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Do the Adjusting- and Increasing-Delay Tasks Measure the Same Construct – Delay Discounting?

Andrew R. Craig, Adam D. Maxfield, Jeffrey S. Stein, C. Renee Renda, and Gregory J. Madden

Department of Psychology, Utah State University.

Abstract

Delay discounting describes the subjective devaluation of a reward when it is delayed. In animals, the adjusting- and increasing-delay tasks often are used to assess individual differences in, and drug effects on, delay discounting. No study to date, however, has compared systematically the measures of discounting produced in these tasks. The current study examined the correlation between measures of delay discounting derived from adjusting- and increasing-delay procedures. Twenty rats completed 30 sessions under each task (order counterbalanced across rats). Quantitative measures of delay discounting produced by the two tasks were positively correlated, suggesting that the adjusting- and increasing-delay tasks measure the same underlying facet of impulsive choice (i.e., individual or conjoint sensitivities to reward delay and magnitude). The measures derived from either task, however, depended on the sequences in which the tasks were experienced. That is, pre-exposure to one task decreased discounting of delayed rewards in the second task. Consistent with other published findings, exposure to delayed consequences during the initial discounting assessment might explain this effect. Despite the observed correlation between ID and AD indifference delays, we suggest that the ID procedure might be a more appropriate procedure for pharmacological studies.

Keywords

Impulsive choice; adjusting-delay task; increasing-delay task; delay exposure; delay discounting; rats

Impulsive choice may be defined as the propensity of an organism to select relatively small, immediate rewards at the expense of larger, delayed rewards (Ainslie, 1974; Logue, 1988). The temporal myopia inherent in impulsive choice might result from the devaluation of a reward because it is delayed (i.e., delay discounting; see Odum, 2011, for review). The extent to which individuals exhibit impulsive choice in delay-discounting tasks has been correlated with behavioral pathologies of addiction such as substance abuse (e.g., Vuchinich and Simpson, 1998; Bickel et al., 1999; Madden et al., 1997; Heil et al., 2006), pathological

Correspondence: Andrew R. Craig, Department of Psychology, Utah State University, 2810 Old Main Hill, Logan, UT 84322, andrew.craig@aggiemail.usu.edu.

Adam D. Maxfield is now at the Department of Psychology, Fairfield University.

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gambling (e.g., Petry and Casarella, 1999; Albein-Urios et al., 2012), and chronic overeating (e.g., Weller et al., 2008; Rasmussen et al., 2010). Further, some evidence suggests that excessive delay discounting precedes and predicts future susceptibility to addiction (as opposed to excessive discounting *resulting from* addiction; e.g., Audrain-McGovern et al., 2009; Khurana et al., 2013; Perry et al., 2005). Isolating the bio-behavioral processes that underlie delay discounting, then, might have implications for the understanding and treatment of its maladaptive behavioral correlates.

In the animal laboratory, various experimental paradigms have been used to assess delay discounting and its pharmacological and neurobiological underpinnings (see Madden and Johnson, 2010; Stein and Madden, 2013, for review). Among the most common of these preparations are the increasing-delay (ID; Evenden and Ryan, 1996) and the adjusting-delay (AD; Mazur, 1987) tasks, used primarily with rats as subjects. Several procedural elements are common to both tasks. Both are discrete-trial tasks in which subjects choose between a smaller-sooner reward (SSR) and a larger-later reward (LLR), with the time separating choice opportunities held constant, regardless of the reward chosen. In these procedures, free-choice trials are preceded by forced-choice trials in which only one alternative is available, thereby ensuring that both consequences are sampled. Following free-choice trials, the delay to the LLR is varied systematically within sessions to reveal an *indifference delay* – the delay at which the subjective, discounted value of the LLR is equal to the objective, undiscounted value of the SSR. The ID task arrives at this indifference delay by increasing the delay to the LLR (e.g., from 0–60 s) across blocks of forced- and free-choice trials. The indifference delay is estimated by interpolating the point at which percent LLR choice is 50%, either by linear or non-linear regression (see Evenden and Ryan; Stein, Smits et al., 2013). In the AD task, the delay to the LLR increases (decreases) by, for example, 1 s when the rat selects the LLR (SSR) on the two free-choice trials that follow two forced-choice trials. The indifference delay is the mean adjusted delay (MAD) obtained when the adjusted delay value stabilizes.

Although the ID and AD tasks commonly are used to assess delay discounting, some have suggested that procedural differences between tasks might impact the measures of discounting that they produce (see Madden and Johnson, 2010, for a detailed discussion). For example, using an impulsive-choice task in which LLR delay varied across sessions, Fox et al. (2008; Experiment 1) reported longer indifference delays in rats (i.e., less impulsive choice) with increasing compared to decreasing delay order. This finding suggests that current choices made in the ID task (in which LLR delay is varied even more rapidly than in task used by Fox et al. (2008)) are influenced by the arrangement of prior delays, an effect that might lead to a systematic under-estimation of delay discounting when delays increase across trial blocks.

Regarding the AD task, no study to our knowledge has been designed to compare method of within-session delay manipulation (e.g., size of the adjustment increment); Green et al. (2007), however, reported that discounting rates in the AD procedure were quantitatively comparable to discounting rates obtained using an adjusting-amount task (see Richards et al., 1997). Indeed, the discounting functions obtained by Green et al. (2007) under the AD task were slightly more orderly than those obtained in the adjusting-amount task. These

findings, collected with pigeon subjects, provide support for the AD task as a valid means by which to quantify delay discounting. The generality of this finding to rats is an open question, as is the validity of the ID task.

The widespread use of the AD and ID tasks, and the procedural concerns just noted, provide a rationale for evaluating the correlation between the indifference delays provided by these tasks. To date, no direct attempts have been made to cross-validate the discounting measures derived from these tasks. Given that ID and AD tasks are used interchangeably to assess the effects of the same independent variables on impulsive choice (e.g., drug administration; for review, see Stein and Madden, 2013), cross-validation of the measures of discounting derived from these tasks is needed. To address this gap in the literature, rats in the present study completed 30 sessions of either the ID or AD task, followed by 30 sessions of the other task. Correlation analyses were conducted on the discounting measures derived from both tasks.

Method

Subjects

Twenty male, experimentally naïve Long-Evans rats (Charles River Laboratories, Wilmington, MA) served as subjects. Rats were approximately 90 days old at the start of the experiment and were housed individually in polycarbonate cages in a temperature- and humidity-controlled colony room operating on a 12:12-hr light/dark cycle (lights on at 8:00 am). Rats had free access to water in their home cages but were maintained at 85% of their free-feeding weights by the use of supplemental feedings approximately 1 hr after sessions. Sessions were conducted 7 days per week. Half of the rats were selected randomly to complete the AD task first, followed by the ID task (hereafter the *AD-ID* group). The remaining rats completed these tasks in the opposite order (hereafter the *ID-AD* group). Animal care and all procedures described below were conducted in accordance with Utah State University's Institutional Animal Care and Use Committee.

Apparatus

Ten identical operant-conditioning chambers (Med Associates, St. Albans, VT) were used. Each was housed within a sound-attenuating cubicle equipped with an exhaust fan and a white-noise speaker. Two retractable response levers were positioned in the left and right panels on the front wall of the chamber (6.5 cm above the grid floor). A non-retractable lever was positioned on the rear wall in the center panel. Above each lever was a 28-V DC cue light. A pellet feeder (Coulbourn Instruments, Allentown, PA), mounted outside the chamber, delivered grain-based pellets (45 mg; Bio-Serv, Frenchtown, NJ) into a receptacle positioned between the front-wall levers (1 cm above the grid floor). Inside each pellet receptacle was a 2-W stimulus light.

Procedure

Lever training—An auto-shaping procedure was used to establish front-lever responding. Responding on one front lever was trained first, followed by responding on the opposite front lever (order counterbalanced across rats). During each session, the active lever was

inserted into the chamber every 75 s and the cue light associated with the lever was illuminated. Following 5 s, the lever was retracted, the light was extinguished, and one food pellet was delivered following the minimum delay the software allowed (0.01 s; hereafter referred to as 0 s) independently of responding. Rats could earn the food pellet at any time during the 5-s period by pressing the lever. In these and all sessions described below, a 0.75-s flash of the receptacle light accompanied each pellet delivery.

Auto-shaping sessions terminated after 60 pellet deliveries. Rats completed training sessions on each lever until at least 90% of the available reinforcers were earned (by making an operant response) for two consecutive sessions. Once front-lever responding was trained, rats were trained to respond on the rear lever under a chain schedule similar to that used in the impulsive-choice tasks described below. At the beginning of every trial, the cue light above the rear lever was illuminated. A single response on the rear lever extinguished the cue light and resulted in insertion of one pseudorandomly determined front lever and illumination of the associated cue light. A single response on the active front lever initiated the same consequences described above. Rear-lever training continued until rats met the same criterion used during front-lever auto-shaping.

Alternative lever-training methods were used for three rats (A7, A8, and A13) that did not meet the front-lever auto-shaping criterion within 10 sessions. For these rats, an area approximately 6 cm above the active lever was baited with roughly 1 g of commercially available peanut butter to encourage focal exploration of the area surrounding the lever and thus increase the probability of responding. Once lever pressing was initiated using this method (1–2 sessions), baiting was discontinued and responding was subjected to the same criterion described above.

Adjusting-delay task—Rats completed 30 sessions of an AD task that was modeled after the task used by Mazur (1987). A fixed number of sessions was conducted because previous research has demonstrated that 20 – 30 sessions is generally sufficient to achieve stable responding (e.g., Mazur, 2012: stability achieved in 13–22 sessions) and good test-retest reliability (McClure et al., 2014: 15 sessions at test and retest) in the AD task. Each session was divided into fifteen, 4-trial blocks (60 trials total). The first two trials in each block were forced-choice trials, in which only one lever was available (the order of lever presentation varied randomly in every pair of forced-choice trials). The final two trials in each block were free-choice trials, in which both levers were available. At the beginning of each trial, the rear lever was activated and its associated cue light was illuminated. As before, a single response extinguished the associated cue light and caused one or both front levers (depending on trial type) to be inserted and the associated cue light(s) to be illuminated. A single response on the SSR lever produced immediate delivery of one food pellet, whereas a single response on the LLR lever produced delivery of three food pellets following the adjusted delay (see below). The assignment of levers was counterbalanced across rats. A limited-hold omission criterion was imposed on all trials, such that if the rat either did not respond on the rear lever within 20 s of trial onset or on one of the front levers within 20 s of lever insertion, the trial was terminated and was counted as an omission. Pellet deliveries on all trials were followed by a variable intertrial interval (ITI) during which no stimuli were presented. Following each trial, the duration of the ITI was calculated by subtracting total

time in the current trial (i.e., time from the onset of the trial to food delivery) from 80 s. This ITI ensured trials began every 80 s, regardless of which reward was chosen.

The delay to the LLR was set initially to 6 s but was titrated across trial blocks based on each rat's previous choices. Specifically, if a rat chose the LLR on both free-choice trials in a block, the delay to that reward increased by 1 s in the subsequent trial block. Conversely, if the rat chose the SSR on both free-choice trials, the delay decreased by 1 s in the subsequent trial block. If the rat chose one of each reward, the delay remained the same. At the beginning of each subsequent session, the delay to the LLR was carried over from the end of the previous session. Delay adjustments were constrained to a minimum of 0 s and a maximum of 60 s, although the latter constraint was never contacted. During all sessions, the cue light above the LLR lever remained on during the delay.

Increasing-delay task—The ID task likely is the most common method for assessing discounting, and more procedural variations have been reported for this task than for the AD task. Accordingly, a literature review was conducted using Google Scholar and PubMed to determine those aspects of the ID task that are used most commonly. The search included all articles citing Evenden and Ryan (1996) from January 2008 until March 2013. Procedural details of interest included: (1) the range of delays associated with the LLR option within a session; (2) the number of forced-choice and free-choice trials per block; (3) whether the study included an initial amount-discrimination phase, where subjects were required to demonstrate some criterion preference for the LLR over the SSR when both were delivered immediately, prior to collection of terminal data; (4) whether the study included 0-s delay sessions (sessions where no delays were programmed on the LLR option, designed to ensure the subjects maintain amount sensitivity or diagnose insensitivity, if present); and (5) whether blackout periods separated trial blocks (designed to potentially minimize the influence of past delays on current choice). The results from this review are included in the Appendix. The range of delays associated with the LLR option most commonly was 0 – 60 s. The most common free-choice to forced-choice trial ratio was 5:1 (10 free- and 2 forced-choice trials). Amount-discrimination phases, 0-s delay sessions, and inter-block blackouts rarely were used. The procedure below was modeled after these findings.

Each session in the ID task was divided into five, 12-trial blocks (60 trials total). The first two trials in each block were forced-choice trials, as described above. The next 10 trials in each block were free-choice trials. In each session, the delay to the LLR increased monotonically across the five trial blocks (i.e., 0, 10, 20, 40, and 60 s), independent of the rats' previous choices. With the exceptions noted above, all remaining ID task parameters, trial sequence, and number of sessions were identical to those described for the AD task.

As in the AD task, rats completed a fixed 30 sessions under the ID task because previous research has demonstrated that 30 sessions generally is sufficient to achieve stable responding (e.g., Broos et al., 2012; Robinson et al., 2009; Simon et al., 2009). Four rats in the ID-AD group (A4, A7, A13, and A17) demonstrated strict preference for the SSR lever during the first 14 sessions of the ID task. Between sessions 14 and 15, these rats completed two sessions consisting of 60 LLR forced-choice trials. After completing these sessions, the rats were placed back onto the ID task for the remaining 16 sessions.

Statistical analyses—In both tasks, data were taken from the terminal six sessions. All statistics reported below were deemed significant at an α level of less than .05. To calculate indifference delays for individual rats following the ID task, an inverted sigmoid function was fit to percent LLR choice across delays using Microsoft Excel Solver (see Stein, Smits et al., 2013). A 2×2 mixed-model ANOVA was used to assess the effects of Task (AD vs. ID), Sequence (AD-ID vs. ID-AD), and the interaction between these variables on indifference delays.

Results

Indifference Delays

For the ID task, percent LLR choice across trial blocks for each subject are shown in Table 1. The inverted sigmoid function used to derive indifference delays provided excellent fits to individual subjects' percent LLR choice [mean variance accounted for (*VAF*) = 98.65, *SEM* = 0.42; see Table 2]. Mean indifference delays obtained from these fits are shown in Figure 1. Indifference delays obtained in the AD task (i.e., MADs) also are included in Figure 1, and individual subjects' AD indifference delays are included in Table 3. The ANOVA conducted on these data revealed a significant Sequence X Task interaction, $F(1, 18) = 6.18$, $p < .05$, but no significant main effects of Sequence, $F(1, 18) = 0.53$, $p = .48$, or Task, $F(1, 18) = 0.16$, *NS*. The effect of task sequence on indifference delays was not significant in either the AD, $t(18) = -0.54$, *NS*, or the ID task, $t(18) = 1.85$, $p = .08$. Instead, a Wilcoxon signed-rank test revealed a significant effect of sequence: indifference delays tended to be longer in the second delay-discounting task, regardless of the task, $W = 130$, $p < .05$.

Correlation Analyses and Regression Toward the Mean

Figure 2, Panel A, provides a scatterplot of indifference delays obtained in the AD and ID tasks for each subject. Because the residuals around the best-fit regression line were not normally distributed, Kolmogorov-Smirnov $D = .22$, $p < .01$, the Spearman's rank-order correlation coefficient was calculated. Indifference delays from the AD and ID tasks, aggregated across groups, were significantly correlated, $\rho(18) = .71$, $p < .001$. Panel B of Figure 2 is a Galton squeeze plot showing the relation between Z-score standardized indifference delays in the first and second assessments (see Burrell et al., 2010). If the correlation between the standardized first- and second-assessment indifference delays was perfect (i.e., no regression toward the mean), each line would be horizontal from the left to the right axis. The obtained correlation between these assessments was $r(18) = .73$, which is significantly different from a test value of 1.0 ($p < .05$). The estimated proportion of VAF by regression toward the mean ($V_r = 100[1-r]$; Campbell and Kenny, 1999) was 27%.

Latency to Respond

To determine if either task type or task order affected motivation to respond, response-latency analyses were conducted. First, for each subject, mean response latencies (i.e., time from insertion of the choice levers to emission of a lever press) from all free-choice trials during the last six sessions of both procedures were calculated. These latencies then were categorized two ways: the first procedure experienced (AD or ID) vs. the second procedure experienced, and the AD vs. ID procedure (regardless of order). In neither case did response

latencies significantly differ [for task type and task order, respectively: $t(19) = 1.23$, *NS*; and $t(19) = 0.08$, *NS*]. Further, response latencies were positively correlated between tasks, $r(18) = .76$, $p < .001$.

Discussion

The current experiment assessed the extent to which two commonly used delay-discounting tasks, the AD and ID tasks, produce comparable measures of discounting. The indifference delays obtained in these tasks were significantly and positively correlated. These data suggest that AD and ID tasks measure the same underlying facets of impulsive choice (i.e., individual or conjoint sensitivities to reward delay and magnitude). In the paragraphs that follow, we provide a post-results discussion of the validity of the ID and AD tasks and outline some factors that might underlie the less-than-perfect correlation between the indifference delays obtained in these tasks.

Madden and Johnson (2010) speculated that the ID task might be a less valid procedure for assessing delay discounting than other tasks because choices made in the ID task appear to be influenced by both present *and past* LLR delays (see, e.g., Fox et al., 2008). More specifically, in the case of typical ID tasks where subjects experience an increasing progression of delays across trial blocks, indifference delays might be inflated (i.e., diminished impulsive choice) if choice in the current trial block is influenced by the shorter-duration delays arranged in earlier trial blocks. If this was the case in the present experiment, then rats would have attained higher indifference delays in the ID task than they did in the AD task. This systematic difference was not observed, offering further support of the ID task as a valid measure of delay discounting.

The validity of the AD task for assessing delay discounting was less in question as both experiments in the study Green et al. (2007) indicated that the AD task provided more systematic delay-discounting data than did an adjusting-amount task. An earlier study conducted by Cardinal et al. (2002), however, reported that the indifference delays obtained in the AD task were unsystematic and could not be distinguished from computer simulations that made random choices. The parameters of the AD task used in the current experiment were modeled after those most commonly reported in the literature (cf., Perry et al., 2005) and did not match several of the parameters arranged by Cardinal et al. (e.g., percentage-based vs. fixed titration of delays). Thus, the present findings offer further support for the commonly used AD task but do not address the concerns raised by Cardinal et al. (2002) under their less commonly used version of the AD task.

The less-than-perfect correlation between indifference delays obtained in the AD and ID tasks does not appear to have been influenced by motivational factors associated with task type or task order: In both of these comparisons, latencies to respond when choice alternatives were presented were functionally identical at both the group and individual-subject (see correlation, above) levels. The correlation between indifference delays, however, was apparently influenced by time (i.e., maturation, intervening experience) and regression toward the mean. Indifference delays increased from the first to the second discounting tasks, regardless of the order in which rats completed the AD and ID tasks.

Regression toward the mean accounted for 27% of the variance in this shift (see Fig. 2B) as some rats that demonstrated low indifference delays in the first task had high indifference delays in the second. It seems unlikely that the remaining variance owes to maturation alone because past reports of maturation-related decreases in delay discounting have documented changes over far longer proportions of the rodent lifetime (e.g., Simon et al., 2010).

A second factor that might have decreased the rate of delay discounting in the second assessment is previous exposure to delayed reinforcers. Stein et al. (2013a) trained separate groups of rats to press a lever for either immediate or delayed food reinforcers. In a post-training test of impulsive choice, rats that were trained to lever press with delayed reinforcers made significantly fewer impulsive choices than did rats that had no prior experience with delayed reinforcers (see also Eisenberger et al., 1982). In the present study, “pre-training” on either discounting task entailed substantial exposure to delayed reinforcement. Thus, pre-exposure to delayed consequences might be responsible for some of the variance in the decreasing impulsive choice observed over time.

Killeen (2011) suggested that impulsive choice (i.e., selecting a SSR and forgoing a LLR) in nonhuman animals might have little to do with the discounting of the value of the LLR. Instead, forgoing the LLR might occur because the memory trace of the response that produced the LLR has decayed substantially over the response-reinforcer interval. Associating the response that led to the LLR with the LLR itself should be an increasingly difficult task as this memory trace decays and as other candidate responses occur during the delay. Put another way, the rat might choose the SSR over the LLR simply because it can discriminate easily the causal relation between response and reinforcer on that alternative, whereas the causal connection between pressing the other lever and the LLR is less clear. According to this account, prior experience with delayed response-contingent reinforcement (e.g., during the forced-choice trials in the first delay discounting task in the present experiment) should enhance learning of the response-LLR contingency. Thus, exposure to the response-LLR sequence and the associated gradual learning of the contingent relation between these events might play a role in indifference delays increasing from the first to the second task in the present experiment.

If the ID and AD tasks measure the same underlying construct and results from both are susceptible to effects of delay exposure and regression towards the mean, one might anticipate sequence effects similar to those reported here if subjects were to experience either task more than once. To our knowledge, no study to date has directly examined the extent to which discounting measures derived from conventional AD or ID procedures are stable across repeated assessments. McClure and colleagues (2014) however, demonstrated a high degree of test-retest reliability in discounting measures derived from a variant of the AD task. In this task, rats chose between sweetened water delivered after either fixed or variable delays, and the fixed delay decreased gradually across sessions until choice between the two options was indifferent. Fifteen-day assessments were separated by a 15-day break from sessions. The proportion of variance accounted for from regression of discounting measures derived from the second task exposure onto those derived from the first was .76, and scores from the second exposure were significantly higher than scores from the first. Though these authors used a version of the AD task that differs substantially from the

version used here, their AD-task data ordinally agree with the current AD-task data. In terms of the ID task, several studies have examined delay discounting prior to and following various behavioral or pharmacological manipulations. Generally, results from these studies demonstrate strong but less-than-perfect correspondence in measures of impulsive choice between assessments (e.g., Koffarnus and Woods, 2011; Stein, et al., 2013a; Stein, et al., 2013b; but see also Huskinson et al., 2012; Slezak et al., 2012, who reported no difference in discounting between assessments separated by chronic experimenter-administered *d*-amphetamine). Within-subject changes in delay discounting between assessments like those obtained in the current experiment, then, appear to be common in ID and AD tasks. That behavioral or pharmacological interventions occurred between discounting assessments in each study that used the ID task reviewed above, however, limits determination of delay-exposure or regression-towards-the-mean effects. Direct assessments of test-retest reliability in ID task are warranted.

Despite the high degree of correlation between measures of discounting derived from the current AD and ID procedures, practical considerations should be given due weight when selecting between these delay-discounting assessments. For example, acute administration of pharmacological agents, like *d*-amphetamine (Huskinson et al., 2012) and cocaine (Dandy and Gatch, 2009), often decrease preference for larger delayed rewards. However, drug administration also often decreases preference for larger rewards when neither the larger nor the smaller reward is delayed (see Pitts, 2014; Stein and Madden, 2013, for review); when this happens it complicates interpretation of drug effects on impulsive choice. That being said, the ID procedure allows for identification of these effects in the 0-s delay block, whereas the AD procedure, as typically conducted, does not. Further, the ID procedure allows for examination of choice across a full range of delays in approximately the same amount of time that the AD task requires for examination of choice under a single delay. Under conditions of pharmacological treatment, then, the ID procedure would appear to provide a more appropriate measure of impulsive choice than the AD procedure.

Although the AD and ID procedures produced comparable measures of discounting in the present study, additional investigation is needed to determine whether similar concordance would be observed when discounting is manipulated pharmacologically. Agreement might not be expected if drug effects interact differently with the contingencies arranged by ID and AD tasks. For example, drug-induced response perseverance (i.e., consistently choosing one lever regardless of delays arranged; see Loh et al. 1993) likely would manifest differently between tasks. In the ID task, because each session arranges a 0-s LLR delay block initially, perseverance might result in an artificial increase in self-controlled choice across subsequent delay blocks. In the AD task, depending on which lever is chosen at the beginning of a session, perseverance would result in progressive increases or decreases in the adjusted delay, thus producing unsystematic effects across rats. Attention to these and other related effects is necessary when evaluating drug effects on delay discounting.

Conclusion

The present data suggest that the AD and ID tasks produce comparable measures of delay discounting, at least under baseline conditions. The less-than-perfect correlation between the

outcomes of these tasks is likely due to regression toward the mean and exposure to response-reinforcer delays, the latter having been shown previously to decrease delay discounting (Stein, Johnson et al., 2013). Despite the correlation between ID and AD indifference delays obtained here, the ID procedure appears to be a more appropriate assessment of delay discounting in the context of pharmacological intervention.

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References

- Ainslie G. Impulse control in pigeons. *J Exp Anal Behav.* 1974; 21:485–489. [PubMed: 16811760]
- Albein-Urios N, Martinez-Gonzalez JM, Lozano O, Clark L, Verdejo-Garcia A. Comparison of impulsivity and working memory in cocaine addiction and pathological gambling: implications for cocaine-induced neurotoxicity. *Drug Alcohol Depend.* 2012; 126:1–6. [PubMed: 22475814]
- Anderson KG, Diller JW. Effects of acute and repeated nicotine administration on delay discounting in Lewis and Fischer 344 rats. *Behav Pharmacol.* 2010 Advance online publication.
- Audrain-McGovern J, Rodriguez D, Epstein LH, Cuevas J, Rodgers K, Wileyto EP. Does delay discounting play an etiological role in smoking or is it a consequence of smoking? *Drug Alcohol Depend.* 2009; 103:99–106. [PubMed: 19443136]
- Baarendse PJJ, Vanderschuren LJMJ. Dissociable effects of monoamine reuptake inhibitors on distinct forms of impulsive behavior in rats. *Psychopharmacology.* 2012; 219:313–326. [PubMed: 22134476]
- Bañuelos C, Gilbert RJ, Montgomery KS, Fincher AS, Wang H, Frye GD, et al. Altered spatial learning and delay discounting in a rat model of human third trimester binge ethanol exposure. *Behav Pharmacol.* 2012; 23:54–65. [PubMed: 22129556]
- Barbelivien A, Billy E, Lazarus C, Kelche C, Majchrzak M. Rats with different profiles of impulsive choice behavior exhibit differences in responses to caffeine and d-amphetamine and in medial prefrontal cortex 5-HT utilization. *Behav Brain Res.* 2008; 187:273–283. [PubMed: 18029033]
- Bezzina G, Body S, Cheung THC, Hampson CL, Bradshaw CM, Szabadi E, et al. Effects of disconnecting the orbital prefrontal cortex from the nucleus accumbens core on inter-temporal choice behaviour: a quantitative analysis. *Behav Brain Res.* 2008; 191:272–279. [PubMed: 18472170]
- Bezzina G, Cheung THC, Body S, Deakin JFW, Anderson IM, Bradshaw CM, et al. Quantitative analysis of the effects of lesions of the subthalamic nucleus on inter-temporal choice: further evidence for enhancement of the incentive value of food reinforcers. *Behav Pharmacol.* 2009; 20:437–446. [PubMed: 19667971]
- Bickel WK, Odum AL, Madden GJ. Impulsivity and cigarette smoking: delay discounting in current, never, and ex-smokers. *Psychopharmacology (Berl).* 1999; 146:447–454. [PubMed: 10550495]
- Broos N, Diergaarde L, Schoffelmeer ANM, Pattij T, De Vries TJ. Trait impulsive choice predicts resistance to extinction and propensity to relapse to cocaine seeking: a bidirectional investigation. *Neuropsychopharmacology.* 2012; 37:1377–1386. [PubMed: 22318198]
- Burrell, GL.; Thoemmes, F.; MacKinnon, DP. Visual displays of regression toward the mean using SAS® SGplot. *SAS Global Forum 2010.* 2010. <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.180.2923&rep=rep1&type=pdf>
- Campbell, DT.; Kenny, DA. A primer on regression artifacts. New York: The Guilford Press; 1999.
- Cardinal RN, Daw N, Robbins TW, Everitt BJ. Local analysis of behaviour in the adjusting-delay task for assessing choice of delayed reinforcement. *Neural Netw.* 2002; 15:617–634. [PubMed: 12371516]

- Counotte DS, Spijker S, Van de Burgwal LH, Hogenboom F, Schoffelmeer ANM, De Vries, et al. Long-lasting cognitive deficits resulting from adolescent nicotine exposure in rats. *Neuropsychopharmacology*. 2009; 34:299–306. [PubMed: 18580873]
- Dandy KL, Gatch MB. The effects of chronic cocaine exposure on impulsivity in rats. *Behav Pharmacol*. 2009; 20:400–405. [PubMed: 19675455]
- Diergaarde L, Pattij T, Poortvliet I, Hogenboom F, de Vries W, Schoffelmeer ANM, et al. Impulsive choice and impulsive action predict vulnerability to distinct stages of nicotine seeking in rats. *Biol Psychiatry*. 2008; 63:301–308. [PubMed: 17884016]
- Diergaarde L, van Mourik Y, Pattij T, Schoffelmeer ANM, De Vries TJ. Poor impulse control predicts inelastic demand for nicotine but not alcohol in rats. *Addict Biol*. 2012; 17:576–587. [PubMed: 21966927]
- Diller JW, Saunders BT, Anderson KG. Effects of acute and repeated administration of caffeine on temporal discounting in rats. *Psychopharmacol, Biochem, Behav*. 2008; 89:546–555.
- Dunnett SB, Heuer A, Lelos M, Brooks SP, Rosser AE. Bilateral striatal lesions disrupt performance in an operant delayed reinforcement task in rats. *Brain Res Bull*. 2012; 88:251–260. [PubMed: 21515345]
- Evenden JL, Ryan CN. The pharmacology of impulsive behavior in rats: the effects of drugs on response choice with varying delays of reinforcement. *Psychopharmacology*. 1996; 128:161–170. [PubMed: 8956377]
- Flagel SB, Robinson TE, Clark JJ, Clinton SM, Watson SJ, Seeman P, et al. An animal model of genetic vulnerability to behavioural disinhibition and responsiveness to reward-related cues: implications for addiction. *Neuropsychopharmacology*. 2010; 35:388–400. [PubMed: 19794408]
- Fox AT, Hand DJ, Reilly MP. Impulsive choice in a rodent model of attention-deficit/hyperactivity disorder. *Behav Brain Res*. 2008; 187:146–142. [PubMed: 17950930]
- García-Lecumberri C, Torres I, Martin S, Crespo JA, Miguens M, Nicanor C, et al. Strain differences in the dose-response relationship for morphine self-administration and impulsive choice between Lewis and Fischer 344 rats. *J Psychopharmacol*. 2011; 25:783–791. [PubMed: 20488829]
- Green L, Myerson J, Shah AK, Estle SJ, Holt DD. Do adjusting-amount and adjusting-delay procedures produce equivalent estimates of subjective value in pigeons? *J Exp Anal Behav*. 2007; 87:337–347. [PubMed: 17575900]
- Harty SC, Whaley JE, Halperin JM, Ranaldi R. Impulsive choice, as measured in a delay discounting paradigm, remains stable after chronic heroin administration. *Psychopharmacol, Biochem, Behav*. 2011; 98:337–340.
- Harvey-Lewis C, Perdriest J, Franklin KBJ. The effect of morphine dependence on impulsive choice in rats. *Psychopharmacology*. 2012; 223:477–487. [PubMed: 22588252]
- Heil SH, Johnson MW, Higgins ST, Bickel WK. Delay discounting in currently using and currently abstinent cocaine-dependent outpatients and non-drug-using matched controls. *Addict Behav*. 2006; 31:1290–1294. [PubMed: 16236455]
- Huskinson SL, Krebs CA, Anderson KG. Strain differences in delay discounting between Lewis and Fischer 344 rats at baseline and following acute and chronic administration of d-amphetamine. *Pharmacol, Biochem, Behav*. 2012; 101:403–416. [PubMed: 22342664]
- Khurana A, Romer D, Betancourt LM, Brodsky NL, Giannetta JM, Hurt H. Working memory ability predicts trajectories of early alcohol use in adolescents: the meditational role of impulsivity. *Addiction*. 2013; 108:506–515. [PubMed: 23033972]
- Killen PR. Models of trace decay, eligibility for reinforcement, and delay of reinforcement gradients, from exponential to hyperboloid. *Behav Processes*. 2011; 87:57–63. [PubMed: 21215304]
- Koffarnus MN, Woods JH. Individual differences in discount rate are associated with demand for self-administered cocaine, but not sucrose. *Addict Biol*. 2013; 18:8–18. [PubMed: 21812874]
- Kolokotroni KZ, Rodgers RJ, Harrison AA. Acute nicotine increases both impulsive choice and behavioural disinhibition in rats. *Psychopharmacology*. 2011; 217:455–473. [PubMed: 21503608]
- Krebs DL, Anderson KG. Preference reversals and effects of d-amphetamine on delay discounting in rats. *Behav Pharmacol*. 2012; 23:228–240. [PubMed: 22543814]
- Logue AW. Research on self-control: an integrating framework. *Behav Brain Sci*. 1988; 11:665–709.

- Loh EA, Smith AM, Roberts DC. Evaluation of response perseveration of rats in the radial arm maze following reinforcing and nonreinforcing drugs. *Pharmacol Biochem Behav.* 1993; 44:735–740. [PubMed: 8451275]
- Loos M, Pattij T, Janssen MCW, Coughnour DS, Schoffeleers ANM, Smit AB, et al. Dopamine receptor D₁/D₅ gene expression in the medial prefrontal cortex predicts impulsive choice in rats. *Cereb Cortex.* 2010; 20:1064–1070. [PubMed: 19690230]
- Lovic V, Keen D, Fletcher PJ, Fleming AS. Early-life maternal separation and social isolation produce an increase in impulsive action but not impulsive choice. *Behav Neurosci.* 2011; 125:481–491.
- Madden, GJ.; Johnson, PS. A delay-discounting primer. In: Madden, GJ.; Bickel, WK., editors. *Impulsivity: the behavioral and neurological science of discounting.* Washington, DC: American Psychological Association; 2010. p. 11-37.
- Madden GJ, Petry N, Badger GJ, Bickel WK. Impulsive and self-control choices in opiate-dependent patients and non-drug-using control participants: Drug and monetary rewards. *Exp Clin Psychopharmacol.* 1997; 5:256–262. [PubMed: 9260073]
- Madden GJ, Johnson PS, Brewer AT, Pinkston JW, Fowler SC. Effects of pramipexole on impulsive choice in male Wistar rats. *Exp Clin Psychopharmacol.* 2010; 18:267–276. [PubMed: 20545391]
- Mar AC, Walker ALJ, Theobald DE, Eagle DM, Robbins TW. Dissociable effects of lesions to orbitofrontal cortex subregions on impulsive choice in the rat. *J Cogn Neurosci.* 2011; 31:6398–6404.
- Mazur, JE. An adjusting procedure for studying delayed reinforcement. In: Commons, ML.; Mazur, JE.; Nevin, JA.; Rachlin, H., editors. *Quantitative analyses of behavior: the effects of delay and of intervening events on reinforcement value.* Hillsdale, NJ: Lawrence Erlbaum Associates, Inc; 1987. p. 55-73.
- Mazur J. Effects of pre-trial response requirements on self-control by rats and pigeons. *J Exp Anal Behav.* 2012; 97:215–230. [PubMed: 22389527]
- McClure J, Podos J, Richardson HN. Isolating the delay component of impulsive choice in adolescent rats. *Front Integr Neurosci.* 2014;8. [PubMed: 24605091]
- Mendez IA, Simon NW, Hart N, Mitchell MR, Nation JR, Wellman PJ, Setlow B. Self-administered cocaine causes long-lasting increases in impulsive choice in a delay discounting task. *Behav Neurosci.* 2010; 124:470–477. [PubMed: 20695646]
- Mendez IA, Gilbert RJ, Bizon JL, Setlow B. Effects of acute administration of nicotinic and muscarinic cholinergic agonists and antagonists on performance in different cost-benefit decision making tasks in rats. *Psychopharmacology.* 2012; 224:489–499. [PubMed: 22760484]
- Mitchell MR, Mendez IA, Vokes CM, Dambrosky JC, Winzer-Serhan UH, Setlow B. Effects of developmental nicotine exposure in rats on decision-making in adulthood. *Behav Pharmacol.* 2012; 23:34–42. [PubMed: 22123182]
- Odum AL. Delay discounting: I'm a K, you're a K. *J Exp Anal Behav.* 2011; 96:427–439. [PubMed: 22084499]
- Pardey MC, Homewood J, Taylor A, Cornish JL. Re-evaluation of an animal model for ADHD using a free-operant choice task. *J Neurosci Methods.* 2009; 176:66–71.
- Pardey MC, Kumar NN, Goodchild AK, Clemens KJ, Homewood J, Cornish JL. Long-term effects of chronic oral Ritalin administration on cognitive and neural development in adolescent Wistar Kyoto rats. *Brain Sci.* 2012; 2:375–404. [PubMed: 24961199]
- Pattij T, Schetters D, Janssen MCW, Wiskerke J, Schoffeleers ANM. Acute effects of morphine on distinct forms of impulsive behavior in rats. *Psychopharmacology.* 2009; 205:489–502. [PubMed: 19436995]
- Petry NM, Casarella R. Excessive discounting of delayed rewards in substance abusers with gambling problems. *Drug Alcohol Depend.* 1999; 56:25–32. [PubMed: 10462089]
- Perry JL, Larson EB, German JP, Madden GJ, Carroll ME. Impulsivity (delay discounting) as a predictor of acquisition of IV cocaine self-administration in female rats. *Psychopharmacology.* 2005; 178:193–201. [PubMed: 15338104]
- Pitts R. Reconsidering the concept of behavioral mechanisms of drug action. *J Exp Anal Behav.* 2014 Advance online publication.

- Pupe S, Brys I, Asherson PJE, Bizarro L. Prenatal alcohol exposure did not affect impulsivity in rats that performed delay or probability discounting tasks. *Psychol Neurosci*. 2011; 4:123–130.
- Rasmussen EB, Lawyer SR, Reilly W. Percent body fat is related to delay and probability discounting for food in humans. *Behav Processes*. 2010; 83:23–30. [PubMed: 19744547]
- Richards JB, Mitchell SH, de Wit H, Seiden LS. Determination of discount functions in rats with an adjusting-amount procedure. *J Exp Anal Behav*. 1997; 67:353–366. [PubMed: 9163939]
- Robinson ESJ, Eagle DM, Economidou D, Theobald DEH, Mar AC, Murphy ER, et al. Behavioural characterization of high impulsivity on the 5-choice serial reaction time task: specific deficits in ‘waiting’ versus ‘stopping’. *Behav Brain Res*. 2009; 196:310–316. [PubMed: 18940201]
- Schippers MC, Binnekade R, Schoffeleer ANM, Pattij T, De Vries TJ. Unidirectional relationship between heroin self-administration and impulsive decision-making in rats. *Psychopharmacology*. 2012; 219:443–452. [PubMed: 21887498]
- Simon NW, Gilbert RJ, Mayse JD, Bizon JL, Setlow B. Balancing risk and reward: a rat model of risky decision-making. *Neuropsychopharmacology*. 2009; 34:2208–2217. [PubMed: 19440192]
- Simon NW, LaSarge CL, Montgomery KS, Williams MT, Mendez IA, Setlow B, et al. Good things come to those who wait: attenuated discounting of delayed rewards in aged Fischer 344 rats. *Neurobiol Aging*. 2010; 31:853–862. [PubMed: 18657883]
- Slezak JM, Anderson KG. Effects of variable training, signaled and unsignaled delays, and d-amphetamine on delay-discounting functions. *Behav Pharmacol*. 2009; 20:424–436. [PubMed: 19730365]
- Slezak JM, Anderson KG. Effects of acute and chronic methylphenidate on delay discounting. *Pharmacol, Biochem, Behav*. 2011; 99:545–551. [PubMed: 21669219]
- Stanis JJ, Burns RM, Sherrill LK, Gulley JM. Disparate cocaine-induced locomotion as a predictor of choice behavior in rats trained in a delay-discounting task. *Drug Alcohol Depend*. 2008; 98:54–62. [PubMed: 18539407]
- Stanis JJ, Avila HM, White MD, Gulley JM. Dissociation between long-lasting behavioral sensitization to amphetamine and impulsive choice in rats performing a delay-discounting task. *Psychopharmacology*. 2008; 199:539–548. [PubMed: 18473112]
- Stein JS, Madden GJ. Delay discounting and drug abuse: empirical, conceptual, and methodological considerations. In: MacKillop, J.; de Wit, H., editors. *The Wiley-Blackwell handbook of addiction psychopharmacology*. Oxford, UK: Wiley-Blackwell; 2013. p. 165–208.
- Stein JS, Johnson PS, Renda CR, Smits RR, Liston KJ, Shahan TA, et al. Early and prolonged exposure to reward delay: effects on impulsive choice and alcohol self-administration in male rats. *Exp Clin Psychopharmacol*. 2013a; 21:172–180. [PubMed: 23356729]
- Stein JS, Smits RR, Johnson PS, Liston KJ, Madden GJ. Effects of reward bundling on male rats’ preference for larger-later food rewards. *J Exp Anal Behav*. 2013b; 99:150–158. [PubMed: 23319442]
- Sukhotina IA, Dravolina OA, Novitskaya Y, Zvartau EE, Danysz W, Bespolov AY. Effects of mGlu1 receptor blockade on working memory, time estimation, and impulsivity in rats. *Psychopharmacology*. 2008; 196:211–220. [PubMed: 17909752]
- Sun H, Cocker PJ, Zebb FD, Winstanley CA. Chronic atomoxetine treatment during adolescence decreases impulsive choice, but not impulsive action, in adult rats and alters markers of synaptic plasticity in the orbitofrontal cortex. *Psychopharmacology*. 2012; 219:285–301. [PubMed: 21809008]
- Vuchinich RE, Simpson CA. Hyperbolic temporal discounting in social drinkers and problem drinkers. *Exp Clin Psychopharmacol*. 1998; 6:292–305. [PubMed: 9725113]
- Weller RE, Cooke EW, Avsar KB, Cox JE. Obese women show greater delay discounting than healthy-weight women. *Appetite*. 2008; 51:563–569. [PubMed: 18513828]
- Wiskerke J, Schetters D, van Es IE, van Mourik Y, den Hollander BRO, Schoffeleer ANM, et al. μ -opioid receptors in the nucleus accumbens shell region mediate the effects of amphetamine on inhibitory control but not impulsive choice. *J Cogn Neurosci*. 2011a; 31:262–272.
- Wiskerke J, Stoop N, Schetters D, Schoffeleer ANM, Pattij T. Cannabinoid CB1 receptor activation mediates the opposing effects of amphetamine on impulsive action and impulsive choice. *PLoS ONE*. 2011b; 6:e25856. [PubMed: 22016780]

- Xie X, Arguello AA, Reittinger AM, Wells AM, Fuchs RA. Role of nicotinic acetylcholine receptors in the effects of cocaine-paired contextual stimuli on impulsive decision making in rats. *Psychopharmacology*. 2012; 223:271–279. [PubMed: 22526542]
- Zeeb FD, Floresco SB, Winstanley CA. Contributions of the orbitofrontal cortex to impulsive choice: interactions with basal levels of impulsivity, dopamine signaling, and reward-related cues. *Psychopharmacology*. 2010; 211:87–98. [PubMed: 20428999]
- Zuo Y, Wang X, Cui C, Luo F, Yu P, Wang X. Cocaine-induced impulsive choices are accompanied by impaired delay-dependent anticipatory activity in basolateral amygdala. *J Cogn Neurosci*. 2012; 24:196–211. [PubMed: 21916564]

Appendix

Summary of ID procedural components identified in a literature review

Authors	LLR Delays (s)	Trials per Block		Amount. Discrimination Criterion	0-s Delay Sessions	Inter-Block Blackout
		Forced Choice	Free Choice			
Anderson and Diller (2012)	0–60	2	6	✓	✓	
Baarendse and Vanderschuren (2012)	0–60	2	10			
Bañuelos et al. (2012)	0–32	2	10		✓	
Barbelivien et al. (2008)	0–60	2	6		✓	
Bezzina et al. (2008)	0.5–112 [#]	2	4			
Bezzina et al. (2009)	0.5–112 [#]	2	4			
Broos et al. (2012)	0–40	2	10			
Counotte et al. (2009)	0–40	2	10			
Dandy and Gatch (2009)	0–60	2	6	✓		
Diergaarde et al. (2008)	0–40	2	10			
Diergaarde et al. (2011)	0–40	2	10			
Diller et al. (2008)	0–16	2	6	✓	✓	
Dunnett et al. (2012)	0–60	2	10			
Flagel et al. (2010)	0–24	6	6			
García-Lecumberri et al. (2011)	0–60	Not reported				
Harty et al. (2011)	0–60	2	6	✓		
Harvey-Lewis et al. (2012)	0–30	4	10	✓		
Huskinson et al. (2012)	0–60	2	6	✓		
Koffarnus and Woods (2011)	0–60	2	8	✓		
Kolokotroni et al. (2011)	0–60	2	10			
Krebs and Anderson (2012)	0–60	2	6	✓	✓	
Loos et al. (2010)	0–40	2	10			
Lovic et al. (2011)	0–40	2	10	✓	✓	
Madden et al. (2010)	0–30	4	6		✓	✓
Mar et al. (2011)	0–60	2	10		✓	
Mendez et al. (2010)	0–60	2	10			
Mendez et al. (2012)	0–32	2	10			
Mitchell et al. (2012)	0–32	2	10			

Authors	LLR Delays (s)	Trials per Block		Amount. Discrimination Criterion	0-s Delay Sessions	Inter-Block Blackout
		Forced Choice	Free Choice			
Pardey et al. (2009)	0–120	2	30			
Pardey et al. (2012)	0–120	2	30			
Pattij et al. (2009)	0–40	2	10			
Pupe et al. (2012)	0–60	2	10			
Robinson et al. (2009)	0–60	2	10		✓	
Schippers et al. (2012)	0–40	2	10			
Simon et al. (2009)	0–60	2	10			
Simon et al. (2010)	0–60	2	10		✓	
Slezak and Anderson (2009)	0–60	2	6	✓	✓	
Slezak and Anderson (2011)	0–16	2	6	✓	✓	
Stanis, Burns et al. (2008)	0–60	2	10			
Stanis, Avila et al. (2008)	0–60	2	10			
Stein et al. (2013a)	0–45	6	14	✓	✓	✓
Stein et al. (2013b)	0–15	6	14	✓	✓	✓
Sukhotina et al. (2008)	0–60	2	5	✓		
Sun et al. (2011)	0–45	2	10			
Wiskerke, Schetters et al. (2011)	0–40	2	10			
Wiskerke, Stoop et al. (2011)	0–40	2	10			
Xie et al. (2012)	0–60	2	6	✓	✓	
Zeeb et al. (2009)	0–45	2	10		✓	
Zuo et al. (2012)	0–20	2	25			

[#] Reflects maximum delay range across multiple conditions.

Reflects maximum delay range across multiple, subject-specific sub-ranges.

Fig. 1. Mean indifference delays in the AD and ID task for both groups. Error bars represent standard error of the mean.

Fig. 2.

A: Obtained ID indifference delays plotted as a function of obtained AD indifference delays for each subject; the solid line is the line of best fit for the obtained data, while the dashed line represents the line of perfect correspondence between ID and AD indifference delays.

B: Galton squeeze plot of Z-score standardized indifference delays from the first and second discounting assessments.

Table 1

Percent LLR Choice (mean and SEM) for All Subjects in Each Group

Subject	0-s LLR			10-s LLR			20-s LLR			40-s LLR			60-s LLR		
	Choice	SEM		Choice	SEM		Choice	SEM		Choice	SEM		Choice	SEM	
<i>AD-ID</i>															
A2	86.67	5.42		66.67	7.3		16.67	5.42		0	0		1.67	1.83	
A3	98.33	1.83		100	0		88.33	6.58		50	11.31		6.67	5.42	
A5	95	5.48		63.33	6.11		25	7.87		6.67	3.65		3.33	2.31	
A6	98.33	1.83		90	5.66		33.33	10.83		3.33	2.31		3.33	2.31	
A8	100	0		18.33	3.37		1.67	1.83		0	0		0	0	
A9	100	0		96.67	2.31		65	12.57		18.33	7.7		1.67	1.83	
A16	100	0		53.33	6.73		6.67	2.31		1.67	1.83		3.33	2.31	
A18	98.33	1.83		56.67	10.46		10	2.83		1.67	1.83		0	0	
A19	100	0		81.67	6.58		18.33	12.46		0	0		0	0	
A20	100	0		76.67	8.79		15	4.69		6.67	5.42		3.33	3.65	
<i>ID-AD</i>															
A1	100	0		73.67	6.54		28.33	6.01		15	4.28		8.33	1.67	
A4	96.67	2.11		16.67	6.67		0	0		0	0		0	0	
A7	93.33	4.22		1.67	1.67		0	0		0	0		0	0	
A10	98.33	1.67		3.33	2.11		0	0		1.67	1.67		0	0	
A11	100	0		96.67	3.33		43.33	10.85		16.67	5.58		6.67	2.11	
A12	98.33	1.67		10	2.58		0	0		0	0		0	0	
A13	100	0		0	0		0	0		0	0		0	0	
A14	95	2.24		56.67	12.02		18.33	4.01		11.67	4.01		6.67	2.11	
A15	100	0		71.67	6.54		28.33	6.01		15	4.28		8.33	1.67	
A17	100	0		71.67	6.54		28.33	6.01		15	4.28		8.33	1.67	

Note: Mean and SEM were calculated across the last six sessions of the ID procedure.

Table 2

Indifference Delays and Variance Accounted For (VAF) for All Subjects in the ID Task

Subject	Group			
	AD-ID		ID-AD	
	ID Indiff. Delay (s)	VAF	Subject	ID Indiff. Delay (s) VAF
A2	12.74	99.12	A1	15.26 95.25
A3	39.64	99.69	A4	6.77 99.99
A5	13.58	99.05	A7	3.93 99.99
A6	17.59	99.74	A10	5.48 99.96
A8	7.94	99.96	A11	19.64 95.66
A9	26.72	98.78	A12	6.50 99.99
A16	10.51	99.60	A13	4.64 99.98
A18	11.15	99.79	A14	11.87 96.57
A19	15.01	99.99	A15	15.26 95.25
A20	14.08	99.28	A17	15.26 95.25

Table 3

Indifference Delays (mean and SEM) for All Subjects in the AD Task.

Subject	Group			
	AD-ID	ID-AD		
	AD Indiff Delay (s)	SEM	Subject	AD Indiff Delay (s) SEM
A2	15.17	0.32	A1	32.85 0.74
A3	14.57	0.61	A4	8.81 0.35
A5	4.50	0.29	A7	6.33 0.43
A6	17.53	0.56	A10	7.53 0.31
A8	6.10	0.24	A11	32.20 0.25
A9	19.93	0.50	A12	10.13 0.28
A16	7.77	0.37	A13	7.10 0.30
A18	14.77	0.95	A14	11.02 0.47
A19	7.87	0.29	A15	14.39 0.39
A20	12.17	0.70	A17	9.30 0.52

Note: Mean and SEM were calculated across the last six sessions of the AD procedure.