Less carrot more stick: promoting health behavior change with deposit contracts

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Chapter 1

General introduction

"An incentive is a bullet, a key: an often tiny object with astonishing power to change a situation"

Steven Levitt

Financial incentives are everywhere. People receive salary to perform their jobs and are fined if they drive too fast in their cars. Although, arguably, there are other good reasons to work and adhere to speed limits, imagine a world without these incentives. Financial incentives shape behavior in many domains of life. Increasingly, financial incentives are also being applied to health behavior. For instance, health insurance companies provide people with different financial incentives for healthy living (e.g., cinema tickets, discounts on travelling, payback on purchase of an activity tracker, see Hafner et al., 2020). These incentive programs support health behavior change by introducing immediate financial incentives for healthy behavior. As a result, people, impatient by nature, no longer have to wait for the delayed rewards (e.g., becoming more fit) of healthy behavior to emerge. Broadly speaking, financial incentives come in two different shapes: carrots and sticks (Adams et al., 2014). Carrots can be defined as financial incentives that create the opportunity for a financial gain. For example, by rewarding someone with a certain amount of money contingent on successful behavior change. Sticks can be defined as financial incentives that create the threat of a financial loss. For example, by having someone deposit their own money in a deposit contract, and allowing them to earn it back contingent on successful behavior change. A deposit contract adds skin in the game, because when someone is not successful, their monetary deposit could be lost. This dissertation explores if and how deposit contracts can be utilized for health behavior change.

Why health behavior change is necessary

The everyday choices we make impact our health. Unhealthy eating, smoking, alcohol consumption, and physical inactivity are among the most important lifestyle behaviors that contribute to disease and mortality (World Health Organization, 2009). In this dissertation we focus on improving health behavior with a specific focus on physical activity. Daily life has become so sedentary, especially in high-income Western countries, that people now suffer widely from a lack of physical activity, and as a result many negative health consequences (Woessner et al., 2021). Studies show that 27.5% of adults worldwide, and 42.3% or adults in high-income Western countries, are not getting enough physical activity (Guthold et al., 2018). Physical inactivity is one of the key risk factors for non-communicable diseases (e.g., cardiovascular disease, obesity) and causes millions of preventable deaths worldwide (World Health Organization, 2009). Recent analysis shows that up to 8% of non-communicable diseases and around 7% of deaths are attributable to physical inactivity (Katzmarzyk et al., 2022). Furthermore, estimates indicate that the economic burden of physical inactivity on health-care systems worldwide was at least 53.8 billion international dollars in 2013 (Ding et al., 2016). While physical inactivity is linked to chronic disease and early death (Anderson & Durstine, 2019), increasing physical activity is associated with important health benefits. Becoming

more physically active reduces the risk of chronic disease, improves mental health and contributes to longevity (Pedersen & Saltin, 2015). Importantly, these benefits are found not only for intense aerobic training, but also for the mere number of steps taken in daily life (Lee et al., 2019; Saint-Maurice et al., 2020). Meta-analysis among over 200.000 people has shown that increasing daily steps by 1000 steps a day is associated with a 15% decreased risk of all-cause mortality, while walking 500 steps a day more is associated with a 7% decrease in cardiovascular related mortality (Banach et al., 2023).

What makes health behavior change difficult

Although people often have intentions to live healthily, following through on these intentions can be challenging. A rainy day can keep one from going for a run, a well-deserved holiday break can interrupt a successful gym streak, and friends smoking cigarettes at a party can cause a relapse in a smoking cessation attempt. An increasingly large body of research, confirmed by painful personal experience, establishes unequivocally: behavior change is tough. The finding that intentions do not always translate into behavior has been coined the intention-behavior gap and has been found to apply to a variety of (health) behaviors (Sheeran & Webb, 2016), including physical activity (Rhodes & Bruijn, 2013). Although people are often aware of the benefits of physical activity, and have positive intentions to be (more) physically active, many do not achieve sufficient physical activity in daily life (Rhodes & Bruijn, 2013).

Psychological models for behavior, such as the reflective-impulsive model (Strack & Deutsch, 2004), describe why a gap exists between intentions and behavior. In a typical dual process fashion, the reflective-impulsive model explains behavior as a function of both reflective processes and impulsive processes. Both of these processes follow distinct operating principles. Reflective processes are described as effortful decisional processes based on reasoning and knowledge about consequences that lead to intentions, and ultimately behavior. On the other hand, impulsive processes are effortless, and can automatically (without the persons intention or goal), trigger behavior. Imagine someone who - after reflecting on the negative health consequences of being sedentary - intends to go for a walk after work each day. After a long day at work, and when the comfortable couch is in sight, the impulsive system might (automatically) override the previously formed intention to go for a walk, and the person lies down on the couch to watch a sitcom instead. This example illustrates how, under challenging contextual circumstances such as being tired, goal conflicts between reflective and impulsive processes can be triggered by environmental cues (e.g., seeing the couch), and make us fall for immediate temptation (e.g., watch TV) instead of acting in line with our long-term health goals (e.g., be more physically active). Similar explanations for what makes behavior change difficult come from behavioral economics (Mullainathan & Thaler, 2000), a field of study that

has challenged the traditional notion that people act rationally, and in their own best interest. Rather, because they are biased, people often act in predictably irrational ways, even against their own best interest (Mullainathan & Thaler, 2000). A key finding from behavioral economics is that people are present biased; they are more strongly influenced by consequences in the here and now than they are by the long-term consequences of their behavior (Laibson, 1997). As a result, people tend to procrastinate on their long-term goals (Laibson, 1997). Being present biased makes people vulnerable when it comes to improving their long term health outcomes, because living healthily often involves a trade-off between short term temptations (e.g., lying on the couch) and long-term health goals (e.g., losing weight by being physically active)(Hunter et al., 2018). Although behavioral economists label this tendency to grab immediate rewards a 'bias', it was once probably an adaptive response (Haselton et al., 2009). Over the largest part of our evolutionary history, acting on directly available rewards (rather than abstract, uncertain ideas about possible future rewards) had important survival advantages. However, we now live in environments with an abundance of food, and no need for physical exertion to attain it. It appears that when it comes to our health, being present biased no longer helps, but hurts. Importantly, the insight that people are present biased also helps to understand why introducing immediate financial incentives might be suitable as an intervention strategy for health behavior change.

Financial incentives for health behavior change

Incentives can be defined as reinforcements and punishments that motivate people to take up an activity and guide the way they perform it (Hagger et al., 2020). Incentives can be tangible (e.g., money, vouchers, gifts) or intangible (e.g., feedback, praise, affection) (Hagger et al., 2020). Incentive interventions have their roots in operant conditioning, a field of study originated in the 1950s by B.F. Skinner. Skinners' classic experiments with the conditioning of pigeon and rat behavior showed that animal behavior (and ultimately human behavior) is continuously shaped and maintained by its consequences (Skinner, 1953). Broadly speaking, behavior can either be reinforced (strengthened and increased) or punished (weakened and decreased). The stimulus (or consequence) used to shape behavior can be pleasant or aversive, and can either be introduced or removed. This results in the quadrant displayed in *Figure 1.* In this dissertation, we consider financial rewards (or *carrots*) and deposit contracts (or *sticks*) for stimulating increases in healthy behaviors (such as physical activity) as forms of respectively positive and negative reinforcement.

	Reinforcement (increase behavior)	**Punishment** (decrease behavior)
Positive (add stimulus)	Add pleasant stimulus to **Increase** behavior	Add aversive stimulus to **Decrease** behavior
Negative (remove stimulus)	Remove aversive stimulus to **Increase** behavior	Remove pleasant stimulus to **Decrease** behavior

Figure 1. Principles of operant conditioning

A common objection to providing incentives for health behavior change is that extrinsic rewards might undermine (or "crowd out") intrinsic motivation. This objection is based on the tenets of self-determination theory, and its proponents argue that while incentives can increase extrinsic motivation (i.e. desire to do something to receive an external reward), they might also reduce intrinsic motivation (i.e., desire to do something because it is inherently enjoyable) (Deci et al., 1999). Although this objection makes intuitive sense, studies show that providing financial incentives for health behavior does not reduce self-reported intrinsic motivation (Leahey et al., 2017; Ledgerwood & Petry, 2006). More importantly, meta-analyses show that, for a wide range of health behaviors, behavior measured at follow-up often drops back to pre-incentive baselines, but not below baselines (Boonmanunt et al., 2022; Giles et al., 2014; Mantzari et al., 2015; Mitchell et al., 2019). Finally, there is no evidence available that shows lower levels of behavior in previously incentivized groups, compared to no-incentive control groups (Promberger & Marteau, 2013). All in all, there seems to be very little evidence that supports the idea that financial incentives undermine intrinsic motivation for health behaviors. The original studies that did find a crowding out of intrinsic motivation often studied performance in simple tasks not related to health behavior such as completing puzzles or drawing pictures, for which participants already had high intrinsic motivation (operationalized as high pre-incentive levels of performance) (Deci et al., 1999). Health behavior differs from these tasks, because people who are targeted by financial incentive interventions often do not have high levels of pre-incentive intrinsic motivation and high levels of performance of the target behavior (Promberger & Marteau, 2013). Moreover, health behavior typically involves issues of self-control, because people have to trade off long term health benefits to short term temptations. Because financial incentives help tip the decisional balance in favor of the long-term health benefits, people might actually experience them as helpful in bringing their behavior more in line with their preferences (Promberger & Marteau, 2013).

Rewarding someone with an amount of money creates the opportunity for a financial gain (i.e., it adds a pleasant stimulus) contingent on performance of a behavior. Therefore, it is considered as positive reinforcement (Burns & Rothman, 2018). Offering immediate financial rewards for healthy behavior takes advantage of present bias by introducing a monetary benefit in the here and now. In contrast, a deposit contract is defined as an arrangement in which people deposit their own money which they can (partially) earn back by achieving behavioral goals (Donlin Washington et al., 2016). In this case, the threat of losing the deposit acts as an aversive stimulus that is removed when behavioral goals are met. Therefore, a deposit contract is considered as negative reinforcement (Burns & Rothman, 2018). Both financial rewards and deposit contracts bring an incentive into the present. However, deposit contracts bring a risk of loss into the present. Thus, deposit contracts should theoretically be more effective than financial rewards, because they capitalize on loss aversion. Loss aversion is the tendency to assign larger weight to potential losses associated with behavior than to potential gains (Kahneman & Tversky, 1979). For example, a prediction from loss aversion is that losing 100 dollars hurts more, than the pleasure derived from gaining 100 dollars (see *Figure 2* below).

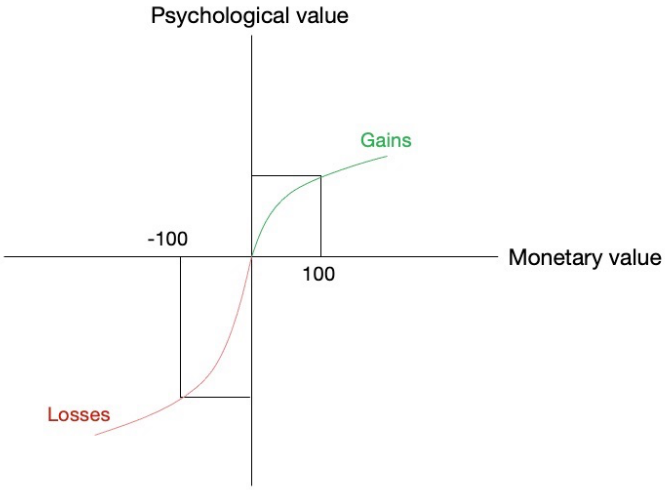

Figure 2. An illustration of loss aversion

Deposit contracts are considered a form of commitment device *(See the box on the next page): "an arrangement entered into by an individual with the aim of helping fulfill a plan for future behavior that would otherwise be difficult owing to intrapersonal conflict stemming from, for example, a lack of self-control"* (Bryan et al., 2010).

The ancient commitment strategy of Odysseus

The Odyssey, written by Homer in around 800 BC, is one of humanities oldest stories and tells the mythical tale of the Greek hero Odysseus' who returns home with his ship and crew after the Trojan war. Odysseus is aware that on his journey homeward he will encounter the Sirens: beautiful but dangerous creatures who lure sailors with their irresistible songs to crash their ships into the rocks. Foreseeing this future temptation, Odysseus orders his sailors to plug their ears with wax and to tie him firmly to the mast of the ship. In so doing, Odysseus is able to avoid the temptation of the Sirens' singing, steer his ship clear of danger, and make it back safe into their home harbor. The ancient strategy that Odysseus applied is what modern behavioral science calls a commitment device (Rogers et al., 2014).

A deposit contract constitutes a monetary commitment device in which the threat of losing the monetary deposit enforces the intended behavior (Giné et al., 2010). Similar to Odysseus' predicament, people often find themselves in situations in which they need to resist unhealthy temptations in the here and now, because they are in conflict with previously formed healthy intentions. In these situations, a deposit contract allows the (reflective) current self to impose restrictions on the behavior of the (impulsive) future self, under the threat of losing something that was once owned (i.e., in this case money). The reflective system in this way 'tames' the impulsive system through attaching financial consequences (i.e., losing or regaining the deposit) to impulse control failure and success.

The effects of financial rewards (carrots)

Financial rewards have proven to be effective in promoting behavior change in a wide range of health domains including: diet (Kurti et al., 2016), substance use (Kurti et al., 2016), physical activity (Mantzari et al., 2015; Mitchell et al., 2019), weight loss (Kurti et al., 2016), smoking cessation (Giles et al., 2014; Mantzari et al., 2015), and vaccination uptake (Giles et al., 2014). Importantly, financial rewards are rarely offered as a stand-alone intervention. Rather, they are usually added as a supplement to multi-component behavior change interventions that already include proven behavior change techniques such as goal setting, goal progress feedback, and counselling (Mantzari et al., 2015; Mitchell et al., 2019). Even when compared against such a strong comparison condition, adding financial rewards roughly doubles the odds of successful behavior change (Mantzari et al., 2015). For physical activity, meta-analysis (N = 6074) shows that adding financial rewards (of approximately US $1.50 per day per person) to existing step count interventions increases daily step counts by an additional 600 steps, or 10-15% (Mitchell et al., 2019).

However, while financial rewards are effective to promote short-term initiation of physical activity, it is uncertain whether effects are maintained in the long-term. Most interventions that target physical activity lasted 3 months or less, with no interventions lasting more than 6 months (Boonmanunt et al., 2022; Mitchell et al., 2019). More importantly, it is unclear what happens with achieved behavior change after incentives are removed. Meta-analyses across different health behaviors generally conclude that evidence for post-incentive behavior change maintenance is limited at best (Giles et al., 2014; Kurti et al., 2016; Mantzari et al., 2015). Research on physical activity indicates that effects are sometimes maintained up to 6 months after incentive removal (Mitchell et al., 2019), whereas other research shows that effects dissipate within three months (Mantzari et al., 2015). Without clear evidence for maintenance of achieved behavior change, offering financial rewards requires sustained funding by the intervention provider, which limits the opportunities for large scale implementation. Another important question is whether vulnerable people (such as those with lower socioeconomic positions) also benefit from financial rewards. This question is also important from an ethical perspective (see Lunze & Paasche-Orlow, 2013), since incentive interventions should contribute to closing (rather than widening) the socioeconomic health gap. Financial rewards might have greater effects on those with lower incomes, because a similar size incentive would provide greater relative value (Vlaev et al., 2019). Indeed, a meta-analysis has provided preliminary indications that people with lower socioeconomic positions show greater improvements when exposed to financial reward interventions (Mantzari et al., 2015).

Rationale for studying deposit contracts (sticks)

For long-term maintenance of behavior change, financial rewards (or *carrots*) would have to be offered indefinitely, or at least for extended periods of time. Importantly, this also means that offering financial rewards for health behavior change requires constant (or at least sustained) funding by the intervention provider. A key aspect of deposit contracts (or *sticks*) is that the incentive is not provided by an external source, but is instead provided by the person attempting the behavior change (Halpern et al., 2012). This results in three crucial benefits that deposit contracts have over financial rewards. Firstly, deposit contracts have the potential for large scale implementation, without requiring external funds to provide incentives. Secondly, because people voluntarily decide to incentivize themselves, the locus of control over the incentive is internal ("I deposit money") rather than external ("the intervention provider rewards me"). This helps to avoid some of the (ethical) concerns that are associated with rewarding people with external funds. For example, rewarding people for behavior that others perform without receiving rewards might be considered unfair, while having people voluntarily deposit their own money avoids this ethical concern (Sykes-Muskett et al., 2015). Thirdly, deposit contracts might

be more effective than financial rewards because people are generally more motivated to avoid losses than they are to receive gains (i.e., they are loss aversive)(Kahneman & Tversky, 1979). Downsides to deposit contracts are that their uptake is generally low (Giné et al., 2010; Kullgren et al., 2016; Royer et al., 2015), and that it is unclear whether they are also suitable for vulnerable subgroups such as people with lower socioeconomic positions, or with chronic conditions (e.g., cardiovascular disease).

The effects of deposit contracts (sticks)

Deposit contracts appear to have potential to improve health behavior change generally, and physical activity specifically. Deposit contracts have been applied successfully to weight loss (Kullgren et al., 2016; Volpp et al., 2008), smoking cessation (Halpern et al., 2015; Jarvis & Dallery, 2017) and daily step counts (Budworth et al., 2019; Burns & Rothman, 2018; Donlin Washington et al., 2016; Krebs & Nyein, 2021; Stedman-Falls & Dallery, 2020). However, the studies targeting daily step counts were either underpowered to determine effectiveness (Donlin Washington et al., 2016; Krebs & Nyein, 2021; Stedman-Falls & Dallery, 2020), or did not use an actual deposit of participants' own money (Budworth et al., 2019; Burns & Rothman, 2018). For example, Burns & Rothman (2018) used loss framing to mimic an actual deposit of their own money by telling participants at the start of intervention that they would receive $50, and that they would lose money for each day they did not meet their walking goal. As another example, Budworth et al. (2019) first provided participants with vouchers for participation, which could then be used as a deposit. These operationalizations do not require participants to deposit their own money, and thus do not allow for a valid assessment of deposit contract uptake or effects. There are also some indications that deposit contracts might be effective to promote maintenance of physical activity after incentive removal (see Boonmanunt et al., 2022), but more fully powered research with actual deposits of participants' own money is needed. Furthermore, also for deposit contracts specifically, long-term effects have not yet been examined, and it remains unclear whether deposit contracts are suited for more vulnerable subgroups.

Features that make deposit contracts more effective

Designing a financial incentive entails making design decisions on features such as frequency, channel, duration, framing, and schedule of incentive delivery (Adams et al., 2014). Existing meta-analyses across different health behaviors have not yet been able to identify which features of financial incentive interventions make them more effective (Giles et al., 2014; Mantzari et al., 2015). However, with regards to financial incentives for physical activity, previous research indicates that longer intervention duration,

more immediate incentive delivery, higher incentive amounts, and targeting less active populations increases intervention effects (Mitchell et al., 2019). Furthermore, several studies indicate that financial incentives might be more effective when they leverage our tendency to be loss aversive, such as is the case with a deposit contract (Boonmanunt et al., 2022; Haff et al., 2015; Vlaev et al., 2019). One option to increase deposit contract effects would be to use loss framing to further enhance feelings of losses (thus capitalizing on loss aversion) and potentially increase the effectiveness of a deposit contract. Loss framing has been shown to increase the effectiveness of financial rewards (Patel et al., 2016), but no research has been done yet on whether loss framing enhance the effects of deposit contracts. A second possibility to increase deposit contract effects is to make use of what has been called the Fresh Start Effect (Dai et al., 2014). Research has shown that interest to pursue lifestyle goals peaks around fresh start moments such as the first day of the week, month, or year (Dai et al., 2014). Possibly, because of the peak in motivation that surrounds the passage of the calendar year, the effects of a deposit contract would be enhanced when it is started as a New Year's Resolution. Finally, research might further investigate how deposit contracts should be designed for optimal effectiveness, without compromising uptake. As an example, larger deposit amounts are predicted to have stronger effects on behavior, but might deter people from participating, thus reducing overall uptake and ultimately efficacy of the intervention (Halpern et al., 2012).

Strategies that help increase the uptake of deposit contracts

It is important to explore methods for increasing deposit contract uptake, because research shows that uptake of deposit contracts is generally low, often below 15% (Giné et al., 2010; Kullgren et al., 2016; Royer et al., 2015). Low uptake is especially problematic when those most in need of intervention (e.g., lower socioeconomic subgroups) would not be reached. Strategies that hold potential to increase deposit contract uptake are customization and matching. Firstly, offering a customizable deposit contract allows participants to self-tailor the right deposit amount (Sykes-Muskett et al., 2015) instead of offering a take it or leave it fixed deposit amount. A fixed deposit amount might deter people who are reluctant to participate or who think the fixed deposit amount is too high, and customization might thus remove a barrier for participation by allowing small deposit amounts. Secondly, matching a deposit (doubling the deposit amount with an additional reward of equal size) adds elements of positive reinforcement to the existing negative reinforcement that is already present in a deposit contract, and might increase the overall attractiveness of the deposit contract (Finkelstein et al., 2019). However, to the best of our knowledge, whether customization and matching of deposit contracts indeed increase uptake has not been shown yet. The only study known to us provided matching of deposit contracts for weight loss, but did not find an effect on uptake (Kullgren et al., 2016).

The acceptability of deposit contracts for people with cardiovascular disease

Because deposit contracts have been shown to have low uptake, it is important to study their acceptability among different subgroups. One subgroup to whom lifestyle change is critically important are those with cardiovascular disease (CVD). After a health incident, people with CVD are often referred to cardiac rehabilitation (CR): a 12-week program during which patients receive psycho-education, support with lifestyle change and guided physical exercise training (Brouwers et al., 2021). Although lifestyle changes are often initiated successfully during cardiac rehabilitation, when people return to everyday life they often relapse into their old unhealthy habits (Kotseva et al., 2019). Therefore, there is an urgent need to find new approaches that help solidify lifestyle changes in people with CVD, and that can serve as a supplement to cardiac rehabilitation. Deposit contracts might form such a supplement. Offering deposit contracts might be beneficial to for example cardiovascular disease patients who are in a pre-operative lifestyle change program, recovering in a post-operative cardiac rehabilitation program, or who are entering the non-supported home environment after cardiac rehabilitation is completed. To the best of our knowledge, little research has been done yet on whether people with cardiovascular disease find deposit contracts for lifestyle change acceptable. One study among overweight and obese recipients of incentives did show low support for any type of financial incentive for weight loss, and especially for deposit contracts (McGill et al., 2018). More specifically, another study among a sample of cardiac rehabilitation patients found that nearly all participants preferred voucher-based incentives over cash incentives, which might indicate low acceptability of monetary deposit contracts among CVD patients (Mitchell et al., 2014). Furthermore, although evidence from other countries on the acceptability of financial incentives among healthcare professionals (HCPs) is promising (Hoskins et al., 2019), whether Dutch healthcare professionals find financial incentives for health promotion among CVD patients acceptable is unclear. More research is needed to assess the acceptability of deposit contracts from the perspective of both patients themselves and HCPs involved in cardiac care.

Despite their proven effectiveness in changing health behavior, using financial incentives to promote health has raised ethical objections. The main objections are that incentives may be coercive, undermine autonomy of individuals, undermine personal responsibility for health, and may be considered unfair to those who already have healthy lifestyles (Ashcroft, 2011; Lunze & Paasche-Orlow, 2013). Although these ethical objections exist, it appears that they can be mitigated through thoughtful incentive design. For example, among cardiovascular disease patients, ethical concerns to using financial incentives were prominent, but highly dependent on how incentives were designed (Mitchell et al., 2014).

The current dissertation

Deposit contracts are promising for improving population health, because they might be implemented on a large scale without requiring external funding of incentives. The main aim of this dissertation is to fill the knowledge gap surrounding the effectiveness of deposit contracts for health behavior change. Existing research has shown that deposit contracts hold potential to improve health behavior change in physical activity, but previous work was either underpowered or has used loss framing or vouchers that were first given to mimic an actual deposit of participants' own money. Therefore, to assess their potential to increase population health it is important to establish the effects of actual deposit contracts, and which features make them more effective. Generally, low uptake is a key obstacle for large scale implementation of deposit contracts, and it is unclear how uptake can be increased. Finally, because health behavior change is critically important for people with chronic conditions such as cardiovascular disease, it is important to investigate patients' and healthcare professionals' opinions on using financial incentives, and more specifically deposit contracts, for health behavior change. Our ultimate aim is to stimulate further theoretical investigation and practical application of deposit contracts for health behavior change.

To summarize, the main aim of this dissertation is to assess the potential of deposit contracts for health behavior change. More specifically we aim to:

1. Establish the effects of deposit contracts
2. Explore which features of deposit contracts make them more effective
3. Identify strategies that help increase the uptake of deposit contracts
4. Assess the acceptability of deposit contracts for people with cardiovascular disease

Overview of the chapters of this dissertation

This dissertation starts with the results of two field experiments in which we manipulated features of deposit contracts and measured effects on uptake and effectiveness (chapters 2 & 3). In addition, we report an observational study in which we evaluate the real-world effects of commercially available deposit contracts (chapter 4). Finally, we report two studies on the perspectives of cardiovascular disease patients and healthcare professionals to gauge acceptability (chapters 5 & 6).

Chapter 2 explores the effectiveness and uptake of deposit contracts for improving physical activity. Comparing the existing evidence on the effectiveness and uptake of deposit contracts for physical activity between studies is complicated, because existing studies were underpowered and operationalizations of deposit contracts differed substantially. Sometimes completely self-funded deposit contracts are used, and sometimes loss framing is used to create the psychological experience of losing one's

own money, without actually requiring individuals to put money at risk. Therefore, in a field experiment we aim to disentangle the effects of incurring actual losses (through self-funding a deposit contract) and loss framing. We use a smartphone app that provides financial rewards or requires actual deposit contracts of participants' own money (which are either loss or gain framed) and measure uptake and the effects on daily step counts of healthy students. We expect that, due to loss aversion, deposit contracts are more effective than financial rewards, and that loss gained incentives are more effective than gain framed incentives.

Chapter 3 follows up on the results of *Chapter 2* and investigates ways to increase the uptake of a deposit contract. Low uptake is an important obstacle to large scale implementation of deposit contracts, especially when groups that are most in need of intervention are not reached. Therefore, in *Chapter 3* we investigate how the uptake of deposit contracts for physical activity can be increased. Two elements that might increase deposit contract uptake are: (1) deposit matching (doubling the money participants deposit) and (2) deposit customization (allowing self-selection of what amount of money participants want to deposit). We revised the smartphone app that was designed for chapter 2 and implement deposit contracts that are either matched (or not), and customizable (or fixed). We investigate the effects of these manipulations on the uptake and effectiveness among healthy students. We expect that both matching and customization of deposit amounts increase the uptake of a deposit contract for physical activity.

Chapter 4 moves beyond the realm of traditional academic research and investigates what the effects are of publicly accessible deposit contracts for physical activity. We report analysis of over 70.000 gamified deposit contract challenges to increase step counts that are offered through a commercial smartphone app. Understanding whether deposit contracts are not only efficacious in lab settings, but also effective in real life conditions, provides important additional evidence that may help inform public health policy making and future intervention design. We perform a naturalistic evaluation of the challenges and their association with increases in physical activity, explore for whom these challenges work best, and under which conditions they are most effective.

Chapter 5 explores what people with cardiovascular disease (CVD) think of using deposit contracts for their lifestyle change. Because people with CVD often have difficulties maintaining the lifestyle changes that are important to their health, there is an urgent need to find new approaches that improve long-term adherence to a healthy lifestyle. Although people with CVD might benefit from using deposit contracts, it is unknown whether they would find deposit contracts acceptable. The limited evidence that is available implies that, despite their effectiveness in helping people achieve lifestyle goals, deposit contracts might in fact not be acceptable to people with CVD. Therefore, in *Chapter 5* we investigate the acceptability of a deposit contract for physical activity

with a survey among members of the Harteraad patient panel of the Dutch CVD patient organization.

Chapter 6 investigates healthcare professionals' perspectives on using financial incentives to support healthy living among people with cardiovascular disease. When financial incentives are applied to patient populations, healthcare professionals are expected to deliver the intervention, promote uptake among patients, and guide implementation in current health care. Although financial incentives have proven to be effective, their implementation in healthcare remains controversial. It is unknown whether healthcare professionals involved in CVD care find it acceptable to provide financial incentives to patients with CVD as support for lifestyle change. Therefore, in *Chapter 6* we report the results of 16 qualitative interviews with Dutch Healthcare professionals' who are involved in supporting people with cardiovascular disease with their lifestyle changes.