Fall 2014

The interaction of patience and resistance to miserly information processing on life outcomes

Tristan Kirkman
James Madison University

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Tristan Bruce Kirkman

A thesis submitted to the Graduate Faculty of

JAMES MADISON UNIVERSITY

In

Partial Fulfillment of the Requirements

For the degree of

Master of Arts

Psychological Sciences

December 2014

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Resistance to Miserly Information Processing on Life Outcomes

Tristan Kirkman

James Madison University

Author Note

Tristan Kirkman, Department of Graduate Psychology, James Madison University.

This research was supported by a grant from the John Templeton Foundation to Keith E. Stanovich and Richard F. West. The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of the John Templeton Foundation.

Correspondence concerning this study should be addressed to Tristan Kirkman, Department of Graduate Psychology, James Madison University, Harrisonburg, VA 22801. E-mail: kirkmatb@dukes.jmu.edu

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Abstract

This study examined the relationships between three factors: patience, resistance to miserly information processing (RMIP), and life outcomes. Patience, or the ability to delay gratification in exchange for a larger reward, has been associated with having fewer negative life outcomes— those who are able to wait tend to have better lives. RMIP involves the tendency to think analytically instead of using heuristics (mental shortcuts). RMIP has had only limited study in terms of its relationship to actual life outcomes, but what has been examined so far has also suggested a positive relationship. In the present study, it was found that RMIP predicted general life outcomes, such that those with higher RMIP had fewer negative life outcomes above and beyond covarying factors, and the theoretical implications of RMIP as an area of study are discussed. Patience, as measured by a temporal discounting task, was not associated with life outcomes, and was not associated with RMIP. The researchers hypothesize that temporal discounting tasks may fail to adequately represent patience as a whole.

Keywords: patience, delay discounting, heuristics and biases, dual process theory, outcomes

The Interaction of Patience and Resistance to Miserly Information Processing on Life Outcomes

The goal of this study was to examine the complex relationship between patience, miserly information processing, and life outcomes, and to determine how patience and miserly information processing measures predict life outcomes. Patience is loosely defined as the ability or tendency to favor rewards of greater magnitude over rewards of greater immediacy. Miserly processing involves the general tendencies among individuals toward fast, efficient, and occasionally sloppy thinking styles versus slow, attention-demanding, and deliberate thinking styles. Both of these factors are highly relevant in day-to-day decision-making. We must often make choices between immediate and higher magnitude outcomes—a cupcake now, versus a flatter stomach later; or more take-home pay now, versus more savings for retirement later in life. We must also choose how to allocate our limited attention spans—to go with one's quick intuitions about a legal document, or to carefully read the whole thing; to make a gut decision between two outcomes or to do a careful cost/benefit analysis. There are individual differences for both of these factors—so what kinds of individuals typically end up with the best outcomes?

Patience

Patience is most often studied through a binary choice procedure, in which a subject is asked to choose between a smaller, sooner (SS) reward and a larger, later (LL) reward (Logan, 1965). Selecting the SS choice represents an impulsive choice, and selecting the LL choice represents a more self-controlled choice (Rachlin & Green, 1972). A classic example of this kind of paradigm is the Marshmallow Test, in which a child is given the choice of either one marshmallow now, or if they can wait a bit longer, two marshmallows in the future (Mischel & Ebbesen, 1970). In a series of longitudinal follow-up studies, those children who were able to resist the temptation of the immediate reward (in exchange for a later reward of larger magnitude--an extra marshmallow) were found to generally have more positive life outcomes in adulthood, including higher emotional coping ability, higher academic performance and educational achievement, higher intelligence, higher ability to concentrate, lower likelihood of crack-cocaine use, and lower risk of obesity (Ayduk, Mendoza-Denton, Mischel, Downey, Peake, & Rodriguez, 2000; Mischel, Shoda, & Peake, 1988; Schlam et al., 2013; Shoda, Mischel, & Peake, 1990). Even though this research is correlational, it suggests that patience could be potentially very important for bettering human development.

For adults, patience is most often studied through a delay-discounting paradigm (Green & Myerson, 2004). In this kind of procedure, subjects are asked to make choices between real or hypothetical SS and LL rewards (most typically money). The questions are arranged in such a fashion as to identify an indifference point. This is a point where the preference is equal between the SS and LL rewards, after the personal, subjective value of those rewards after delay has been accounted for. For example, a highly patient subject may be indifferent between the choice of $90 right now and $100 in one year. If instead given the choice of $91 right now, that subject would choose the immediate reward, and if given the choice of $89 right now, that subject would choose the larger, delayed reward ($100 in one year), but at $90 the subject is indifferent (displays no preference) to the two outcomes. Thus, that individual's subjective value of $100 in one year is equal to the subjective value of $90 right now. This kind of procedure allows patience to be quantified in a continuous manner: With any given amount and delay, subjects with higher indifference points are more patient, and subjects with lower indifference points are less patient. This kind of procedure is typically repeated multiple times at varying delays (e.g., 1 month, 6 months, 1 year), and the indifference points can then be aggregated into a single continuous variable that is representative of their patience as a whole for that particular reward relative to others.

This aggregation process is typically done in one of two ways. The first and simplest way is to calculate an Area Under the Curve (AUC) for that individual, which means that once an individual's indifference points have been graphed (using delay on the x axis and subjective value on the y axis), AUC is the portion of the graph that remain under a line that connects the sequential indifference points. As such, an individual with lower indifference points will have a lower AUC. AUC alone however does not reveal when an individual displays nonsensical data though, such as when subjective value indifference points rise over increased delay— for example, $500 when delayed for 6 months having a subjective value of $200, but when delayed for 5 years, a subjective value of $400.

The second common method is through fitting a predictive curve to the observed indifference points and delays. Empirical data have shown that in most cases a hyperbolic function best describes how an individual's indifference points decay over increased delay, meaning that the fitted curve's slope is much steeper at smaller delays than larger delays (Myerson & Green, 2004). Thus, the difference in subjective value for a given reward is larger between more immediate delays (e.g., between 1 month and 6 months) than the difference in subjective value between more eventual delays (e.g., between 5 years and 6 years). The fitting of a hyperbolic curve to an individual's data observed indifference points results in two parameters: a *k* value, which represents how steep or shallow the generated curve is (steeper meaning lower indifference points), and an R^2 value, which represents how well the generated curve fits to the observed indifference points. The *k* value can be used to aggregate differential patience between individuals for the given reward across multiple delays, and the R^2 value reveals the presence of nonsensical data.

Delay discounting studies have found a number of associations between patience and life outcomes, typically by examining mean indifference points across differing populations. Those who are addicted to recreational drugs, for example, tend to have lower indifference points (less patience) than those who are not (Bickel & Marsch, 2001; Kirby et al., 1999). Similar findings have been found for those who are overweight (Borghans et al., 2005; Weller et al., 2008) and those who are heavy smokers (Bickel, Odum, & Madden, 1999), and delay discounting has been found to predict a number of other health related behaviors as well (Daugherty & Brase, 2010). These findings suggest that patience is an important predictor of life outcomes. This makes a great deal of theoretical sense, as impatience typically comes with a cost. Those children who could not wait for a second marshmallow receive fewer marshmallows in the end, and those who have lower indifference points in a monetary delay-discounting task receive fewer dollars: Patience is a highly useful attribute for maximizing the acquisition of one's goals and preferences.

However, patience is not always a positive factor. Important to the field of decision-making is the concept of delay costs. Delay costs in this case mean when there are negative consequences tied to the choice of a larger later outcome that are not tied to the more immediate outcome. An affluent subject may have very few or no delay costs associated with delaying a monetary reward, but others may not. An indebted subject whose rent is due cannot afford to wait for a reward of greater magnitude—unless they receive money immediately, they may face eviction. A subject who was maximizing the acquisition of their goals would be right to take a lesser amount in exchange for immediacy in such a case. Studies with large samples have attempted to spread such variance across multiple groups through random assignment, yet in correlational studies this kind of variance may be more concentrated in some populations than others. These potential differential delay costs between groups erodes the validity of some important findings concerning different populations' indifference points and levels of patience. For example, a subject heavily addicted to drugs may have a powerful delay cost tied to a larger, later reward that a non-addicted subject may not: the possibility of undergoing withdrawal. Though it is clear from the data that drug-addicted subjects tend to have lower indifference points (Bickel & Marsch, 2001; Kirby et al., 1999), the interpretation that this is solely due to those drug-addicted subjects having less ability to delay gratification might not be true.

More poignantly, the concept of delay costs may also confound the conceptual equality between the standard delay-discounting tasks used with human subjects (monetary indifference points) and tasks similar to the Marshmallow test (Paglieri, 2013). Specifically, tasks such as the Marshmallow test require a subject to actually wait for the larger reward, with some restrictions on what can be done during this waiting period. A subject involved in such a task typically has to remain alone in a windowless room without distraction or outside entertainment until the LL reward (the extra marshmallow) arrives. Considering this, things like boredom become highly important delay costs, and this element is noticeably absent from the types of delay discounting tasks used with adult subjects in temporal discounting studies. For example, in the choice between $90 now and $100 in a year, the experimental assumption is that the subject's behavior is not restricted in any fashion during that year of waiting, and that they are merely 'postponing' the reward—it is hard to imagine any human subject who would be willing to sit alone in a windowless room for one year in order to gain an extra $10. However, in the experimental literature, these two types of tasks are often implicitly treated as equivalent, such that the findings on "waiting" tasks (like the Marshmallow test) are generalized to subjects within "postponing" tasks, or improper comparisons are made across the different kinds of tasks. For example, Paglieri (2013) noted that:

> [Because] data on delay discounting show that humans are willing to accept delays of days, weeks, months and even years to maximize reward amount, whereas other species tested so far are no capable of tolerating delays longer than a few seconds, or a handful of minutes at most… [there is] widespread conviction that *Homo sapiens* is by far the most delay-tolerant species. However, this allegedly exceptional tolerance for delay is no longer observed when human are tested with roughly the same experimental paradigms commonly employed with

> other species—that is, on [waiting] tasks rather than with questionnaire-based procedures. (p. 362)

Combined with the possibility of differing delay costs across populations (e.g., drug addicted subjects [with the population-specific delay cost of withdrawal] compared to non-addicted subjects) in temporal discounting procedures, many of the suggested interpretations of the associations between life outcomes and indifference points are perhaps more questionable than they are initially presented.

Resistance to Miserly Information Processing

Human decision-making processes are typically divided into two generalized types: heuristic processes and analytic processes (Evans, 2003, 2005, 2008; Kahneman, 2011; Kahneman & Frederick, 2002; Stanovich, 1999, 2004). Heuristic processes are fast, intuitively based, and are characterized by their ability to run automatically and in parallel with other processes, with little mental effort expended. As difficult situations are encountered and dealt with, we often can learn to provide the correct response with less and less effort over multiple repetitions, becoming much more efficient in our thinking over time (Smith, 2000). For example, an over-learned stimuli such as "what is 2 + 2?" is repeatedly associated with the correct response of "4", and evoking this response gradually comes to require very little use of mental resources or energy.

Our brains are designed to default to these "miserly" heuristics whenever possible, and for good reason: The ability to conserve and optimize the allocation of mental resources is highly adaptive when appropriate (Gigerenzer & Goldstein, 1996). However, as automatic and autonomous processes, these heuristics are outside of any possible conscious control or awareness, which can lead to errors if they are evoked in an inappropriate situation. These errors are analogous to visual illusions—in the case of determining the absolute size of an object, for example, we are so used to seeing objects in a three dimensional environment that when converging lines are placed nearby the object (creating the illusion of depth), the object will appear larger or smaller depending on its relative location to the converging lines (Ponzo, 1912). Even when an observer is aware of the visual illusion, they cannot simply choose to stop seeing it—the process is automatic and autonomous from conscious control.

A large empirical literature has shown that there are many times when heuristic processing leads to decisions that are not normative (or at least not optimal) (Kahneman & Tversky, 1979; Thaler, 1980; Tversky & Kahneman, 1974, 1981). Resistance to miserly information processing (RMIP) refers to the ability to override default miserly heuristic processes in situations where more analytical processes are more appropriate (Toplak, West, & Stanovich, 2013). In the modern world, heuristic processes may conflict with logical, statistical, or other acquired rules, and RMIP can be measured using tasks specifically designed to create conflicts between heuristic and analytical processes. In such tasks, a stimulus is designed to evoke an easy, automatic, and intuitive response that also happens to be wrong. Those who answer with this intuitive response are interpreted as using mainly miserly heuristics in their decision-making process, while those who are able to detect this conflict and arrive at a correct response anyway are interpreted as being able to resist and override their heuristic processing.

RMIP has been extensively studied and is a core component of many Dual Process Theories (Toplak, West, & Stanovich, 2013). Within the models such as the

Toplak, West, and Stanovich Dual Process model, decision-making processes are typically sorted into two types: Type 1 processing (sometimes referred to as System 1), which is heuristically based and often learned through direct experience, and Type 2 processing (sometimes referred to as System 2), which is analytically based, algorithmic, serial, and resource demanding (Evans & Stanovich, 2013). Examples of Type 2 processes include the solving of difficult math problems, generation of hypothetical models, and abstract or 'decoupled' thought. Type 2 processes are generally available in 'conscious' thought, depend upon working memory and relative freedom from distraction, and also have the potential to inhibit or override Type 1 processes when appropriate. Responding with the correct answer on an RMIP task is typically assumed to involve the use of Type 2 processing in this fashion, and suggests a higher relative likelihood of engaging in other Type 2 processes as well (Frederick, 2005). Likewise, when Type 1 or Type 2 processes are differentially encouraged or primed by instructions such as ”respond with your first instinct” versus “think very carefully about each answer,” there can be dramatic differences in scores (Miu & Crisan, 2011; Sokol-Hessner et al, 2009).

The ability to selectively apply Type 2 thinking when appropriate, instead of being governed by heuristic thinking, seems to be (somewhat ironically) intuitively important for predicting life outcomes. There is some evidence that this may be true--proper selective use of Type 2 thinking has been found to be negatively related to some maladaptive behaviors, including aggression, delinquency, alcohol and drug use in male young adults (Parker & Fischhoff, 2005), and children with better decision-making ability have been found to have higher academic performance and fewer behavioral problems (Weller, Levin, Rose, & Bossard, 2012). Adults with better Type 2 based decision-making ability over a wide range of ages have also been found to have fewer negative life events on the Decision Outcomes Inventory, which includes a composite of behaviors ranging from “returned a movie you rented without having watched it at all” to “declared bankruptcy” and “been in a jail cell overnight” (Bruin, Parker, & Fischhoff, 2007).

However, there is also some evidence that the unnecessary use of Type 2 processing can lead to negative outcomes, particularly in preference formation: When determining whether or not an individual prefers one item over another, relying on heuristic responses (and specifically avoiding Type 2 responses) may lead to better choices (Wilson & Schooler, 1991). For example, when asked about strawberry jam preferences, those who were told to make fast, intuitive judgments between jams tended to align their preferences with professional taste testers, while those who were told to write down a list of stated reasons they preferred a jam tended to prefer the jam with the lowest professional rating. Similarly, when given the choice between a set of posters, those who were told to make intuitive judgments tended to choose different posters than those who were told to write a list of reasons for preferences, and those who relied on heuristic responses tended to be much happier with their choice one week later (Wilson et al., 1993).

The Current Study

The current study is designed to examine the relationship between patience, as measured by a temporal discounting / indifference point task, RMIP, as measured by a collection of four miserly processing tasks, and life outcomes. It is hypothesized that both patience and RMIP will positively correlate with life outcomes.

Method

Participants and Procedure

A group of 222 participants (88 women, 134 men, M_{age} = 32.3 years, SD_{age} = 9.8, age range: 18-66 years) were recruited from Amazon's Mechanical Turk (Mturk) (www.MTurk.com). A Mturk sample was selected to allow for a wide range of participant ages and life outcomes, though only those currently in the United States of America were invited to participate. The participants had a wide range of educational achievement, including 35 who had only a high school degree, GED, or lower, 94 who had completed some college, 88 who had a Bachelor's degree, and 7 who had a Master's degree, Ph. D., or Professional degree. Demographic measures can be found in Appendix A. Participants completed the battery of tasks below, as well as some other measures not included in this paper, during a single online session, and received $15 for their participation. All participants completed a consent form prior to any testing.

Tasks and Variables

Life outcomes

In order to assess life outcomes on a general level, 14 questions were asked that were judged ahead of time by the researchers to be good indicators of poor real-life decision-making, and further, that participants would also be likely to agree were indicators of poor real-life decision-making. These 14 items assessed current smoking behavior, current use of a cell-phone while driving (phone calls and texting), history of a suspended driver's license, history of driving an uninsured vehicle, history of driving while intoxicated, history of taking short-term (payday) loans, history of having possessions repossessed, history of being fired, history of problematic drug or alcohol use (assessed via missing school or work due to intoxication), history of having a home foreclosed upon, history of bankruptcy, history of missed mortgage or car payments, and history of being charged late fees for missed credit card payments (See Appendix B for exact wordings). Though these 14 items represented a generally multifarious set of behaviors, each item was designed to reflect an example of (or the results of) poor decision-making. Each negative outcome was scored as either 0 (the participant had never engaged in this behavior) or 1 (the participant had engaged in this behavior at least once/currently engaged in this behavior), and then a summed composite was then formed from these 14 items. This composite acted as an indicator of poor-decision making on a general level, with lower scores representing fewer poor decisions and higher scores representing more poor decisions. Because of the count-based nature of this composite, the composite was not intended to offer information about specific behaviors or patterns of behaviors; instead, this composite was intended to function as a limited proxy for general life outcomes.

Patience

In order to assess patience, the researchers used a five-step staircase temporal discounting task to isolate indifference points for a loss in value of $1,000 over delays of 1 month, 3 months, 6 months, 1 year, 2 years, 5 years, and 10 years (as used in Du, Green, & Myerson, 2002). To generate these indifference points, participants were asked initially if they would prefer $500 immediately or $1,000 after the delay. Selecting the larger amount ($1,000) resulted in a following question that increased the smaller amount by 50%; asking if they would prefer $750 immediately or $1,000 after the delay. Selecting the smaller amount resulted in a following question that decreased the smaller amount by 50%; asking if they would prefer $250 immediately or $1,000 after the delay. Repetition of this adjustment procedure allowed the isolation of indifference points to an accuracy of within 1.5%. These six indifference point values were then aggregated into a single AUC score that ranged from 0 to 1, with lower scores representing less patience and higher scores representing greater patience. See Appendix C for example questions.

Resistance to miserly information processing (RMIP)

In order to assess RMIP, four different decision-making tasks were used, and final scores were aggregated into a single composite score via a principle component analysis. The four tasks included a belief bias syllogisms task, a denominator neglect task, a disjunctive reasoning task, and the 3 Item Cognitive Reflection Test, all of which have been theoretically linked to RMIP (Frederick, 2005; Toplak, West, & Stanovich, 2011, 2013). Each of these tasks was designed to generate a heuristic response in a subject, and responding correctly on these tasks is assumed to require the use of Type 2 processing in order to veto the heuristic response. Prior research has confirmed that these tasks are well correlated, suggesting a high likelihood that they are examining either a single variable or highly similar variables (Toplak, West, & Stanovich, 2011, 2013), justifying the use of a PCA in order to appropriately aggregate the responses.

Belief bias syllogisms. The sixteen syllogistic reasoning problems were based on a task used by Stanovich and West (in press). The syllogisms were similar to those used in earlier studies of belief bias (Markovits & Nantel, 1989; Stanovich & West, 1998). Examples of the syllogisms are the following:

> In the following problems, you will be given two premises *which you must assume are true*. You must decide whether the conclusion *necessarily follows logically* from the premises. It is important that you assume the premises to be true and ignore whether the conclusion is factually correct. Rate the conclusion only in terms of whether it *necessarily* follows.

1. <u>Premises</u>:

   Premise 1: All hammertops are good for the health.

   Premise 2: All cigars are hammertops.

   <u>Conclusion</u>:

   All cigars are good for the health.

   a. Conclusion *necessarily* follows from premises. (Correct)

   b. Conclusion does not *necessarily* follow from premises.

2. <u>Premises</u>:

   Premise 1: All teragins can be used as fuel.

   Premise 2: No pieces of coal are teragins.

   <u>Conclusion</u>:

   No pieces of coal can be used as fuel.

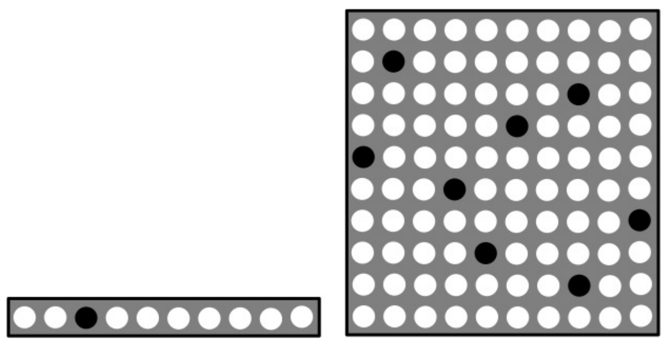
   a. Conclusion *necessarily* follows from premises.

b. Conclusion does not *necessarily* follow from premises. (Correct)

In the syllogistic reasoning task, subjects were presented with two premises and asked whether or not the conclusion logically followed from them. A critical feature of these problems was that (1) the conclusions contradicted participant's knowledge about the world when the syllogism was valid, as in the first example above, or (2) the conclusions were consistent with the participant's knowledge about the world when the syllogism is invalid, as in the second example above. For the purposes of a separate study, two different answer formats of the belief bias syllogisms task were used, with some participants receiving the first and others the second. The first format followed that in the examples above. In the second format, after viewing the two premises, participants were asked to determine "Which of three conclusions *necessarily* follow from the premises:" In the first example above, the three options were as follows: a. All cigars all good for the health; b. No cigars are good for the health; or c. Neither conclusion necessarily follows. Option "a" is the correct answer to this example. Although the second format (M = 10.95, SD = 2.998) was significantly more difficult than the first format (M = 11.75, SD = 2.929), $t(220) = 2.016$, $p = .045$, the two formats of the syllogisms task did not result in them having different associations with the other RMIP tasks. Because of this, and because of the high degree of similarity between the formats (e.g., identical prompts), the two versions were equated and treated as a single variable in the analyses that follow. This was accomplished via a mean equating procedure, and the scores from participants that received the second format were increased by 0.803 to make the two formats equivalent in difficulty.

Denominator neglect. Fifteen denominator neglect problems were based on a task used by Stanovich and West (in press). The problems were similar to those used in earlier studies of denominator neglect (Denes-Raj & Epstein, 1994; Stanovich & West, 2008). Examples of the problems are the following:

1. Assume that you are presented with two trays of black and white marbles (pictured below). The small tray contains 10 marbles. The large tray contains 100 marbles. The marbles inside each tray will be randomly mixed up, and you must draw out a single marble from one of the trays without looking. If you draw a black marble you win $5.



(1 black and 9 white) (8 black and 92 white)

In a real situation, which tray would you prefer to select a marble from?

a. Strongly prefer the small tray (Correct)

b. Moderately prefer the small tray (Correct)

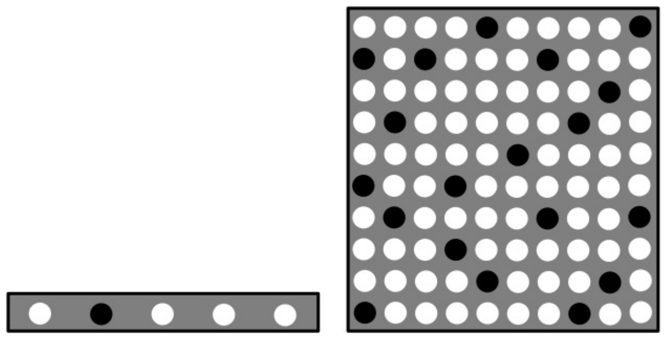
c. Slightly prefer the small tray (Correct)

d. Slightly prefer the large tray

e. Moderately prefer the large tray

f. Strongly prefer the large tray

2. Assume that you are presented with two trays of black and white marbles (pictured below). The small tray contains 5 marbles. The large tray contains 100 marbles. The marbles inside each tray will be randomly mixed up, and you must draw out a single marble from one of the trays without looking. If you draw a black marble you win $5.



(1 black and 4 white) (19 black and 81 white)

In a real situation, which tray would you prefer to select a marble from?

a. Strongly prefer the small tray (Correct)

b. Moderately prefer the small tray (Correct)

c. Slightly prefer the small tray (Correct)

d. Slightly prefer the large tray

e. Moderately prefer the large tray

f. Strongly prefer the large tray

In each problem, the two trays were different in that one had a larger absolute number of black marbles and one had a larger probability of drawing a black marble than the other. A correct answer from the participant would be to choose to draw from the tray that had the highest probability of drawing a black marble. In all but 3 foil problems, the smaller tray had a higher likelihood of producing a black marble, even though the larger trays displayed a larger number of black marbles. An incorrect choice (choosing the larger tray with the lower probability of selecting a black marble) was interpreted as being the result of miserly information processing, as in such a case a participant was assumed to be choosing based on the appearance of more marbles instead of doing the mental work of calculating the respective probabilities for each tray.

Disjunctive Reasoning. Six disjunctive reasoning problems were based on a task used by Stanovich and West (in press). The problems were inspired by the work of Levesque (1986, 1989) and were similar to those used in earlier studies of disjunctive reasoning (Toplak and Stanovich, 2002). Examples of the problems are the following:

1. Jack is looking at Ann but Ann is looking at George. Jack is married but George is not. Is a married person looking at an unmarried person?

Jack →	Ann →	George

   a. Yes (Correct)
   b. No
   c. Cannot be Determined

2. There are 3 blocks in a stack, where each of the blocks is either new or old. The top block is new, and the bottom one is old. The middle block is either new or old. Is there a new block directly on top of an old block?

Top Block	← New
Middle Block	← New or Old

Bottom Block	← Old

a. Yes (Correct)

b. No

c. Cannot be Determined

In each case, the 1st and 3rd object or individual's group status was known, the 1st and 3rd were always different groups (e.g., Jack is married and George is not married, and the top block is new and the bottom block is old), and the 2^{nd} object or individual's group status was unknown but still limited to being one of the two binary groups (e.g., Ann can only be either married or not married, and the middle block can only be new or old). In each case, no matter which of the binary groups the 2^{nd} object or individual was a member of, the condition asked in the question was necessarily fulfilled (e.g., if Ann is married, Ann is looking at [unmarried] George and fulfills the condition, and if Ann is not married, [married] Jack is looking at Ann and still fulfills the condition. Similarly, if the middle block is new, the middle block is on top of the [old] bottom block, and if the middle block is old, the [new] top block is on top of the middle block). Incorrect answers of 'No' or 'Cannot be Determined' were interpreted as being the result of miserly processing, as in such a case a participant was assumed to be avoiding the mental work of checking each possible binary outcome of the middle object or individual.

3-Item Cognitive Reflection Test (CRT). The CRT, developed by Frederick (2005), is composed of three questions:

(1) A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? ___ cents.

(2) If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? ___ minutes.

(3) In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? ___ days.

For each of these problems, a quick, intuitive answer is readily available (10 cents, 100 minutes, 24 days), but those answers are also incorrect. Giving the correct answer (5 cents, 5 minutes, 47 days) on these items is assumed to require the mental work of suppressing and/or evaluating the readily available (and incorrect) answers in order to do the necessary calculations.

Results

The initial PCA of the four miserly information processing tasks resulted in a single component structure accounting for 50.9% of variance. A visual analysis of the Scree Plot (See Figure 1) confirmed a single component structure among the four tasks. All four tasks had un-rotated factor loadings of greater than 0.6 on the first component (CRT = .684, belief bias syllogisms = .789, disjunctive reasoning = .752, denominator neglect = .617). This first component was used as a measure of RMIP for all subsequent analyses. RMIP scores for the 222 participants varied between -2.965 and 1.584, M = 0.000, SD = 1.000. Intercorrelations, ranges, means, and standard deviations for the four tasks can be seen in Table 1.

The next analysis used was designed to determine the relationships between RMIP, patience, the interaction of RMIP and patience (created by multiplying their centered values), and general life outcomes, while attempting to account for the demographic variables of age and education level. Age was selected because past research has shown that delay discounting positively correlates with age (Reimers et al., 2009). Education was selected as a limited proxy for socio-economic status and potentially intelligence, which has been shown to be related to RMIP (Stanovich, West, & Toplak, 2013). A correlation analysis revealed a significant correlation between age and life outcomes, $r(220) = .145$, $p = .031$, and a significant correlation between RMIP and life outcomes, $r(220) = -.172$, $p = .010$, but no significant correlation was found between RMIP and AUC or AUC and life outcomes ($p > .05$). Age was also significantly correlated to AUC, $r(220) = .142$, $p = .035$, and education significantly correlated with RMIP, $r(220) = .208$, $p = .002$. The interaction term was found to only be significantly correlated with its RMIP component and education, $r(220) = .196$, $p = .003$. Intercorrelations, means, and standard deviations for age, education, RMIP, AUC, the interaction term, and life outcomes can be seen in Table 2. A multiple regression analysis was then used, using age, RMIP and patience at a first step, and age, RMIP, patience, and the interaction of RMIP and patience at a second step (education was not included because it failed to significantly correlate with life outcomes). The first model significantly predicted general life outcomes, $R^2 = .039$, $F(3, 218) = 3.979$, $p = .009$. Within the first model, age and RMIP were the only significant predictors of life outcomes, but accounted for separate variance in the model, $\beta = -.150$, $sr^2 = .022$, $p = .025$ and $\beta = -.174$, $sr^2 = .030$, $p = .009$ respectively. The second model failed to add significant variance accounted for, and similarly each component in the second model (with the exception of age) failed to contribute significant individual variance accounted for ($p > .05$). Figure 2 shows a scatter-plot of the relationship between RMIP and Life Outcomes.

The next analysis was designed to determine the relationships between RMIP, patience, the interaction of RMIP and patience, and each of the fourteen binary life outcomes items, in order to look for patterns among the individual items. This was done through a series of logistic regression analyses, predicting one life outcome from RMIP and patience at a first step, and RMIP, patience, and the interaction of RMIP and patience at a second step. The full analysis of the 14 life outcomes can be found in Table 3. Within each of the first models, RMIP was found to predict smoking behavior ($B = -.355$, $p = .022$), a history of having taken a short-term loan ($B = -.418$, $p = .006$), and a history of having possessions repossessed ($B = -.510$, $p = .001$). AUC was found to predict a history of having been charged a late fee for missing a credit card payment ($B = -1.520$, $p = .022$), but the coefficient for AUC in the overall model for this outcome was not significant ($p = .058$). No other statistically significant relationships were found between the predictors and the individual life outcomes ($p > .05$), and in no case did the overall model (including both RMIP and patience) predict any individual life outcomes when a single component did not ($p > .05$). In no case did the addition of the interaction term to the model significantly improve the variance accounted for by the model.

Discussion

The first step of this study was to determine whether the four RMIP tasks used had a single component structure. The PCA used provided evidence that the four tasks together do have a single component structure, and suggests that all four were measuring the same underlying factor of resistance to miserly information processing, lending evidence to the models suggested by Toplak, West, and Stanovich (2011, 2013). Though it is possible that this single component was something other than RMIP, such as general intelligence, the past research suggests that RMIP is a more likely candidate (Toplak, West, & Stanovich, 2011, 2013). Errors on these tasks might also have been due to a lack of attention to the tasks, but when the participants underwent a brief instructional manipulation check at the end of the tasks, 99.1% (220 out of 222) passed, suggesting that most were in fact paying attention.

The next goal of this study was to determine the relationship between RMIP and life outcomes. RMIP was found to modestly predict life outcomes at a general level, such that those with higher RMIP had fewer negative life outcomes after controlling for age and patience. RMIP was also found to predict three of the fourteen examined items: smoking behavior, a history of having an item repossessed, and a history of having taken a short-term high-interest loan. Though these are important life outcomes, it is unlikely that these three outcomes were driving the relationship between RMIP and the 14-item general life outcomes composite. As this was an exploratory study, no bonferroni correction was used to account for the increased likelihood of Type 1 Error on these results, and in no case were the effects of RMIP and AUC on the individual outcomes overwhelmingly large. This suggests that RMIP, while likely able to predict life outcomes at a more aggregate level, generally cannot predict specific life outcomes; or in other words, RMIP is likely a useful predictor of the number of negative life events an individual may have, but not which negative life events.

The usefulness of RMIP as a predictor of life outcomes lends extra weight to its importance for research. Our results suggest that those who are more likely to engage in Type 2 processing on our laboratory RMIP tasks are also more likely to avoid certain pitfalls in modern life, presumably via a similar tendency to engage in Type 2 processing outside of laboratory conditions. This is potentially valuable because RMIP is theoretically malleable, in that it can be improved with teaching and training (Toplak, West, & Stanovich, 2012). If manipulations can be developed that categorically improve RMIP and increase the tendency to engage in Type 2 processing, it is possible that those manipulations may result in more positive life outcomes for individuals.

The next goal of this study was to determine the relationship between patience and life outcomes. Our study failed to replicate earlier findings that suggested a significant relationship between life outcomes at both the general and specific levels with temporal discounting tendencies (e.g., Bickel & Marsch, 2001; Bickel, Odum, & Madden, 1999; Borghans et al., 2005; Daugherty & Brase, 2010; Kirby et al., 1999; Weller et al., 2008). This failure to replicate may be due to a number of different factors. One potential reason we might not have found the same relationship between Delay Discounting and life outcomes is simple measurement error. This could be the case, but for the most part our Delay Discounting task still worked—the individuals did in fact discount. Delay discounting also correlated with age, which is consistent with past research (Reimers et al., 2009). The failure to replicate may also have been due to difference in the measured life outcomes—our life outcome measures did not include many health related behaviors or histories, and none were pathological in nature. For example, while previous research has found differences in indifference points between non-smokers and potentially pathologically addicted smokers (such as was found in Bickel, Odum, & Madden, 1999), our study attempted to predict groups of "non-smoker" versus "any smoker"—which may have contributed to its failure to replicate. It may also be that our life outcome choices were simply too different from previous research as well, but that possibility is not very satisfying, as the life outcomes we selected were specifically chosen due to their importance for people's lives. On a broader level, this failure to replicate may also lend evidence to the suggestion that the temporal discounting task used may not be an adequate measure of patience and the ability to delay gratification, as theorized by Paglieri (2013), or that it may be a measure of only a specific, limited aspect of patience, which may be a broad, multifarious construct. In such a case, the strong associations of patience with positive life outcomes and lack of negative outcomes as found by researchers such as Mischel (e.g., Ayduk et al., 2000; Mischel, Shoda, & Peake, 1988; Schlam et al., 2013; Shoda, Mischel, & Peake, 1990) may be due to the specific way patience was measured in these cases, in that participants were actually forced to wait and experience delay costs in order to receive the reward of greater magnitude.

The last goal of this study was to examine the relationship between RMIP and patience. Our study found no significant correlative relationship between RMIP and temporal discounting tendencies, and in no case did an interaction term of RMIP and temporal discounting tendency significantly improve a predictive model of life outcomes. This suggests that patience and the ability to curb miserly (or impulsive) thinking may be separate mental processes. Thus, this would imply that doing well on an RMIP task is not simply a matter of having the patience to figure out the correct answer, and also that maximization in a delay discounting task is not simply a matter of resisting miserly processing. However, once again, it is possible that this result may be due to the specific measurement of patience in this case, as forced waiting, with experience of delay costs, as discussed by Paglieri (2013), was not examined. Given that previous research has found strong evidence that waiting ability predicts some life outcomes (Ayduk et al., 2000; Mischel, Shoda, & Peake, 1988; Schlam et al., 2013; Shoda, Mischel, & Peake, 1990), and that RMIP has also been found to predict life outcomes in this study, it is highly recommended that future research examine the interaction between patience as measured by waiting and RMIP within a life outcomes model, and to test a wider range of life outcomes than were used in this study. Although the current study failed to find a significant relationship between RMIP and temporal discounting, it is fully possible that RMIP and waiting ability may be well-related. For example, in the marshmallow test, children experienced a delay cost if they chose to wait for the extra marshmallow: boredom. As noted above, they were alone in a windowless room, without distraction or entertainment. One of the findings of the marshmallow test was that children who were able to wait for the LL reward often employed useful strategies for alleviating this boredom: playing small games, singing songs, or distracting themselves in some other manner. In such cases, these individuals were able to reduce the delay costs of the LL reward, and shift what was at first a waiting task into a postponing task instead.

This ability to create distraction, without the presence of external stimuli, could be the result of higher RMIP and a better ability to engage in Type 2 processing, as these distractions could be thought of as the creation of hypothetical environmental stimuli. Similarly, the strategies used by those who were successful in the marshmallow test (games, songs, etc.), in addition to reducing the delay cost of waiting, may also serve the secondary purpose of reducing the relative saliency of the SS reward as well. Research has found that increasing the saliency of an option (or at least the saliency of that option's positive aspects) will increase relative preferences for that option (Milosavljevic et al., 2011). By using Type 2 processing to create internal distraction from the boredom of waiting, the children may also be creating distraction from the reward itself. By reducing the saliency of the SS reward, the difference in saliency between the SS and LL rewards shrinks, and the saliency effects that would normally encourage choosing the SS reward (e.g., seeing a marshmallow, smelling a marshmallow) would also be diminished.

In terms of decision-making outcomes, this would translate into those who engage in Type 2 processing (as measured by higher RMIP scores) being more willing to wait for a delayed outcome on a waiting task, but not necessarily on a postponing task like that which is used with temporal discounting indifference point tasks. Similarly, while differences in waiting tasks would account for differences in life outcomes, differences in postponing tasks would not. If this were to be the case, both RMIP and waiting ability would still be positively correlated with life outcomes, but the two would correlate, and the accounted variance in life outcomes would be likely to overlap.

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Table 1.
Summary of Intercorrelations, Observed Ranges, Means, and Standard Deviations for RMIP tasks

Measure	Cognitive Reflection Test	Syllogisms	Disjunctive Reasoning	Denominator Neglect
Cognitive Reflection Test	-	0.394***	0.361***	0.205**
Belief Bias Syllogisms		-	0.442***	0.350***
Disjunctive Reasoning			-	0.297***
Denominator Neglect				-
Range	0-3	4-16.8	0-6	1-15
M	2.18	11.75	3.46	10.49
SD	1.114	2.958	2.068	3.745

** Correlation significant at the p<0.01 level.

*** Correlation significant at the p<0.001 level.

Table 2.
Summary of Intercorrelations, Observed Ranges, Means, and Standard Deviations for Age, Education, RMIP, AUC, Interaction, and Life Outcomes

Measure	Age	Education^	RMIP	AUC	Interaction	Outcomes
Age	-	0.153*	0.019	0.142*	0.082	**0.145***
Education		-	0.208**	0.064	0.196**	-0.105
RMIP			-	0.089	0.829**	**-0.172****
AUC				-	0.090	-0.006
Interaction					-	-0.130
Outcomes						-
M	32.340	2.297	0.000	0.360	0.022	3.360
SD	9.833	0.768	1.000	0.244	0.433	2.611

^ Education was coded ordinally with 1 = High School / GED or lower, 2 = Some College, 3 = Bachelor's Degree, 4 = Master's / Ph. D. / Professional Degree

* Correlation significant at the $p < 0.05$ level.

** Correlation significant at the $p < 0.01$ level.

Table 3.

Logistic Regression Analyses of RMIP and AUC to predict individual Life Outcomes

Life Outcome	Sample Size	Variable	B	SE	Exp(B)	Sig.
Smoking	167 *No*	**RMIP**	**-0.355**	**0.155**	**0.701**	**0.022**
	55 *Yes*	AUC	-1.358	0.701	0.257	0.053
		Model Chi-Square = 9.992				**0.007**
Phone Calls while Driving	120 *No*	RMIP	0.038	0.136	1.038	0.782
	102 *Yes*	AUC	-0.381	0.557	0.683	0.494
		Model Chi-Square = 0.517				0.772
Texting while Driving	150 *No*	RMIP	0.020	0.145	1.020	0.889
	72 *Yes*	AUC	-0.441	0.599	0.644	0.462
		Model Chi-Square = 0.553				0.759
Suspended License	182 *No*	RMIP	-0.160	0.171	0.852	0.351
	40 *Yes*	AUC	0.556	0.707	1.744	0.431
		Model Chi-Square = 1.350				0.509
Driving while Uninsured	155 *No*	RMIP	-0.200	0.145	0.818	0.167
	67 *Yes*	AUC	0.108	0.604	1.114	0.858
		Model Chi-Square =1.901				0.387
Driving while Intoxicated	205 *No*	RMIP	-0.123	0.248	0.884	0.618
	17 *Yes*	AUC	1.476	0.989	4.377	0.136
		Model Chi-Square = 2.313				0.315
Payday Loans	165 *No*	**RMIP**	**-0.418**	**0.152**	**0.659**	**0.006**
	57 *Yes*	AUC	0.174	0.642	1.190	0.787
		Model Chi-Square = 7.575				**0.023**
Items Repossessed	153 *No*	**RMIP**	**-0.510**	**0.149**	**0.600**	**0.001**
	69 *Yes*	AUC	0.847	0.609	2.334	0.164
		Model Chi-Square = 13.327				**0.001**
Fired	152 *Yes*	RMIP	-0.120	0.145	0.887	0.407
	70 *No*	AUC	0.870	0.590	2.386	0.141
		Model Chi-Square = 2.653				0.265
Problematic Drug or Alcohol Use	188 *No*	RMIP	-0.216	0.182	0.806	0.235
	34 *Yes*	AUC	1.096	0.746	2.993	0.142
		Model Chi-Square = 3.228				0.199
Home Foreclosure	210 *No*	RMIP	-0.529	0.276	0.589	0.056
	12 *Yes*	AUC	0.890	1.191	2.434	0.455
		Model Chi-Square = 3.921				0.141
Bankruptcy	204 *No*	RMIP	-0.133	0.240	0.876	0.580
	18 *Yes*	AUC	0.821	0.977	2.273	0.401
		Model Chi-Square = 0.918				0.632
Missed Car or Mortgage Payment	154 *No*	RMIP	-0.230	0.145	0.795	0.112
	68 *Yes*	AUC	-0.311	0.610	0.733	0.610
		Model Chi-Square = 2.936				0.230
Late Credit Card Fees	158 *No*	RMIP	0.073	0.153	1.076	0.631
	64 *Yes*	**AUC**	**-1.520**	**0.662**	**0.219**	**0.022**
		Model Chi-Square = 5.709				0.05 8

Note: in each analysis, N = 222, df (RMIP) and df (AUC) = 1, and df (Model) = 2. A score of 1 on the DV indicated the presence of the behavior or occurrence of the event.

Figure 1.

Scree Plot of the PCA of Belief Bias Syllogisms, Denominator Neglect, Disjunctive Reasoning, and the 3 Item Cognitive Reflection Test.

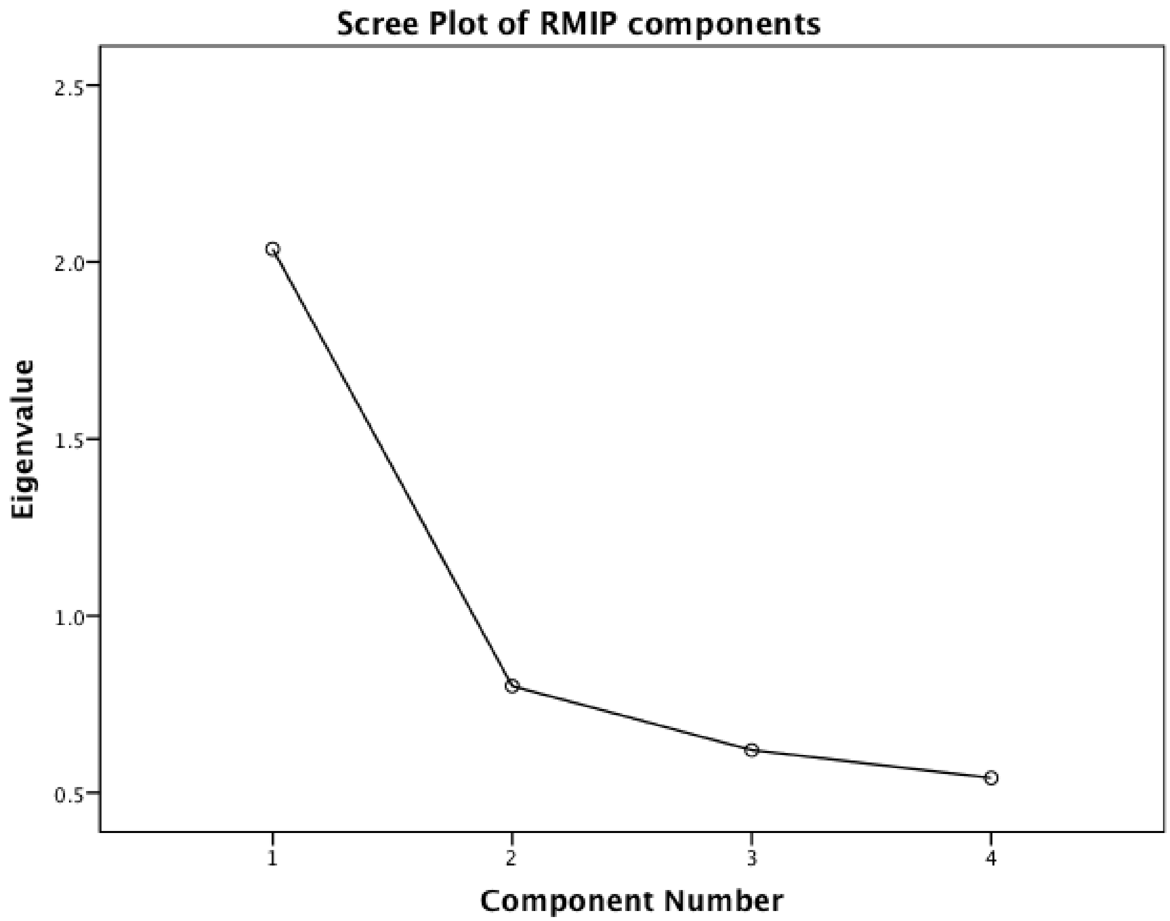
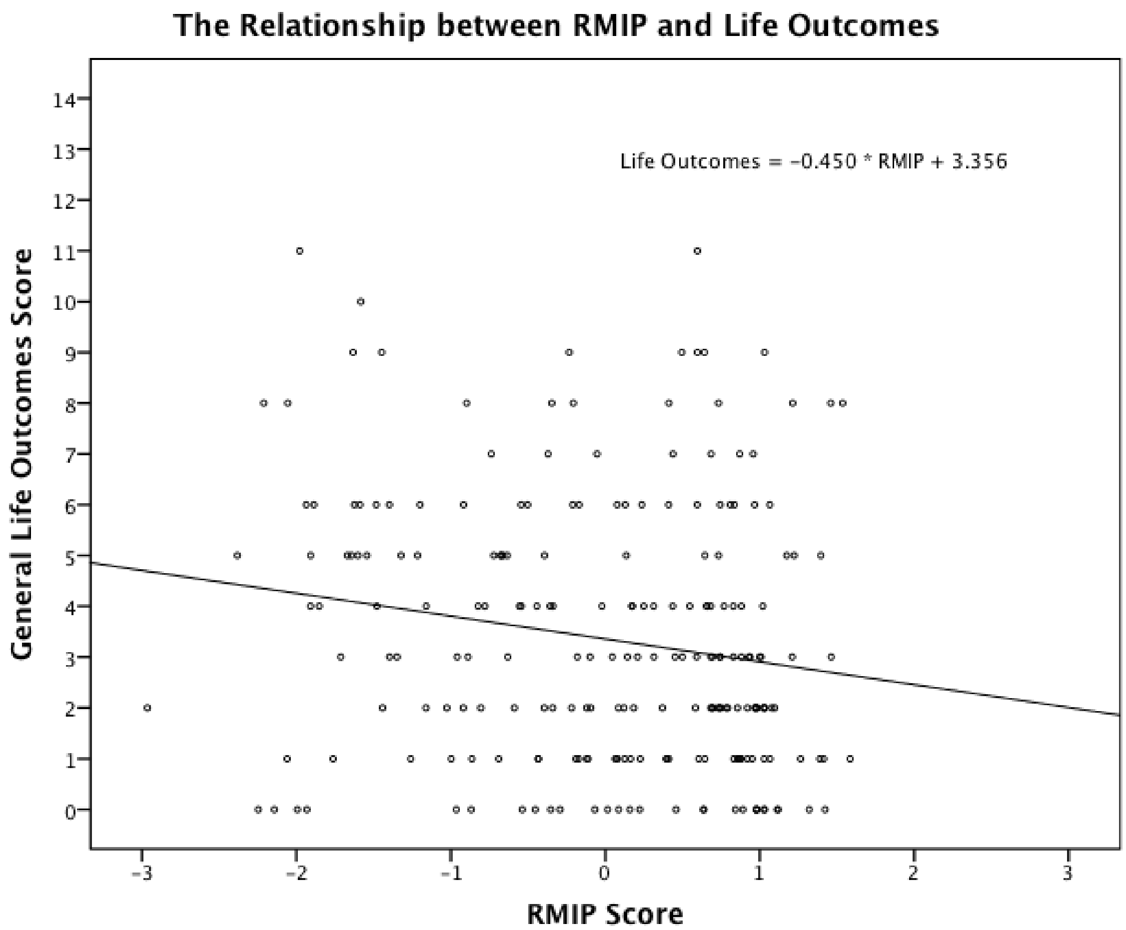


Figure 2.

Regression analysis using RMIP to predict Life Outcomes.



Note: A higher General Life Outcomes score indicates a greater history of negative life outcomes, and a lower General Life Outcomes score indicates a lower frequency of negative life outcomes.

Appendix A

Demographic Questions

1. What is your age?
2. What is your sex?
    a. Male
    b. Female
3. Was English your first language?
    a. Yes
    b. No
4. Are you currently a college student?
    a. Yes
    b. No
5. What is the highest level of education you have received?
    a. Less than a high school diploma
    b. High school diploma or GED
    c. Some college
    d. B.A. degree
    e. M.A. degree
    f. Ph.D.
    g. Professional degree (e.g., law, medicine)
    h. Not applicable

Appendix B

Life Outcome measures

1. How many cigarettes do you smoke a day?

2a. How many times a week do you talk on a hands-free cell phone while driving?

2b. How many times a week do you talk on a handheld cell phone while driving?

3. How many times a week do you send or look at text messages while driving?

4. Have you ever had your driver's license suspended? (Never, Once, 2-3 times, 4 or more times)

5. Have you ever driven a car that is not insured? (Never, Once, 2-3 times, 4 or more times)

6. Have you ever been charged with a DUI (Driving Under the Influence)? (Never, Once, 2-3 times, 4 or more times)

7. Have you ever taken out a very short-term (e.g., payday) loan? (Never, Once, 2-5 times, 6-10 times, more than 10 times)

8. Have you ever had anything you own repossessed? (Never, Yes)

9. How many times have you been fired from employment?

10a. How many times has the use of drugs or alcohol caused you to miss a class or work in the past year?

10b. How many times has the use of drugs or alcohol caused you to not show up for work when expected?

11. Have you ever had a home foreclosed upon? (Never, Once, 2-3 times, 4 or more times)

12. Have you ever declared bankruptcy? (Never, Once, 2-3 times, 4 or more times)

13. Have you ever missed a mortgage or car payment? (Never, Once, 2-3 times, 4 or more times)

14. In the past five years how many times were you charged a late fee for missing a credit card payment deadline?

Appendix C

Delay Discounting Example Questions

1. Which would you prefer?
    a. $500 right now
    b. $1,00 in 1 month
2. Which would you prefer?
    a. $750 right now
    b. $1,000 in 1 month