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A visual aid to decision-making for people with intellectual disabilities

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ABSTRACT

Previous studies have shown that people with mild intellectual disabilities have difficulty in 'weighing-up' information, defined as integrating information from two different sources for the purpose of reaching a decision. This was demonstrated in two very different procedures, temporal discounting and a scenario-based financial decision-making task. In the present study, both tasks were presented to 24 participants who attended day services for people with learning disabilities (mean Full-Scale IQ = 59.8), half of whom were trained to use a visual aid to support decision-making. Performance of control participants did not change over repeated testing, but use of the visual aid substantially improved the quality of decision-making on both tasks: temporal discounting performance became more orderly, and participants were able to provide more information to justify their decisions in the financial decision-making task. The visual aid also substantially improved participants' ability to justify decisions they made about their own lives. We suggest that, while the visual aid was designed and evaluated as a means of increasing the quality of reasoning that supports a decision, it may also have potential as an aid to therapeutic interventions aimed at encouraging wiser decision-making.

1. Introduction

Decision-making is only possible if the decision-maker has the mental ability to engage in reasoning and manipulate information rationally, so as to weigh the pros and cons of the alternative outcomes (Buchanan & Brock, 1989; Grisso & Appelbaum, 1998; Mental Capacity Act, 2005). There are numerous factors that influence the difficulty of any particular decision (British Psychological Society, 2006), but one factor that bears particularly on the ability to weigh information is the dimensions in which the elements of the decision are expressed. Weighing-up two items of information is very simple when they are expressed in the same dimensions (e.g. the choice between paying £10 or £100 for the identical outcome), but becomes much more problematic when there is a need to integrate information from two or more sources that are expressed in different dimensions (Green & Myerson, 2004).

The problem of integrating information that is expressed in different dimensions is captured by a popular laboratory decision-making task, temporal discounting (TD), in which decisions are based on both the magnitude and the delay of an expected reward. In TD tasks, participants are presented with a series of choices between small immediate and large delayed rewards. The overwhelming majority of typically developing adult participants produce an orderly trade-off between magnitude and delay, such that larger rewards are preferred at short delays, but smaller rewards are preferred when there is a long wait for the larger alternative (Chapman & Elstein, 1995; Critchfield & Kollins, 2001; Estle, Green, Myerson, & Holt,

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2007; Green & Myerson, 2004; Reynolds, 2006; Wileyto, Audrain-McGovern, Epstein, & Lerman, 2004). Using a version of the TD task designed for young children to use without prior training (Scheres et al., 2006), we found that, unlike typically developing participants, almost all participants with intellectual disabilities either behaved randomly, or used only a single source of information: there was very little evidence that participants were taking both sources of information into account and 'weighing' them. Furthermore, when a single source of information was used, this usually took the form of impulsive responding: choosing the immediate alternative, irrespective of the pay-off (Willner, Bailey, Parry, & Dymond, 2010a, 2010c). The ability of participants with intellectual disabilities to respond consistently in the TD task was strongly related to executive functioning, but was not significantly related to IQ (Willner et al., 2010a, 2010c).

Very similar results were seen in a second, more realistic, financial decision-making task (FDMT) that was developed for use with people with intellectual disabilities (Suto, Clare, Holland, & Watson, 2005). The task consists of five scenarios, of increasing complexity, describing choices that people identified in the scenario need to make, each followed by a structured interview, based loosely on the MacArthur Competence Tool (Grisso, Appelbaum, & Hill-Fotouhi, 1997). While participants with intellectual disabilities were usually able to make a decision, they were very rarely able to provide more than a single pro or a single con to justify it: there was very little evidence in either task that information from two sources was being 'weighed'. As in the TD task, there was a strong relationship between performance in the 'reasoning' component of the FDMT and executive functioning, but no significant relationship to IQ (Willner et al., 2010c).

Taken together, these two studies suggest that executive functioning, rather than IQ, underpins reasoning abilities in people with intellectual disabilities, and that, as a result of problems in executive functioning (Willner, Bailey, Parry, & Dymond, 2010b), they may have a general difficulty in integrating information from two sources. In the present study, we have sought to use these insights to design and evaluate a decision-making aid aimed at improving reasoning ability.

Executive functioning refers to the complex set of cognitive processes that regulate an individual's ability to organize thoughts and activities, prioritize tasks, manage time efficiently, and make decisions. They include goal setting and planning, organization of behaviour over time, response initiation, response inhibition, attention, working memory, set shifting and fluency (Lezak, 1982; Meltzer, 2007; Pennington & Ozonoff, 1996). The executive functioning system uses internal resources to manage situations where responding in habitual, automatic ways to external stimuli would not produce the desired outcome (Norman & Shallice, 1986). Programmes to assist people with problems of executive dysfunction (e.g. following a traumatic brain injury) typically include external practical aids (e.g. alarms or diaries) to compensate for deficient internal processes. Research has shown that executive functioning encompasses three broad sets of skills: inhibition of impulsive responding, mental flexibility (initiating actions or changing strategies under internal control), and using working memory to monitor one's own behaviour (Miyake et al., 2000). The visual aid described here has features that are relevant to each of these areas.

If what makes 'weighing-up' difficult is the need to integrate information that is expressed in different dimensions (Green & Myerson, 2004), then the solution to this problem is to translate all of the information into a common currency. The most familiar example of a common currency is money: a choice between two alternative outcomes is often made by estimating and comparing their respective monetary values. Here, we taught participants to translate information about the pros and cons of different choices into a single evaluative dimension by manipulating coloured bars, where the lengths of the bars corresponded to the values ascribed to the different items of information. On the basis of the cultural connotations of green as good (traffic lights, environment), green and red bars were used to represent benefits and costs, respectively, and participants were taught to 'choose the greenest' option.

We describe an evaluation of the decision-making aid using the two tasks described above, and an extension to real-life decision-making. It was predicted that use of the visual aid would improve participants' ability to 'weigh-up' information, and that by so doing, would also help participants to inhibit impulsive responding.

2. Method

2.1. Design

The study involved two groups of participants (initially, $n = 12$ per group) who performed a series of decision-making tasks. One group was supported for each task by the use of a visual decision-making aid; the other was not.

2.2. Participants

The participants attended day services for people with mild to moderate learning disabilities. [The term 'learning disability' is used in the UK to refer to people with significant impairments of both intellectual and functional abilities, acquired in childhood (British Psychological Society, 2000). Participants' disabilities were of mixed etiology, and the etiology was typically unknown.] All participants provided informed consent and the study was approved by the Local National Health Service Research Ethics Committee. Participants were screened using a simple test of financial knowledge (Coins and Costs: Willner et al., 2010a), with a threshold value of 4. All potential participants met this criterion.

Participants were assessed for intellectual ability using the Wechsler Abbreviated Scale of Intelligence (WASI), so as to confirm that they met the IQ criterion for a diagnosis of 'learning disability' (Full-Scale IQ < 70), and for receptive language ability using the British Picture Vocabulary Scale (2nd edition) (BPVS).

Executive functioning (EF) was evaluated using two batteries of tests, the Children's version of the Behavioural Assessment of the Dysexecutive Syndrome (BADS-C: Emslie, Wilson, Burden, Nimmo-Smith, & Wilson, 2003), which includes six tests of EF, and the Cambridge Executive Functioning Assessment for people with Intellectual Disability (CEFA-ID: Ball, Holland, Treppner, Watson, & Huppert, 2008), which consists of eight EF tests (including two tests of 'executive memory') and four memory tests, the results of which are not reported (Ball et al., 2008). The procedure for the BADS-C was as described in the user guide (Emslie et al., 2003) with some minor modifications that were made in order to increase accessibility and decrease dependence on literacy (Willner et al., 2010c). The CEFA-ID EF tests were administered as described by Ball et al. (2008). These tests were included to ensure that the two groups were comparable, and for comparison with samples of participants included in previous studies. One participant did not complete the BADS-C because of illness.

2.3. Temporal discounting

The TD task was programmed in E-Prime and presented on a laptop computer. The task consisted of a series of choices between small immediate and large delayed rewards, which were presented on the screen, while the experimenter also provided the same information verbally. Feedback was also presented both visually and verbally. (See Willner et al., 2010a for further details of task presentation.)

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", while 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 1–6 s that increased as a function of the actual delay. The test was preceded by a first block of 16 practice trials in which the participant was asked to choose between immediate delivery of different amounts of money (£10 vs. £2/4/6/8), a second 20-trial practice block where the choice was between delayed deliveries of £10 (Now vs. 1/2/4/7/14 days), and a third practice block of six choice trials where the two alternatives varied in both value and delay. On the first two blocks of practice trials (which unlike later choice trials have a right and a wrong answer), feedback, and in the case of incorrect responses, an explanation, were provided to all participants after each trial, as this has been found to improve choice performance in the main task (Willner et al., 2010a).

2.3.1. Scoring

We have previously reported that a proportion of participants tested in this task produce an essentially random pattern of choices, while others behave in a more orderly manner, and that participants who behave non-randomly vary greatly in the extent to which their choices reflect the use of both sources of available information (money and time). Two measures were developed to capture these features, *Complexity*, which measures the extent to which participants use both choice dimensions and *Inconsistency*, which measures the extent to which choices are made in a disorderly fashion (Willner et al., 2010a). These two measures were used to categorize participants as performing randomly or consistently. On the basis of earlier data (Willner et al., 2010a, 2010c), participants who scored higher than 6 on the inconsistency measure were categorized as random, while those with a score of 6 or below were categorized as consistent.

For participants who performed consistently, a TD function was constructed by determining the indifference point at each time delay, defined as the monetary value at which the immediate alternative was chosen on 50% of trials (for further details, see Willner et al., 2010a). The indifference points were summed to provide an 'area under the curve' (AUC: Myerson, Green, & Warusawitharana, 2001). AUC values were used to categorize participants as 'impulsive' (AUC = 0–10), 'orderly' (AUC = 11–49) or 'acquisitive' (AUC = 50–60). 'Orderly' sessions were further categorized as 'partially orderly' where participants made differentiated choices but largely using a single dimension (time or money) or 'fully orderly' where there was evidence of an orderly trade-off between the two dimensions. Participants were categorized as being partially orderly using the money dimension when they chose to wait for £10 at least 20% more often when the immediate value was either £2 or £4 versus when the immediate value was £6 or £8. Likewise, participants were categorized as being partially orderly using the time dimension when they chose to wait for £10 at least 20% more often when the delay was 1 day or 2 days versus when the delay was 1 or 2 weeks. Participants were categorized as being fully orderly when these criteria were fulfilled for both dimensions.

Examples of each type of performance are shown in Fig. 1, which orders them according to quality from 'random', through 'impulsive' and 'acquisitive' (the latter being assumed to be superior because impulsive decision-making frequently presents as a problem requiring clinical intervention), to 'partially orderly' and 'fully orderly'. (With one exception, 'partially orderly' performances in this study were all as shown in the middle right panel.)

Quality of performance was scored, using these categories, on a 5-point scale (0–4).

2.3.2. Visual aid

The visual aid consisted of a set of green bars representing benefits and a set of red bars representing costs. The green bars were marked with 2, 4, 6, 8 or 10 'smiley' faces, while the red bars were marked with 1, 2, 4, 7 or 14 'frowny' faces, with the size of the bars corresponding to their values.

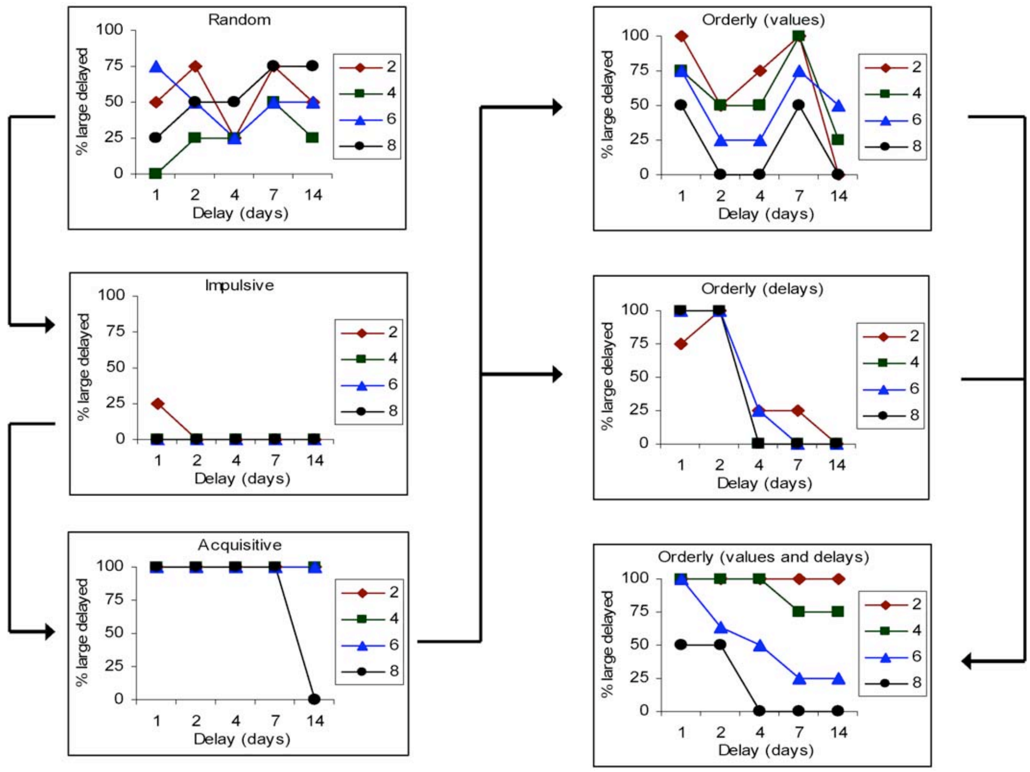

Fig. 1. The figures illustrate increasing quality of performance in the TD task. Each figure shows, for a single session, the probability of choosing the larger delayed alternative (vertical axis) as a function of the length of delay (horizontal axis) and the value of the immediate alternative (colours/symbols). The bottom right panel shows an appropriate trade-off between value and delay; the top and middle right panels show, respectively, a session in which choice is lawfully related to the value of the immediate alternative but there is little influence of delay, and a session in which choice is lawfully related to delay but there is little influence of value. The top left panel shows an essentially random pattern of choice, while the middle and bottom left panels show almost exclusive choice of the small immediate option and the larger delayed option, respectively.

In the first block of practice trials (£10 vs. £2/4/6/8 now) participants were shown how to place a green bar representing the value below each of the choice options, as shown in Fig. 2 (top panel), and then to 'choose the greenest' by pressing the corresponding key on the computer keyboard. In the second block of practice trials (£10 now vs £10 delayed), the green bars were the same size, but a red bar, representing the delay, was used to cover the top of the green bar, effectively decreasing its value; again, participants were asked to 'choose the greenest'. In the third block of practice trials, which were identical to the actual choice trials, the green bars varied in size, corresponding to the two monetary values, but the larger (£10) bar was partially occluded by a red bar representing the delay. A schematic example is shown in Fig. 2 (middle panel), where the computation shows that £10 delayed for 2 days appears as a better (greener) choice than £6 now. On the first trial in each practice block the correct procedure was modeled for the participant; following this, participants were then prompted as much as necessary to carry out the correct procedure for the first half of the practice trials in each block. For the second half of the practice trials in each block, participants completed the procedure unaided by the researcher (with no prompting) but were given feedback on their performance after each trial.

On choice trials where the visual aid was used, participants received no prompting in advance of making their choice, but in the event of an error, they were given feedback that explained the error and demonstrated how to correct it. The type of error (choosing the wrong bar, putting it in the wrong place, or choosing the less green option) was recorded.

2.4. Financial decision-making task

The financial decision-making task (FDMT) was based on that described by Suto et al. (2005). It consisted of 10 vignettes, each describing a situation where a choice has to be made (including the first three scenarios from Suto et al., 2005). Two parallel sets of vignettes were constructed, with one set used in pre- and post-training sessions and the other in training sessions. After each scenario, a series of questions is asked, to assess Identification (of the choice to be made and who has to make it), Understanding, Reasoning, Appreciation (of who is affected) and Communication. The assessment of Understanding asks participants to provide information for and against each alternative. The difficulty of the scenarios was set, in pilot work, at a level where it was expected that, for all scenarios, the majority of participants would be able to provide information from at least two of these four categories (Willner et al., 2010c). The quality of Reasoning was only scored for scenarios and participants where this was the case.

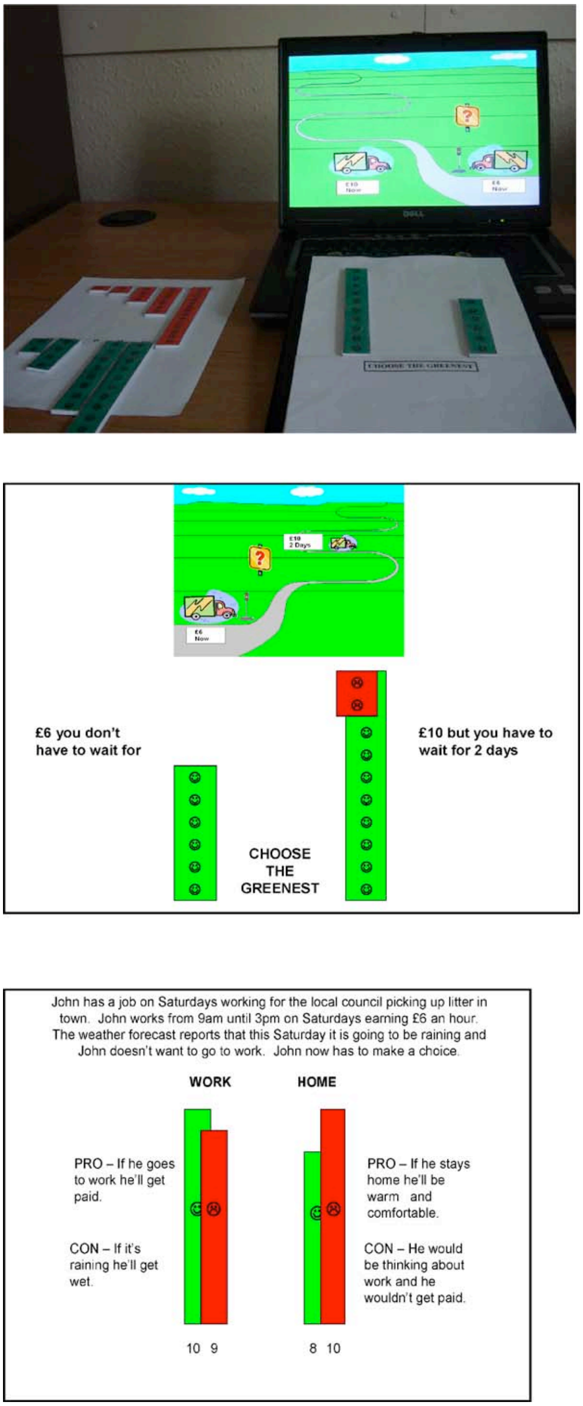

Fig. 2. Top: The visual aid applied, in the TD task, to a practice-trial choice between £10 now and £6 now, represented by the two green bars. The response keys are the 'A' and 'L' keys on the computer keyboard, above the white board on which the visual aid is laid out. To the left are the other red and green bars that are not used for this trial. Middle: A schematic of the choice between £6 now and £10 in two days, with values represented by green bars with 6 or 10 'smiley' faces, and the delay by the red bar with two 'frowny' faces. The words 'choose the greenest' appear in the display (see top panel); the other text represents the voice-over that describes the choices. Bottom: A schematic of the visual aid applied to the FDMT. The participant has identified the pros and cons shown in relation to the scenario at the top of the figure. The participant has then placed a numerical value (shown below the columns) on each of these four elements, and constructed the display as shown. The text is shown for illustrative purposes: all that appears on the table are the four bars and the words "work" and "home". (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of the article.)

2.4.1. Scoring

On the Reasoning component of the FDMT, a score of 1 was given for stating a choice and a score of 2 was awarded if a "sufficient explanation" is given (Suto et al., 2005). Four types of valid information could be provided to justify a decision, reflecting the pros and cons of each of the two options. A score of 3 was awarded if reasons for the decision were given from at least two different categories of evidence, providing evidence that information was being 'weighed' (Willner et al., 2010c).

2.4.2. Visual aid

For the FDMT, the visual aid was redesigned such that the bars could vary in size from 1 to 10, and each green and red bar carried a single 'smiley' or 'frowny' face. When participants had considered the problem and identified pros and cons of each option (giving at least two items of information from different categories) they were asked to estimate how good or bad each item would be by selecting the appropriate green or red bar, and to lay out the computation on the table in a similar manner to that used previously in the TD task. In the example illustrated in Fig. 2 (bottom panel) the option 'work' has been valued as a net benefit (more green than red), while the option 'home' has been valued as a net cost (more red than green). Occasionally, participants realized that the computation was driving them to the wrong decision, and they were allowed to select different bars to change the values that they were placing on the elements, so as to bring the reasoning into line with the decision. Following a decision, feedback was provided on any errors (choosing the 'less green' option).

2.5. Real-life decision-making

Participants were first administered the Choice Questionnaire (Stancliffe & Parmenter, 1999), which asks whether the service user or someone else makes decisions for the service user in 26 areas of daily living. Six choices were selected for each participant, taken from the areas that service users identified as choices that they made for themselves. (The limit of 6 was set because, for some participants, this was as many independent choices as it was possible to identify.) These choices were then subjected to the same procedure and scoring as the FDMT, with the visual aid used in exactly the same way.

2.6. Procedure

Participants first provided informed consent; which was witnessed by a staff member, and completed the psychometric assessments.

They then completed six sessions on the TD task, typically at weekly intervals. Following the three blocks of practice trials, the first and last sessions comprised 80 choice trials, while the 2nd to 5th sessions comprised 40 choice trials, and in these sessions, one group of participants used the visual aid. In these four sessions the aid was used on all practice trials, but the number of choice trials on which the aid was used decreased over sessions, from 40 to 30 to 20 to 10. For purposes of analysis, the 2nd and 3rd sessions, and the 4th and 5th sessions, were amalgamated to provide 2 blocks of 80 trials, including, respectively 70 and 30 trials with the visual aid.

Following an interval of approximately 5 weeks, the same participants were tested 6 times on the FDMT, with the visual aid used, in the trained group, on the 2nd to 5th sessions. For the Reasoning component of the FDMT, participants in the trained group were asked "Why do you think that this option is better than that option?" with the visual aid still present. Of the 24 participants, one declined to continue with the study and one became unavailable owing to illness leaving 11 participants in the each group. Of these 22 participants, three (two from the trained group and one from the control group) were excluded from the analysis because they were unable to demonstrate sufficient understanding of the scenarios. Averaged across trials, these three participants were able to provide information from at least two categories for no more than six of the ten scenarios, whereas participants included in the analysis were able to provide the necessary information for at least nine of the ten scenarios.

Approximately 13 weeks later, participants were re-tested in the FDMT, followed by a second session a week later in which they first completed the FDMT, then moved on to real-life decisions. As the real-life decision-making task (RLDMT) included only six decisions, the FDMT was also reduced to six scenarios for this study. Participants in the trained group were supported with the visual aid in all three tests. Eighteen of the 19 participants who demonstrated sufficient understanding in the FDMT completed the RLDMT; one control participant declined to continue with the study, leaving nine participants in each group.

After each decision-making session, participants were asked to rate their experience on a 3-point scale ("I didn't like it"; "I liked it a bit"; "I liked it a lot"). Across the three experiments, data were collected from a total of 294 sessions. 289 sessions were rated as "liked a lot", and 5 as "liked a bit". No sessions were rated as "not liked".

2.7. Statistical analysis

The effects of training were analyzed by 2-way analysis of variance, with the between-subjects factor Group and the within-subjects factor Trials. *T*-tests were used for comparisons between groups and Pearson's product-moment correlation coefficient was used to examine relationships between variables prior to training. 1-tailed tests were used for replication of effects reported previously.

Table 1
Characteristics of the two groups.

	Trained	Control	t
Age	41.17 (±4.35)	40.73 (±3.24)	0.08
Gender (M/F)	5/7	5/7	
Full-scale IQ	61.58 (±1.53)	58.08 (±1.36)	1.71
BPVS raw score	87.83 (±7.64)	74.92 (±6.12)	1.32
BADS-C	22.17 (±1.41)	20.09 (±1.44)	1.03
CEFA-ID	50.92 (±2.74)	43.33 (±3.44)	1.73

BPVS: British Picture Vocabulary Scale; BADS-C: Behavioural Assessment of the Dysexecutive Syndrome, Children's version; CEFA-ID: Cambridge Executive Functioning Assessment for people with Intellectual Disability. Values are means ± standard error.

3. Results

3.1. Pre-training performance

Table 1 shows that the two groups of participants were comparable on all demographic and psychometric measures. (The trained group had slightly higher scores on psychometric measures but none of the differences were significant.) Participants were also comparable on all measures to participants included in previous studies (cf. Willner et al., 2010c, Fig. 1).

Across all participants, in pre-test sessions without the visual aid, there was a significant correlation between quality of performance in the TD task, and quality of reasoning in the FDMT [$r(18) = 0.51$, $p < 0.05$]. As reported previously (Willner et al., 2010a, 2010c), participants who responded randomly in the TD task ($n = 10$) had lower scores on the BADS-C than participants ($n = 14$) who responded consistently [$t(21) = 2.13$, $p < 0.025$], and there was a significant correlation between reasoning scores on the FDMT and scores on the CEFA-ID [$r(18) = 0.44$, $p < 0.05$].

3.2. Temporal discounting

Quality of responding in the TD task is shown in Fig. 3. Performance did not change with repeated practice in the control group, but participants in the trained group showed a substantial improvement when using the visual aid, on sessions 2–5 [group x trials interaction: $F(3,66) = 17.0$, $p < 0.001$]. On sessions 2–3, where 70 of the 80 trials were aided, ten participants (83%) performed in a partially or fully orderly manner, and nine participants' performance was orderly on sessions 4–5, where only 30 of the 80 trials were aided. Performance decreased only slightly from sessions 2–3 to sessions 4–5, as the visual aid was gradually withdrawn [$t(11) = 1.48$, NS]. Performance decreased significantly in the post-test without the visual aid [$t(11) = 2.24$, $p < 0.05$], but remained well above pre-test levels [$t(11) = 5.4$, $p < 0.001$]. 11/12 participants performed better at post-test than at pre-test. (The 12th was the participant who had the best performance prior to training.) The five participants who performed randomly at pre-test presented after training as impulsive ($n = 1$), acquisitive ($n = 2$), or partially orderly ($n = 2$). The four participants who were impulsive at pre-test showed a four-fold increase in AUC after training, to become acquisitive, partially orderly ($n = 2$) and fully orderly. No improvements were shown by the random or impulsive participants in the control group.

Participants made relatively few errors when using the visual aid. Across all 100 aided trials, errors were made on 11.2% of trials, with the wrong bar used on 4.0% of trials, the bar misplaced on 1.6% of trials, and the 'less green' option selected on 5.6%

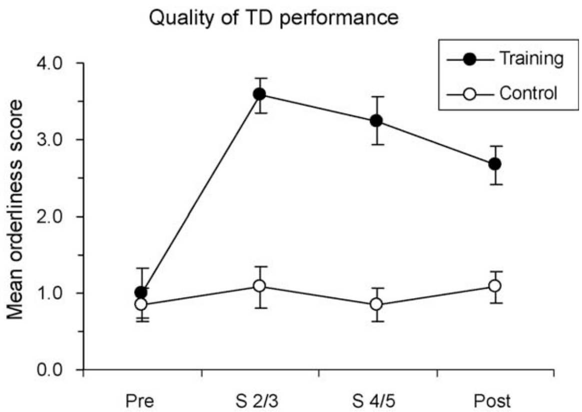

Fig. 3. Quality of temporal discounting (TD) performance before (pre) and after (post) training, and during four training sessions (S2/3 and S4/5) with the visual aid.

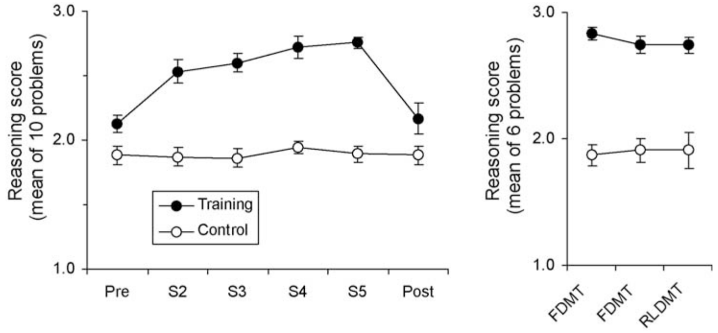

Fig. 4. Left: Reasoning scores on the financial decision-making task (FDMT) before (pre) and after (post) training, and during four training sessions (S2–5) with the visual aid. Right: Performance with the visual aid in two tests on the FDMT, followed by a test on the real-life decision-making task (RLDMT).

of trials. (The latter figure inflates the true error rate because participants sometimes realized immediately that they had pressed the wrong key, but the computer program did not allow for error correction.) Error rates on visually aided trials changed very little across the four training sessions (results not shown).

3.3. Financial decision-making

The effect of training on reasoning performance in the FDMT is shown in Fig. 4 (left panel). As in the TD task, performance did not change with repeated practice in the control group, but participants in the trained group showed a substantial improvement when using the visual aid on sessions 2–5 [group x trials interaction: $F(5,85) = 15.5$, $p < 0.001$]. However, unlike the situation in the TD task, this improvement was not sustained in the post-test without the visual aid. The proportion of scenarios on which trained participants showed evidence of 'weighing-up', by providing at least two pieces of information to justify their choice, increased from a mean of 58% in the first two training sessions to 77% in the last two training sessions, with 8/9 participants showing improvement (the 9th stayed the same). In the control group, evidence of 'weighing-up' was seen on only 4% of trials.

Errors (selecting the 'less green' alternative) were made on 5.6% of trials in the first two training sessions, but no errors were made in the second two training sessions.

3.4. Real-life decision-making

Fig. 4 (right panel) shows that when the trained group were re-tested with the visual aid, they regained all of the improvement that had been lost on the post-test without the aid, and the improvement was maintained in full when they were subsequently tested on the RLDMT [$F(1,16) = 77.3$, $p < 0.001$].

4. Discussion

We have previously reported that there is a significant relationship between level of executive functioning and performance in decision-making tasks by people with intellectual disabilities (Willner et al., 2010a, 2010c), and these findings were replicated. Executive functioning includes three components, inhibition of prepotent responses, mental flexibility, and monitoring of ones own behaviour (Miyake et al., 2000). The visual aid that we describe has features that potentially address each of these problems.

First, the fact of using a decision-making aid in itself creates a delay that prevents impulsive responding. There are a number of studies in which rewards were used to teach people with intellectual disabilities to tolerate delay, using simple tasks that, like the more complex TD task, offer a choice between a smaller immediate and a larger delayed pay-off (Cuskelly, Einam, & Jobling, 2001; Dixon et al., 1998; Dixon, Horner, & Guercio, 2003; Ragotzy et al., 1988; Schweitzer & Sulzer-Azaroff, 1988; Vollmer, Borrero, Lalli, & Daniel, 1999). Here, no rewards were used, but substantial improvements in temporal discounting performance were achieved by providing participants with a framework for decision-making, and once learned, the skill was largely maintained when participants were tested without the visual aid.

In addition to supporting behavioural inhibition, the visual aid also provides participants with a strategy to use, bypassing the need to initiate action or exercise mental flexibility, and decreases the working memory load, by externalizing the information needed to reach a decision and reducing it to a single comparison. The contribution of those aspects of the visual aid to its efficacy in these two decision-making tasks is uncertain. However, in a different decision-making task, we reported that the use of a visual aid appeared to compensate for deficits in mental flexibility (Dymond, Bailey, Willner, & Parry, 2010). Of the three aspects of executive functioning, behavioural inhibition can be learned. So too can strategic thinking, which decreases the need for mental flexibility when the same task is presented repeatedly. However, there is much less scope for training to improve working memory. The FDMT has a much greater working memory load than the TD task, where all of the information is present throughout the trial. Participants were able to maintain their improvement in TD when the aid was withdrawn, whereas in the FDMT they improved their performance using the visual aid, but did not maintain those gains when the aid was withdrawn. This strongly suggests that the visual aid also supports working memory.

TD provides an experimental model of decision-making that uses a procedure – a long series of repeated choices – that would not typically be encountered in real life. The application of the visual aid also has an artificial element, in that the relationship between costs and benefits was set by the experimenter rather than the participant: for example, the red bar representing a 'cost' of 14 days to wait was the exact same size as the green bar representing the 'benefit' of £10. However, in the FDMT, values of both costs and benefits were set by the participants themselves, and in the later stages of training, participants were 100% accurate in making the choice implied by their valuations of pros and cons. In both procedures, the visual aid enabled participants to demonstrate that they were able to 'weigh-up' evidence, in the TD task by improving the consistency of their choice performance, and in the FDMT by providing more information to justify their reasoning. We cannot be certain that participants in the control group were not weighing-up information to reach a decision in the FDMT, but on only 4% of trials did participants demonstrate this by providing more than one piece of information to justify a decision, even though all participants had been able to demonstrate, through their identification of pros and cons, that they had at least two pieces of information available.

The most important finding of this study was that after training on TD and the FDMT, participants were able to use the visual aid to address decisions from their own lives, which had been identified prior to the test using the Choice Questionnaire (Stancliffe & Parmenter, 1999). Some participants commented that they had found this helpful. We suggest that people with mild intellectual disabilities might benefit from training to use the visual aid and then utilizing it to analyze real-life decisions, as demonstrated here. By enabling a richer consideration of pros and cons the visual aid should enable people who use it to demonstrate mental capacity more readily.

Although this technique was designed and evaluated as a means of increasing the quality of reasoning that supports a decision, it also has potential as an aid to wiser decision-making. Many seemingly irrational decisions are in fact rational outcomes that follow from placing an unconventional value on an element of a decision. The visual aid makes overt the values that are placed on each element feeding in to the decision, and could therefore provide a basis for therapeutic conversations, using motivational interviewing (Miller & Rollnick, 2002), to support a service user to make more conventional re-valuations.

A limitation of this study is that only relatively able participants were included: they needed to demonstrate some basic financial knowledge to be included at all, and, for testing on the FDMT, they needed to demonstrate the ability to identify pros and cons (which resulted in three participants being excluded at this stage). However it is possible that with appropriate training and support, the visual aid might also be used effectively by less able service users.

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References

Ball, S. L., Holland, A. J., Treppner, P., Watson, P. C., & Huppert, F. A. (2008). Executive dysfunction and its association with personality and behavior changes in the development of Alzheimer's disease in adults with Down syndrome and mild to moderate learning disabilities. *British Journal of Clinical Psychology, 47*, 1–29.

British Psychological Society. (2000). *Learning disability: Definitions and contexts*. Leicester: British Psychological Society.

British Psychological Society. (2006). *Interim guidelines on the assessment of mental capacity*. Leicester: British Psychological Society.

Buchanan, A. E., & Brock, D. W. (1989). *Deciding for others: The ethics of surrogate decision making*. Cambridge: Cambridge University Press.

Chapman, G. B., & Elstein, A. S. (1995). Valuing the future: Temporal discounting of health and money. *Medical Decision Making, 15*, 373–386.

Critchfield, T. S., & Kollins, S. H. (2001). Temporal discounting: Basic research and the analysis of socially important behavior. *Journal of Applied Behavior Analysis, 34*, 101–122.

Cuskelly, M., Einam, M., & Jobling, A. (2001). Delay of gratification in young adults with Down syndrome. *Down Syndrome Research & Practice, 7*, 60–67.

Dixon, M. R., Hayes, L. J., Binder, L. M., Manthey, S., Sigman, C., & Zdanowski, D. M. (1998). Using a self-control training procedure to increase appropriate behavior. *Journal of Applied Behavior Analysis, 31*, 203–210.

Dixon, M. R., Horner, M. J., & Guercio, J. (2003). Self-control and the preference for delayed reinforcement: An example in brain injury. *Journal of Applied Behavior Analysis, 36*, 371–374.

Dymond, S., Bailey, R., Willner, P., & Parry, R. (2010). Symbol labelling improves advantageous decision-making on the Iowa Gambling Task in people with intellectual disabilities. *Research in Developmental Disabilities, 31*, 536–544.

Emslie, H., Wilson, F. C., Burden, V., Nimmo-Smith, I., & Wilson, B. A. (2003). Behavioural Assessment of the Dysexecutive Syndrome for Children (BADS-C). *Child Neuropsychology, 13*, 539–542.

Estle, S. J., Green, L., Myerson, J., & Holt, D. D. (2007). Discounting of monetary and directly consumable rewards. *Psychological Science, 18*, 58–63.

Green, L., & Myerson, J. (2004). A discounting framework for choice with delayed and probabilistic rewards. *Psychological Bulletin, 130*, 769–792.

Grisso, T., & Appelbaum, P. A. (1998). *The assessment of decision-making capacity: A guide for physicians and other health professionals*. Oxford: Oxford University Press.

Grisso, T., Appelbaum, P. S., & Hill-Fotouhi, C. (1997). The MacCAT-T: A clinical tool to assess patients' capacities to make treatment decisions. *Psychiatric Services, 48*, 1415–1419.

Lezak, M. D. (1982). The problem of assessing executive functions. *International Journal of Psychology, 17*, 281–297.

Meltzer, L. (2007). Executive function: Theoretical and conceptual frameworks. In L. Meltzer (Ed.), *Executive Function in Education* (pp. 1–3). New York: The Guilford Press.

Mental Capacity Act. (2005). *Office for public sector information*. London, United Kingdom.

Miller, W. R., & Rollnick, S. (2002). *Motivational interviewing: Preparing people to change* (2nd ed.). London: Guilford Press.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex 'Frontal Lobe' tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49–100.

Myerson, J., Green, L., & Warusawitharana, M. (2001). Area under the curve as a measure of discounting. *Journal of the Experimental Analysis of Behavior, 76*, 235–243.

Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behaviour. In M. S. Gazzaniga (Ed.), *Cognitive neuroscience: A reader* (pp. 376–390). Oxford: Blackwell.

Pennington, B. F., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry, 37*, 51–87.

Ragotzy, S. P., Blakely, E., & Poling, A. (1988). Self-control in mentally retarded adolescents: Choice as a function of amount and delay of reinforcement. *Journal of the Experimental Analysis of Behavior, 49*, 191–199.

Reynolds, B. (2006). A review of delay discounting research with humans: Relations to drug use and gambling. *Behavioural Pharmacology, 17*, 651–667.

Scheres, A., Dijkstra, M., Ainslie, E., Balkan, J., Reynolds, B., Sonuga-Barke, E., & Castellanos, F. X. (2006). Temporal and probabilistic discounting of rewards in children and adolescents: Effects of age and ADHD diagnosis. *Neuropsychologia, 44*, 2092–2103.

Schweitzer, J. B., & Sulzer-Azaroff, B. (1988). Self-control: teaching tolerance for delay in impulsive children. *Journal of the Experimental Analysis of Behavior, 50*, 173–186.

Stancliffe, R. J., & Parmenter, T. R. (1999). The choice questionnaire: A scale to assess choices exercised by adults with intellectual disability. *Journal of Intellectual and Developmental Disability, 24*, 107–132.

Suto, W. M. I., Clare, I. C., Holland, A. J., & Watson, P. C. (2005). Capacity to make financial decisions among people with mild intellectual disabilities. *Journal of Intellectual Disability Research, 49*, 199–209.

Vollmer, T. R., Borrero, J. C., Lalli, J. S., & Daniel, D. (1999). Evaluating self-control and impulsivity in children with severe behavior disorders. *Journal of Applied Behavior Analysis, 32*, 451–466.

Wileyto, E. P., Audrain-McGovern, J., Epstein, L. H., & Lerman, C. (2004). Using logistic regression to estimate delay-discounting functions. *Behavior Research Methods, 36*, 41–51.

Willner, P., Bailey, R., Parry, R., & Dymond, S. (2010a). Performance in temporal discounting tasks by people with intellectual disabilities reveals difficulties in decision-making and impulse control. *American Journal on Intellectual and Developmental Disability, 115*, 157–171.

Willner, P., Bailey, R., Parry, R., & Dymond, S. (2010b). Evaluation of executive functioning in people with intellectual disabilities. *Journal of Intellectual Disability Research, 54*, 366–379.

Willner, P., Bailey, R., Parry, R., & Dymond, S. (2010c). Evaluation of the ability of people with intellectual disabilities to 'weigh-up' information in two tests of financial reasoning. *Journal of Intellectual Disability Research, 54*, 380–391.