment, similar to what can happen in everyday life. Research into complex ambivalence could illuminate processes underlying maladaptive financial behaviours such as compulsive spending or credit card abuse via theories of addiction, for example, Herrnstein and Prelec (1992); and stock-market runs that occur during downturns, whereby investors withdraw early, instigating a positive feedback process that can turn into a full scale crash.

Insight into one’s own behavioural tendencies, including the possibility of an impulsive preference reversal, encourages the control of future behaviour. Temptation becomes harder to control when it is proximate, so the individual tries to control expenditure from a distance. The question arises as to whether insight into one’s own preference reversal habits and susceptibility to impulse solves the problem of temptation. O’Donoghue and Rabin (2000) identify a behavioural tendency which adds insight or “sophistication” to myopic impulsiveness. Sophisticates know they will respond impulsively to forthcoming rewards. O’Donoghue and Rabin show how sophistication encourages suboptimal decisions where rewards for impulsivity occur immediately, as is usual with expenditure. Sophisticates err on the side of caution. They “preoperate” (act too soon) to avoid an expected preference reversal. They envisage future impulsive action and choose a lesser alternative to subvert it. This principle argues against insight as a simple solution to impulsiveness.

**Investments With Probabilistic Returns**

Following its examination of delay discounting, the research investigated how risk affects investment appraisals. Kahneman and Tversky’s Prospect Theory proposes risk aversion
towards gains as a general behavioural principle. The probability discounting literature was also invoked. Risk averse investment decisions were expected, especially for larger investment amounts and shorter terms. This bias would have investors preferring smaller, guaranteed returns to normatively superior returns involving risk. Other discounting effects with potential relevance for investment decisions involving risk include higher probability discounting rates for larger rewards (as opposed to reduced delay discounting for larger rewards); a reduction in the certainty effect with increasing delay, equivalent to delay discounting of risk; and the principle developed newly for this thesis, that compound interest compensates for risk with increasing term, assuming a constant rate of hyperbolic probability discounting (see Table 5.1, p. 163, and associated commentary about the $h_i$ parameter).

Three experiments investigated appraisals of probabilistic returns, commencing with maximum resemblance to real-life investment scenarios, then moving towards maximum experimental control of confounding factors by breaking the link between payout and delay. As expected, risk aversion occurred often, especially with high interest combined with moderate risk. For Experiment 7, underestimation of compound interest returns could account for risk aversion, but not so with Experiment 8 and Experiment 9, which provided payout information. Participants either misapplied or failed to apply the simple formula for calculating expected utility as the product of reward size and probability. Instead, they appeared more sensitive to risk than to reward size, leading them to choose safe, low-return investments when larger but probabilistic returns offered superior expected utility.

Experiment 7 and Experiment 9 findings offered some, though not conclusive, support for increased probability discounting of larger investment rewards.
None of the experiments with probabilistic returns found evidence for reduced probability discounting of increasingly delayed rewards. Experiment 8 found against the prediction, based on Table 5.1, that compound interest returns could offset risk aversion with increasing term. The prediction from Table 5.1 ignores the separate possibility that larger rewards from longer term compound interest are associated with increased rates of probability discounting, which could have negated the term effect.

Of the three studies in Chapter 7, Experiment 9 was the best designed to detect reduced risk aversion with increased delay because higher investment payouts were unrelated to investment terms. Experiment 9 found contrary to the principle, described in Keren and Roelofsma (1995), that risk is delay discounted. An explanation for this discrepancy may reside with binding commitment to an investment over a long term. Recall that Experiment 9 offered participants the same set of dollar amounts ($526 to $10,000 with risk, or $500 guaranteed) across two levels of investment term (2 years and 5 years). The relevant analysis compares risk aversion towards, for example, a 50% chance of receiving $10,000 after 2 years and the same 50% chance of receiving the same $10,000 after 5 years. Respondents were more risk averse towards the 5-year term than the 2-year term (see especially Figure 6.4b, p. 211) when, if risk were delay discounted, the risk option would seem the better prospect after 5 years than 2 years. However, consider also that respondents risked receiving no profit after 2 years or no profit after 5 years. Receiving no profit after a 5-year term represents a worse outcome than no profit after a 2-year term. Compared with the 5-year term, the 2-year term allows investors another 3 years to reinvest capital which was never exposed to risk, and perhaps to achieve a positive return. The increased averseness to risk associated with the 5-year term seems reasonable given the context.
In Experiment 9, the rate of return made no difference to risk aversion. Instead, the dollar value of the profit affected risk aversion. An interpretation of this finding is that the absolute amount of money earned expressed in currency units (e.g., dollars) rather than percentage changes to wealth were what guided decisions. In this case the finding contradicts the Prospect Theory principle that rewards are evaluated on the basis of increments to a starting point rather than absolute values, that is, “gains and losses” (Kahneman & Tversky, 1979, p. 263), or “changes of wealth rather than ultimate states of wealth” (Kahneman & Tversky, 1984, p. 342). However, a profit expressed in dollars represents a change to wealth, so in this sense the Prospect Theory principle may in fact apply. The source of confusion is the two ways of defining “changes of wealth.”

The distinction between the absolute value of change in wealth and the relative change in wealth measured as a percentage or fraction is important because it affects experimental predictions and interpretations. The relevant research question is how, if at all, decision makers distinguish between absolute and relative changes to wealth.

Existing and well-known research (e.g., Tversky & Kahneman, 1981; Kahneman and Tversky, 1984) has already shown that people are sensitive to relative changes in wealth in purchase decisions for everyday items. In an investment context, Experiment 9 suggests that investors will respond to absolute changes and ignore relative change because in that experiment the investment amount effect, which determined relative changes to wealth, was nonsignificant. On the other hand, Experiment 7 presented profits only as percentages. The significant effect of percentage return in Experiment 7 implies sensitivity to relative wealth. The same experiment also found a significant effect for investment amount, suggesting sensitivity both to absolute and relative wealth because the same level of percentage return provides different levels of dollar profit (absolute wealth) when different
amounts are invested. It could be that investors are always sensitive to absolute gains, whether relative or absolute changes to wealth are presented; yet they are sensitive to relative wealth only when relative wealth changes are given (Experiment 7), and not when they are omitted from the scenario (Experiment 9). In this regard the difference in sensitivity to relative wealth between Experiment 7 and Experiment 9 is an artefact of presentation, that is, a framing effect.

Research by Moon, Keasey, and Duxbury (1999) offers a more comprehensive explanation for the insensitivity to relative wealth changes that occurred for Experiment 9. Moon et al.’s findings suggest that sensitivity to relative wealth depends on the absolute amount of money involved. Their experimental scenarios related to consumer expenditure rather than investment, but it was found that sensitivity to relative changes in wealth diminished as the changes to absolute wealth increased. On this basis, presenting dollar values of large amounts of investment money as per Experiment 9 may have been sufficient to eliminate sensitivity to percentage gains. In Experiment 7, profit dollar values were concealed. Participants saw the percentage returns, which indicated relative wealth and involved only small numbers.

Further testing for the dominance of absolute or relative changes to wealth could involve testing for preferences between a 20% p.a. investment that pays $10,000 profit, and a 10% p.a. investment that pays $11,000 profit over the same term, without the scenario mentioning the different investment amounts, which subjects would estimate if they wanted. The 20% p.a. investment has merit because it requires a smaller investment amount to make a $10,000 profit with the same term. Emphasis on relative changes to wealth would see the 20% p.a. investment favoured. Though it may seem inconceivable that the 10% p.a. investment could be favoured, it would be favoured if absolute changes to

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wealth dominated relative changes. More sophisticated experiments could establish
acceptable limits for tradeoffs between relative and absolute changes to wealth,
discovering how much relative wealth and upfront cost investors will sacrifice for higher
absolute wealth, and optionally relating both of these profit measures to risk and time. In
another context, Experiment 6 found subjects willing to pay a temporary upfront cost in
order to expedite an investment. Within limits, they may also accept a higher upfront cost
and lower relative changes to wealth via a reduced percentage returns with lower risk
simply to make more dollars. In short, they could compensate for lower expected returns
by investing more in an effort to avoid risk. This research would also address issues such
as the maximum amount of money people will contribute to superannuation per rate of
interest. The practical choice is between a larger investment with a lower rate of return and
lower risk, or an alternative, smaller investment (effectively a lower upfront cost) and a
higher rate of return that offers the same potential dollar payout but with higher risk.
Investors have to trade upfront cost against risk while maintaining a desired level of dollar
return. Knowledge of how people respond to these contingencies would assist financial
planners to tailor investment options to clients’ preferences.

Referring still to scenario presentation, the Chapter 7 experiments presented risk as a
percentage chance of an outcome, or what Gigerenzer (2002) describes as a single-event
probability. This presentation facilitated calculation of expected utility for participants who
could do so. It was consistent with much experimentation in the relevant literature and was
intended to provide at least a perception of ordinal risk (see p. 173 above).

Gigerenzer, supported by recent evidence, argues that single-event probabilities are
difficult to interpret even for an expert audience. Gigerenzer contends that single-event
probabilities are intrinsically misleading because they typically fail to specify the class of
Chapter 8 – General discussion

events to which the percentage chance refers. Presenting probabilities in terms of frequencies of events occurring within a reference class is said to improve appraisal of probabilistic information (Cosmides & Tooby, 1996; Gigerenzer, 1996; Gigerenzer & Hoffrage, 1995; see also Harries & Harvey, 2000). A frequency presentation for probabilistic returns could show the number of investments or years from a single investment with a nil or negative return from a larger set of investments or years, in the manner of yearly percentages in the investment evaluation survey. However, rephrasing probabilistic scenarios as frequencies would not affect investment appraisals unless perceived risk or hyperbolic probability discounting rates vary according to how probabilities is presented. This question will need to be resolved empirically.

Risk and uncertainty are technical terms in the decision literature. Gigerenzer (2002) and Lopes (1994) refer to known probabilities as risks, and unspecified probabilities as uncertainties. The commonplace term “investment risk” corresponds to the technical definition of uncertainty, because probabilities associated with future gains and losses are unknown in genuine investment. In their behavioural ecology research, Rode, Cosmides, Hell, and Tooby (1999) investigated a well-established phenomenon known as ambiguity avoidance, also described in Lopes (1983), for which people tend to avoid uncertain prospects (with unknown probability) even more than merely risky prospects (of known probability) when the actual economic utilities correspond. Rode et al. drew on optimal foraging theory applicable to nonhuman animals and humans engaged in a hunter-gatherer lifestyle. According to this theory, ambiguous prospects may offer the same overall reward as merely risky prospects, but are likely to have higher variance in returns. Consistent with optimal foraging theory predictions, Rode et al. found that people will choose an ambiguous, high variance prospect when the rewards from the known probability prospect are insufficient. When survival depends on higher rewards than offered by a prospect with
known probability, people will choose the higher variance option when it would otherwise have been avoided. If these principles influence financial decisions, uncertain investment prospects should boost risk aversion even higher than for a specified risk, but may nevertheless be chosen in preference to modest returns, such as bank savings account interest, when the desire and need to make money is strong.

**Incidental Scenario Characteristics and Framing Effects**

Experiment 1 and Experiment 2 suggested that returns from $1,000 investments were not delay discounted hyperbolically; yet plenty of other experiments have used amounts of $1,000 (Rachlin et al., 1991) or much less (Kirby, 1997; Kirby & Maraković, 1995) to demonstrate hyperbolic delay discounting and preference reversals indicative of hyperbolic delay discounting (Kirby & Herrnstein, 1995). The investment context for the current thesis apparently altered decisions about how $1,000 should be managed.

This conclusion is a restatement of the framing effects discussed in Kahneman and Tversky (1984; see also p. 19 above). Tversky and Kahneman (1981, p. 453, italics added) stated that framing effects are “controlled partly by the formulation of the problem and partly by the norms, habits and personal characteristics of the decision-maker.” In Tversky and Kahneman (1981), responses to economic choices depended on whether outcomes from the same problem were described as gains (promoting risk averse responses) or losses (encouraging risk seeking). On this basis, the risk aversion noted in Experiment 8 and Experiment 9 could be a framing effect because the scenarios presented outcomes as gains or lack of gain, but never a loss. (Experiment 7 presented outcomes as gains, and nil returns or unspecified losses.) To examine the extent to which risk aversion is a framing effect, scenarios in future research could be recast so that guaranteed but modest returns are presented not as gains but as opportunity costs compared with larger, probabilistic
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rewards. Instead of offering the choice between a guaranteed $500 profit as opposed to a 50% chance of $1,000 profit and a 50% chance of $0 profit, the scenarios would offer a guaranteed loss of $500 or the alternative option of a 50% chance to lose $1,000 and a 50% chance to lose nothing. The latter scenario, emphasising loss, should promote higher preference for the risk investment than the first scenario, which emphasises profit. It may seem artificial or false to characterise a low but fixed interest investment as a guaranteed loss, but the experiment’s purpose would be to demonstrate that risk aversion in response to more conventionally worded scenarios which mention only profits is a consequence of emphasising gains rather than losses.

Order effects from the presentation of scenarios were a dormant issue in the current dissertation because the associated hypotheses were not relevant to the principal aims of examining discounting effects on single outcomes. Where order effects were examined for the discounting experiments, results were consistent with Loewenstein and Prelec’s (1993) findings of preferences for improving rather the deteriorating sequences of events, contrary to the “sooner the better” principle associated with isolated rewards. An implication from order effect findings is that investments will be appraised more favourably when they are superior to previously encountered results.

Investment Evaluation Survey

The investment evaluation survey provided the optimistic finding that decision makers, or at least those with some training in finance, can distinguish between varying levels of return, even when embedded in fairly high random variation (volatility). Survey respondents performed better than might be expected from existing research (see p. 16 and p. 20 above), although it was noted above that in Harvey’s (1988) forecasting task, subjects were able to represent a time series pattern internally.
Investment evaluation survey results suggest that a set of 10 yearly percentages enables investors to discriminate between 5% p.a. increments to returns. Their ability to estimate the actual percentage returns rather than merely to compare returns remains an issue for further research, but the ability to discriminate between levels of return provides a sufficient basis for investment decisions to the extent that past investment performance predicts future performance. As well, survey participants demonstrated awareness of how volatility affects returns. Their evaluations corresponded to the investments’ underlying properties quite well, evidenced in direct analysis of rating scale responses, and correlational analyses. Participants’ reluctance to rate 3 and 10-year investment prospects differently, despite identical information about past performance, suggests a strong adherence to the ostensible properties of the investment. Prospective term influenced appraisals when interest rates were high, possibly because interest became important where there was a substantial time commitment and risk of opportunity cost with long terms, as noted in the survey discussion.

When sequencing was introduced, participants tended to cue on the location of better and worse returns within a series. Responses were partly consistent with predictions from existing research and theory insofar as improving returns with superior recent performance were perceived as better than sequences with superior early performance, but the results’ typical lack of distinction between deteriorating and random returns implies a limit to this effect. Any distinction based on the sequencing of returns was erroneous. Subjects were alert to sequencing, but should have ignored this attribute of the investments. The practical implication is that investors could be misled by investments with a strong recent performance while disregarding strong performance from the distant past.
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The investment evaluation survey has considerable scope for further research. A worthwhile extension would be to adopt a signal detection paradigm, identifying just noticeable differences at various levels of percentage return and volatility. Experiment 5 used a signal detection approach to compare hyperbolic and exponential delay discounting models. The new suggestion is to apply signal detection to investment comparisons. Interest rate would serve as “signal,” which subjects could ideally detect. Volatility presents investors with a more complex problem, serving as “noise” which conceals underlying returns, but serving as signal for the evaluation of risk. Higher volatility would presumably increase the minimum difference between returns that subjects could discriminate. Comparing different ways of presenting historical returns would reveal how to amplify discriminability. The larger analysis of the investment evaluation survey summarised in Bidewell (2001) involved such comparisons. The resulting information has value for investment managers and financial planners wanting to assist investors to choose between different investments or perhaps, on occasions, cynically to disguise performance differences between investments.

A signal detection approach to researching discriminability of investment returns requires a more sophisticated technology than a pencil and paper survey. Adaptive testing using computer presentations could titrate scenarios back and forth using ever smaller increments and decrements until threshold levels of discriminability are established. Adaptive testing offers better possibilities for computer presentation than were available for discounting experiments in the current thesis. For the current research, ensuring that sufficient numbers of participants changed preferences necessitated large numbers of items in order to represent every subject’s switch point; and even then constant responding often occurred. An adaptive testing regime would initially present large increments to scenario properties with the aim of quickly identifying the general region along a continuum where the
preference change will occur for that subject, and subsequently would concentrate on this region using smaller differences between scenarios. This method would yield preference changes for every subject using fewer items and shorter experiments than is possible with one large set of scenarios. In catering for a wider range of preferences with relatively brief testing, experiments would remain practical even with highly diverse samples. Computers could generate scenarios while testing, using predetermined algorithms which include a randomising component. This method would enable expansion of the content domain compared with the four random number sets used to generate items in the investment evaluation survey.

Adaptive titration methods would enable accurate identification of discount rates applied to investments and, consequently, testing the generality of discount rates across a wide range of scenarios. Delay or probability discount rate parameters could become dependent variables for research about individual differences in investment appraisals, as well as the more traditional studies about the effects of reward, delay and risk which were the main topic of the current research. An individual differences approach to future embodies the notion that an investment appraisal represents the combination of an investment with its specified properties, and the individual investor, with personal characteristics that impinge on decisions. This concept has broad relevance for behavioural finance research.

Further Comments on Hypothetical Investment Scenarios Used With Student Samples

Chapter 1, p. 21 argued that hypothetical investment scenarios with amounts of money and terms that resemble genuine investment scenarios are better than offering token amounts of real money for investments lasting hours or days. Even so, for the current dissertation the practicality of short-term investments involving small amounts of money provided by the
Chapter 8 – General discussion

experimenter was explored in pilot form for future reference. To establish levels of return that would satisfy respondents so that meaningful items could be generated, 10 subjects participating in other experiments were informally asked to nominate the minimum sum of money they would prefer to have after a 4-hour, 24-hour or 1-week delay, instead of AU$5 received immediately. For the 4-hour delay, minimum acceptable alternatives to an immediate $5 ranged from $5.05 to $20.00 ($M = $10.23, $SD = $4.18). In other words, one subject was prepared to wait 4 hours to gain 5 cents more than the $5, whilst another subject wanted an extra $15 for the same delay. For the 24-hour delay, minimum acceptable alternatives ranged from $6 to $20 ($M = $14.00, $SD = $6.02), and for the 1 week delay the minimum alternatives ranged from $6 to $79 ($M = $22.89, $SD = $23.61). One subject would have refused $78 available after 1 week rather than $5 paid immediately. The same subject wanted $14 for a 4-hour delay.

These inconsistent and sometimes outlandish responses brought the abandonment of plans to provide participants with small amounts of real money to invest for short terms. It was impossible to identify a rate of interest indicative of real investments that could reliably satisfy or dissatisfy most subjects. Admittedly, these explorations were themselves hypothetical because no student was offered a $5 note. However, speculative piloting was required to establish starting values, and the outcome was not encouraging.

On p. 26 in Chapter 1 the relevance of investment scenarios to student samples was discussed. During experimental debriefing, a surprisingly large proportion of the students who commented at length described the scenarios as thought provoking and personally relevant. Although no formal data were collected about undergraduates’ actual investment holdings, it cannot be assumed that undergraduates have insufficient funds to consider investment opportunities (see Wade, 2002). Some participants admitted to day-trading or
other investing over the Internet. A few stated that they had received large amounts of money, such as inheritances, and were considering their investment options.

Nor should it be assumed that young undergraduates are committed to immediate gratification. That these individuals are willing to forego wages and incur a higher education contribution liability in pursuit of rewards that may be postponed for at least 3 years suggests an acceptance of delayed financial gratification. For these reasons and others discussed earlier, it seems that undergraduates were capable of providing worthwhile data for the purposes of the current research.

**Additional Suggestions for Future Research**

Investment decision making offers research opportunities beyond suggestions mentioned above. Discounting research could integrate with consumer response theory, which examines competing incentives for immediate expenditure and long term reward from an economic rather than a delay discounting perspective (Ganz, King, & Mankiw, 1999; Peterson, 1989; Pindyck & Rubinfeld, 1992).

On several occasions the current thesis suggested that reduced delay discounting of larger rewards would further enhance the appeal of longer term compound interest investments (e.g., see p. 40). Another issue is whether larger prospective losses bring about increased or reduced discounting. Reduced delay discounting of larger prospective losses could increase risk tolerance for large investments. No one invests with the intention of losing money. Nevertheless, occasional losses must be expected with some types of investment. As well, low interest, cash investments that are likely to pay less in the long term than equities investments can be presented as highly probable opportunity costs, which equate to losses.
via scenarios similar to the investment version of the Tversky and Kahneman (1981) reflection effect scenario – see p. 269 above.

Notable in the current research is considerable within-subject variation in responses. Sources of this variance, such as subject demographic characteristics, personality, abilities, aptitudes, and prior investment experiences, could explain why individuals differ in how they apply their money, how they value delayed financial rewards, and how they respond to financial risk and how they interpret past performance. The investment evaluation survey briefly explored these issues, which were excluded from the current thesis because its scope was already sufficiently large.

**Further Applications of $k_i$**

The $k_i$ parameter underpinned the delay discounting research in Chapter 3 and especially Chapter 4. The combination of exponential discounting and hyperbolic delay discounting from which $k_i$ is derived is a novel and distinctive feature of the current research.

The $k_i$ parameter and its rationale have value beyond research into compound interest investment appraisals. The $k_i$ parameter could predict responses to choices between any future reward and any immediate reward so long as the rewards are quantified on the same scale. A discount rate parameter analogous to $k_i$ can be derived for any combination of immediate reward, delayed reward and delay duration via Equation 3. The same three principles that related to compound interest investments should predict responses in a generalised application of $k_i$:

1. Preference for the delayed reward over the earlier reward implies a personal discount rate parameter lower than the $k_i$ parameter calculated for the scenario.
2. Preference for the earlier reward implies a personal discount rate parameter higher than the scenario’s \( k_i \) parameter.

3. More generally, higher calculated \( k_i \) parameters render a delayed reward more attractive to someone who delay discounts hyperbolically at a constant rate, compared with lower values for \( k_i \).

Conformity of responses with predictions based on \( k_i \) across a wide range of scenarios tests the wider relevance of hyperbolic delay discounting. The following section suggests ways by which \( k_i \) or a related parameter could be applied to other than investment decisions.

**Loans and Credit**

The current thesis examined investment behaviours, but the general rationale for the research is readily applied to loans and credit. Borrowing and investing may appear contrary processes, yet fundamentally both involve amortising a sum of money. Borrowing and investing operate in reverse. The borrower receives the reward and then amortises. The investor amortises before receiving the reward. The borrower pays interest on what has not been paid back (assuming reducible interest) while the investor earns interest on what has been paid. Rachlin (2000) explains the economic concept of interest paid by borrowers and interest paid to investors in terms of exponential delay discounting. Banks buy money from borrowers at a discount because the bank is paid later. Investors buy money from the bank at a discount because the investor is paid later. Regardless of the differences between borrowing and investing, the same delay discounting principles should apply.

The reversal in time of the amortisation and receipt of the reward ensures that borrowing and investing are in some ways asymmetrical. Higher interest extends the amortisation term for the borrower, while higher interest shortens the term for investing, other things
being equal. Both the investor and the borrower can improve their situation by contributing as much and as early as possible, to reduce the interest bill for the borrower or to increase earnings for the investor. Larger and earlier sacrifice provides greater long term benefit, which imposes the prototypical delay discounting dilemma.

People who are prepared to pay $100 or similar per month into either a loan account or an investment account over a long period at moderate interest have the choice of either a small amount of money borrowed now or a large amount of money collected in the future. It is easy to imagine that a considerable rate of delay discounting of future rewards would be required for people to borrow $7,630 now at a cost of $12,000 over 10 years, instead of investing $12,000 paid in over 10 years and receiving $20,655, with interest at 10% p.a., yet credit flourishes, suggesting that high rates of delay discounting do apply, or (most likely) that people do not compare loan costs with investment payouts. Immediate rewards available from credit can be compared with delayed rewards from investment. Values for $k_i$ can be calculated from these comparisons, and the consistency of people’s responses to predictions from $k_i$ can be evaluated to determine whether hyperbolic delay discounting predicts credit decisions. This type of research would show how $k_i$ and related parameters can be applied to financial decisions beyond the compound interest scenarios reported in the current dissertation.

**Generalising Beyond Financial Decisions**

Insights into discounting of investment returns could inform the study of other types of economic decision, such as consumer behaviour. The principle that compound interest investments appreciate in subjective value with time despite delay discounting was the foundation for much of the research in this thesis. Technological advances in some types of consumer goods are another example of how perceived value can increase with time. A
consumer considering the purchase of what Sultan (1999) calls “technology-driven durable products” (p. 24) such as personal computers and peripherals, home entertainment and telecommunications hardware, imaging equipment, other consumer appliances, or motor vehicles must decide whether to purchase existing technology today, or delay their purchase in anticipation of technological improvements.

Arguing against the postponement of purchase is the prospect of future price rises, when the current technology is entirely serviceable, as with motor vehicles. Problems with backwards compatibility may occur. Tomorrow’s camera may not accept today’s accessories. Existing, valued technologies could disappear altogether (e.g., film cameras, vinyl record turntables and cassette tapes). Prospective purchases like these involve risk similar to investment risk. Probability discounting also comes into play when consumers have to predict whether an emerging technology will receive indefinite market support or will be abandoned for an alternative technology or industry standard.

Sultan (1999) examined preferences for current and future technology by calculating the “rate of time preference” which measures “the difference in value to the customer of obtaining the same innovation at two different points in time,” that is, “the change in preference over time for a particular level of a technology” (p. 27). Sultan found that consumers are less willing to pay for a technology the longer they have to wait for it; that future technologies are discounted less rapidly than current technologies; and that interim technologies offering some of the benefits of a forthcoming technology are perceived less favourably than the later technology because the interim technology is perceived as deficient compared with the later technology rather than superior to current technology. Sultan’s results indicate delay discounting of future technologies, less so for the larger reward (i.e., higher technology). Hyperbolic delay discounting is not mentioned, although
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the consumer choice scenario described here offers another opportunity to combine a
growth function (in technological innovation) with a delay discounting function.

If consumers discount future technologies hyperbolically, their likely response to future
technologies could be predicted if the rate of change in the technology is known. The rate
of technological advancement can often be quantified, and possibly predicted, for example,
computing power, resolution of printers and digital imaging equipment, as can price
reductions for existing technologies. If future computing power increases exponentially
with time as is popularly suggested, and if perceived utility of a personal computer
increases proportionately to power, a hyperbolic delay discounter would value prospective
computer technologies ever more favourably the longer they are delayed. As a
consequence, purchase would be postponed to the extent possible.

One problem is that perceived marginal utility of technological progress may not relate
directly to the quantitative specifications of the improvement. The perceived utility of a
personal computer may not be directly proportional to processor speed, or memory and
storage capacity. Perceived utility should be mapped against specification. One way to do
this would be to map maximum acceptable price against specification, for example, finding
the number of dollars per pixel a consumer will pay for a digital camera.

Varying levels of quality often coexist in a market. The decision to purchase a higher or
lower specification article is about whether extra quality immediately justifies extra cost,
and as such is not a discounting issue. However, preference reversals could occur when
future purchases are planned. Saving to buy a house is an example. Someone may
commence regular savings with the intention of accumulating the deposit for a well-located
house. Enough funds accrue for the deposit on a house in a poorer location. A preference
change occurs and the investor decides to purchase in the inferior location. When both
purchases are distant in time, the better location is preferred. With reduced delay the worse location gains precedence. The preference change suggests hyperbolic delay discounting of the perceived value of houses in the two locations.

Hyperbolic delay discounting may affect value perceptions of the commodities that future investment can buy, which in turn may affect investment decisions. Discounting may also affect past decisions. After moving into the poorly located house, the buyer realises that the better house would have been worth the wait. Quality is remembered after price.

Quality remains an immediately accessible reward, whereas price recedes into the past and is therefore liable to retrospective delay discounting, if it occurs. The notion that past rewards or, more generally, any events are discounted in relation to how long ago they occurred brings with it new possibilities for research that builds on existing models about discounting of future events. Research into discounting of the past may contribute to models of memory, just as memory research could enlarge understanding of how past events are valued in relation to time. Presumably, the past loses power to influence current decisions the longer it recedes, just as longer delays to future rewards diminish perceived value, but at what rate is the past discounted, and according to what function?

**Concluding Remarks**

Read et al. (1999) distinguished between a vice, which is a low-value reward achieved at the expense of delayed, high-value benefit; and virtue, which is low-value cost incurred to achieve long term, high-value benefit. The current research could be construed as saying that immediate expenditure amounts to vice, and saving to virtue. As if it were that simple. Rachlin (2000) argues that decisions must be evaluated in relation to time. With short time horizons, spending on successive, low-value commodities appears the better option than a
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distant, high-value goal. Increase the evaluation period, and the high value delayed reward is perceived as worth more than the sum of a series of low value rewards. Perceived value depends on the evaluation time span.

Complicating the issue further is the money paradox. Money lacks intrinsic value until spent, except as a way of making more money; and via the pleasure of anticipated future consumption – what Loewenstein (1987) describes as savouring. When spent, money is forfeited permanently. Ironically for the current research about investment, the value of money is instantaneous and fleeting – limited to the moment of purchase.

Gratification postponed forever amounts to no gratification at all, hence discounting. Investment research should not aim to create a society of misers. For want of an objective standard for evaluating decisions independently of time and consistent with actual risk, and for want of failsafe ways to present historical investment returns, the ideal investment strategy will satisfy people in hindsight. Correct financial decisions minimise future regret.


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References


# Appendix A

## Percent Subjects Choosing Risk Investments for Chapter 6 Experiments

### Experiment 7

<table>
<thead>
<tr>
<th>Interest p.a. for risk option, and level of risk of &lt; 5% p.a.</th>
<th>Presentation order, term and investment amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Improving (n = 30)</td>
</tr>
<tr>
<td></td>
<td>5 years</td>
</tr>
<tr>
<td>10% p.a.</td>
<td>$1,000</td>
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<tr>
<td>10% risk</td>
<td>67%</td>
</tr>
<tr>
<td>20% risk</td>
<td>70%</td>
</tr>
<tr>
<td>30% risk</td>
<td>53%</td>
</tr>
<tr>
<td>40% risk</td>
<td>27%</td>
</tr>
<tr>
<td>50% risk</td>
<td>17%</td>
</tr>
<tr>
<td>60% risk</td>
<td>7%</td>
</tr>
<tr>
<td>70% risk</td>
<td>7%</td>
</tr>
<tr>
<td>15% p.a.</td>
<td></td>
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<tr>
<td>10% risk</td>
<td>63%</td>
</tr>
<tr>
<td>20% risk</td>
<td>83%</td>
</tr>
<tr>
<td>30% risk</td>
<td>77%</td>
</tr>
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<td>53%</td>
</tr>
<tr>
<td>50% risk</td>
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<td>7%</td>
</tr>
<tr>
<td>70% risk</td>
<td>0%</td>
</tr>
<tr>
<td>20% p.a.</td>
<td></td>
</tr>
<tr>
<td>10% risk</td>
<td>77%</td>
</tr>
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<td>20% risk</td>
<td>93%</td>
</tr>
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<td>30% risk</td>
<td>83%</td>
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<tr>
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<td>63%</td>
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<tr>
<td>70% risk</td>
<td>7%</td>
</tr>
<tr>
<td>25% p.a.</td>
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<td>10% risk</td>
<td>97%</td>
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<tr>
<td>70% risk</td>
<td>7%</td>
</tr>
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</table>

Includes all participants with complete data. Percentages refer to presentation order group.
### Experiment 8 – Percent Subjects Choosing Risk Investments

<table>
<thead>
<tr>
<th>Term and risk of 0%</th>
<th>Presentation order and % p.a. return for risk option</th>
<th>Improving order (n = 24)</th>
<th>Deteriorating order (n = 29)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>10%</td>
<td>15%</td>
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<tr>
<td>2 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10%</td>
<td></td>
<td>83%</td>
<td>83%</td>
</tr>
<tr>
<td>20%</td>
<td></td>
<td>79%</td>
<td>79%</td>
</tr>
<tr>
<td>30%</td>
<td></td>
<td>75%</td>
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<td></td>
<td>33%</td>
<td>42%</td>
</tr>
<tr>
<td>50%</td>
<td></td>
<td>17%</td>
<td>33%</td>
</tr>
<tr>
<td>60%</td>
<td></td>
<td>4%</td>
<td>17%</td>
</tr>
<tr>
<td>70%</td>
<td></td>
<td>0%</td>
<td>13%</td>
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<td>80%</td>
<td></td>
<td>0%</td>
<td>8%</td>
</tr>
<tr>
<td>90%</td>
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<td>4%</td>
<td>8%</td>
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<td>4 years</td>
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<tr>
<td>10%</td>
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<td>92%</td>
<td>88%</td>
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<td>83%</td>
<td>75%</td>
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<tr>
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Percentages refer to presentation order group.
### Experiment 9 – Percent Subjects Choosing Risk Investments

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Percentages refer to presentation order group.
Appendix B  Investment Evaluation Survey Example and Items

Investment Evaluation Survey

About the survey

This survey examines how people evaluate investments based on how much the investment earns from year to year. You may know from personal experience that most types of investments earn different amounts over time, as interest rates vary and the economy goes through its ups and downs. Some types of investments can even lose value occasionally.

When choosing the best place for their money, many investors look at several investment options and see how they have performed over recent years. Most investors want a high return with minimal risk of losing money.

This survey contains made-up examples of investments and how much interest they earned over a ten year period, from 1990 to 1999. For the technically minded, you should ignore issues such as the difference between investment income and capital growth – for our purposes these types of return are the same. Nor is any information given about where and how the money is invested (shares or bonds etc., in Australia or overseas). It doesn’t matter for this questionnaire.

All examples are fictitious, and not intended to resemble actual returns from any particular investments during the 1990s or any other time. Nor are they intended to predict the future returns from any particular investments.

What you are asked to do

Each investment example is followed by the same set of four questions. To answer each question, you tick one box. The questions ask you to rate the investment in terms of:

• The overall adequacy of its earnings. In other words, how much the investment increases in value with time.
• The overall risk associated with the investment. Risk is the chance of losing money.
• Whether or not it would be a good idea for a personal investor to place a large amount of money in that investment for a short time (3 years or less) or a long time (10 years or more). “A large amount of money” means several tens of thousands of dollars, or even more; a large enough amount so that the investment’s performance would matter to the typical small investor.

You don’t have to do any calculations in order to answer the questions. We want to know your intuitive opinions.

After the investment section, there are some questions about your own approach to investment, and demographic details.

If you have any questions about the survey, please ask the researcher.

Thank you for your interest in the survey.
Investments

Imagine placing some money in an investment fund at the beginning of 1990 and leaving it there until the end of 1999. Each year from 1990 to 1999 the investment is likely to earn a different rate of interest. As a result, the investment will gain (or lose) value by different amounts each year. The following example shows the percentage of interest earned by an imaginary investment each year, starting with 1990 and ending in 1999.

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<tbody>
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<td>% gained (+) or lost (−)</td>
<td>+2.0%</td>
<td>+4.0%</td>
<td>+6.0%</td>
<td>+8.0%</td>
<td>−6.0%</td>
<td>−4.0%</td>
<td>−2.0%</td>
<td>+4.0%</td>
<td>+6.0%</td>
<td>+8.0%</td>
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</tbody>
</table>

The table shows that the value of the investment:

- gained 2% in 1990
- gained 4% in 1991
  - gained 6% in 1992
    - gained 8% in 1993
- lost 6% in 1994 – a minus sign indicates a percentage loss in value of the investment for that year.
- and so on, finishing with an 8% gain in 1999, the final year of the investment.

Other patterns of returns are presented on following pages. They all show the percentage gained (+) or lost (−) each year. Please answer the questions by ticking one box on each row.
### Sample layout for items – forward order, first three items

#### Investment 1

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<td>+9.1%</td>
<td>+15.8%</td>
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**Earnings from this investment are:**
- Very poor
- Poor
- Fair
- Good
- Very good
- Excellent

**The risk of losing money at any time with this investment is:**
- Very low risk
- Low risk
- Moderate risk
- High risk
- Very high risk
- Extreme risk

**As a way to invest a large sum of money for 3 years or less in the future, the above investment is:**
- Very poor
- Poor
- Fair
- Good
- Very good
- Excellent

**As a way to invest a large sum of money for 10 years or more in the future, the above investment is:**
- Very poor
- Poor
- Fair
- Good
- Very good
- Excellent

#### Investment 2

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<td>+4.8%</td>
<td>+1.1%</td>
<td>+4.1%</td>
<td>+10.8%</td>
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</tbody>
</table>

**Earnings from this investment are:**
- Very poor
- Poor
- Fair
- Good
- Very good
- Excellent

**The risk of losing money at any time with this investment is:**
- Very low risk
- Low risk
- Moderate risk
- High risk
- Very high risk
- Extreme risk

**As a way to invest a large sum of money for 3 years or less in the future, the above investment is:**
- Very poor
- Poor
- Fair
- Good
- Very good
- Excellent

**As a way to invest a large sum of money for 10 years or more in the future, the above investment is:**
- Very poor
- Poor
- Fair
- Good
- Very good
- Excellent

#### Investment 3

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**Earnings from this investment are:**
- Very poor
- Poor
- Fair
- Good
- Very good
- Excellent

**The risk of losing money at any time with this investment is:**
- Very low risk
- Low risk
- Moderate risk
- High risk
- Very high risk
- Extreme risk

**As a way to invest a large sum of money for 3 years or less in the future, the above investment is:**
- Very poor
- Poor
- Fair
- Good
- Very good
- Excellent

**As a way to invest a large sum of money for 10 years or more in the future, the above investment is:**
- Very poor
- Poor
- Fair
- Good
- Very good
- Excellent
Appendixes

Investment evaluation survey items

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Chapter 9 – Appendixes
Set 2 – Investment evaluation survey items
Mean

SD

5
5
5

Sequence

Year 1

Year 2

Year 3

Year 4

Year 5

Year 6

Year 7

Year 8

Year 9

Year 10

5
5
5

Random
-0.5%
Improve
2.1%
Deteriorate 11.5%

6.9%
-0.4%
7.4%

5.4%
-1.1%
5.5%

-1.1%
-0.5%
6.9%

2.1%
5.4%
13.2%

11.5%
11.5%
2.1%

13.2%
7.4%
-0.4%

7.4%
5.5%
-1.1%

5.5%
6.9%
-0.5%

-0.4%
13.2%
5.4%

10
10
10

5
5
5

Random
4.5%
Improve
7.1%
Deteriorate 16.5%

11.9%
4.6%
12.4%

10.4%
3.9%
10.5%

3.9%
4.5%
11.9%

7.1%
10.4%
18.2%

16.5%
16.5%
7.1%

18.2%
12.4%
4.6%

12.4%
10.5%
3.9%

10.5%
11.9%
4.5%

4.6%
18.2%
10.4%

15
15
15

5
5
5

Random
9.5%
Improve
12.1%
Deteriorate 21.5%

16.9%
9.6%
17.4%

15.4%
8.9%
15.5%

8.9%
9.5%
16.9%

12.1%
15.4%
23.2%

21.5%
21.5%
12.1%

23.2%
17.4%
9.6%

17.4%
15.5%
8.9%

15.5%
16.9%
9.5%

9.6%
23.2%
15.4%

5
5
5

25
25
25

Random
-22.4%
Improve
-9.7%
Deteriorate 37.6%

14.7%
-22.2%
17.2%

7.1%
-25.5%
7.3%

-25.5%
-22.4%
14.7%

-9.7%
7.1%
45.9%

37.6%
37.6%
-9.7%

45.9%
17.2%
-22.2%

17.2%
7.3%
-25.5%

7.3%
14.7%
-22.4%

-22.2%
45.9%
7.1%

10
10
10

25
25
25

Random
-17.4%
Improve
-4.7%
Deteriorate 42.6%

19.7%
-17.2%
22.2%

12.1%
-20.5%
12.3%

-20.5%
-17.4%
19.7%

-4.7%
12.1%
50.9%

42.6%
42.6%
-4.7%

50.9%
22.2%
-17.2%

22.2%
12.3%
-20.5%

12.3%
19.7%
-17.4%

-17.2%
50.9%
12.1%

15
15
15

25
25
25

Random
-12.4%
Improve
0.3%
Deteriorate 47.6%

24.7%
-12.2%
27.2%

17.1%
-15.5%
17.3%

-15.5%
-12.4%
24.7%

0.3%
17.1%
55.9%

47.6%
47.6%
0.3%

55.9%
27.2%
-12.2%

27.2%
17.3%
-15.5%

17.3%
24.7%
-12.4%

-12.2%
55.9%
17.1%

Set 3 – Investment evaluation survey items
Mean

SD

5
5
5

Year 1

Year 2

Year 3

Year 4

Year 5

Year 6

Year 7

Year 8

Year 9

Year 10

5
5
5

Random
10.6%
Improve
1.4%
Deteriorate 10.6%

11.8%
1.0%
9.7%

5.4%
-1.9%
5.4%

1.0%
0.7%
9.4%

-1.9%
1.7%
11.8%

0.7%
10.6%
1.4%

1.4%
9.7%
1.0%

9.7%
5.4%
-1.9%

9.4%
9.4%
0.7%

1.7%
11.8%
1.7%

10
10
10

5
5
5

Random
15.6%
Improve
6.4%
Deteriorate 15.6%

16.8%
6.0%
14.7%

10.4%
3.1%
10.4%

6.0%
5.7%
14.4%

3.1%
6.7%
16.8%

5.7%
15.6%
6.4%

6.4%
14.7%
6.0%

14.7%
10.4%
3.1%

14.4%
14.4%
5.7%

6.7%
16.8%
6.7%

15
15
15

5
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5

Random
20.6%
Improve
11.4%
Deteriorate 20.6%

21.8%
11.0%
19.7%

15.4%
8.1%
15.4%

11.0%
10.7%
19.4%

8.1%
11.7%
21.8%

10.7%
20.6%
11.4%

11.4%
19.7%
11.0%

19.7%
15.4%
8.1%

19.4%
19.4%
10.7%

11.7%
21.8%
11.7%

5
5
5

25
25
25

Random
33.2%
Improve
-12.9%
Deteriorate 33.2%

39.1%
-14.8%
28.5%

6.9%
-29.3
6.9%

-14.8%
-16.6%
27.2%

-29.3%
-11.3%
39.1%

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33.2%
-12.9%

-12.9%
28.5%
-14.8%

28.5%
6.9%
-29.3%

27.2%
27.2%
-16.6%

-11.3%
39.1%
-11.3%

10
10
10

25
25
25

Random
38.2%
Improve
-7.9%
Deteriorate 38.2%

44.1%
-9.8%
33.5%

11.9%
-24.3%
11.9%

-9.8%
-11.6%
32.2%

-24.3%
-6.3%
44.1%

-11.6%
38.2%
-7.9%

-7.9%
33.5%
-9.8%

33.5%
11.9%
-24.3%

32.2%
32.2%
-11.6%

-6.3%
44.1%
-6.3%

15
15
15

25
25
25

Random
43.2%
Improve
-2.9%
Deteriorate 43.2%

49.1%
-4.8%
38.5%

16.9%
-19.3%
16.9%

-4.8%
-6.6%
37.2%

-19.3%
-1.3%
49.1%

-6.6%
43.2%
-2.9%

-2.9%
38.5%
-4.8%

38.5%
16.9%
-19.3%

37.2%
37.2%
-6.6%

-1.3%
49.1%
-1.3%

300

Sequence


## Appendixes

### Set 4 – Investment evaluation survey items

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<th>Year 4</th>
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<th>Year 6</th>
<th>Year 7</th>
<th>Year 8</th>
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### Appendix C Investment Evaluation Survey Descriptive Statistics

Table 9.1 Descriptive statistics for Investment Evaluation Survey 6-point rating scales

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<td>0.97</td>
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</tr>
</tbody>
</table>
Table 9.2  Personal financial and associated behaviours

**Personal expenditure tendency (N = 22)**

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely spends rather than saves</td>
<td>0%</td>
</tr>
<tr>
<td>Tends to spend rather than save</td>
<td>23%</td>
</tr>
<tr>
<td>Tends to save rather than spend</td>
<td>64%</td>
</tr>
<tr>
<td>Definitely saves rather than spends</td>
<td>14%</td>
</tr>
</tbody>
</table>

**Higher priority when investing a large sum of money (N = 22)**

<table>
<thead>
<tr>
<th>Priority</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoiding the risk of losing money, even if it means a lower return</td>
<td>64%</td>
</tr>
<tr>
<td>Achieving a high return, even if it involves the risk of losing money</td>
<td>36%</td>
</tr>
</tbody>
</table>

**How often participates in any form of gambling or betting (N = 21)**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Once a year or less</td>
<td>52%</td>
</tr>
<tr>
<td>A few times a year</td>
<td>24%</td>
</tr>
<tr>
<td>Several times a year</td>
<td>14%</td>
</tr>
<tr>
<td>At least monthly</td>
<td>0%</td>
</tr>
<tr>
<td>At least fortnightly</td>
<td>10%</td>
</tr>
<tr>
<td>At least weekly</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Currently has money in following types of investment (N = 22)**

<table>
<thead>
<tr>
<th>Investment Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank, building society or credit union term deposits or other investment accounts where the interest rate is fixed. Does not include regular savings accounts</td>
<td>41%</td>
</tr>
<tr>
<td>Bonds, money market securities, whether directly purchased or via managed investment fund</td>
<td>9%</td>
</tr>
<tr>
<td>Investment property, either residential or commercial, or via property securities, listed property trusts or a managed fund (property securities). Does not include own home</td>
<td>23%</td>
</tr>
<tr>
<td>Shares, whether directly purchased and owned, or via a managed investment fund (unit trust)</td>
<td>36%</td>
</tr>
<tr>
<td>Tradeable commodities or the futures market, either directly or via a managed investment fund (unit trust)</td>
<td>0%</td>
</tr>
<tr>
<td>No investments listed above</td>
<td>32%</td>
</tr>
</tbody>
</table>