Performance in Temporal Discounting Tasks by People With Intellectual Disabilities Reveals Difficulties in Decision-Making and Impulse Control

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Abstract
The subjective value of rewards declines as a function of the delay to receive them (temporal discounting). Three temporal discounting tasks that assessed preferences between small amounts of money (10 pence) over short delays (60 s), moderate amounts of money (£10) over moderate delays (2 weeks), and large amounts of money (£1000) over long delays (12 months) were presented to people with intellectual disabilities (Full-Scale IQ < 70) and to a comparison group (*n*s = 20 for each group). Measures of IQ, financial knowledge, memory, and executive functioning were also obtained. Only a third of the service users were able to perform the temporal discounting tasks consistently, and they tended to respond impulsively. The proportion of participants responding consistently increased following training. Both the initial performance and the effect of training were related to executive functioning but not IQ.

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In a choice between a small immediate reward and a larger delayed reward, the likelihood of choosing the smaller immediate pay-off typically increases the longer the wait for the delayed alternative and the larger the size of the immediate alternative. This behavior is known as *temporal discounting*, which implies that delayed pay-offs are perceived as having a lower subjective value and discounted. Temporal discounting is typically studied using tasks that offer a range of choices between immediate and delayed financial rewards, but similar functions are seen across a wide variety of outcomes, such as consumables (foods or drugs), health outcomes, or leisure activities (Chapman & Elstein, 1995; Critchfield & Kollins, 2001; Estle, Green, Myerson, & Holt, 2007; Green & Myerson, 2004; Reynolds, 2006). Temporal discounting is also seen in animals (e.g., rats or pigeons), which, after training, produce temporal discounting functions that are indistinguishable from those seen in people (Critchfield & Kollins, 2001; Dalley, Mar, Economidou, & Robbins, 2008; Green & Myerson, 2004; Kacelnik, 1997; Rodriguez & Logue, 1998), and single neurons have been detected in the pigeon brain that encode the trade-off between value and delay (Kalenscher et al., 2005).

In some circumstances, temporal discounting is rational; after very long delays, the value of goods may genuinely decrease (e.g., because of inflation, depreciation, or missed opportunities). However, in most examples of temporal discounting, such factors are not present, and temporal discounting then represents a form of *impulsivity*, a preference for immediate over delayed gratification even when this incurs a cost. Impulsivity has been demonstrated, using temporal discounting tasks, in several clinical groups of people who are known to behave impulsively. Examples are those scoring high on an impulsiveness trait (Ostaszewski, 1997), substance abusers (Bickel et al., 2007; Green & Myerson, 2004; Reynolds, 2006), pathological gamblers (Dixon, Jacobs, & Sanders, 2006; Reynolds, 2006), children and adolescents with ADHD (Barkley, Edwards, Lanieri, Fletcher, & Matevia, 2001; Marco et al., 2009; Schweitzer & Sulzer-Azaroff, 1995; but see Scheres et al., 2006; Scheres, Lee, & Sumiya, 2008), and patients with traumatic brain injury (McHugh & Wood, 2008) or impulse control problems (Crean, de Wil, & Richards, 2000). Temporal discounting is also greater in children than in adults (Olson, Hooper, Collins, & Luciana, 2007; Scheres et al., 2006; Steinberg et al., 2009). Abnormally high rates of temporal discounting (i.e., high levels of impulsivity) are typically associated with poor performance on executive functioning tasks (Barkley et al., 2001; Bickel et al., 2007; Hinson, Jameson, & Whitney, 2003; Shamosh et al., 2008; Weber & Huettel, 2008).

Anecdotally, many people with intellectual disabilities experience difficulty in delaying gratification, but this has rarely been formally studied. A procedure involving a single choice between a small immediate reward (e.g., a marshmallow) and a larger delayed alternative (e.g., two marshmallows) has been used to examine inhibition of immediate responding by people with intellectual disabilities and to teach tolerance to delay, but these studies did not include a comparison with intellectually able participants (Cuskelly, Einam, & Jobling, 2001; Dixon et al., 1998, Dixon, Homer, & Guercio, 2003; Vollmer, Borrero, Lalli, & Daniel, 1999). To the best of our knowledge, the only studies that did include this comparison were in young children with Down syndrome, who did tend to be less able to inhibit responding than the comparison group (Cuskelly, Zhang, & Hayes, 2003; Kopp, 1990).

Temporal discounting tasks address a similar question, but by presenting a multiplicity of choices, they provide a more sophisticated account of the trade-off between reward value and delay. This is achieved by establishing the extent to which different rewards are discounted at different delays, from which a measure of impulsivity can be derived that is independent of specific rewards and delays. Temporal discounting procedures in which the delay intervals were gradually increased, over an extended training period, were used in two early studies to teach tolerance to delay to three adolescents with severe mental retardation (Ragotzy et al., 1988) and five impulsive preschool children (Schweitzer & Sulzer-Azaroff, 1988). In both studies, food rewards and brief delays of less than 3 min were used.

Our aim in the present study was to develop a temporal discounting task that could be used to study financial decision-making by people with intellectual disabilities involving time scales (days or weeks rather than minutes) that are typical of such decisions. We also wished to avoid the need for extensive training in order to minimize the load on participants. These are the typical conditions used in contemporary temporal discounting studies (see, e.g., Green & Myerson, 2004); however, temporal discounting tasks using symbolic reinforcers (e.g., money) and delays longer than a few minutes, and not requiring training, have not previously been used with people who have intellectual disabilities, perhaps because typical temporal discounting procedures are unsuitable (too complex or too abstract) for presentation to people with intellectual disabilities. Recently, however, a version of the temporal discounting task was developed that is accessible to young children without extended training and could, in principle, be extended to long delays. Scheres et al. (2006) used pictorial representations of choices between small amounts of money (up to 10¢) and short delays (up to 60 s) and reported steeper temporal discounting by 6- to 11-year-olds than by adolescents. In the present study we examined temporal discounting in adults with intellectual disabilities, using a modified version of the task described by Scheres et al. as well as two comparable tasks with a similar format, to examine temporal discounting for larger rewards (up to £1000) and longer delays (up to 12 months).

An inability to delay gratification creates a bias in financial decision-making that, if sufficiently large, may raise a question as to whether the capacity to make such decisions is undermined (McHugh & Wood, 2008). It is, therefore, important to be able to measure impulsivity so that the extent of this bias can be assessed. However, there is also another way in which temporal discounting tasks may be relevant to the question of decision-making capacity. In England

and Wales the Mental Capacity Act (2005) defines *capacity* as the ability to understand and retain relevant information, weigh the information for the purpose of reaching a decision, and communicate the decision; but what does it mean to "weigh" information in order to reach a decision? If two choices are expressed in the same units (e.g., £10 vs. £100), then the problem of deciding between them is trivial. The essential problem in weighing information arises when there is a need to integrate information from two or more sources that are expressed in different dimensions (Green & Myerson, 2004, p. 569). This exactly describes the temporal discounting task, which consists of a series of trade-offs between reward magnitude and delay. Viewed in this light, the ability to perform the temporal discounting task, irrespective of the gradient of discounting, represents a significant feat of decision-making that requires a set of strategies to be formulated and held constant for the duration of the experimental session. This analysis suggests a role for executive functioning in weighing information and implies that a sufficient level of executive functioning may be essential for temporal discounting tasks to be performed in a meaningful way. In order to evaluate this possibility, we also incorporated two batteries of executive functioning tests (Ball, Holland, Treppner, Watson, & Huppert, 2008; Emslie, Wilson, Burden, Nimmo-Smith, & Wilson, 2003), with the hypothesis that performance in temporal discounting tasks would be impaired in people with low executive functioning.

Method

Participants

The participants were 20 individuals who attended a day service for people with intellectual disabilities and a control group of 20 staff members working in intellectual disability services. Data for one of the service users were excluded because this person did not have the requisite financial knowledge for the temporal discounting task to be meaningful (see below: *Financial knowledge*). All participants provided informed consent, and the study was approved by the Local Research Ethics Committee.

The service users all met the World Health Organization definition of *intellectual disability* (which in the United Kingdom is termed *learning disability*), using the criteria of significant impairments of both intellectual and functional ability acquired in childhood (British Psychological Society, 2000). They were verified (see below: *Cognitive ability*) as having a Full-Scale IQ of < 70 ($M = 59.8$, $SD = 5.4$). Functional ability was not assessed but can be assumed to be significantly impaired on the basis that attendance at the day service is a scarce resource that is reserved for individuals who have substantial support needs.

Temporal Discounting Tasks

Participants completed three temporal discounting tasks, Planes, Trucks, and Ships, which were programmed in E-Prime and presented on a laptop computer. In all tasks, a series of choices between small immediate and large delayed rewards was presented on the screen, and the experimenter provided the same information verbally. Feedback was also presented both visually and verbally. Participants were told that no rewards would actually be delivered.

Planes. The Planes task was a modified version of the task described by Scheres et al. (2006). The main modifications were the use of pence rather than cents, the addition of two blocks of practice trials, and the use of verbal prompts.

On each trial, two airplanes appeared, one at each side of the screen. One flew at ground level and carried 2, 4, 6. or 8 coins (pence in this version), while the other carried 10 pence and flew at varying heights; the position of the two options varied in a counterbalanced manner from trial to trial (see Scheres et al., 2006, Figure 1). The experimenter explained the nature of the choice (small immediate vs. larger delayed reward) and stated that the larger reward "might not arrive." The participant made a choice by pressing the *A* key for the plane on the left of the screen and the *L* key for the plane on the right of the screen. If participants chose the ground level plane, the money it carried was immediately dropped into a container in the center of the screen. The choice of the higher plane led to 10 pence being dropped into the container after an interval of 5, 10, 20, 30, or 60 sec, depending on the height of the plane. This was accompanied by the message "Well done: You have won x pence." The experimenter then initiated the next trial; no intertrial interval was added, so trials varied in duration according to the choice made. A total of 80 trials was presented, 4 each at each combination of 4 values and 5 times, with the total amount won displayed at the end of every 10 trials.

Participants were given a practice block of 10 trials that were not scored. Two additional blocks of practice tests were inserted prior to the main test, in which choices were presented between alternatives varying along a single dimension. In the first practice block (20 trials) participants were offered a choice between the same amount of money (£10) at different heights (immediate delivery vs. 5, 10, 20, 30 or 60 s); in the second practice block (16 trials), participants were offered a choice between planes at the same height (ground level) carrying different amounts of money (10 pence vs. 2, 4, 6, or 8 pence).

Trucks. The Trucks task used essentially the same software and instructions as the Planes task, but involved a longer time scale; therefore, it did not take place in real time. On each trial the participant saw a picture of a long road winding into the distance up the screen and was offered a choice between a truck at the bottom of one side of the screen and a second truck some way up the road at the opposite side of the screen. The closer truck carried either £2, £4, £6, or £8 to be delivered now, whereas the more distant truck carried £10 to be delivered after 1 day, 2 days, 4 days, 1 week, or 2 weeks, with increasing times represented by a smaller picture higher on the screen (i.e., further away). If the participant chose the immediate alternative, the message "Well done! You have won £x" was presented immediately. If the delayed alternative was chosen the message "Well done! You have won £10 but you will have to wait for it" was presented, after a symbolic delay of 1 to 6 s.

As in the Planes task, participants were given a first block of practice trials in which they were asked to choose between immediate delivery of different amounts of money (£10 vs. 2, 4, 6, or 8) and a second practice block where the choice was between delayed deliveries of £10 (now vs. 1, 2, 4, 7, or 14 days).

Ships. The Ships task was exactly parallel to the Trucks task. The only difference was that the visual display showed two ships, one in the dock carrying £200 to £800 to be delivered immediately, the other out at sea and carrying £1000 to be delivered after 1, 2, 3, 6, or 12 months.

Scoring

Figure 1 shows the performance of 4 participants tested in one of the temporal discounting tasks in a pilot study. Figure 1C depicts a typical, orderly, temporal discounting performance, where choice of the delayed alternative decreases as the delay increases and/or the value of the immediate alternative increases. The two extremes of performance are also shown, labeled impulsive (Figure 1A: the small immediate alternative is almost always chosen) and acquisitive (Figure 1B: the large delayed alternative is almost always chosen). However, we also saw many sessions resembling Figure 1D. (It was these sessions that led us to add practice blocks to the procedure to determine whether participants who produced this type of performance were able to perform appropriately on unidimensional choice tasks.)

Inconsistent responding in temporal discounting tasks is typically dealt with by discarding data from participants who perform in this way (e.g., Dixon et al., 2006; Olson et al., 2007; Wileyto, Audrain-McGovern, Epstein, & Lerman, 2004). However, in the present study the frequency of inconsistent responding was so high that it would be unreasonable simply to discard all of these data. Instead, we devised two measures to characterize these unusual performances.

Complexity measures the extent to which participants use both dimensions. The use of a single dimension would be reflected in choice scores for the delayed alternative of 0 (impulsive) or 100% (acquisitive). Complexity is, therefore, defined as the number of choices where the score is neither 0 nor 100%, except where this reflects a transition between the two extremes. (Complexity scores are 1 for Figures 1A and 1B, 5 for Figure 1C, and 17 for Figure 1D.)

Inconsistency measures the extent to which choices are made in a disorderly fashion. Conventionally, choice scores should decrease when moving from top left to bottom right. Inconsistency is, therefore, defined as the number of choice scores that increase when moving from left to right along the value functions at each delay (i.e., the lines in Figure 1) and from top to bottom down the delay functions at each value (inconsistency scores are 0 for Figures 1A, B, and C, and 13 for Figure 1D).

For sessions where performance was nonrandom, we constructed a temporal discounting function by reading off the indifference point at each time delay, defined as the value at which the immediate alternative was chosen on 50% of trials (see dotted line at 50% in Figure 1C). Values of 0 or 100% were attributed where the choices were all above 50% (cf. Figure 1B, delays 1-4) or below

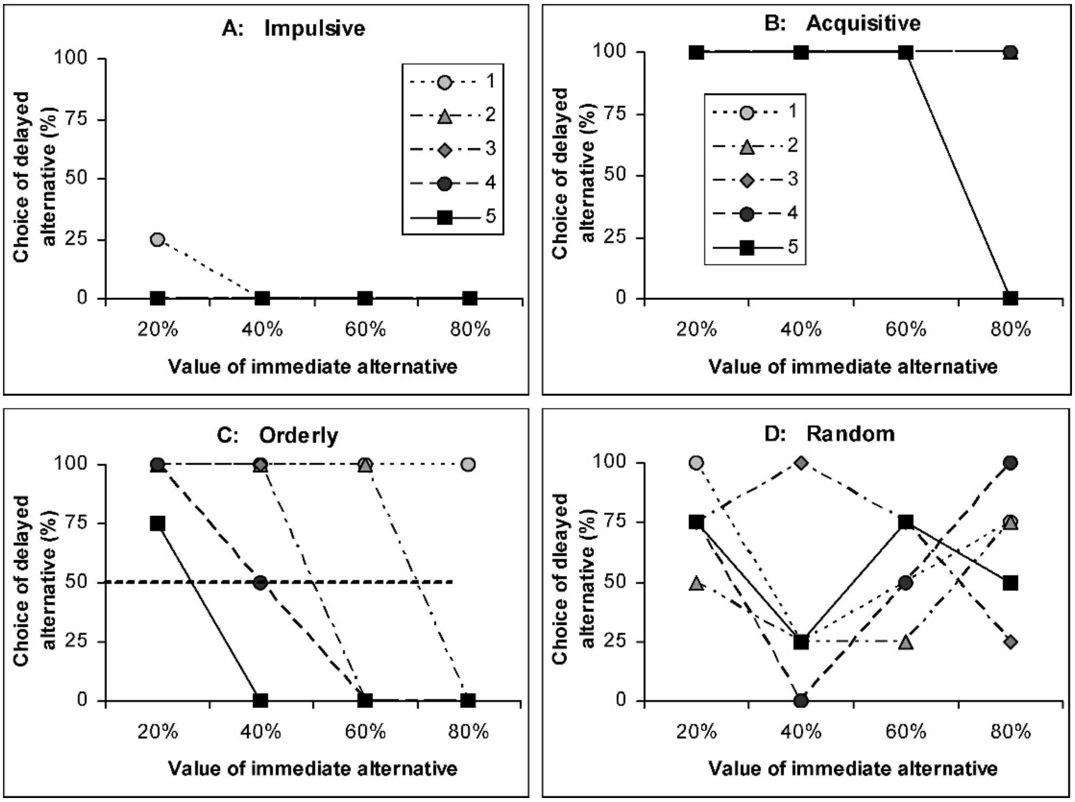

Figure 1. Results for 4 participants showing the relationship between value of the immediate alternative (horizontal axis) and choice of the delayed alternative (vertical axis) as a function of the length of the delay (shown in the key, where 1 is the shortest delay and 5 the longest). As these figures show representative examples of different types of performance, values are shown as a percentage of the maximum value (which could be 10 p, £10, or £1000) and delays are shown as five levels (which could be 5 to 60 s, 1 to 14 days, or 1 to 12 months).

50% (cf. Figure 1A, delays 1–5). The indifference points were summed to provide an area under the curve (AUC) (Myerson Green, & Warusawitharana, 2001). A small AUC reflects steep temporal discounting (cf. Figure 1A), while a large AUC reflects shallow temporal discounting (cf. Figure 1B).

Other Tests

Cognitive ability. All participants were assessed for receptive language ability using the British Picture Vocabulary Scale, 2nd ed. (BPVS), a British version of the Peabody Picture Vocabulary Scale, and services users (but not staff) were also assessed for intellectual ability using the Wechsler Abbreviated Scale of Intelligence (WASI). The WASI Verbal IQ (VIQ) and Performance IQ (PIQ) scores are equivalent to the Verbal Comprehension Index and the Perceptual Organization Index on the Wechsler Adult Intelligence Scale (WAIS). These measures are considered to provide purer measures of intellectual ability than do the WAIS VIQ and PIQ scores, which also include elements of executive functioning.

Financial knowledge. Service users' financial knowledge was assessed using a novel test, Coins and Costs. In Part A (Coins), two of each of the eight coins of the realm were spread on a table and the participant was asked to identify each coin (once). In Part B (Costs) the participant was shown six pictures, identified as an ice cream, a CD (compact disc), a small television, a nice holiday for two, a new car, and a small house, and they were asked to identify which item would cost £1, £10, £100, £1000, £10,000, or £100,000. Half a point was awarded for coins correctly identified and one point, for costs correctly identified, making a maximum score of 10. The mean score on this test was 6.55, with an *SD* of 1.46. One participant scored 3 on the test, which is a statistical outlier (> 2 *SD*s below the group mean). As some degree of financial knowledge is essential for the temporal discounting task to be meaningful, this participant's data were discarded.

Executive functioning. We evaluated executive functioning, for service users only, using two batteries of tests: the Children's version of the Behavioural Assessment of the Dysexecutive Syndrome–BADS-C (Emslie et al., 2003), which includes five tests of executive functioning; and a recently described battery, the Cambridge Executive Functioning Assessment for People With Intellectual Disability (CEFA-ID), which consists of six executive functioning tests and six memory tests (Ball et al., 2008). In addition to the original sources, details of both test batteries are provided in Willner, Bailey, Dymond, and Parry (in press).

Procedure

All participants first provided informed consent; in the case of service users, a staff member witnessed this procedure. Staff members completed the three temporal discounting tasks and the BPVS over two sessions. The Planes task was presented in one session and the Trucks and Ships tasks in the other, with the order (Planes/Trucks/Ships vs. Ships/Trucks/Planes) counterbalanced across participants.

Service users were tested over five sessions. Tests were conducted in the following order: Session 1: WASI, BPVS, Coins and Costs; Sessions 2 and 3: temporal discounting tasks, with the order (Planes/Trucks/Ships vs. Ships/Trucks/Planes) counterbalanced across participants; Session 4: BADS-C; Session 5: CEFA-ID.

After each session, we asked service users to rate their experience of the session on a 3-point scale ("I didn't like it"; "I liked it a bit"; "I liked it a lot"). Ninety nine of the 100 sessions were rated as "liked a lot" and 1 as "liked a bit."

Approximately 8 months later, 12 of the service users were retested twice with the Trucks task. The first test was identical to the earlier test. For the second test the blocks of practice trials with performance on a single dimension (time or value) were modified such that the first half of the trials in each practice block were used as training trials, in which the experimenter gave feedback on each trial and, in the event of an incorrect response, an explanation of how the task should be performed.

Statistical Analysis

We initially assessed performance on the temporal discounting tasks by analysis of variance (ANOVA), with the between-groups factor Group (service users vs. staff) and the within-groups factor Task. In a subsequent analysis we added the additional factor Order (Planes/Trucks/Ships vs. Ships/Trucks/Planes). Differences on other variables between service users and staff members, between subgroups of service users, and between successive tests were evaluated using *t* tests. We employed a cluster analysis to confirm the existence of two distinct groups of service users and stepwise logistic regression to examine the relative importance of executive functioning and IQ in relation to the difference between these two groups. We evaluated relationships between AUC in different tasks and between temporal discounting measures and executive functioning scores, using Pearson's product-moment correlation.

Results

Demographics

The two groups were similar in age (mean ± standard error): service users, 40.7±2.8; staff, 41.7±2.4, and gender distribution (service users, 50% female; staff, 75% female), As expected, receptive language ability was higher for staff members than for service users (mean ± standard error BPVS raw scores: 149±3 vs. 84±7 corresponding to standardized scores of 133 and 55). The control group's apparently very high score reflects the fact that the highest age-standardized norms for the BPVS are for 15-year-olds, which tends to inflate the score obtained by able adults.

Performance on Temporal Discounting Tasks

Performance on the three temporal discounting tasks is shown in Figure 2. Overall, complexity of performance was significantly higher for service users than for staff, $F(1, 37) = 10.19$, $p < .01$, and inconsistency was much higher, $F(1, 37) = 50.01$, $p < .001$. Service users also made many more errors on practice tasks, $F(1, 37) = 63.18$, $p < .001$. Performance on all three measures was very similar across the three tasks, all F values less than 1 for main effects of Task or Task × Group interactions.

Figure 3 shows performance on the Planes and Ships tasks according to whether the task was presented first or third. There were no significant order effects, and max F value for main effects or

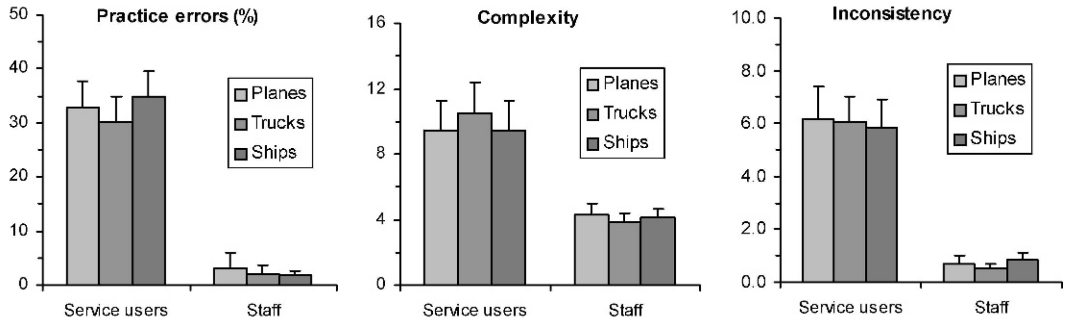

Figure 2. Performance of service users and staff on the three temporal discounting tasks. Practice errors are shown as a percentage of the maximum (36 trials); for definitions of *complexity* and *inconsistency*, see text.

interactions was 1.15, indicating that temporal discounting performance did not improve with practice.

Figure 4 is a scatter plot of individual complexity and inconsistency scores, summed across the three tasks. It is clear from inspection of the figure that service users' scores show a bimodal distribution on both measures. We confirmed this finding by conducting a cluster analysis that identified two groups of service users, a larger group ($n = 13$), with very high scores on both measures; and a smaller group ($n = 6$), whose scores are more comparable to those of the control group. Within the control group, one participant, who had scores that were not consistent with the rest, was confirmed as a statistical outlier (>2 *SD* above the mean on both complexity and inconsistency). This participant, who was close to the group mean on both age and BPVS score, was excluded from further analyses.

Performance in the larger group of service users identified in Figure 4 resembled that shown in Figure 1D. With the exception of a small number of sessions on an individual temporal discounting task that was not replicated in the other tasks, these service users performed the temporal discounting tasks in an essentially random fashion. In the smaller group, inconsistency scores were very similar to those of the staff group, $t(23) = 0.88$, $p > .5$, but they had significantly lower complexity scores, $t(23) = 5.56$, $p < .001$. In effect, the staff group was performing in the manner shown in Figure 1C, while the performance of the small group of service users was closer to that shown in Figure 1A or 1B. Inspection of the individual performances showed that the service users were predominantly impulsive (72% of sessions), as in Figure 1A.

Relationship to Executive Functioning

The two groups of service users identified in Figure 4 did not differ significantly in age, IQ, receptive language ability, financial knowledge, or the memory component of the CEFA-ID, although the consistent group scored higher on all assessments than did the inconsistent group, and the differences for receptive language and mem-

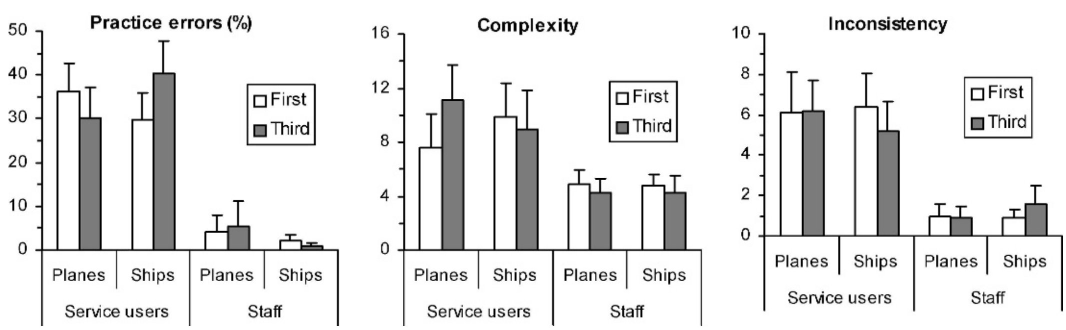

Figure 3. Performance in temporal discounting tasks as a function of the order of presentation (planes/trucks/ships or ships/trucks/planes). Practice errors are shown as a percentage of the maximum (36 trials); for definitions of *complexity* and *inconsistency*, see text.

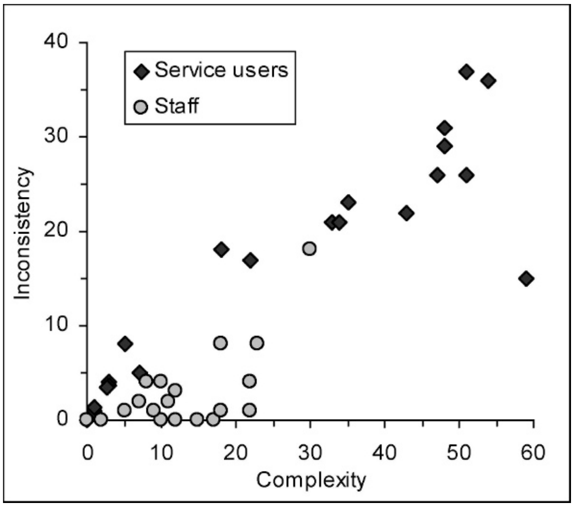

Figure 4. Scatter plot showing the relationship between complexity and inconsistency scores for individual participants. Cluster analysis confirmed the presence of two distinct groups of service users (*n*s = 13 and 6). There was also one very atypical staff member.

ory were almost significant (Table 1). However, the random group scored substantially lower than the consistent group on both batteries of executive functioning tests (BADS-C: $t(17) = 3.20$, $p < .01$; executive functioning component of the CEFA-ID: $t(17) = 2.42$, $p < .02$). The tests that showed the greatest separation between groups were the Key Search test from the BADS-C and the Tower of London test from the CEFA-ID battery, $t(17) = 3.61$, $p < .002$, and $t(17) = 3.11$, $p < .005$, respectively). The random group also made many more practice errors (*M*s = 15.4±3.1% vs. 40.5±4.1%), $t(17) = 4.88$, $p < .001$. Although there was no overall difference in the memory component of the CEFA-ID, the random group had significantly lower scores on one subtest (Prospective Memory *M*s = 3.67±0.21 vs. 2.31±0.41), $t(17) = 2.92$), $p < .01$, which is considered to include an executive functioning component (Ball et al., 2008).

We used logistic regression analyses to examine whether IQ and executive functioning scores would predict group membership. When FSIQ was entered alongside either BADS-C or CEFA-EF) scores, the executive functioning scores were both retained as significant predictors, *p*s < .01 and.05, respectively), but IQ was not.

Because the random group performed poorly on the one-dimensional practice trials, the temporal discounting task was subsequently modified to provide training on these practice tasks. The re-test was completed for 12 of these 13 participants (one participant was no longer attending the center). Performance on the first re-test, using the identical version of the Trucks task to that used earlier, was essentially unchanged from the initial test (results not shown), confirming the finding that simple repetition of the task did not improve performance (Figure 3). Training resulted in a substantial decrease in practice errors, $t(11) = 4.32$, $p < .001$, which was very similar on the first half of each practice block, when feedback was

Table 1. Comparisons Between Groups of Service Users Performing Consistently and Randomly in Temporal Discounting Tasks

	Consistent		Random		
Measure	Mean	*SD*	Mean	*SD*	*t*(17)
Age	41.2	6.5	40.5	3.0	0.10
Full-Scale IQ	62.5	2.8	58.5	1.5	1.19
Verbal IQ	65.5	3.3	62.4	2.5	0.71
Performance IQ	64.7	2.4	60.3	1.0	1.55
BPVS[a] raw score	101.8	9.4	72.1	8.8	2.00
Coins & Costs	7.3	0.4	6.5	0.3	1.60
Memory[b]	81.2	2.3	68.4	5.9	2.01
BADS-C[c]	27.0	2.9	18.6	1.6	3.20*
CEFA-EF[d]	38.8	2.1	29.5	3.3	2.42*

[a]British Picture Vocabulary Scale. [b]From the Cambridge Executive Functioning Assessment for People With Intellectual Disability (CEFA-ID). [c]Children's Version of the Behavioural Assessment of the Dysexecutive Syndrome. [d]Executive Functioning score.
*$p < .02$.

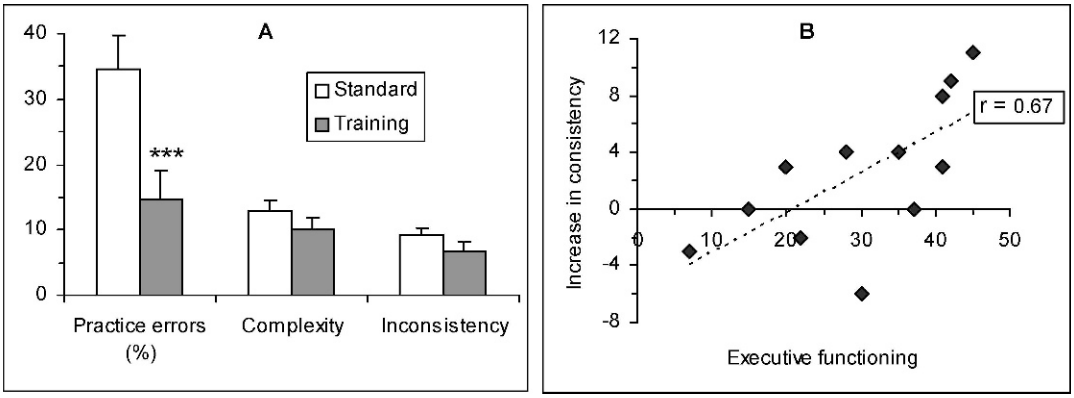

Figure 5. A. Performance of the randomly performing group of service users on two further sessions using the Trucks task. The first session was carried out using standard presentation, with performance essentially the same as that shown in Figure 1; the second session included the provision of feedback on the first half of each block of one-dimensional practice trials. *** $P < .001$. B. Relationship between the change in Inconsistency scores following training on practice trials and scores on the Executive Functioning component of the Cambridge Executive Functioning Assessment for People With Intellectual Disability (CEFA-ID).

provided, and the second half of each block, which was performed without feedback (*M*s and standard errors = 2.8±0.8 and 2.6±0.8 errors, respectively). Training had relatively little effect overall on complexity and inconsistency scores (Figure 5A). However, 4 of the 12 participants now had very low inconsistency scores (0–2), comparable to those of the consistent group. These 4 participants also made very few practice errors compared with a decreased, but still relatively high level of practice errors by the 8 participants who remained unable to perform consistently (M = 2% vs. 21% errors, respectively). A relationship to executive functioning was again apparent, as there was a significant correlation between the decrease in Inconsistency scores following practice training and scores on the executive functioning component of the CEFA-ID (see Figure 5B), $r(11) = .67$, $p < .02$. Again, there was no significant relationship to IQ or BPVS scores, max $r(11) = .28$.

Impulsivity

The AUC was calculated for each of the three tasks, for the 25 participants who performed consistently in the initial tests (19 staff members and 6 service users). Mean (±SEM) AUC was very similar for all three tasks, despite the very large differences of scale (Planes: 29.6±3.4; Trucks: 34.3±3.1; Ships: 31.4±2.8). The relationship between performance on the Trucks and Ships tasks, $r = .90$, $p < .001$, was significantly stronger, $p < .001$, than the relationship between Planes and either Trucks, $r = .43$, $p < .05$, or Ships, $r = .37$, $p = .06$. A similar picture was seen when these analyses were restricted to staff members, but the three correlation coefficients were now closer together (.82, .63, and .52, respectively), and the differences between Planes and Trucks or Ships failed to reach significance.

Figure 6 shows the temporal discounting performance on the Trucks task (which was used in both the initial tests and the retest), comparing staff members ($n = 19$) and service users ($n = 10$, 6 from the first test and 4 from the final test). Service users showed substantially greater discounting, as confirmed by a significant difference in area under the curve, $t(28) = 2.98$, $p < .005$.

Discussion

Temporal Discounting Tasks

The three temporal discounting tasks used in the present study together span an extremely wide range of durations (from seconds to a year) and values (from pence to £1000). The fact that the AUC measure (Myerson et al., 2001) revealed essentially the same discounting function in all three tasks provides further confirmation of the very well established magnitude effect in temporal discounting, namely, that smaller rewards are discounted more steeply than are larger rewards (e.g., Green, Fisher, Perlow, & Sherman, 1981; Green & Myerson, 2004; Johnson & Bickel, 2002;

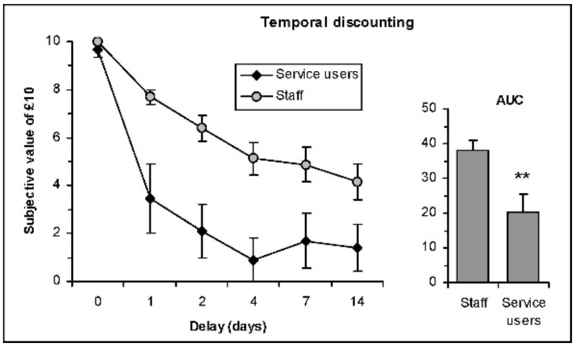

Figure 6. Left panel: Indifference curves showing the subjective value of £10 as a function of delay (Trucks task). Right panel: Area under the curve (AUC). Values are means±SEM. $^{**}p<.01$.

Kirby, 1997). The tasks used here include the original version of the child-friendly task devised by Scheres et al. (2006), which is conducted in real time, and the two novel imagined versions, which involve decision-making in relation to larger amounts of money over longer time scales.

In all tasks, rewards were hypothetical (i.e., no rewards were actually delivered). The evidence suggests that, in general, it makes very little difference to performance in temporal discounting tasks whether real or hypothetical rewards are used (Johnson & Bickel, 2002; Madden, Begotka, Raiff, & Kastern, 2003). However, there is some evidence of a difference between performance for real and hypothetical rewards for children with ADHD (Scheres et al., 2008), and this might also be the case for people with intellectual disabilities. There did appear to be a subtle difference between the Planes task on the one hand, and the Trucks and Ships tasks on the other because although significant correlations were seen between discounting rates on all of these tasks, the correlation between performance on the Trucks and Ships tasks was higher than the correlations of either of these tasks with the Planes task. This suggests that the latter task may involve processes that are partly independent of those underlying performance on the former tasks. This could relate either to the smaller magnitude (up to 10 pence) and shorter time scale (up to 60 s) of the Planes task or to the fact that in this task, although the rewards were hypothetical, the delays were real.

Consistency of Performance

Perhaps the most striking finding of this study was that almost half of the service users were unable to perform the temporal discounting tasks in a consistent fashion. The temporal discounting literature includes studies in the general adult and child populations and in a variety of clinical groups, but we are not aware of any previous study in which so many of the participants performed inconsistently. To the best of our knowledge, the highest proportion of inconsistent responding in the literature is below 20%, (Olson et al., 2007), and the criterion used in that study would have excluded some of our consistent group in addition to our inconsistent responders. Rather than discarding these data, the typical way of dealing with this problem, we developed measures–complexity and inconsistency–that describe the quality of performance. Using these measures, we found a similar level of difficulty with all three tasks. Greater familiarity with the procedure did not appear to improve performance, because there was no evidence of improvement over successive tests, but performance did improve in some individuals following training on the practice elements that preceded the main task.

Participants who performed inconsistently on the temporal discounting tasks, both the services users and the one inconsistent staff member, also made numerous errors on the practice tasks, which rely on simple unidimensional judgments of quantity (less vs. more) or time (now vs. later). As the ability to make financial decisions depends crucially on an understanding of quantity, these practice tasks might prove useful in the early stages of a capacity assessment: A person who is unable to express a consistent preference for the larger of two sums of money, or for the earlier delivery of a fixed reward, might be unlikely to have sufficient understanding to make more complex financial decisions.

Relationship to Executive Functioning

Both the ability to perform the temporal discounting task consistently initially and the ability to benefit from training to achieve a consistent performance were dependent upon executive functioning ability but not on IQ. Although based on a small sample, we confirmed the relationship to executive functioning rather than IQ by using regression analysis, and it has been replicated in a further study in an independent sample of service users (Willner, Bailey, Dymond, & Parry, 2010). A study in typically developing children and adolescents reported that IQ was lower in inconsistent responders than in consistent responders (Olson et al., 2007). However, that study involved a much wider range of IQ values than did the present study (*SD* = 10.9 vs. 5.4), and the discrepancy with the present results could be accounted for by the significant correlation between IQ and executive functioning (Ardila et al., 2000; Duff, Schoenberg, Scott, & Adams, 2005).

Beyond the simple numerical operations discussed above, temporal discounting involves a set of strategic decisions (e.g., always choose the smaller alternative if it is greater than x; always choose the delayed alternative if the delay is less than y). In fact, the two individual subtests that best distinguished the consistent and inconsistent groups, the Key-Search test from the BADS-C and the Tower of London test from the CEFA-ID, are arguably the tests that involve the greatest requirement to formulate and execute a strategy. Consistent performance on the temporal discounting task also requires the strategy to be held constant over time, which in turn means remembering to behave in accordance with the rules that have been formulated. It is, therefore, hardly surprising that difficulty in remembering what to do (Prospective Memory) is also associated with poor performance in the temporal discounting task. In short, there are several aspects of executive functioning that, if lacking, are likely to create difficulty in maintaining consistency over the course of a series of decisions.

Nevertheless, it is likely that difficulty in responding consistently can be explained without recourse to these more complex processes. As noted above, the service users who were unable to respond consistently also experienced difficulty in making simple unidimensional decisions. Their performance on the practice tasks improved with training, but errors remained high. Compliance with even a simple unidimensional rule (e.g., always choose the larger, or the earlier, alternative) would be more difficult in the context of the two-dimensional temporal discounting task because of the distraction provided by the additional irrelevant information. The relationship to executive functioning could, therefore, relate either to the attentional demands of the temporal discounting task or to a role for executive functioning in decision-making per se (even the simplest of decisions) or in unidimensional comparisons (e.g., more vs. less, now vs. later). The former hypothesis is consistent with a recent study that identified a relationship between temporal discounting and inattention specifically, as distinct from other clinical symptoms, in children with ADHD (Paloyelis, Asherson, & Kuntsi, 2009).

Impulsivity

Those service users (just over half the sample) who did demonstrate an ability to respond consistently on temporal discounting tasks, tended to perform in a highly impulsive fashion, expressed as a high rate of discounting. (For example, Figure 6 indicates that, for an average service user, a £10 reward loses two thirds of its subjective value if payment is delayed until the next day.) Impulsivity has previously been implicated as a factor in aggression (Crocker, Mercier, Allaire, & Roy, 2007; van Nieuwenhuijzen, de Castro, van Aken, & Matthys, 2009), sexual offending (Parry & Lindsay, 2003), and self-injurious behavior (Petty & Oliver, 2005) among people with intellectual disabilities, but without comparisons with the general population. In some previous studies researchers have documented that people with intellectual disabilities display a preference for small immediate rewards over larger delayed rewards (Cuskelly et al., 2001; Dixon et al., 1998, 2003; Vollmer et al., 1999), but, again, these investigators did not include a comparison with people who did not have disabilities who, as shown in Figure 6, also displayed temporal discounting, albeit to a much smaller extent. The only studies of delayed gratification that did include a control group were in young children with Down syndrome (Cuskelly et al., 2003; Kopp, 1990). As far as we are aware, the present study is the first to provide evidence, as distinct from clinical anecdote, that adults with intellectual disabilities may have more difficulty in delaying gratification than individuals in the general adult population.

Difficulties in delaying gratification are typically associated with poor performance in executive functioning tasks (Barkley et al., 2001; Bickel et al., 2007; Hinson et al., 2003; Shamosh et al., 2008; Weber & Huettel, 2008). At first sight, therefore, it may appear paradoxical that the group of service users who performed consistently in the temporal discounting tasks were found to have higher levels of executive functioning and yet were highly impulsive. However, although this group had higher executive functioning scores relative to service users who were unable to perform the temporal discounting task, they would still be classified as having a severe impairment of executive functioning when compared with the general population (using the published norms for the BADS-C: Emslie et al., 2003). Several neuroimaging studies have reported that choice of an immediate alternative is associated with increased neural activity in the ventral striatum and ventromedial prefrontal cortex, whereas choice of a delayed alternative is associated with activation in dorsolateral prefrontal and posterior cingulate cortex (McClure, Ericson, Laibson, Loewenstein, & Cohen 2007; McClure, Laibson, Loewenstein, & Cohen, 2004; Shamosh et al., 2008; Tanaka et al., 2004; Weber & Huettel, 2008). Hence, the greater impulsiveness of service users might indicate a developmentally acquired impairment of functioning in dorsal prefrontal and/or posterior cingulate cortex. To the best of our knowledge, there are as yet no relevant neuroimaging data.

The lack of relationship between temporal discounting and IQ was to some extent unexpected, as a recent meta-analysis reported an inverse relationship between impulsivity, as expressed by an inability to delay gratification, and general intelligence (Shamosh & Gray, 2008). However, the relationship was relatively weak overall and was reported to weaken further as the mean IQ of the sample decreased. In fact, the meta-analysis included only two studies that involved people with intellectual disabilities (children and young adults with Down syndrome), and there was no significant relationship either between intelligence (assessed by a measure of receptive language ability) and the ability to withhold a response (Cuskelly et al., 2001, 2003). Although it is questionable whether executive functioning or IQ is the more relevant variable for understanding impulsivity in the general population, or, indeed, if there is a justification for separating these two sets of abilities (Shamosh et al., 2008), executive functioning does appear to be the more relevant variable in relation to decision-making by people with intellectual disabilities. Research in this area has been hampered by the lack of validated instruments for assessing executive functioning in people of limited intellectual ability. The CEFA-ID was developed specifically for this purpose, and our experience from the present study suggests that the BADS-C is also a viable instrument for use with adults with intellectual disabilities (see also Willner et al., in press).

Conclusions and Implications

In conclusion, we have identified two distinct biases in decision making by people with mild to moderate intellectual disabilities. One group of service users was unable to maintain a consistent strategy, resulting in seemingly random responding in the temporal discounting task. This group was characterized by difficulty in making unidimensional judgments (e.g., a preference for larger rewards), which would make difficulty on a two-dimensional task almost inevitable, and very low executive functioning scores. We suggest that these measures may be more useful than IQ for informing a general impression of a person's capacity to make financial choices or, indeed, other complex choices that require the weighing of information. The second group demonstrated an ability to weigh information, but most did so in a highly impulsive manner. The temporal discounting task provides a means of quantifying this behavior that may be helpful in considering whether this bias is so extensive as to undermine the ability to make choices.

The association of both of these difficulties with impairments of executive functioning, and their lack of relationship to IQ, has some important practical implications. In England and Wales, the Mental Capacity Act (2005) defined *incapacity* as the inability to make a decision "because of an impairment of, or a disturbance in the functioning of, the mind or brain." In practice, this means that the Mental Capacity Act only applies when a diagnosis can be applied. In the context of intellectual disability, the relevant diagnosis in the United Kingdom is *learning disability*, one of the criteria for which is "a significant impairment of intellectual ability," usually interpreted as a Full-Scale IQ of less than 70. (All of the participants in the present study met this criterion.) However, it is likely that there are many people with IQs greater than 70 whose decision-making may be compromised by impairments of executive functioning, but who are deemed to be capable on the basis that their IQ is not less than 70 and, therefore, that by definition they do not meet the criteria for diagnosis. If, as suggested by the present results, decision-making is more dependent on executive functioning than on IQ, then the criterion used to decide whether to apply the Mental Capacity Act may need to be reconsidered.

It remains to be established to what extent the two difficulties identified in this study generalize to other aspects of service users' life in the real world. However, the results suggest that the majority of people with intellectual disabilities might have difficulty with decisions that involve a time element, such as spend versus save or current lifestyle choices versus later health outcomes. It is also will also be important to seek to develop remediation strategies to improve decision-making ability, in relation to both the ability to weigh information and the ability to delay gratification.

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