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Authors
Tompkins, D Andrew
Johnson, Patrick S
Smith, Michael T
et al.

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Temporal preference in individuals reporting chronic pain: discounting of delayed pain-related and monetary outcomes

D. Andrew Tompkins, MD, MHS[a], **Patrick S. Johnson, PhD**[b], **Michael T. Smith, PhD**[a], **Eric C. Strain, MD**[a], **Robert R. Edwards, PhD**[c], and **Matthew W. Johnson, PhD**[a]

[a]Department of Psychiatry and Behavioral Sciences, Johns Hopkins University School of Medicine, Baltimore, MD, USA

[b]Department of Psychology, California State University - Chico, Chico, CA, USA

[c]Department of Anesthesiology, Perioperative, and Pain Medicine, Harvard Medical School, Brigham and Women's Hospital, Boston, MA, USA

Abstract

Opioid therapy for pain is associated with an increased risk for substance use disorders (SUD). This study's purpose was to determine the association between opioid misuse propensity (Screener and Opioid Assessment for Patients in Pain-Revised; SOAPP-R) and delay discounting, a behavioral process linked to SUD which quantifies the extent to which outcomes are devalued due to their delay. Participants reporting chronic pain (PRCP N=249) answered pain and opioid use questions, and then completed four delay discounting tasks. Each of these tasks assessed either money or pain consequences, framed as either rewards or punishments. Each task involved hypothetical choices between immediate smaller vs. delayed larger consequences. The extant Monetary Choice Questionnaire (MCQ) assessed delay discounting of money rewards, and a modified version assessed discounting of money losses (immediate smaller loss vs. larger delayed loss). Based on the MCQ, the novel Pain Relief Choice Questionnaire (PRCQ) assessed choices between an immediate short duration of pain relief vs. a longer duration of pain relief. Similarly, the novel Additional Pain Choice Questionnaire (APCQ) assessed choices between an immediate short duration of additional pain vs. a longer duration of additional pain. Discounting of both additional pain and money losses were significantly associated with high SOAPP-R scores – indicating participants at greatest risk for opioid misuse discount future punishments rather than future rewards compared to those at low risk. Measures of delay discounting may have promise in more accurately identifying individuals at highest risk for opioid misuse during chronic opioid therapy.

Keywords

delay discounting; chronic pain; addiction; opioid misuse; Amazon Mechanical Turk

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Correspondence to: D. Andrew Tompkins, MD, MHS, Behavioral Pharmacology Research Unit, 5510 Nathan Shock Drive, Baltimore, MD 21224, USA, dtompki1@jhmi.edu, Office: 1-410-550-5953, Fax: 1-410-550-0030, http://www.hopkinsmedicine.org/profiles/results/directory/profile/0019515/david-tompkins.

1. INTRODUCTION

Chronic pain is defined as pain lasting longer than the expected healing time, typically operationalized as pain lasting 3 months or more [20]. Opioid medications are prescribed to manage a variety of chronic pain syndromes [1] and their use has dramatically increased since the 1990s [22]. Two potential and significant problems with chronic opioid administration for pain are the development of opioid misuse (e.g., taking more opioids than prescribed, running out of opioid medication early, taking other opioids that are not prescribed) and opioid use disorder (OUD; a "compulsive desire to take [an opioid] despite serious adverse consequences" [47]). Opioid misuse is a risk factor for the development of OUD in chronic pain patients [30]. The exact rate of OUD in chronic pain patients is not known, but is thought to increase as the daily opioid dose increases and may be as high as 26% among patients prescribed opioids [10]. OUD is associated with significant individual and societal costs [6, 48], so a better understanding of the basic behavioral risk factors for developing these disorders in chronic pain patients is needed. In addition, efficient tools that can aid clinicians in identifying individuals at higher risk for OUD prior to prescribing opioids would be of value to the clinical community.

OUD is hypothesized to result from an impaired decision making process [4,26]. Patients with OUD tend to undervalue long-term rewards relative to immediate rewards, a process termed delay discounting (DD) [5,24,25]. These patients are also significantly less sensitive to future punishments (e.g., worse health outcomes or loss of money) compared to healthy controls [39]. Chronic opioid use and associated withdrawal symptoms may affect outcomes described as "impulsivity," as demonstrated by pre-clinical investigations [17,18,37]. The presence of chronic pain adds complexity to DD measurement, as chronic pain patients may be especially sensitive to rewards and punishments involving pain [32,46].

The relationship between DD, risk of opioid misuse, and chronic pain has been a relatively understudied area. Among chronic pain patients, it is possible that those with an increased risk of opioid misuse have an underlying difference in their discounting of future rewards and punishments, compared to those with a lower risk for eventual opioid misuse. While DD is unlikely to be the sole explanatory feature for risk of opioid misuse, it may be a key behavioral component that helps to better understand the basis and drives for opioid misuse in individuals with chronic pain. The present project was an anonymous online survey of participants reporting chronic pain (PRCP) that completed assessments of pain, impulsivity and DD, and risk for opioid misuse, and hypothesized that PRCP at higher risk for opioid misuse would differ in DD tasks, relative to a similar population at lower risk for opioid misuse.

2. METHODS

2.1. Participants

An online survey was hosted on the Amazon Mechanical Turk (AMT) crowdsourcing platform. Survey respondents are known as "workers" on AMT, and each worker can voluntarily complete "human intelligence tasks (HIT)" for a small sum of money. "Requestors" are individuals or companies that require a scalable human workforce to

complete a HIT, such as an online survey. Requestors develop and publish HITs on the Internet, and set the desired number of workers who can complete each task. After completion of a HIT, a worker is rated by the requestor as having satisfactorily completing the task or not. HITs, such as the current survey, can be published on AMT and targeted to particular workers, i.e. US residents. Each worker can complete a HIT only once. AMT has been used in the past for research in a variety of medical disciplines, e.g. addiction medicine, surgery, occupational health, and psychiatry [2,16,29,40].

For the present survey, at least a 95% approval rating (i.e., 95% of at least 20 previously submitted HITs were satisfactorily rated by their requester) was required to view and accept the HIT. Participation was voluntary and anonymous, and consent was indicated via completion of the main online survey. The Johns Hopkins University Institutional Review Board approved this study.

Prior to accepting the HIT, participants completed a screening questionnaire consisting of questions related to demographic characteristics (age, sex, race, ethnicity, country of residence), chronic pain, and past use of opioids. In order to qualify for the study, participants had to (1) be 18 years old, (2) be a resident of the United States, (3) have chronic pain, and (4) correctly respond to questions designed to detect inattention. Chronic pain was defined as (1) having pain present for at least three months, (2) reporting past-week pain intensity of at least moderate at worst and at least mild on average (using a 5-point scale consisting of "none," "mild," "moderate," "severe," and "very severe), and (3) reporting that the intensity of the last pain experienced was 2 (using an 11-point visual analog scale). If a participant qualified, he/she was given a code to access the main survey. A total of 249 participants completed the main survey and were included in analyses. Fourteen additional participants completed the survey but were removed from analyses because they only reported fibromyalgia or chronic headaches – two pain conditions for which recommendations do not support the chronic use of opioids for pain control [28,34].

2.2. Measures

2.2.1. Basic demographics—At the beginning of the main survey, participants were asked about basic demographics, including age, gender, race, ethnicity, sexual orientation, state of residence, level of education, and annual household income. For race, the predominant choice was Caucasian (87.2%) and so race was dichotomized into Caucasian and Non-Caucasian in the analyses. Education was categorized into high school graduate, some college, bachelors, and graduate degree. Income categories above $100,000 were collapsed to increase normality of data.

2.2.2. Pain / opioid use—Participants were asked to rate their average pain intensity on an 11-point visual analog scale (ranging from 0 = "No pain at all" to 10 = "Worst pain imaginable"). Participants also selected parts of the body where their pain was located, and chose from a list of illnesses that caused their pain. Total number of body parts that were painful as well as number of painful conditions were summed. A modified Brief Pain Inventory (BPI) [44] was completed for participants' primary pain condition and, if applicable, their secondary pain condition. BPI severity scores were calculated separately for

primary and secondary pain syndromes. An overall BPI pain interference score was also calculated using standard methods [11]. Finally, participants were asked whether they had any past experience with opioids (both licit and illicit) and, if so, the duration of opioid use.

2.2.3. Delay discounting (DD)—A valid measure of DD asks a series of questions that force a respondent to choose between a hypothetical smaller reward now versus a larger reward at some time in the future, e.g. "Would you prefer to receive $31 today, or to receive $85 in seven days?" [21,25]. Participants who choose the larger-later reward across longer delays can be considered as having greater "self-control" than who choose smaller-sooner rewards at those delays [25]. Additional discounting assessments used modified versions of this questionnaire to assess discounting of monetary losses, as well as pain-related rewards (i.e., Pain Relief Choice Questionnaire (PRCQ)) and losses (i.e., Additional Pain Choice Questionnaire (APCQ)). All discounting assessments featured 27 questions, each involving a choice between a "smaller-sooner" outcome (e.g., "receive $15 today") and a "larger-later" outcome (e.g., "receive $35 in 13 days"). Within the 27-question set, 3 outcome magnitudes —small, medium, and large—were assessed (9 questions each).

Participants completed the DD tasks in the following order: the original Monetary Choice Questionnaire that assessed discounting of monetary rewards (i.e., gains), a version of the Monetary Choice Questionnaire modified to assess discounting of monetary losses (e.g., "pay $15 today, or pay $35 in 13 days?"), the PRCQ that assessed discounting of durations of pain relief (e.g., "experience 15 days of complete pain relief starting today, or experience 35 days of complete pain relief starting in 13 days?"), and the APCQ that assessed discounting of durations of additional pain (e.g., "experience 15 days of additional pain starting today, or experience 35 days of additional pain starting in 13 days?"). In addition to the 27 questions originally featured in the Monetary Choice Questionnaire, each assessment included three questions designed to detect participant inattention (e.g., "receive $54 today, or receive $85 today?"). Please see Supplemental Tables 1a–d to see the actual questions posed and the percentages of the total study population that chose each response.

Delays were identical across assessments. Nominal values of different outcomes were also identical across assessments (e.g., if $15 was the value in a money task, 15 days of pain relief / additional pain was used as the value in pain task). For all discounting assessments participants were instructed to take into account their current financial state (for monetary assessments) or their current pain intensity (for pain assessments). For the additional pain discounting assessment, participants were asked to assume that the additional pain would be of the same intensity across each choice.

2.2.4. Screener and Opioid Assessment for Patients in Pain-Revised (SOAPP-R)—The SOAPP-R is a 24-item self-report instrument used to predict possible opioid misuse by chronic pain patients being considered for opioid therapy; it queries patients about drug craving, substance abuse history, and emotional factors such as distress, anger, and interpersonal conflict [7,8]. SOAPP-R scores (range 0 to 96) have been predictive of subsequent aberrant drug related behaviors [36] thought to be related to the development of OUD. A score of 18 or greater has clinical utility in identifying at-risk patients [36]. In

the present study, total scores were calculated for the SOAPP-R, and a categorical variable for opioid misuse risk was created using established SOAPP-R cutoffs (>=18 or <18).

2.2.5. Mental health and behavior inventories—Participants completed the Patient Health Questionnaire-2 (PHQ-2), a two-question screening tool used to assess for possible depressive disorders [27]. The two questions examine the frequency of depressed mood and anhedonia over the past two weeks (i.e., "Not at All," "Several Days," "More Than Half the Days," or "Nearly Every Day"). PHQ-2 scores range from 0 to 6, with higher scores indicating a higher likelihood of having a depressive disorder.

The Generalized Anxiety Disorder 7-item scale (GAD-7) was also administered to assess frequency of anxiety symptoms experienced over the past two weeks [42]. The seven questions are rated using the same scale as PHQ-2 items. GAD-7 scores range from 0 to 21, with higher scores indicating a higher likelihood of having GAD.

The Barrett Impulsiveness Scale (BIS-11) consists of 30 brief behavioral descriptions (e.g., "I plan tasks carefully") [38]. Participants indicated the frequency with which they behave in a manner consistent with each description (i.e., "Rarely/Never," "Occasionally," "Often," or "Almost Always/Always"). Three subscales—attentional, motor, and non-planning—were scored based on participants' responses.

The Pain Catastrophizing Scale (PCS) is a 13-item scale that assesses important affective and cognitive aspects of pain [43]. The PCS instructions asked participants to reflect on past painful experiences and to indicate the degree to which they experienced a particular thought or feeling when experiencing pain. Responses were rated on a five-point scale from 0 ("Not at All") to 4 ("All the Time"). PCS scores range from 0 to 52, with higher scores indicating heightened distress responses when exposed to aversive stimuli.

The Insomnia Severity Index (ISI) is a five-item self-report questionnaire that assesses insomnia levels in the last 2 weeks [3]. Each item is assessed on a five-point Likert scale (0–4). ISI total scores range from 0 to 28, with higher scores indicating a higher likelihood of clinical insomnia.

Total scores were calculated for the PHQ-2, GAD-7, BIS-11 subscales, PCS, and ISI.

2.3. Procedures

The survey was initially advertised on AMT with limited enrollment on 12/5/14, followed by a second launch with expanded enrollment from 12/12/14 to 12/13/14. The survey was advertised with the HIT title, "Chronic Pain and Decision Making." All surveys were hosted online by Qualtrics (Provo, UT).

2.4. Data analysis

For the DD assessments, the primary dependent measure was the proportion of self-control choices selected (out of 27 questions). Specifically, for the assessments involving choices between smaller-sooner and larger-later monetary or pain-related *rewards*, the proportion of larger-later choices was calculated, as preference for larger-later rewards is an index of

greater self-control. Conversely, for the assessments involving choices between smaller-sooner and larger-later monetary or pain-related *punishments*, the proportion of smaller-sooner choices was calculated, as preference for smaller-sooner punishments is an index of greater self-control (contrasted with preference for smaller-sooner rewards indicating greater impulsivity). We chose to calculate a proportion choice measure rather than the typical Monetary Choice Questionnaire outcome measure—the k value, the discounting rate derived from a formal model—because proportion choice measures are atheoretical (i.e., they do not require assumption of a potentially inappropriate discounting model) and are strongly correlated with k values (Pearson $r > .97$ [31]). In addition to the total proportion choice measure for each assessment, proportion choice measures were calculated for each magnitude (small, medium, and large) of choice to examine the "magnitude effect," a highly reliable outcome of discounting assessments in which smaller magnitudes are discounted more steeply than larger magnitudes [45]. To examine the magnitude effect, two-factor (magnitude, SOAPP-R category) repeated measures analysis of variance (ANOVA) was performed on each outcome.

To examine the relationship between each DD assessment and predictors, generalized linear model (GLM) analyses were used with a logit link, binomial distribution and robust standard error estimation (STATA v.11.2, StataCorp, LLP, College Station, TX). Although the outcomes were not binary, each did range between 0 and 1. Past research has shown the above GLM analysis can correctly model relationships when the dependent measure is a proportion [35], especially when a significant number of outcomes are either 0 or 1 as was the case for DD of punishments (money losses and additional pain; please see Supplemental Figure 1).

Four separate GLM analyses were done for the four DD assessments. Correlations between predictors and DD assessments were initially examined (please see Supplemental Table 2). Predictors included SOAPP-R category, age, gender, sexual orientation, ethnicity, race, education, annual household income, length of chronic pain, number of chronic pain diagnoses, last pain VAS, usual pain VAS, BPI for the primary pain, BPI interference VAS, whether or not a respondent had ever used opioids, PHQ-2 total score, GAD-7 total score, PCS total score, and ISI total score. As this is the first study examining DD in PRCP, a preliminary investigation into the relationship between predictors and each DD assessment was conducted using univariate GLM analyses with the same link and distribution as the subsequent multivariate analyses. The univariate analyses were not used in deciding which predictors to include in multivariate models. To build the four final multivariate DD assessment models, stepwise backward selection was utilized, where predictors were removed from the model if p>0.2. Each of the predictors used in the univariate analyses were placed in the multivariate model. As GLM analyses employ listwise deletion, BPI scores for secondary pain syndrome were not included in the model to increase total number of observations used in model development – as only 169 participants reported a secondary pain condition.

3. RESULTS

3.1. Participant characteristics

Table 1 shows participant characteristics broken down by SOAPP-R category. A total of 249 participants completed the survey and were included in the analyses. Participants ranged in age from 26–79 (mean 47.4) years and resided in 44 different states. The sample was predominantly female (70.7%), Caucasian (87.2%), heterosexual (89%), and non-Hispanic (93%). Participants had between 1–11 (mean 2.8) self-reported pain diagnoses; the most common diagnoses included arthritis (39.4%), neuropathy (30.5%), disc problems (21.7%), and headaches (21.3%).

Participants with high SOAPP-R scores were significantly younger, more likely to self-identify as non-heterosexual, report smaller annual household income, report higher frequency of disc problems, report greater overall pain interference, and were more likely to have tried opioid analgesics than participants with low SOAPP-R scores. PRCP with high SOAPP-R scores were also significantly more likely to have taken opioid analgesics for a longer period of time, as well as report higher ratings of depressive symptoms, anxiety, pain catastrophizing, insomnia symptoms, and have higher total scores on all three Barrett Impulsiveness subscales than PRCP with low SOAPP-R scores.

3.2. Discounting of rewards

In the following paragraphs, the outcome of interest is the proportion of discounting questions answered that corresponded to greater self-control, from 0–1; the higher the proportion, the greater the self-control. For rewards, the proportion represents the proportion of larger-later responses. Figure 1 shows the mean proportion of responses indicating self-control for each DD task by SOAPP-R status. (Please also see Supplemental Figure 2 for a scatterplot of DD outcomes by SOAPP-R total scores.)

3.2.1. Discounting of money gains—In univariate analyses (Supplemental Table 3), increases in many of the pain variables were associated with a significant decrease in larger-later responses (indicating less self-control), including last pain VAS, usual pain VAS, BPI interference, and worst pain, average pain and pain severity outcomes on BPI for the primary pain condition. Although nonsignificant, participants with greater SOAPP-R scores had 15% fewer choices demonstrating self-control with money gains as an outcome – the largest magnitude of any β coefficient (β=−0.15, 95% CI=−0.34, 0.04, p=0.11) and in the expected direction – compared to PRCP with low SOAPP-R scores. There was also a significant increase in proportion of larger-later responses as a participant's annual household income increased, consistent with past findings [15]. In multivariate analyses (Table 2), two predictors were significantly associated with DD of money gains. As usual pain VAS ratings increased, the proportion of choices representing self-control in DD of money gains decreased. Annual household income showed the opposite relationship – as income increased proportion of choices representing self-control in DD of money gains also increased. As expected, there was a significant main effect of magnitude in DD of money gains (F=178.77, df=2, 494, p<0.001) but no significant effect for magnitude × SOAPP-R category (F=1.37, df=2, 494, p=0.26).

3.2.2. Discounting of pain relief—In univariate analyses (Supplemental Table 3), participants reporting greater length of chronic pain showed a greater willingness to wait for pain relief when given the choice between smaller-sooner and larger-later number of days of complete pain relief. There was no significant relationship between SOAPP-R category and pain relief discounting (β=−0.06, 95% CI= −0.27, 0.16, p= 0.62). Women showed a significantly higher proportion of responses indicating self-control as compared to men – meaning women were more likely than men to wait to receive a larger number of days of complete pain relief (β= 0.27, 95% CI= 0.03, 0.52, p=0.03). There was also a significant increase in the proportion of larger-later responses as a participant's annual household income increased. In multivariate analysis (Table 3), increases in length of chronic pain, increases in annual household income, and female gender (as compared to male) were associated with increases in proportion of larger-later responses. There was a significant main effect of magnitude in DD of pain relief (F=73.07, df=2, 494, p<0.001) but no significant effect for magnitude × SOAPP-R category (F=1.25, df=2, 494, p=0.29).

3.3 Discounting of punishments

For punishments, the outcome of interest represents the proportion of smaller-sooner responses – indicating self-control. Individuals with a SOAPP-R score >=18 showed significantly greater DD in discounting of additional pain and money losses (Figure 1). (Please also see Supplemental Figure 2 for a scatterplot of DD outcomes by SOAPP-R total scores.)

3.3.1 Discounting of money losses—In univariate analyses (Supplemental Table 3), PRCP with high SOAPP-R scores had a smaller proportion of smaller-sooner responses compared to PRCP with low scores (β= −0.31, 95% CI −0.61, −0.01, p= 0.046). There was also a significant increase in proportion of smaller-sooner responses as a participant's annual household income increased (β= 0.13, 95% CI= 0.05, 0.22, p= 0.003). There was a non-significant trend for the proportion of smaller-sooner responses to increase as the level of education increased (β=0.17, 95% CI= −0.02, 0.37, p=0.08). In multivariate analysis (Table 4), SOAPP-R was included in the model (p<0.20) but there was no significant association between SOAPP-R score and proportion of smaller-sooner responses. The only significant predictor for DD of money losses in multivariate analysis was annual household income, indicating as annual income increased, the proportion of smaller-sooner responses increased. There was a significant main effect of magnitude in DD of money losses (F=10.17, df=2, 494, p<0.001) but no significant effect for magnitude × SOAPP-R category (F=1.32, df=2, 494, p=0.27).

3.3.2 Discounting of additional pain—In univariate analyses (Supplemental Table 3), there was a significant decrease in proportion of smaller-sooner responses comparing PRCP with low versus high SOAPP-R scores – the second largest magnitude of any β coefficient (β=−0.47, 95% CI= −0.79, −0.16, p= 0.003). As in discounting of pain relief, increases in self-reported pain (i.e., last pain VAS, BPI least pain VAS for primary pain condition) resulted in a decrease in the proportion of choices demonstrating self-control. Interestingly, as total scores on the GAD-7, PCS, and ISI increased, there were significant decreases in proportion of smaller-sooner choices. In multivariate analysis (Table 5), PRCP

with high SOAPP-R scores had significantly smaller proportion of smaller-sooner responses compared to PRCP with low SOAPP-R scores. Increases in PCS total score and BPI least pain VAS (for primary pain) were associated with significant decreases in proportion of smaller-sooner responses; whereas, PRCP who identified as Hispanic had a significantly smaller proportion of smaller-sooner responses compared to PRCP that identified as non-Hispanic. There was a significant main effect of magnitude in DD of additional pain (F=27.59, df=2, 494, p<0.001) but no significant effect for magnitude × SOAPP-R category (F=0.12, df=2, 494, p=0.88).

4. DISCUSSION

This study is one of the first to examine the relationship between risk of opioid misuse and another known risk factor of opioid use disorder (OUD) – delay discounting (DD) – in PRCP. Prior research has shown that risk for opioid misuse does longitudinally predict opioid misuse [7], and misuse behaviors are associated with OUD [30]. Additionally, OUD is a risk factor for still worse outcomes, including death. Therefore, this was the first in a planned series of studies that would evaluate the contribution of person-to-person variation in DD to long-term opioid outcomes among individuals reporting chronic pain.

The propensity to misuse opioids in chronic pain patients may be manifested initially as running out of prescriptions early, forging prescriptions, using other people's opioids, buying illicit opioids off the street, or using other substances (e.g., alcohol, cannabis) to enhance the effect of opioids. The decision to engage in opioid misuse behaviors places a higher value on achieving an immediate reward/avoidance of an immediate punishment compared to long-term rewards/punishments, similar to the decision persons with OUD must repeatedly make: immediate drug use versus long-term abstinence [5]. For chronic pain patients, the decision process likely involves consideration of pain-related rewards and punishments. A salient immediate reward of an opioid for patients is pain relief. Other rewards could be opioid subjective effects, e.g. feeling "high" or elevation in mood. Conversely, an immediate punishment without taking an opioid could be enhanced pain. The drives behind the decision to misuse opioids are important as differing drives could necessitate differing interventions to prevent or treat opioid misuse. If pain relief were the desired outcome, attempting to provide analgesia without opioids or using adjuvant non-opioid analgesics to decrease opioid requirements would be part of a treatment strategy. If avoidance of additional pain were the desired outcome, psychological interventions to reduce fear of pain and/or to enhance self-efficacy in handling pain would be part of a treatment strategy.

In this study, there was a negative relationship between high SOAPP-R scores (>=18; indicating high risk for opioid misuse) and discounting of punishments – so that PRCP with high SOAPP-R scores were significantly less likely to choose the smaller-sooner punishment (additional pain or money losses), indicative of self-control, compared to participants with low SOAPP-R scores. High SOAPP-R scores were not significantly associated with DD of rewards. These results suggest chronic pain patients at higher risk for misusing prescription opioids and subsequently developing OUD may worry more about avoiding additional pain than those patients at lower risk for opioid misuse. The significant association between DD

and high SOAPP-R scores provides additional evidence of SOAPP-R's face validity in measuring opioid misuse potential.

Why might avoidance of punishments today be more salient than receiving rewards today in chronic pain patients at higher risk for opioid misuse? First, patients with elevated SOAPP-R scores may also have higher levels of pain catastrophizing; excessive rumination about pain and its possible worsening may build up in these patients. Pain relief may not be as enjoyable to them because these patients are expecting the pain will return and it will be worse. However, if they could act to avoid immediate pain worsening (i.e., consume more than the prescribed amount of opioid), they would do so even if it meant greater pain in the future (i.e., running out of opioids early with subsequent pain worsening) due to the delay in receiving it. In these analyses, there was a significant difference in total PCS scores between participants with high versus low SOAPP-R scores (Table 1) and there was a significant correlation between SOAPP-R and PCS total scores (r=0.44; Supplemental Table 2). However, when PCS was controlled for in the additional pain multivariate analyses, SOAPP-R was still a significant predictor of worse self-control. Second, individuals at higher risk for opioid misuse may be more sensitive to pain (i.e., hyperalgesic) as suggested by a study [12] or be at greater risk for developing opioid-induced hyperalgesia. Pain sensitivity may increase both awareness of pain and desire to avoid future pain – not as a reward but as a way to avoid suffering. Hyperalgesia was not assessed in this study, although quantitative sensory testing could be added to future in-person surveys. Third, chronic pain patients may have repeated experiences with opioid withdrawal (which can manifest as worsening pain) and place higher value on avoiding future withdrawal episodes than receiving opioid rewards. Discounting of delayed rewards has been shown to increase during periods of mild opioid withdrawal compared to periods of opioid satiation in individuals with OUD [14]. The use of opioids, irrespective of withdrawal, is also associated with DD of rewards [18,23,41].

Chronic opioid therapy has been increasingly used for the treatment of a wide variety of pain syndromes, including musculoskeletal and neuropathic pain [9]. However, clinicians have few tools to assist in identifying individuals who may be at high risk for development of opioid misuse or OUD. Current screeners rely upon self-report or access to a clinical psychologist / psychiatrist – both of which have drawbacks in clinical practice. This study assessed the relationship between the SOAPP-R and a novel set of questions, which assessed choices between hypothetical rewards or punishments. These questions were simple to administer and achieved orderly results consistent with past research [9,13,33]. Although this study is preliminary, DD surveys as part of a comprehensive evaluation may make it easier for clinicians to individualize chronic opioid therapy and monitoring as these questions are quick to administer, can be given with distractor questions to ensure accurate reporting, and provide an easy to interpret outcome (proportion of self-control choices). Future prospective evaluations of DD in guiding clinical care with opioids may be warranted if these findings can be replicated in an in-person study population derived from chronic pain treatment clinics.

This study also demonstrated the utility of using AMT for quick and reliable recruitment of PRCP. Along with successful recruitment of other hard to reach clinical populations

(individuals with substance use disorders and risky sexual practices [19]), this method has great potential to streamline survey research in the US and abroad with great cost savings (survey participants were paid up to $3 for a completed survey).

This study had several limitations. First, as this survey was anonymous, there is a chance that individuals misrepresented their chronic pain status. However, the use of screening questions and several safety functions built into choosing AMT respondents (high success rate in filling out prior surveys and high quality ratings from prior "Requesters") as well as the small amount of reimbursement available increases confidence that the participants did in fact have chronic pain. The use of distractor questions helped ensure that participants were also paying attention. Second, this survey relied upon the SOAPP-R as an indicator of opioid misuse risk and was cross-sectional in nature. Therefore, it is unclear if participants had current OUD or misuse (most individuals indicated they had no history of diagnosis or treatment for an alcohol or drug problem on SOAPP-R (data not shown)). Third, the population of AMT workers reporting chronic pain may not generalize to the larger chronic pain population. However, we did achieve a wide diversity of US state residences, income, education, and a substantial number of sexual minorities. However, the survey was mostly female and Caucasian with a low percentage of Hispanic participants, and the participants had relatively little experience with opioids (only 33.9% had >6 months of lifetime opioid use). Fourth, this survey utilized novel DD surveys without prior validation, although the novel scales used the same absolute values of outcomes and delay lengths as the validated MCQ [25]. The Additional Pain Choice Questionnaire (APCQ) was the only scale that involved a qualitative, non-quantitatively defined decision, as the magnitude of additional pain was never quantitatively defined. Given consistency with past DD research and across DD of both punishments, we believe the nature of the punishment did not overly influence the study's findings. Fifth, the study did not include healthy controls. However, the SOAPP-R is not meant to be used in healthy controls, and the primary purpose of the study was to examine the relationship between SOAPP-R and DD. As no prior DD research has investigated discounting of pain-related rewards/punishments, it is unclear if healthy controls would function differently than chronic pain patients on these tasks. However, a recent review noted that chronic pain alters brain pathways involved in motivation and reward – suggesting that there may be differences between persons with and without chronic pain [32]. Finally, the DD questions involved hypothetical pain relief and additional pain. This, in part, is also a limitation related to the online nature of this work. Further studies that examine DD in chronic pain patients who are tested in a laboratory setting could address and help to validate the current findings – by offering choices between actual pain relief as well as choices between additional pain interventions (e.g. quantitative sensory testing).

In conclusion, PRCP at greatest risk for opioid misuse discount future punishments rather than future rewards compared to those at low risk. Measures of DD may be added to comprehensive assessments to more precisely identify individuals at highest risk for opioid misuse during chronic opioid therapy. If these findings are replicated in clinically verified chronic pain patients, future controlled investigations should be undertaken to investigate the utility of DD in guiding opioid therapy in the treatment of chronic pain and whether person-to-person variation in DD is associated with long-term opioid use outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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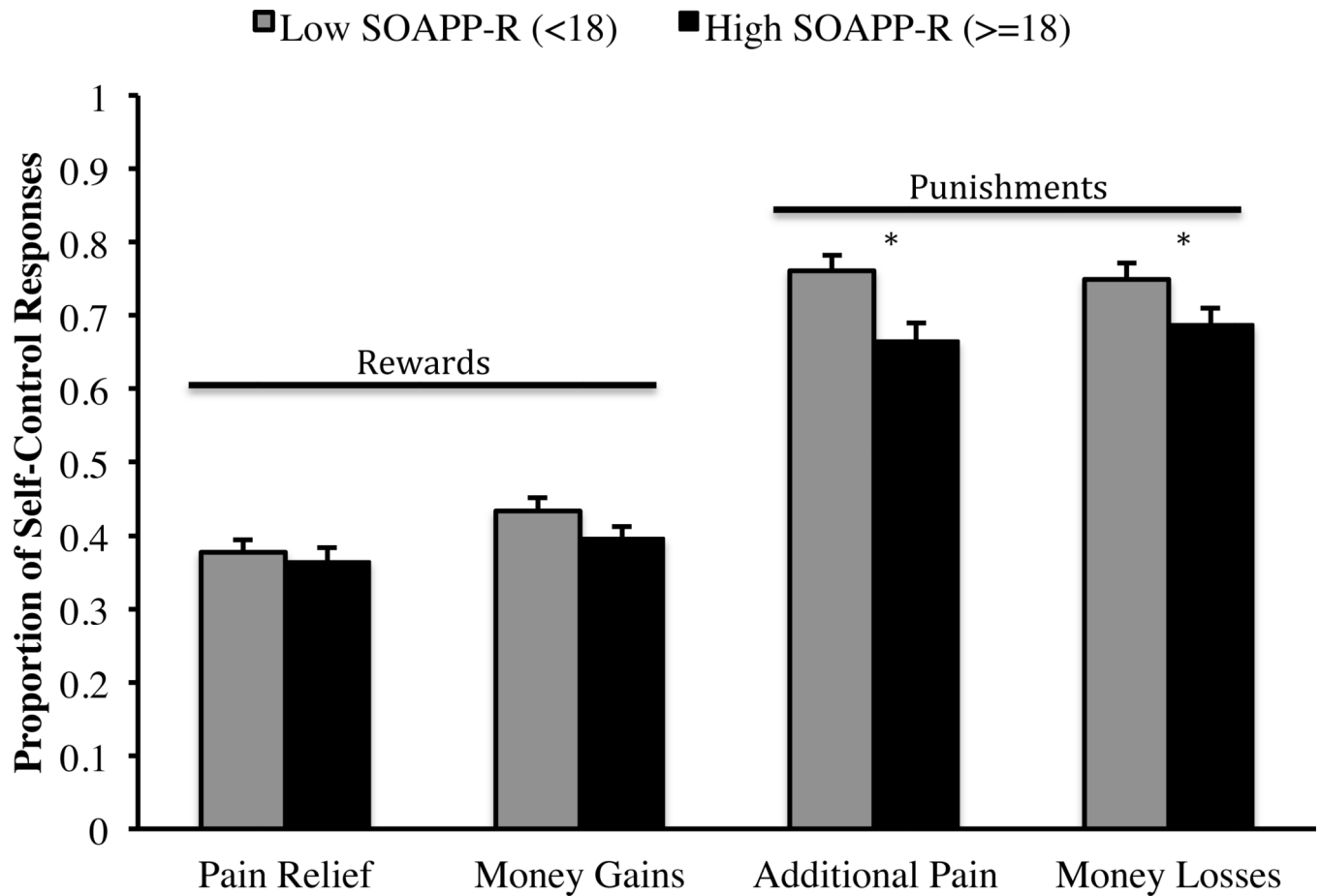
Figure 1. Mean Proportion of Responses Indicating Self-control on Four Separate Delay Discounting Tasks

SOAPP-R= Screener and Opioid Assessment for Patients in Pain – Revised. *p<0.05. For this figure, larger proportions indicate greater self-control. Choices for larger-later rewards and for smaller-sooner punishments represent self-control in these delay discounting tasks.

Table 1

Participant Characteristics.

		Total N=249	Low (SOAPP-R) N=120	High (SOAPP-R) N=129	p-value
Age - years (SD)		47.4 (12.1)	49.6 (12.7)	45.4 (11.2)	**0.01**
Gender (% female)		70.7	72.5	69	0.54
Sexual orientation (% non-heterosexual)		11.2	5	17.1	**<0.01**
Hispanic		7.2	5	9.3	0.19
Race (% Caucasian)		87.2	90.8	83.7	*0.09*
Education	High school graduate	7.2	7.5	7	0.18
	Some college	49.8	45	54.3	
	Bachelors degree	34.9	35.8	34.1	
	Graduate degree	8	11.7	4.7	
Income	0–10k	7.2	1.7	12.4	**0.02**
	10k–20k	9.2	8.3	10.1	
	20–35k	18.5	21.7	15.5	
	35–50k	24.1	25	23.3	
	50–75k	20.5	22.5	18.6	
	75–100k	14.9	12.5	17.1	
	100–200k	3.2	5	1.6	
Pain - how long experienced	3–6 months	4.8	4.2	5.4	0.76
	6–12 months	9.6	10.8	8.5	
	>12 months	85.5	85	86.1	
Cause of pain (Dx with >10% respondents)	Arthritis	39.4	41.7	37.2	0.47
	Neuropathy	30.5	25.8	34.9	0.12
	Other	26.9	29.2	24.8	0.44
	Disc problems	21.7	15.8	27.3	**0.03**
	Headaches	21.3	19.2	23.3	0.43
	Knees	21.3	20	22.5	0.63
	Joints (generally)	21.3	20	22.5	0.63
	Fibromyalgia	13.3	15.8	10.9	0.25

	Total N=249	Low (SOAPP-R) N=120	High (SOAPP-R) N=129	p-value
Sciatica	11.2	10	12.4	0.55
Number of pain diagnoses (SD)	2.8 (1.9)	2.7 (2)	2.8 (1.9)	0.65
Last pain (SD; 0–10 VAS)	6.4 (1.9)	6.4 (1.8)	6.5 (2)	0.68
Usual pain (SD; 0–10 VAS)	5.9 (1.9)	5.8 (1.8)	6.1 (1.9)	0.24
BPI - primary pain (SD) Worst (0–10 VAS)	6.5 (2.2)	6.2 (2.3)	6.7 (2)	*0.08*
Least (0–10 VAS)	3.3 (2.4)	3.1 (2.3)	3.5 (2.5)	0.13
Average (0–10 VAS)	5.4 (1.6)	5.2 (1.6)	5.5 (1.7)	0.14
Right now (0–10 VAS)	4.5 (2.4)	4.3 (2.5)	4.8 (2.4)	*0.09*
Severity (composite score)	4.9 (1.8)	4.7 (1.9)	5.1 (1.8)	*0.06*
BPI - secondary pain (N=169) Worst (0–10 VAS)	4.9 (2.7)	4.6 (2.7)	5.1 (2.6)	0.17
Least (0–10 VAS)	2.3 (2.3)	2.2 (2)	2.5 (2.6)	0.31
Average (0–10 VAS)	3.6 (2.2)	3.3 (2.1)	4 (2.3)	**0.04**
Right now (0–10 VAS)	2.9 (2.5)	2.6 (2.2)	3.2 (2.6)	*0.08*
Severity (composite score)	3.4 (2.1)	3.1 (2)	3.7 (2.2)	*0.08*
BPI - % relief from treatments	44.7 (29.1)	46.4 (31.2)	43.1 (26.9)	0.37
BPI - pain interference	5 (2.4)	4.1 (2.3)	6 (2)	**<0.01**
Exposure to opioid analgesics (% Yes)	67.5	58.3	76	**<0.01**
Length of exposure to opioids	27.4	38.6	19.4	**<0.01**
<1 month	27.4	38.6	19.4	
1–3 months	17.9	8.6	24.5	
4–6 months	10.1	8.6	11.2	
7–9 months	4.8	8.6	2	
10–12 months	6	7.1	5.1	
>12 months	33.9	28.6	37.8	
PHQ-2 (SD)	1.8 (1.8)	0.81 (1.1)	2.7 (1.8)	**<0.01**
GAD-7 (SD)	6.4 (5.7)	3 (3.3)	9.5 (5.6)	**<0.01**
PCS (SD)	23 (12.5)	17.3 (10.8)	28.2 (11.7)	**<0.01**
ISI (SD)	11.8 (6.6)	8.7 (6)	14.7 (5.8)	**<0.01**
Barrett Impulsiveness Scale -11 (SD) Attentional	14.9 (4.4)	12.9 (3.8)	16.9 (4.1)	**<0.01**
Motor	20.3 (4.5)	18.7 (3.5)	21.9 (4.7)	**<0.01**
Non-planning	23.1 (5.7)	20.9 (4.6)	25.2 (5.8)	**<0.01**

SOAPP-R= Screener and Opioid Assessment for Patients in Pain - Revised; SD=standard deviation; VAS=visual analog scale; BPI= Brief Pain Inventory; PHQ=Patient Health Questionnaire 2-item depression screener; GAD=Generalized Anxiety Disorder 7-item scale; PCS=Pain Catastrophizing Scale; ISI=Insomnia Severity Index.

Table 2

Multivariate Analysis: Delay Discounting of Money Gains.[*]

Variable		β	95% CI
Income		**0.09**	**0.03, 0.15**
Length of Chronic Pain		0.12	−0.04, 0.27
Usual Pain VAS		**−0.09**	**−0.16, −0.03**
BPI – Primary Pain	Least	0.04	−0.02, 0.09
BPI	Interference	*−0.05*	*−0.09, 0.00*

[*] Negative β coefficients indicate lower self-control. **p<0.05;** *p<0.10.*

CI=confidence interval; VAS=Visual Analog Scale.

To build the multivariate model, stepwise backward selection was utilized, where predictors were removed from the model if p>0.2. See Supplemental Table 2 for list of predictors included in model building.

Table 3

Multivariate Analysis: Delay Discounting of Pain Relief.[*]

Variable		β	95% CI
Age		−0.01	−0.01, 0.002
Gender	Male vs. Female	**0.28**	**0.03, 0.52**
Income		**0.09**	**0.01, 0.16**
Length Chronic Pain		**0.18**	**0.02, 0.35**
BPI	Interference	*−0.05*	*−0.10, 0.00*
ISI		*0.02*	*−0.003, 0.04*

[*] Negative β coefficients indicate lower self-control. **p<0.05**; *p<0.10.*

CI=confidence interval; BPI= Brief Pain Inventory; ISI=insomnia Severity Index.

To build the multivariate model, stepwise backward selection was utilized, where predictors were removed from the model if p>0.2. See Supplemental Table 2 for list of predictors included in model building.

Table 4

Multivariate Analysis: Delay Discounting of Money Losses.

Variable		β	95% CI
SOAPP-R	Low vs. High	−0.25	−0.47, 0.05
Gender		0.22	−0.09, 0.53
Income		**0.12**	**0.04, 0.21**

[*] Negative β coefficients indicate lower self-control. **p<0.05.**

CI=confidence interval; SOAPP-R= Screener and Opioid Assessment for Patients in Pain-Revised.

To build the multivariate model, stepwise backward selection was utilized, where predictors were removed from the model if p>0.2. See Supplemental Table 2 for list of predictors included in model building.

Table 5

Multivariate Analysis: Delay Discounting of Additional Pain.[*]

Variable		β	95% CI
SOAPP-R	Low vs. High	**−0.41**	**−0.79, −0.04**
Ethnicity	Non-Hispanic vs. Hispanic	**−0.69**	**−1.3, −0.06**
Last Pain VAS		*−0.10*	*−0.22, 0.02*
BPI – Primary Pain	Least Pain VAS	**−0.12**	**−0.22, −0.01**
	Average Pain VAS	*0.14*	*−0.02, 0.30*
BPI	Interference	0.07	−0.02, 0.17
PCS		**−0.02**	**−0.03, −0.004**

[*] Negative β coefficients indicate lower self-control. **p<0.05** and *p<0.10*.

CI=confidence interval; SOAPP-R= Screener and Opioid Assessment for Patients in Pain-Revised; VAS=visual analog scale; BPI= Brief Pain Inventory; PCS=Pain Catastrophizing Scale.

To build the multivariate model, stepwise backward selection was utilized, where predictors were removed from the model if p>0.2. See Supplemental Table 2 for list of predictors included in model building.