UNIVERSIDADE FEDERAL DE SÃO PAULO

Departamento de Psicobiologia

# Waiting Game:

## User's guide for a Delay Discounting open-source software


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# Summary

# List of links

1) First, install the WinRAR application here. Download the programme folder (DD_1.0.3-6.rar) from GitHub here. To unzip it, right-click on the folder, locate the “WinRAR” command and click on “Extract to 'DD_1.0.3-6'”;
2) Access the user interface (Google Spreadsheet) here. Make a copy of the user interface and rename it;

3) To download the programme for Linux and macOS operating systems, contact the authors.

For more details about installation, system requirements and software handling, see section 3.2. Opening the programme.

# 1. Introduction

The Waiting Game is a free, open-source programme/software of delay discounting (DD). It contains three identical tasks in which language, instructions, length of delays and type/magnitude of rewards can be edited by researchers without prior programming knowledge through a friendly user interface (Google Spreadsheet). Such characteristics favor its adaptation to different sociocultural contexts and research objectives. The programme contains the following games:

1) **Imaginary Game**, in which delays are hypothetical and no reward other than points is delivered;
2) **Real Game**, in which delays are experienced and the rewards in points are converted into a real reward chosen by the experimenter; and
3) **Patience Game**, in which delays are experienced but no reward other than points are delivered.

This user's guide aims to:

1) Provide a background and the rationale for the development of these computerized DD tasks which involved game design elements;

2) Describe the development strategies of the programme;

3) Provide instructions on how to download, administer, edit and obtain data/scores from the programme.

# 2. Background

The tendency to prefer immediate rewards over delayed ones is described as choice impulsivity (Hamilton et al., 2015, Stevens et al., 2015). Among the paradigms that evaluate this type of impulsivity, we mention the delay discounting (DD, or temporal discounting) - an intertemporal choice task (Stevens, 2010) that describes the extent to which a reward has its subjective value decreased as the time of its delivery increases (Killeen, 2009). Impairments in the ability to delay rewards are very common in clinical conditions such as attention-deficit/hyperactivity disorder (ADHD), autism spectrum disorder, conduct disorder, oppositional defiant disorder (Jackson & MacKillop, 2016), gambling, drug abuse, obesity, and others (Odum et al., 2020).

DD tasks usually involve presenting a sequence of binary choice situations in which the subject is encouraged to choose a smaller reward immediately or waiting for some delay to receive a larger one, as illustrated in Figure 1.


**Figure 1.** A DD task includes a set of trials, each of which presents the option between receiving a smaller reward immediately or waiting for some delay to receive a larger reward, which is usually fixed.

DD does not assess the same abilities as delay of gratification task (DG). In AG only one choice is made (i.e., get a marshmallow now or wait to receive two marshmallows), and the test-taker can reverse his/her choice at any moment during the delay. Differently, DD involves many trials and test-takers must choose whether or not they are willing to wait before the delay is imagined or experienced (Reynolds & Shiffbauer, 2005).

However, DD paradigms used in the literature vary in many respects (Mishra & Lalumière, 2016), as discussed below.

**2.1. Methods for obtaining the subjective value**

Some methods of obtaining the discount rate require the calculation of the subjective value (SV) of the larger reward per delay. This value is calculated when the test-taker shows indifference between receiving the larger reward after a delay and receiving a smaller reward immediately (Mitchell, Wilson & Karalunas, 2016). Thus, when a person chooses $10 now over $15 in a month, it can be said that $15 suffered a subjective devaluation due to a specific delay. Based on this, the subjective value of the larger reward given the one-month wait is the average of $15 and $10, i.e., $12.50 (Killeen, 2009; Tesch & Sanfey, 2008; Myerson, Green, & Warusawitharana, 2001).

However, there are cases in which the same choice option is repeated several times throughout the task, which makes the individual calculation of the SV very laborious and time-consuming (Staubitz, Lloyd & Reed, 2018). In view of this, methods have been developed that simplify the calculation of the SV, such as the pre-determined rules method (Critchfield & Kollins, 2001) and the proportion of delayed reward choices method (Mies et al., 2018).

In the pre-determined rules method, the options are organized in ascending order, that is, combinations between the smaller immediate reward and the *shortest delay* are placed first, followed by the pairings between the smaller immediate reward and the *second shortest delay*, and so on. As shown in Table 1, combinations of the same type form a pair of choices coded with the letters D (choice for delayed reward) or I (choice for immediate reward). The SV of a delay is obtained based on a set of rules that establish the value of certain configurations of the choice pairs along this delay. For example, choices made when the delay was 10 s can be illustrated as DD - DD - DD - II, whose subjective value is 12.5, because this is the average between 10 and 15. The correction is made by two judges, who reach a consensus through discussion in case of disagreement (Scheres et al., 2006).

However, inconsistencies in choices not foreseen by the predetermined rules method may occur (Scheres et al., 2010a), such as in the sequence II – ID - II - DI represented in the last columns of Table 1. In these cases, it is often not possible to determine the SVs and the responses may end up being considered missing data.

**Table 1.** Ascending order of choices (trials) of a delay discounting procedure.

| Immediate rewards in dollars | Delays associated with the US$ 20 delayed reward | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 5 s | | 10 s | | 20 s | | 40 s | |
| | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 |
| 2 | D | D | D | D | D | D | I | I |
| 5 | D | D | D | D | D | I | I | D |
| 10 | D | D | D | D | I | I | I | I |
| 15 | D | D | I | I | I | I | D | I |

Note. T1: trial 1; T2: trial 2; Choices for delayed and immediate rewards are coded, respectively, with the letters D and I. In this example, each delay is made up of choice pairs (T1 and T2).

Alternatively, it is possible to use the proportion of delayed reward choices method (Mies et al., 2018) as it is easy to automate and is not affected by inconsistent choice reversals. To calculate it, all choices made in favor of the larger reward in a given delay are considered, regardless of the order in which they were presented, following equation 1:

$$P = \frac{Number\ of\ delayed\ choices\ per\ delay}{Total\ number\ of\ choices\ per\ delay} \times Plausible\ range\ of\ SV + lowest\ plausible\ SV \quad (1)$$

Where P is the proportion of delayed choices at a given time, the plausible range of subjective value (SV) is the difference between the highest plausible SV (average between the highest immediate reward and the delayed reward), and the lowest Plausible SV (average between zero and the lower immediate reward).

Back to the previous example, when the delay was 10s the subjective value of the sequence DD - DD - DD - II by the pre-determined rules method was 12.5. By the proportion of delayed reward choices method, we have that the highest plausible SV is 17.5 ((20 + 15)/2), the lowest plausible SV is 1 ((0 + 2)/2), and the plausible range of SV is 16.5 (17.5 - 1). Therefore, when the time is 10 s, one can calculate:

$$P = \left(\frac{6}{8}\right) \times 16.5 + 1$$

$$P = 13.4$$

And for the sequence II – ID - II - DI, which could previously be considered missing data, the SV is 5.12.

## 2.2. Methods for obtaining the discount rate

The discount rate of a reward as a function of time is well explained by a hyperbolic function (Peters, Miedl & Büchel, 2012; van den Bos & McClure, 2013), and there are two main methods to achieve it. The first is by calculating *k parameter*, which describes how the value (V) of a reward (A) decreases as a function of time (T), based on the slope of the discount curve (Mazur, 2000). Thus, the greater the slope, the higher the impulsivity (Beck & Triplett, 2009). The parameter *k* can be calculated using the equation 2:

$$V = \frac{A}{(1 + k.T)} \quad (2)$$

The second methods is by the area under the curve (AUC; Myerson, Green & Warusawitharana, 2001), which is calculated based on the subjective values of the choices made by the individual for each delay (Reynolds, 2006). To this end, test-takers' subjective values are plotted on a graph, with delays arranged on the X-axis and the subjective value on the Y-axis Figure 2 shows the subjective value of the larger reward as a function of progressively longer delays, which are used for the AUC calculation. The higher the AUC value, the lower the discount or the lower the impulsivity.

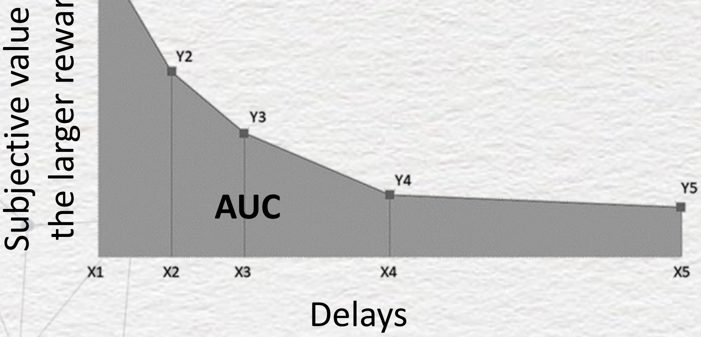



**Figure 2**. Illustrative graph of discount function by the for area under the curve (AUC) method, in which x corresponds to the delays and y to the subjective values of the larger devalued reward as a function of time. To obtain the AUC, the areas of the trapezoids (colored in gray) are calculated and added, using equation 3.

As Figure 2 shows, the points corresponding to the subjective values are connected and then a vertical line is drawn from each subjective value towards their respective waiting times on the x-axis, generating trapezoids. Then, the area of each trapezoid is calculated and summed using the equation (Myerson et al., 2001):

$$AUC = \left[(x2 - x1).\left(\frac{y1+y2}{2}\right)\right] + \left[(\mathrm{x3} - \mathrm{x2})\,.\left(\frac{\mathrm{y2} + \mathrm{y3}}{2}\right)\right] + \cdots \quad (3)$$

From this procedure, an index of impulsivity can be reached, with lower and upper limits, being appropriate for the evaluation of non-normal data – common situations in assessment of human choice behavior (Reynolds, 2006).

## 2.3. Differences in DD tasks regarding hypothetical and real delays and rewards

DD tasks involve two main parameters, namely delay and reward. One or both can be hypothetical or real, as detailed in Table 2.

**Table 2.** Possible combinations between the parameters (delay and reward) regarding the condition (hypothetical and/or real) with which they are presented in each delay discounting task.

| | Tasks | | | |
|---|---|---|---|---|
| Parameters | Hypothetical[1] | Real-time[2] | Real-reward[3] | Hypothetical with temporal expectation[4] |
| Delay | Only imagined | Experienced | Only imagined | Experienced |
| Reward | Not delivered | Delivered | Delivered based on probabilities | Not delivered |

Note. [1-3]Task names as refered by Reynolds (2006); [4]Task name as referred by Utsumi, Miranda & Muszkat (2016).

According to Reynolds (2006), there are three combinations between these parameters often found in DD research:

1) Hypothetical delays/rewards (often called *hypothetical task*), in which delays are not experienced, only imagined, and real rewards are not delivered (only points are gained);
2) Real delays/rewards (*real-time task*), in which delays are experienced, and some type of real reward is delivered (e.g., money); and
3) Hypothetical delays/real rewards (*real-reward task*), in which delays are hypothetical and all but one of the rewards chosen by the test-taker during the task is randomly selected and delivered, as in a lottery system. The underlying assumption in this latter type of task is that the potential gain of one of the rewards would guide the test-takers to choose as if all the rewards were real, that is, actually delivered to them at the end of the task.

In addition to these three combinations between the parameters, there is a fourth possible combination: real delays/hypothetical reward (*hypothetical with temporal expectation task*; Utsumi et al., 2016), which will be discussed in chapter 4, section 4.3. Patience Game.

## 2.4. Differences in DD tasks regarding length of delays and type/magnitude of rewards

Aside from involving hypothetical and real delays and rewards, DD paradigms can also differ in terms of the timeframes used to measure delays and types or amounts of rewards.

Frequently, hypothetical and real-reward tasks involve longer delays (days, weeks and years) and higher rewards (e.g., up to hundreds of dollars). Differently, real-time tasks usually involve delays lasting seconds to a few minutes, and lower rewards, such as a maximum of a few US dollars or other material prizes of similarly low financial value (see Reynolds, 2006; Jackson & MacKillop, 2016). This difference is due to the infeasibility of having a budget and longer times in real experimentation conditions in which hundreds of people are evaluated (Matusiewicz et al., 2013; Robertson & Rasmussen, 2018).

With regard specifically to the reward, classical DD tasks often involve monetary gains because money it is a durable good of quantitatively determined value (Glimcher et al., 2009). Other durable goods such as objects have also been used and they have been shown to elicit a cash-like discount pattern (Demurie et al., 2013). Differently, consumable rewards, such as food and cigarettes in smokers, are discounted more than money (Staubitz, Lloyd & Reed, 2018), so tend to be avoided or are only used in specific populations like people with eating disorders or smokers, respectively.

**2.5. Tasks Comparisons**

It is noted in the literature that studies that intended to directly assess the level of association between DD tasks did not consider at least one of the factors described above. These differences lead to an increase in the sources of variation in research, which does not allow for consistent comparisons between DD tasks or knowing which cognitive skills are involved in the choice process (Ernst, 2014).

For instance, two influential studies have shown task equivalence between hypothetical and real-reward conditions in adults, using the same delays up to six months and rewards up to US$ 10 per trial on both tasks (Johnson & Bickel, 2002; Madden et al., 2004). These results have been used as “evidence” that "hypothetical" and "real" tasks measure the same cognitive constructs (e.g., Mahalingam et al., 2016). However, the reliability of the comparisons made is doubtful, since probabilistic procedures differ from DD, and do not necessarily reflect the behavior in situations where the real gain is independent of luck and/or risk of loss (Green et al., 1999; Kahneman, 2012).

Therefore, based on these studies **it is not possible to state that the performance on real-reward task is similar to that on hypothetical task or even similar to the real-time task in which delays are experienced and rewards are actually delivered (*when luck is not involved*).**

Studies that compared performance on hypothetical and real-time tasks are scarce and reached conflicting results, possibly due to factors such as age range, sample size, number of trials per task, health condition and method for obtaining the discount rate. For example, Scheres et al. (2010a), noted equivalent performance in healthy 18-19-year-olds between hypothetical and real-time tasks, each with 40 trials and exactly the same delays (up to 60 s) and rewards (maximum U$ 0.10 per trial), using AUC as the DD index. However, in the same study performance differed between a version of the hypothetical task involving larger rewards (e.g., US$100) and longer delays (e.g., 120 months) and the other tasks: hypothetical and real-time with smaller values and delays, indicating that hypothetical and real-time tasks can vary depending on the magnitude of parameters.

Differently, Miller (2019) did not observe the equivalence between the hypothetical and real-time tasks, although he also used the same short delays and small rewards in both tasks. However, each task consisted of five trials to assess only 9 children aged 7 to 10 years with impulsive characteristics, adopting the parameter k as a measure of discount.

Lagorio and Madden (2005), in turn, noted the AUC equivalence between similar but not equal hypothetical and real-time tasks with longer delays and larger rewards (which could be exchanged for food or drink) in only six healthy participants aged between 19 and 20 years old. Furthermore, the number of trials was not fixed in advance (see pp. 177-178). Finally, Lane et al. (2003) found that the performance of healthy participants aged between 19 and 37 years was different in hypothetical and real-time conditions that were not congruent in terms of scales to measure delays and rewards, using parameter k. In addition, the real-time condition involved delivering a trial-by-trial reward, which differs from the reward system commonly used in most real-time tasks.

**Hence, in healthy adults, there is controversy regarding the comparability in performance in hypothetical and real DD tasks and a dearth of studies that compared hypothetical and real-time tasks in which the lengths of delays and the magnitude of rewards were matched. Even more insufficient is the knowledge about the performance of typical adolescents in these tasks.**

## 2.6. Paper-and-pencil vs. computer-based application

Hypothetical DD tasks can be administered through paper-and-pencil questionnaires or using automated tasks, both of which are considered equivalent to obtain a discount rate (Smith

& Hantula, 2008). However, non-automated administration and scoring can lead to errors. Automation allows better management, organization and pre-processing of data, as responses are automatically stored and scoring algorithms and equations can be inserted into the programme script (Paul et al., 2005). Additionally, computer-based tasks also have the advantage of requiring fewer evaluators to assess more participants (Staubitz et al., 2018). Furthermore, automated tasks allow motivation in carrying them out to be increased through task *gamification* (Turan et al., 2006; Sailer et al., 2017), that is, using "[…] game design elements in non-game contexts" (Deterding et al., 2011; p. 10) which also reduces task anxiety (Cerrato & Ponticorvo, 2017). This is important because it is known that low-motivated and anxious individuals do not behave at their full potential (Edwards et al., 2015). Hence, comparing performance in hypothetical and real-time DD tasks benefits not only from enabling matching of delay times and rewards, but also from using automized administration of DD, as done using the programme developed here, **which was developed for testing DD in adolescents**.

## 2.7. The current DD tasks

According to this overview, there are contradictory findings regarding DD performance in real-time and hypothetical DD tasks. Furthermore, it was noted that the real-reward task does not exactly reflect what was proposed in the hypothetical task, because it involves probabilities.

Therefore, we developed a DD software composed of identical tasks in appearance, delays and rewards. The computer-based procedure was chosen to avoid application and scoring errors (Paul et al., 2005). This procedure included the imputation of algorithms in the programme script for the calculation of subjective values by the proportional method and the area under the curve - both easy to automate and considered appropriate for the analysis of inconsistent choices (Mies et al., 2018) and non-normal data (Reynolds, 2006), respectively.

We also incorporated game design resources into the programme as this increases motivation (Lumsden et al., 2016) and reduces test-related anxiety (Cerrato & Ponticorvo, 2017), which are potential factors that can influence performance (Martin & Franzen, 1989; Edwards et al., 2015).

Additionally, the programme is open access, so is accessible to researchers with little funding, and it is editable: it not only allows changing delays and rewards of the tasks, but also facilitates the adaptation to experiments conducted in varied sociocultural contexts (e.g., language can be altered) (Staubitz et al., 2018).

Note that the DD studies mentioned above were generally conducted with samples of developed nations, so it is important to provide tools to study DD in samples from different countries to determine if DD performance patterns are generalizable across diverse samples.

# 3. Development and functioning of the programme

The Waiting Game was developed to be used in adolescents based on the studies of Scheres et al. (2006; 2008; 2010a,b; 2014), Demurie et al. (2013) and Utsumi et al. (2016). It contains three games or DD conditions: 1) Imaginary Game (hypothetical delay/reward or hypothetical task); 2) Real Game (real delay/reward or real-time task); and 3) Patience Game (real delay/hypothetical reward or hypothetical with temporal expectation task).

This programme was built in Unity3D (by Unity Technologies), version 2018.2.21.fl in order to resemble a video game. The code was written using the Rider IDE. Artistic assets were created in GIMP, a free image editor in which it is possible to change its source code, and Photoshop. Most of the source code is in C# (C-Sharp); however, there is a front-end user interface (UI) for researchers, where they can create new configuration files for the programme using Google Spreadsheets. The script that generates the code from the data sheet is written in JavaScript.

The user interface (UI) was built based on the Model-Driven Game Development, in which programmes can be created using a domain-specific model (DSM) and/or a domain-specific language (DSL; Zhu & Wang, 2019). This enables users to directly modify the programme contents through Google spreadsheets (DSM), which act as a modeling tool, generating a new script file saved in JSON (DSL) - a standard file format used in a huge variety of software.

This approach allows users to manage the versioning of the programme using only the models (i.e., the spreadsheet), but not the generated code (Kelly & Tolvanen, 2008, p. 308).

Programme's UI allows text editing and selection of one of default language options (English, Brazilian Portuguese or Spanish). It is also possible to add a new language and change parameters such as magnitude and type of reward and length of delays.

## 3.1. System requirements

The Waiting Game is compatible with Windows 7 (SP1+) and later versions. It is installable on computers, notebooks and tablets. The binaries included were only for Windows x64, however, because Unity is built on top of Mono, users can quickly recompile the project for any Operating System that is supported by Unity, such as macOS High Sierra 10.13+, and Linux Ubuntu 20.04 and later versions (Figure 3).

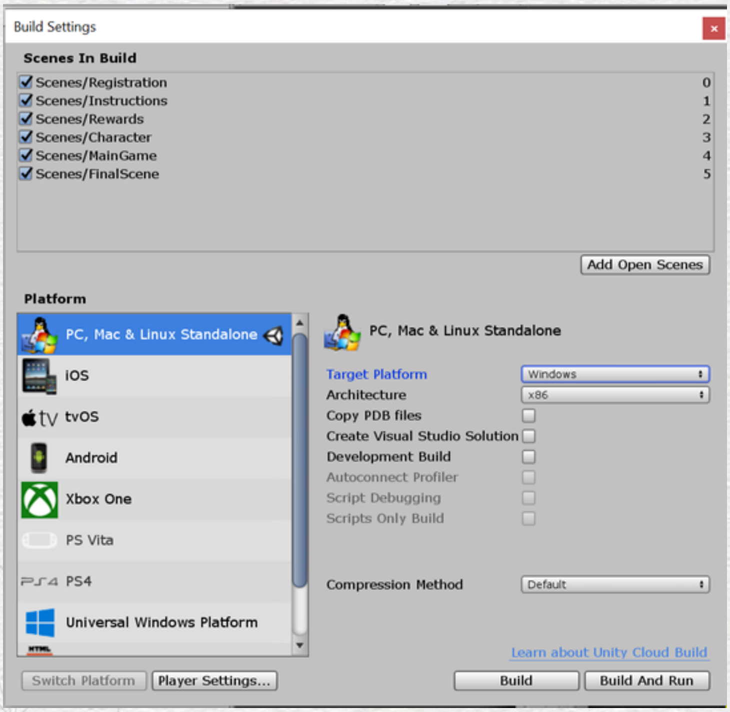



**Figure 3.** To compile the project yourself, download Unity Hub and install Unity version 2018.x (any 2018 version should work). Open the folder with the source files in Unity and open File > Build Settings.

## 3.2. Opening the programme

i) Download the zipped folder from GitHub (DD_1.0.3-6.rar) here, having WinRAR previously installed. To unzip the folder, right-click on it, find the "WinRAR" command and click on "Extract to 'DD_1.0.3-6'". Afterwards, you can move the folder to the desired directory. Click here and make a copy of the user interface (Google Sheets), **renaming it**. Click here to access the source code. **To download the programme for Linux and macOS operating systems, contact the authors.**

ii) Inside the unzipped folder, locate the exe file (AR_Project) and open it;

iii) A dialog box will open with options for screen resolution and graphics. If you want the programme to open in a window, click on "Windowed"; otherwise click directly on "Play!" to start the game. However, to exit the full screen it is necessary to click the following keys: ALT + F4 or ALT + TAB or WINDOWS + D (Figure 4).

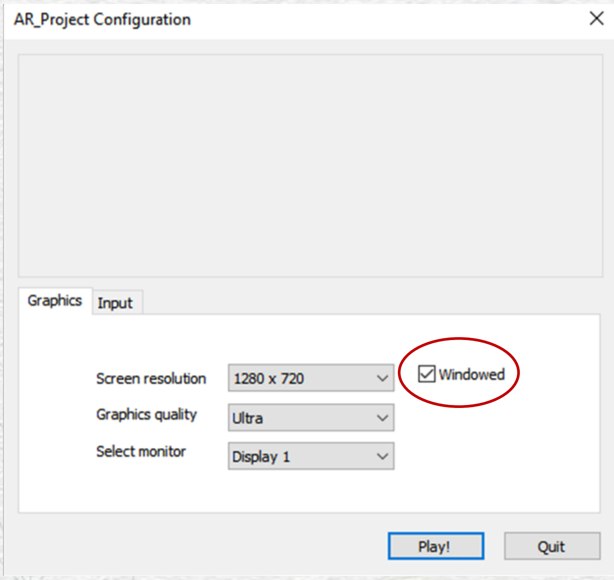



**Figure 4.** Most computers today should work fine with "Ultra" quality. However, if that does not work, you can select a lower configuration

### 3.3. General description of the tasks/games

In each game/task, participants are encouraged to choose between immediately receiving a lower reward (i.e., 100, 400 or 700 points with zero delay) or waiting for varying periods of time (i.e., 7, 15, 30 or 60 s) to receive a higher reward (1000 points).

These points and delays were chosen based on prior work on underaged test-takers (Scheres et al., 2014; Utsumi et al., 2016), but all these parameters can be altered (see chapter 6. User Interface below about editing the programme).

In the literature the number of trials is quite variable, but it is usual that the same pairing between a delay and a reward (e.g., 400 points immediately vs. 15 s to get 1000 points) is presented more than once (Patros et al., 2016).

In the Waiting Game each lower reward is paired three times with each delay, excluding zero time. For instance, the choice between immediately receiving 100 points and waiting 7 seconds to get 1000 is repeated three times during each game. So, for each delay there are 12 possible pairings with the immediate rewards, totaling 36 trials per game. Points were used as a reward and, in the case of real rewards, more points within certain bins can be converted into higher monetary values (see Utsumi et al., 2016) that can be determined by experimenters.

The visual layout was developed having adolescents in mind. To mimic the usual style of videogames the programme includes icons and pictures substituting texts whenever possible and written instructions were minimized.

Delays, rewards and total scores are always represented in the same spatial locations to minimize cognitive demands because people implicitly learn about regularities in the environment and this facilitates making predictions (e.g., Garrido et al., 2016). Hence, we avoided violations of such regularities so that test-takers could focus on the demands of the DD paradigms.

Additionally, carrying out the tasks involving real delays require test-takers be represented by an avatar. Avatars follow a manga style, a type of Japanese graphic novel (comic) which, along with its animated version, anime, constitutes a highly popular multimillion dollar industry worldwide that has influenced people’s imagination (Majaw, 2015; Alt, 2020). This aesthetic style is often present in videogames making it common and appealing to adolescents, which we hoped would help increase motivation in carrying out the DD tasks, including clinical populations (e.g., youngsters in the autism spectrum disorder: Rozema, 2015). The programme provides four choices of manga characters that serve as avatars (female, male and androgenous) to allow sex/gender identification (see Trepte & Reinecke, 2010).

## 3.4. General administration of the tasks

The administration of the programme involves six steps as shown in Figure 5, which are detailed next:

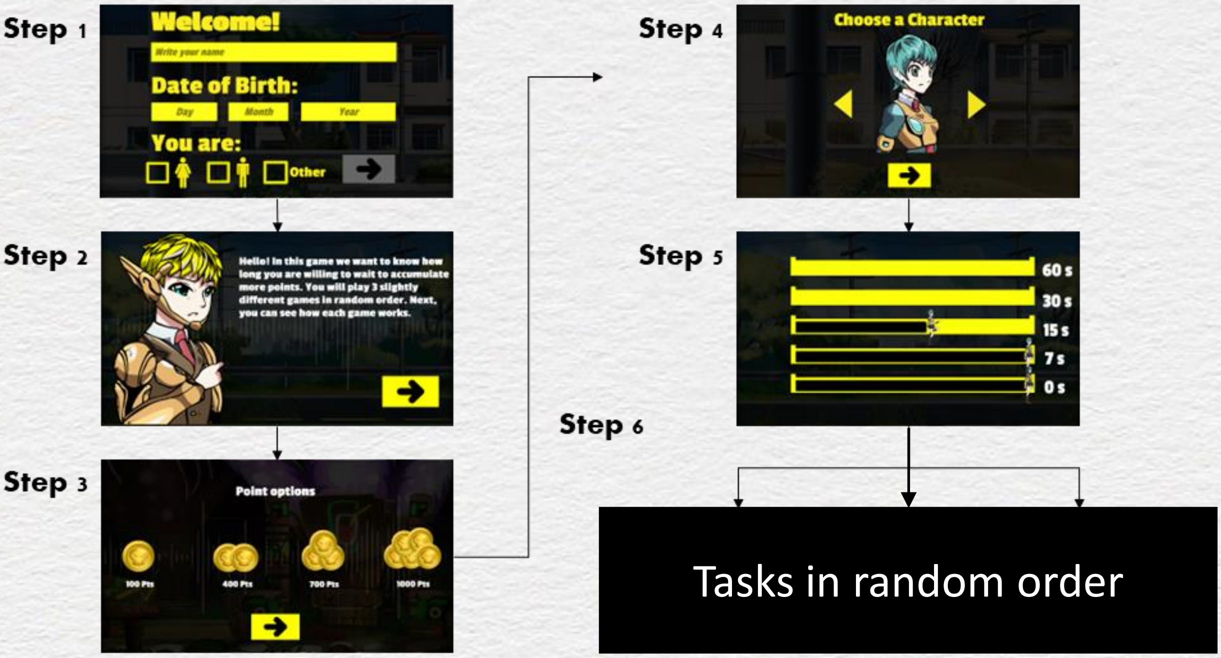



**Figure 5.** This figure illustrates the steps when running the programme: 1) Registration; 2) Initial instructions; 3) Presentation of points; 4) Choosing an avatar; 5) Presentation of delays; and 6) Games, presented in random order: Imaginary Game (hypothetical task), Real Game (real-time task) and Patience Game (hypothetical with temporal expectation).

### 3.4.1. Registration

In this screen, the test-takers are asked to enter their full name, date of birth (dd / mm / yyyy) and gender. Note that the "Other" option has been included for test-takers who do not consider themselves male or female. Test-takers can then click on the ARROW (next), located in the lower right corner (Figure 6). If you want to see how the programme works in an abbreviated way, type "debug" in the Name field. This will make it unnecessary to wait for any delay.

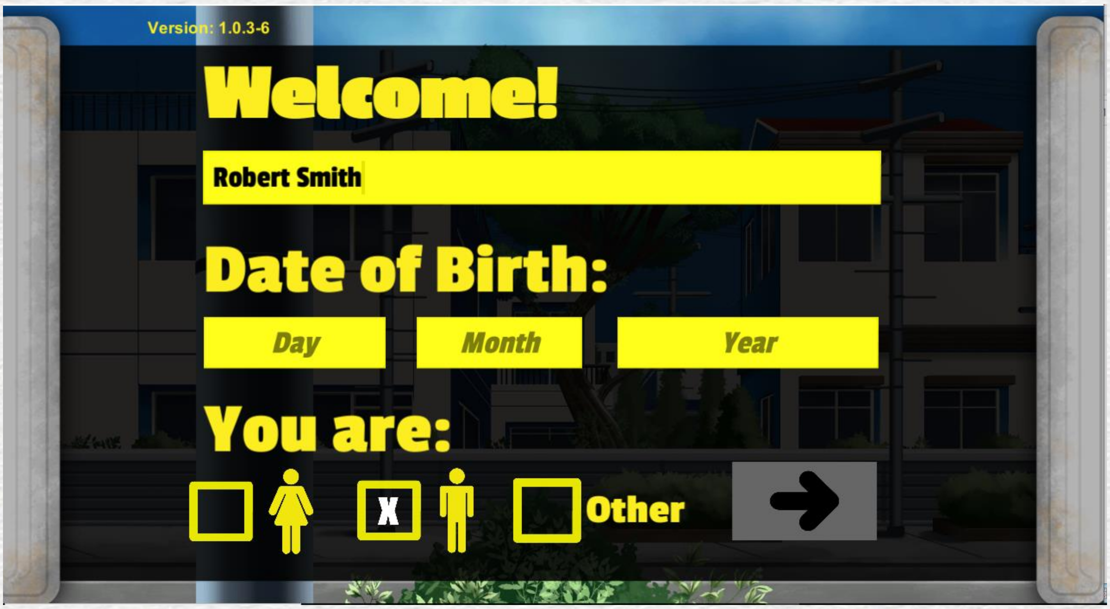



**Figure 6.** Registration screen.

### 3.4.2. Initial Instructions

This screen presents basic textual information about the DD tasks (Figure 7). In case of doubts, it can be complemented with verbal information, such as: ***"In this activity you will make several choices between receiving less points immediately or waiting some time to receive more points. The longer you***

***wait, the more points you will accumulate. In just one of the games the points you accumulate will be converted into real prizes [inform the prize]. The more points you score, the greater the chance you will receive a better prize. Before each game you will be informed if you will receive a prize, ok?"***

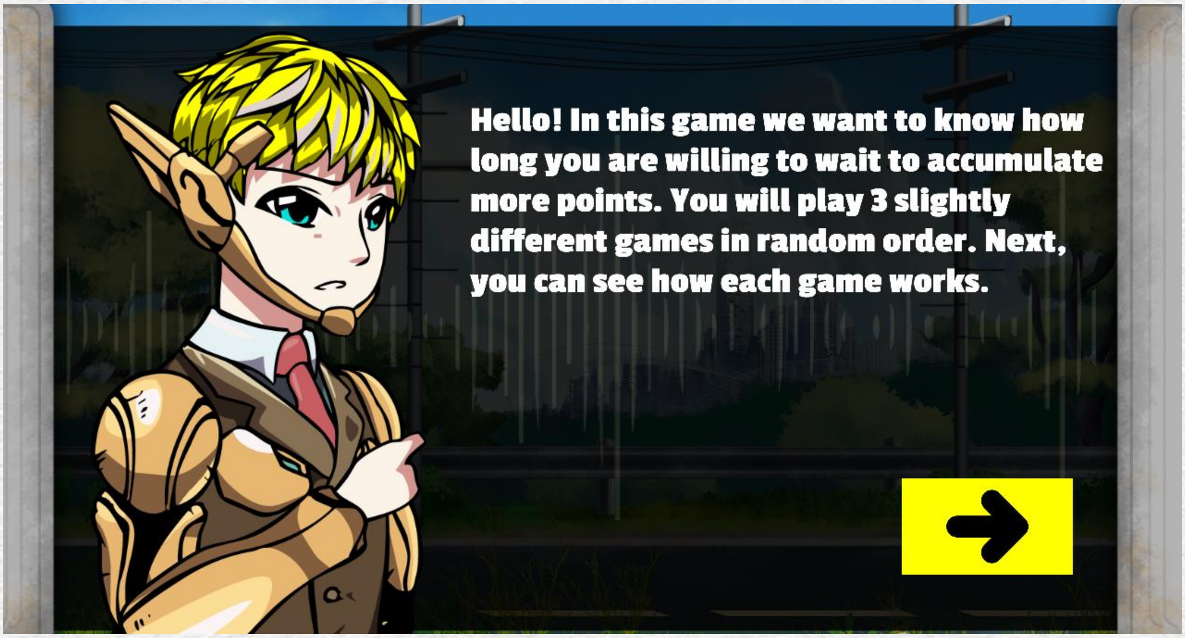



**Figure 7.** Editable screen that presents basic textual information about the activity.

### 3.4.3. Points Presentation

On this screen (Figure 8) the options for points (100, 400, 700 and 1000) are presented from left to right in increasing order of magnitude. These options are changeable when using the user interface.

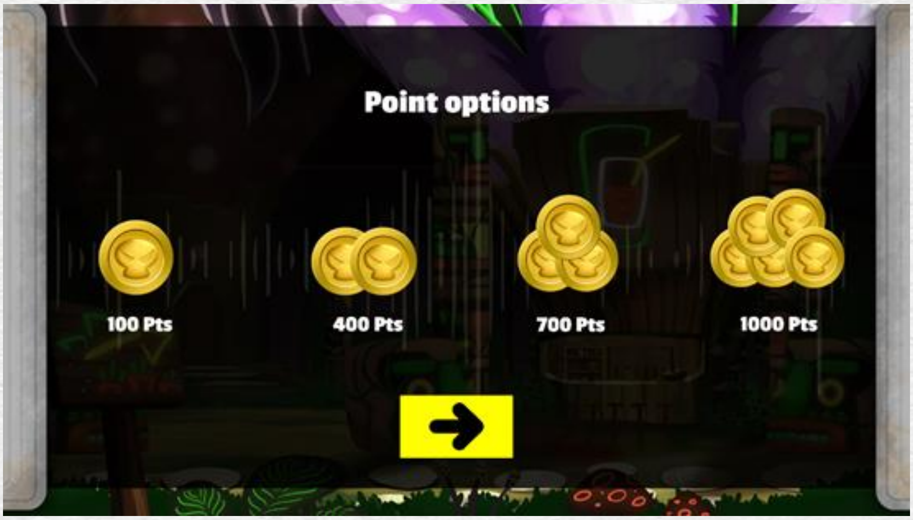
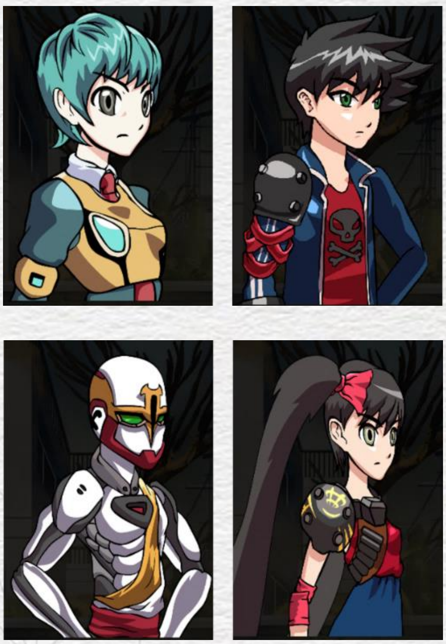



**Figure 8.** Point options, changeable when using the user interface

### 3.4.4. Choosing an avatar

In this screen, the test-taker chooses an avatar, that is, a character, among the four available ones, that will represent him / her in all games (Figure 9). To scroll through the avatars, the test-taker needs to click on the triangles pointing left or right. The chosen avatar must be visible when the test-taker clicks on the arrow located below the chosen avatar to proceed.



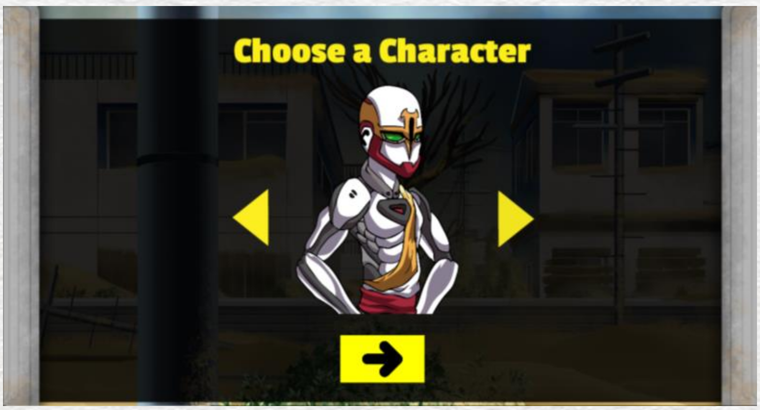



**Figure 9.** Avatar selection screen (above). To view the options and choose one of four avatars (on the left), click on the triangles on the right or left and then on the ARROW below the avatar.

### 3.4.5. Presentation of delays

This step aims to allow test-takers to experience the duration of all delays that are used in the games. Two screens are shown: the first (Figure 10A) informs that some delays will be presented. In the second (Figure 10B), delays are presented as five horizontal lanes one above the other on the screen. They correspond to the following delays, from top to bottom: 60, 30, 15, 7 and 0 s. The chosen avatar is positioned in the lowest lane (corresponding to zero delay), and it moves from left to right in 0.5 seconds. This time was included for the sole purpose of providing a speed reference. After that, the avatar appears positioned on the far left of the lane immediately above the last, and runs to the far right in 7 seconds, and so on. The test-taker is encouraged to experience all delays to ensure they have a real time reference to base their choices on.

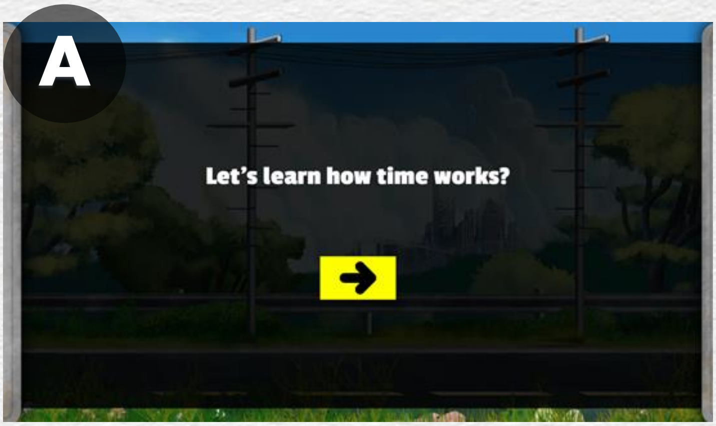



**Figure 10.** (A) Screen that informs the delays that will be part of the tasks will be presented / experienced.


(B) This screen shows all the delays that will be part of the tasks. Starting with zero seconds (referring to the immediate reward). The chosen avatar crosses the lane in 0.5 seconds. Then, in the lane immediately above, the avatar crosses the lane in 7 seconds, and so on.

# 4. Games (see Appendix A for online administration)

**IMPORTANT:**

1) The Waiting Game contains three games (tasks) presented in random order. Trials are presented in a pseudo-random order, but they change with each administration;

2) Each game is preceded by 8 practice trials. In the actual games, each immediate reward is paired three times with each delay. As there are three immediate rewards and four delays (except for zero s), each game has 36 trials;

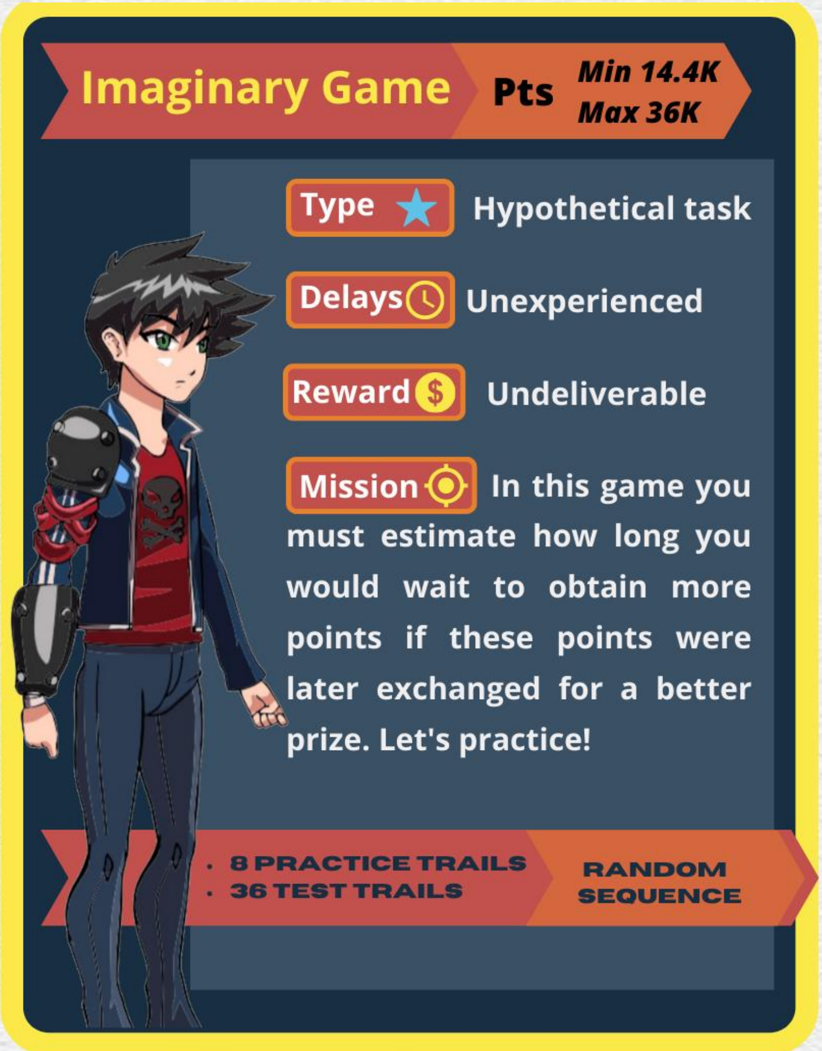
4) Before each game, we suggest verbal instructions be given in addition to those that appear in writing;

5) Before the beginning of each game the test-taker should be verbally informed whether he/she will or will not receive any material reward/prize;

6) It is essential that the examiner adopt a neutral stance and pay attention to the behavior shown by the test-taker. In waiting situations, some people try to talk, get up, use their cell phone, etc. Therefore, the test-taker must be asked to be silence, seated and to switch off their cell phones while playing. It is important that the examiner speak only when strictly necessary and to encourage the test-taker to return to their focus of the game. The examiner must not issue comments as this can influence the test-takers' choices. In case in which the test-takers have questions, examiners must answer briefly and objectively. If the test-taker becomes impatient they must be allowed to take a short break of 5 minutes or so between games. If the test-taker asks about the duration of the task, they can be told that the entire activity lasts from 15 to just over half an hour. During the execution of the games, it is recommended that the examiner keep little away from the test-taker to minimize the feeling that their choices are being watched;

7) Discontinuation criteria: 1) if the test-taker expresses the desire to withdraw from the activity; 2) noticeable lack of understanding of instructions; 3) negligence and carelessness with the activity, to the point of making data collection unfeasible due to: aggressive, offensive and/or destructive behavior.

## 4.1. Imaginary Game (hypothetical delays and rewards)





If this game is the first to be presented, it can be said as a way of complementing the instruction:

> ***"Here you don't have to wait, and you won't receive a prize at the end of the game either but try to imagine what you would do if you had to really wait to receive a better prize. Before the game you will be able to practice to understand how it works."*** (Figure 11A).

If this game is the second or third to be presented, then the examiner can say:

***"In this game, unlike the last (or others), try to imagine if you would wait longer to accumulate more points. Here you will NOT receive a material prize but make the choices as if you were going to receive one. Let's practice."*** (Figure 11A).

Figure 11B shows one of the practice trial screens. To complement the understanding, the following can be said:

***"Now you are going to practice. You will see screens like this one, where you need to choose if you prefer to wait some time to accumulate the higher score or if you prefer to accumulate a lower score immediately. To choose, just click on the chosen points, which will appear on the scoreboard [point to the scoreboard]. Each time you choose the points they will be added to the previous ones and will appear here [scoreboard]. See how it works."***

Using Figure 11B as an example, you can say:

***"Take a look at this screen: we have 400 points here, which you can accumulate now and 1000 points in this other lane, which you will accumulate after waiting 15 seconds [say pointing to the corresponding lanes]. In this game, you don't really have to wait, but it is important that you imagine if you would wait to accumulate more points and thus receive a better prize or not."***

Even if the test-taker understands the instruction they may nonetheless need to be encouraged to pass on to carry out the practice trials.

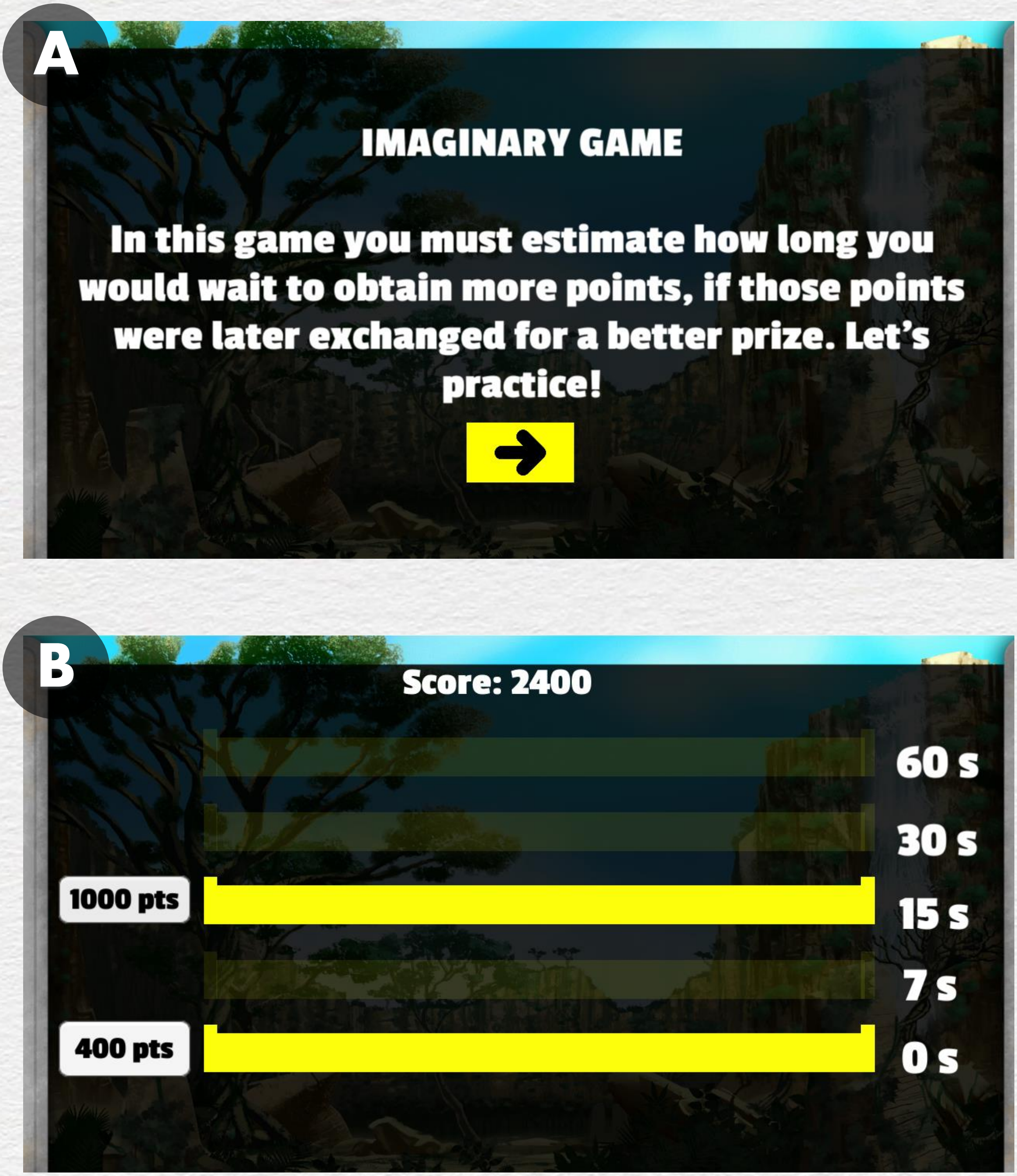



**Figure 11.** (A) Basic instructions for performing the Imaginary Game; (B) Practice screen in which the test-taker must choose between waiting 15 seconds to accumulate 1000 points or receiving 400 points immediately. As it is a hypothetical task, then it is necessary to reinforce that the times are not experienced and that the test-taker does not receive a material reward at the end of the game.

After practicing, the first Imaginary Game screen appears, and it is important to ensure the task-takers understands what they are supposed to do. If not, repeat the instructions in another way. Then remind the test-takers that they will NOT receive a material reward at the end of the game (Figure 12A). At this moment, the examiner can say:

***"Now that you have practiced, you can play the game. Remember, in this game you will NOT receive a material prize but make the choices as if you were going to receive one. You can start."***

A screen like the one shown in Figure 12B then appears. All games have the same layout, with the only difference that in the Imaginary Game the avatar does not cross the lane. Instead, by clicking on the desired score, the next trial (choice screen) is presented. After 36 trials a screen appears showing the total score achieved in the game (Figure 12C).

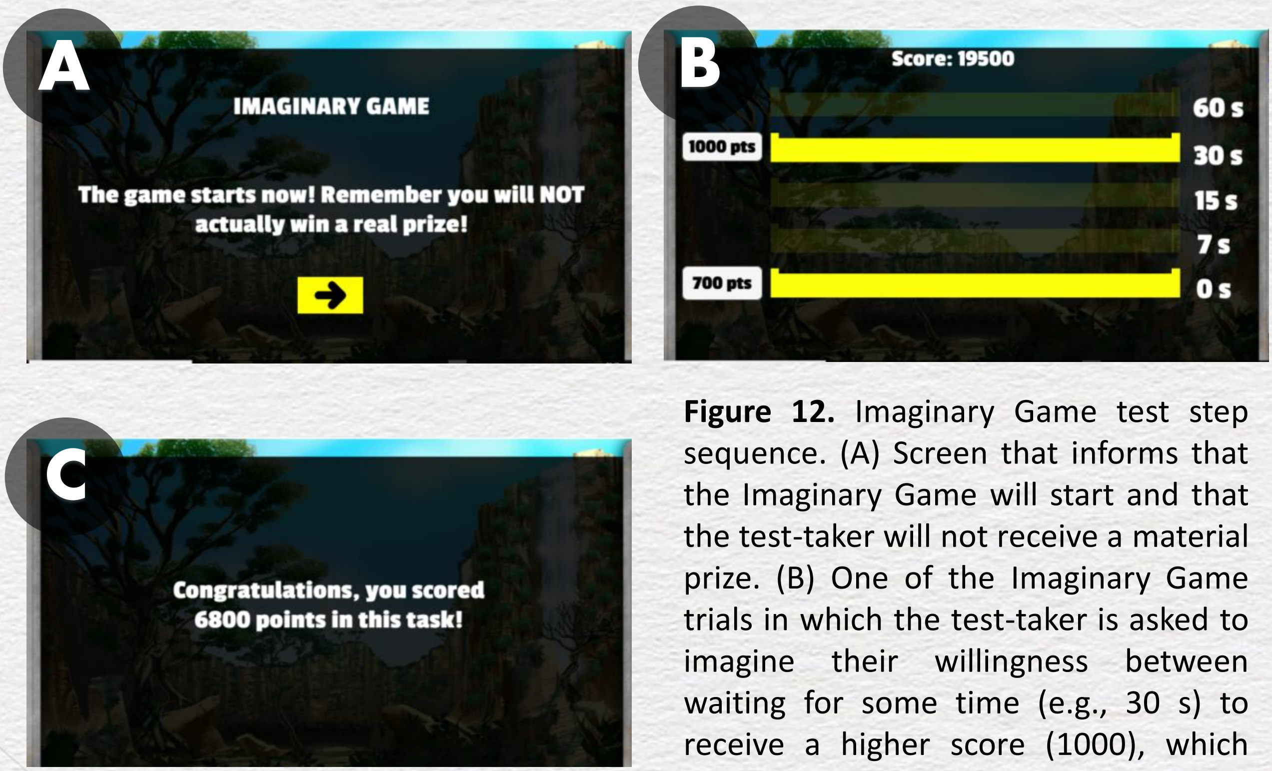
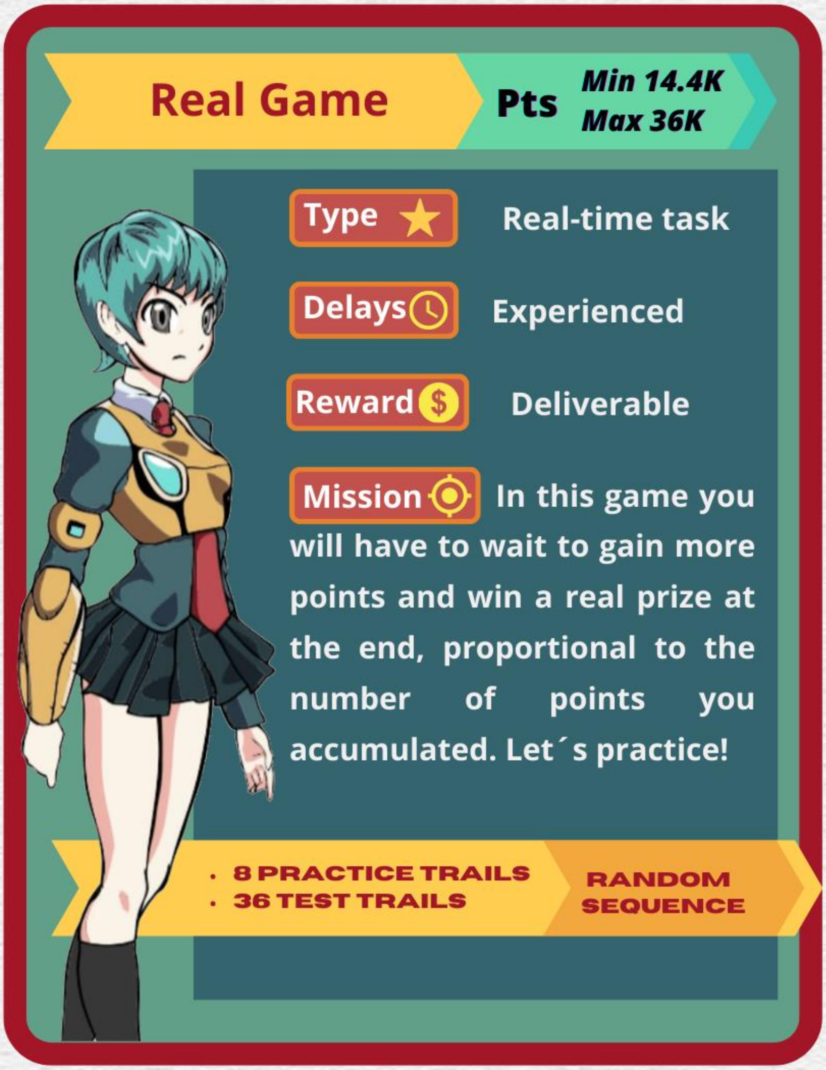



**Figure 12.** Imaginary Game test step sequence. (A) Screen that informs that the Imaginary Game will start and that the test-taker will not receive a material prize. (B) One of the Imaginary Game trials in which the test-taker is asked to imagine their willingness between waiting for some time (e.g., 30 s) to receive a higher score (1000), which could revert to a higher hypothetical prize, or receive a lower score (700 points) immediately.

(C) Final screen where the final score in Imaginary Game is displayed.

## 4.2. Real Game (real delays and rewards)





If this game is the first to be presented, it can be said as a way of complementing the instruction:

> ***"Here you must wait to accumulate more points that will be converted into a real prize. To get the more points you need to wait for some times. You will win a material prize proportional to the points you accumulate at the end of the game. Before the game you will practice to understand how it works."*** (Figure 13A).

If this game is the second or third to be presented, then you can say:

***"In this game, unlike the last (or others), evaluate your willingness to actually wait to accumulate more points. Here you WILL receive a material prize proportional to the points you reach at the end. Let's practice!"*** (Figure 13B).

Figure 13B shows one of the practice screens. As a way to complement the instructions, the following can be said:

***"Now you are going to practice. You will see screens like this, where you need to choose between waiting some time to get more points or get less points immediately. To choose, just click on the chosen points, which will appear on the scoreboard [point to the scoreboard]. ach time you choose the points they will be added to the previous ones and will appear here [scoreboard]. See how it works."***

Adopting Figure 13B as an example, you can say:

***"Take a look at this screen: we have 100 points here [after choosing the points are under penumbra], which you can accumulate now and 1000 points in this other lane, which you will accumulate after waiting 7 seconds [say pointing to the corresponding lanes]. In this game, if you press that button [corresponding to the biggest reward], you will need to really wait, in this case, for 7 seconds. Remember, the more points you accumulate, the bigger the prize you get at the end."***

If the test-takers understands the instructions, they may nonetheless need to be encouraged to pass on to carry out the practice trials.

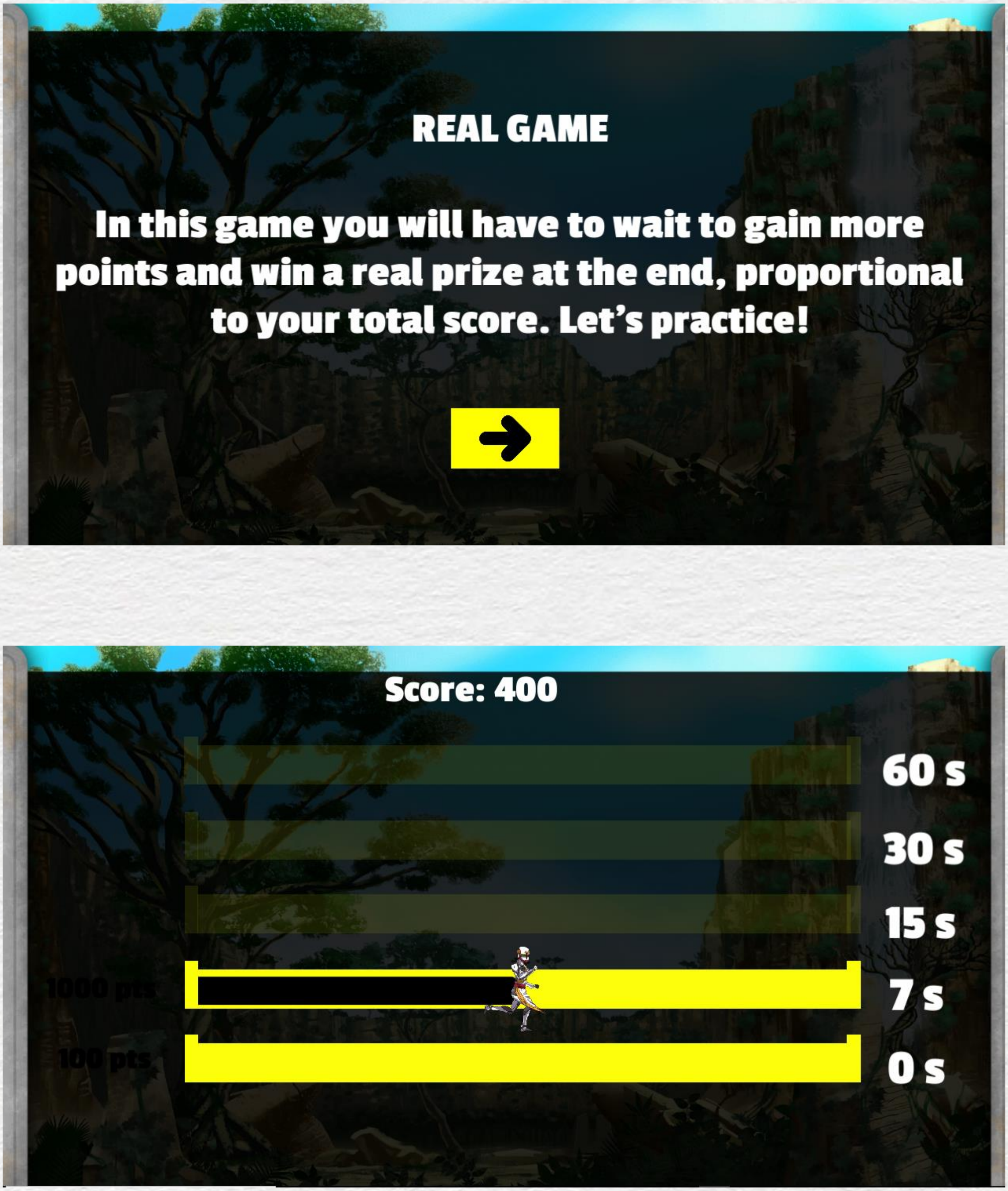
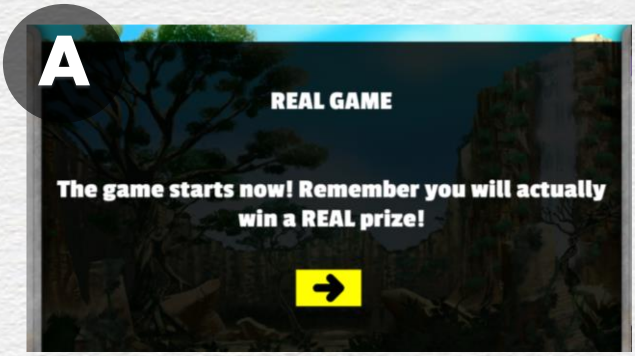



**Figure 13.** (A) Basic instructions for performing the Real Game; (B) Practice screen in which the test-taker is instructed to choose between an immediate lower score (100) or wait 7 s to receive the highest score and thus increase the chances of the total score being converted into a better material prize.

After training, the first Real Game screen appears, and it is important to remind the test-taker WILL receive a material reward at the end of the game (Figure 14A). At that moment, the examiner can say:

***"Now that you have practiced, let's play the game. In it you WILL receive a real prize the higher the points you reach. You can start."***

A screen like the one shown in figure 14B then appears. All games have the same layout, but different from Imaginary Game, here the avatar appears. After 36 trials a screen appears showing the score achieved in the game (figure 14C).



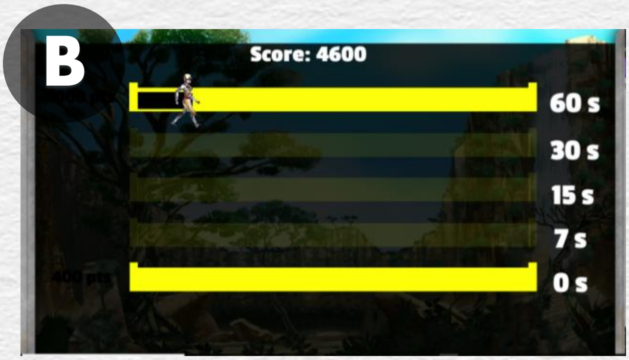
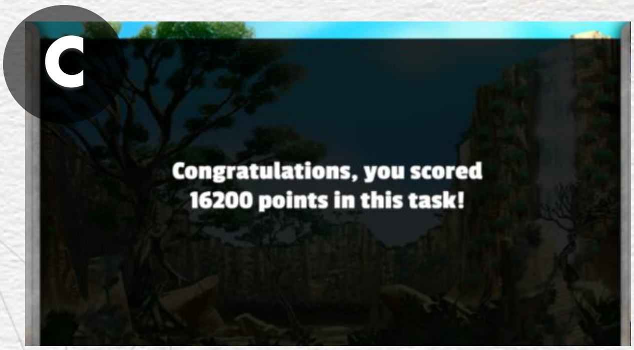




**Figure 14.** Real Game test step sequence. (A) Screen that informs that the Real Game will start and that the test-taker will receive a material reward.

(B) Different from Imaginary Game, the avatar appears here. The option is given between waiting 60 s to receive the highest score (1000) and receiving 400 points immediately.




(C) Final screen where the final score is displayed. At the end of all games, the score in this game is converted proportionally into a real prize.

## 4.3. Patience Game (real delays, hypothetical rewards)



### Why include this game?

The Patience Game is another type of DD task in which delays can be experienced, but no material reward is delivered. It was developed based on previous study to assess the aversion to waiting (Utsumi et al., 2016).

In Utsumi et al. (2016) control children only performed better than children with attention-deficit/hyperactivity disorder (ADHD) in a game similar to the Patience Game. However, no differences were found with regards the other tasks (akin to the Imaginary and Real games described before) even though all games had matching lengths of delay and magnitude of rewards. Additionally, the Patience task was the only one to be correlate with the Behavior Rating Inventory Scale (BRIEF): better performance (or lower discount) in this task was associated with lower expression of impulsive traits.

If this game is the first to be presented, it can be said as a way of complementing the instruction:

***“Here you can wait for the times to accumulate more points, knowing that you won’t receive a material prize at the end of the game. To get more points you need to wait for some time, but you will not receive a material prize. Before the game you can practice to understand how it works."*** (Figure 15A).

If this game is the second or third to be presented, then you can say:

***"In this game, unlike the last (or others), evaluate your willingness to wait for some times to accumulate more points. Here you will NOT receive a real prize but make the choices as if you were going to. Let’s practice!"*** (Figure 15A).

Figure 15B shows one of the practice screens. As a way to complement the understanding, the following can be said:

***“Now we are going to practice. You will see screens like this, where you need to choose between waiting some time to get more points or getting less points immediately. To choose, just click on the chosen score, which will appear on that scoreboard [point to the scoreboard]. Each score you choose will be added to the previous scores and will appear here [scoreboard]. See how it works.”***

Adopting figure 15B as an example, you can say:

***"Take a look at this screen: we have 700 points here [after choosing the points are under penumbra], which you can accumulate now and 1000 points in this other lane, which you will accumulate after waiting 15 seconds [say pointing to the corresponding lanes]. In this game, if you press that button [corresponding to the biggest reward], you will need to really wait for 15 seconds. Remember, in this game you will not receive a real prize at the end.”***

If the test-taker understands the instructions, they may nonetheless need to be encourage to pass on to carry out the task.

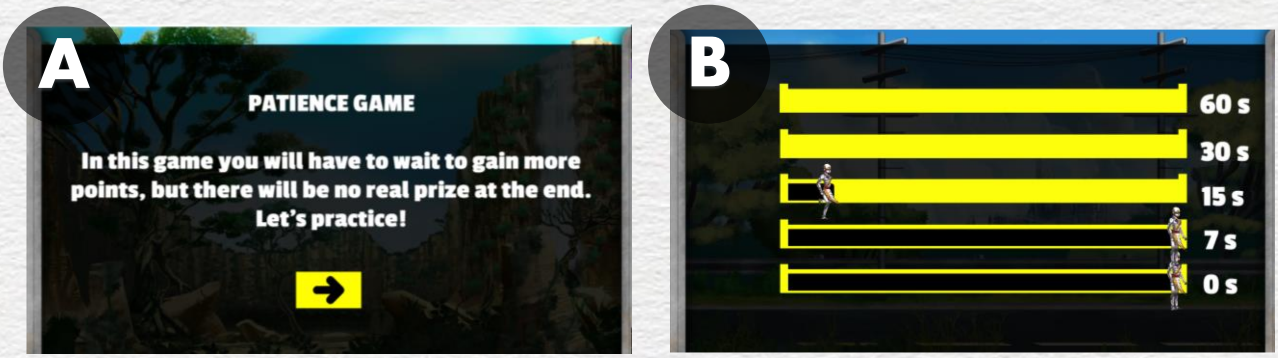



**Figure 15.** (A) Basic instructions for performing the Patience Game. (B) Practice screen in which the test-taker is instructed to choose between an immediate lower score (700) or wait 15 s to receive the highest score, knowing that he / she will not receive a material reward.

After practice, the first Patience Game screen appears, and it is important to remind the test-taker that they WILL NOT receive a material reward at the end of the game (Figure 16A). At this moment, the examiner can say:

***"Now that you have practiced, you can play the game. Remember you WILL NOT receive a material prize. You can start."***

A screen like the one shown in Figure 16B then appears. Visually, the Patience Game is identical to Real Game, that is, the avatar appears. After 36 trials a screen appears showing the total score achieved in the game (Figure 16C).

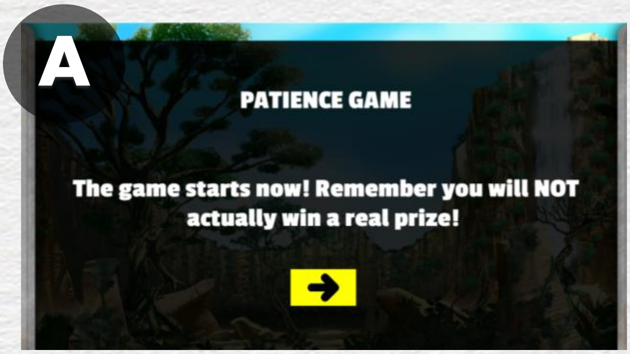
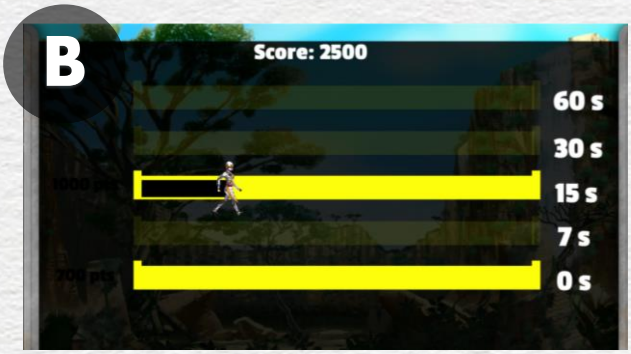
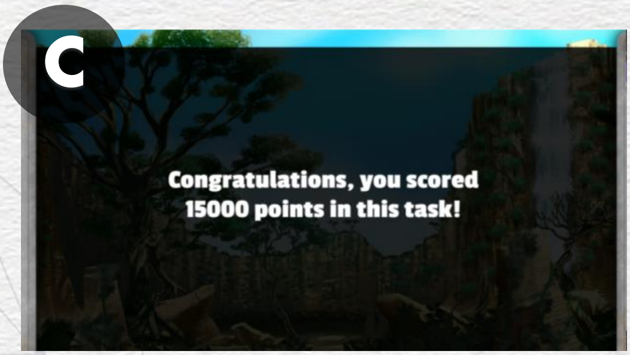



**Figure 16.** Patience Game test step sequence. (A) Screen that informs that the Patience Game will start and that the test-taker will NOT receive a material reward.

(B) Visually, the Patience Game is identical to Real Game (the avatar appears). The option is given between waiting 15 s to receive the highest score (1000) and receiving 700 points immediately.




C) Final screen where the final score is displayed.

## 4.4. Reward

At the end of the three games, the total and Real Game scores are shown (Figure 17); the latter is used to determine the real reward received by the participant (see Table 3). The conversion of scores into material rewards was based on a previous study (i.e., Utsumi et al., 2016). The total amount to be delivered to the participant after the execution of this task followed that suggested by several authors who applied a real-time task, offering a few cents per trial (e.g., Scheres et al., 2014; Yu & Sonuga-Barke, 2016).

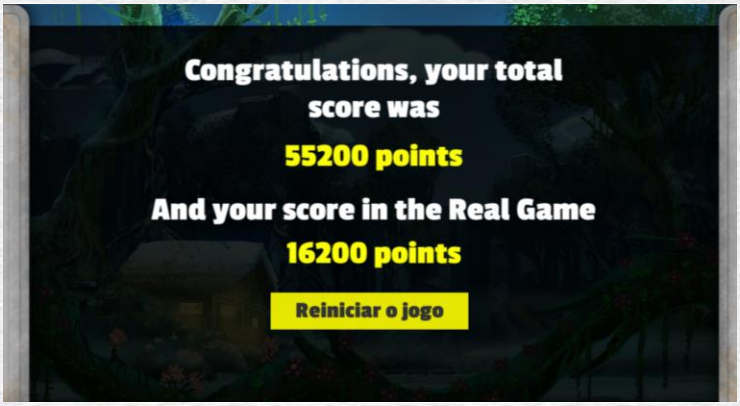



**Figure 17.** Final screen where the total scores are presented. The score in the Real Game is then converted proportionally to a material reward determined by the experimenter. The games can be restarted by clicking on the "Restart" button.

**Table 3.** Suggestion for converting scoring ranges into monetary rewards.

| Scoring range | Monetary Value (US$) |
|---|---|
| 28,801 – 36,000 | 3.00 |
| 21,601 – 23,040 | 2.60 |
| 14,400 – 21,600 | 2.20 |

*Note.* In this case, the maximum and minimum score delta was equally divided into three ranges. Each of them into monetary values. The lower score range corresponds to the minimum value of US$ 2.20. As the test-taker overtakes, the monetary value increases proportionally, which in this case is US$ 0.40.

# 5. Output

There are two outputs types (output 1 and output 2) generated only after the games have been completed. **Both outputs are located at: DD_1.0.3-6 > AR_Project_Data > Data.**

## 5.1. Output 1

This output option is offered to easily visualize the raw data. Each application generates a Data folder identified with three numbers (e.g., Data_000), inside which there are three csv files, one for each game (Figure 18). When opening one of the csv files, it is necessary to divide the information separated by commas into columns for a better visualization. To do this, click on DATA on the toolbar, select the data column A and then click Text for columns. A dialog box will appear; make sure that the "delimited" option is selected and click next. Then, in the delimiters field, click on the comma option, then on next and conclude Figure 19.

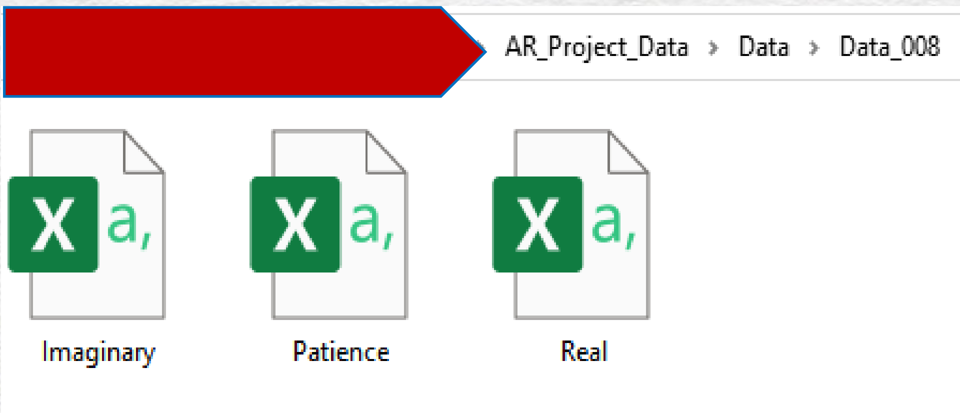



**Figure 18.** Location of output 1. In this example, the Data_008 folder was opened, which contains three csv files corresponding to the three games completed by just one test-taker.

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | Applicati | 01/08/2021 01:37 | | | | | | |
| 2 | Name | Robert Smith | | | | | | |
| 3 | Birth | 09/05/2004 | | | | | | |
| 4 | Gender | male | | | | | | |
| 5 | Avatar | Char02 | | | | | | |
| 6 | Total_Sc | 24000 | | | | | | |
| 7 | Type | Trail | Cluster_II | Smallest_ | Time_On | Chosen_ | Choose_Time | |
| 8 | Training | 4 | C | 700 | 1000 | 1000 | 2.02 | |
| 9 | Training | 8 | F | 400 | 1000 | 1000 | 1.58 | |
| 10 | Training | 2 | B | 400 | 1000 | 400 | 4.60 | |
| 11 | Training | 3 | B | 400 | 1000 | 1000 | 11.00 | |
| 12 | Training | 7 | E | 100 | 1000 | 1000 | 1.02 | |
| 13 | Training | 6 | C | 700 | 1000 | 1000 | 0.80 | |
| 14 | Training | 5 | D | 400 | 1000 | 400 | 0.81 | |
| 15 | Training | 1 | A | 100 | 1000 | 1000 | 0.93 | |
| 16 | Experime | 16 | F | 700 | 1000 | 1000 | 1.55 | |
| 17 | Experime | 1 | A | 100 | 1000 | 1000 | 0.85 | |
| 18 | Experime | 4 | B | 400 | 1000 | 1000 | 0.63 | |
| 19 | Experime | 17 | F | 700 | 1000 | 1000 | 0.80 | |
| 20 | Experime | 31 | K | 400 | 1000 | 1000 | 0.98 | |
| 21 | Experime | 5 | B | 400 | 1000 | 1000 | 1.10 | |
| 22 | Experime | 2 | A | 100 | 1000 | 1000 | 0.75 | |
| 23 | Experime | 6 | B | 400 | 1000 | 1000 | 0.42 | |
| 24 | Experime | 13 | E | 400 | 1000 | 1000 | 0.80 | |

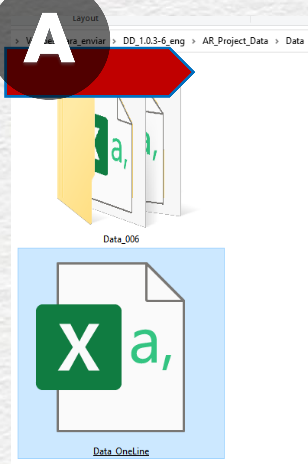
**Figure 19.** Visualization of output 1 data after converting information separated by commas into columns. Each file contains: sociodemographic information of the test taker (name, date of birth, gender and chosen avatar), date and time of the evaluation, total and partial score of each game, delays and time taken between the presentation of the trial and the test-taker's choice.

Output 1 also makes it possible to sort the choices in ascending order. To do so, copy cells A16:G51 and paste into empty cells (e.g., J1) or into another worksheet. Then select the Trial column, click Sort & Filter on the home toolbar, then click Smallest to Largest. For those interested, this organization will make it possible to manually build a matrix similar to Table 1 (see section 2.1. Methods for obtaining the subjective value), from which the subjective values (regardless of the adopted method) and the areas under the curve of each task can be calculated, although this does not necessary, as output 2 provides this and other pre-processed data, as will be described below.

## 5.2. Output 2

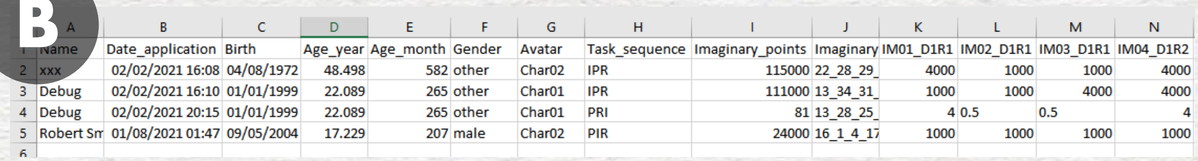
The other output option (Output 2, named Data_OneLine) is a single csv file also located in the Data folder (Figure 20A). It contains all the test-takers' responses in the three games, organized in one line per test-taker. With each new administration a line is added immediately below the first in order to store information in a format that allows statistical analyses by most programmes. In addition to covering all data from the first output, this second option automatically calculates test-takers' age in years and months, provides the sequence of games, gives absolute and normalized DD indexes of the **subjective value** (by the proportion method) and the **area under the curve** (AUC) of each game in one line per test-taker (Figure 20B).

A




(A) Locate the Data_OneLine csv file in the Data folder; (B) As mentioned earlier, it is necessary to divide the information separated by commas in columns. This output stores the information in a way that favors the transposition of the raw data to the database. See on line 4 it was written "Debug", which indicates the game's abbreviated presentation mode, as described in section 6.6. Debug. Also note that in cells K4 to M4 the option values are different as they were previously changed using the user interface, which will be discussed later.

B



| | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Name | Date_application | Birth | Age_year | Age_month | Gender | Avatar | Task_sequence | Imaginary_points | Imaginary | IM01_D1R1 | IM02_D1R1 | IM03_D1R1 | IM04_D1R2 |
| 2 | xxx | 02/02/2021 16:08 | 04/08/1972 | 48.498 | 582 | other | Char02 | IPR | 115000 | 22_28_29_ | 4000 | 1000 | 1000 | 4000 |
| 3 | Debug | 02/02/2021 16:10 | 01/01/1999 | 22.089 | 265 | other | Char01 | IPR | 111000 | 13_34_31_ | 1000 | 1000 | 4000 | 4000 |
| 4 | Debug | 02/02/2021 20:15 | 01/01/1999 | 22.089 | 265 | other | Char01 | PRI | 81 | 13_28_25_ | 4 | 0.5 | 0.5 | 4 |
| 5 | Robert Sm | 01/08/2021 01:47 | 09/05/2004 | 17.229 | 207 | male | Char02 | PIR | 24000 | 16_1_4_17 | 1000 | 1000 | 1000 | 1000 |
| 6 | | | | | | | | | | | | | | |

**Figure 20.** Location and opening of output 2.

Table 4 provides the initials and meanings of the output 2 (Data_OneLine).

**Table 4.** Initials and their meanings of the Output Data_OneLine

| **Initials** | **Meaning** |
|---|---|
| I or IM | Imaginary Game (hypothetical task) |
| P or PT | Patience Game |
| R or RL | Real Game (real-time task) |
| IM$numb_1$_D$numb_2$R$numb_3$ (e.g., IM01_D1R1)<br>PT$numb_1$_D$numb_2$R$numb_3$ (e.g., PT01_D1R1)<br>RL$numb_1$_D$numb_2$R$numb_3$ (e.g., RL01_D1R1) | D = delays; R =reward ; $Numb_1$ = numerical position in ascending order; $Numb_2$ = delay ID (e.g., 1 = 7s, 2 = 15s; 3 = 30s; 4 = 60s); $Numb_3$ = reward ID (e.g., 1 = 100 points, 2 = 400 points, 3 = 700 points). |
| IMSV*numb* / PTSV*numb* / RLSV*numb* | SV = subjective value; numb = represents the SV score according to a specific time (e.g., 0 = SV in time zero, 1 = SV in time 7s, 2 = SV in time 15s, 3 = SV in time 30s, 4 = SV in time 60s). |
| IMSV_N / PTSV_N / RLSV_N | N = normalized subjective value score. |
| IMAUC / PTAUC / RLAUC | AUC = area under the curve. |
| IMAUC_N / PTAUC_N / RLAUC_N | N = normalized area under the curve score. |
| IM_time / PT_time / RL_time | Time elapsed between the presentation of an option and the choice made by the participant in a trial. |

Both output types so far are using the .csv format. To create your own export type, you can create a new class that extends the IOutput interface, located at Scripts/Output/. The interface has methods that will be called at the appropriate time when the user completes the game. The start and end session methods should be used for setting up your exporter when a new session starts and ends. The methods SaveUserData and SaveSelectedCharacter give you more information about the user that will test. The StartExperiments method will be called when the user finishes the registration and will begin the experiments. For each new experiment done, the function SaveExperimentData will be called. Finally, the SaveTotalPoints method will be called.

For an example of how the interface is used, check the package /Scripts/Output/CSV. The CSVAllOutputs uses a Facade pattern for both .csv output modes. The /Scripts/Output/OutputFactory.cs file is where you choose which implementation of IOutput should be used.

## 5.3. Scoring

The Waiting Game offers two discount measures: the subjective value (SV) and the area under the curve (AUC), expressed in absolute and normalized values in *output 2*.

- **Subjective values**: The proportion of delayed reward choices method (Mies et al., 2018) was adopted, calculated by equation 1. The absolute SV for each delay of the three tasks are found in DT to EH cells, while the normalized SV are found in EL to EZ cells (see Table 4). The higher the SV, the lower the discount. Normalized SVs have the advantage of expressing, as a percentage, the preference for the larger reward in a given delay. For example, if in output 2 the result of RLSV_N2 is 0.85, this means that in the Real Game the test-taker chose the larger reward in 85% of the trials involving 7s.

• **Area under the curve (AUC; Myerson et al., 2001)**: AUC is calculated based on equation 3. The absolute AUC of the three tasks are found in EI to EK cells, while the normalized AUC are found in FA to FC cells (see Table 4). The higher the AUC, the lower the discount. Here the normalized AUC values are also useful for the interpretation of the results. For example, a 0.29 IMAUC_N means that in only 29% of all choices made in the Imaginary Game, the test-taker chose the larger reward, that is, there was a steeper discount throughout the task.

## 5.4. Randomization

Games are presented in random order, but the order of the spreadsheet trials follows a pseudo-random order (the same one presented to the test-taker) although the sequence of trials changes with each administration keeping a logic that meets two rules that were necessary to determine the DD scores (see next):

1) The output must allow the raw data to be rearranged in ascending order. That is, choices between the lowest score (100) and the shortest delay (7 s) will be the first, choices between the second lowest score (400) and 7 s will be presented after, and so on;

2) The order of presentation within a set of identical pairs, called cluster, must be respected. In ascending order, each choice has an ID from 1 to 36 and each cluster, identified by letters, is made up of three equal choice pairs. For instance, pairs between 100 points and 7 s belong to cluster A and have IDs from 1 to 3, while pairs between 400 points and 7s belong to cluster B and have IDs from 4 to 6. Clusters can be randomized, but the ID sequence of the trials belonging to each cluster needs to be maintained. This last rule must be followed when calculating the subjective value using the predetermined rules method which corresponds to only one of the outputs (Figure 21).

As far as is known, all studies that involved tasks of this type used a fixed pseudo-random presentation mode (Scheres et al., 2010a). In other words, the presentation was apparently random, but the same for all test-takers, unlike in the Waiting Game, in which this varied.

A

| ID | Cluster | Lowest reward | Delay | Chosen reward |
|---|---|---|---|---|
| 4 | B | 400 | 7 | 1000 |
| 3 | A | 100 | 7 | **1000** |
| 2 | A | 100 | 7 | **1000** |
| 5 | B | 400 | 7 | 1000 |
| 1 | A | 100 | 7 | **100** |

B

| ID | Cluster | Lowest reward | Delay | Chosen reward |
|---|---|---|---|---|
| 1 | A | 100 | 7 | **100** |
| 2 | A | 100 | 7 | **1000** |
| 3 | A | 100 | 7 | **1000** |
| 4 | B | 400 | 7 | 1000 |
| 5 | B | 400 | 7 | 1000 |

C

| ID | Cluster | Lowest reward | Delay | Chosen reward |
|---|---|---|---|---|
| 4 | B | 400 | 7 | 1000 |
| 1 | A | 100 | 7 | **1000** |
| 2 | A | 100 | 7 | **1000** |
| 5 | B | 400 | 7 | 1000 |
| 3 | A | 100 | 7 | **100** |

**Figure 21.** In a real randomization system, a sequence such as presented in Figure A may occur. However, when reorganizing the IDs ascendingly (B), there is an inversion of the positions (highlighted in bold), as if the test-taker had started discounting when, in fact, (s)he only decided in favor of the immediate reward after waiting twice for 7 s to accumulate a total of 2000 points. This inversion changes the subjective value of the reward to a certain delay, according to a predetermined rules method. For this reason, it is not possible to completely randomize trials, so the numerical sequence within the cluster cannot be broken, although it is possible to randomize the clusters. Figure C shows an example of pseudo-randomization, where clusters are presented randomly, but the numerical order within each is preserved. Thus, the probability of inversions and misinterpretations is reduced.

# 6. User Interface

The most practical way to edit the programme's content is through Google spreadsheet (access is provided here) Researchers interested need in editing the language/parameters of the programme need to **create a new version of the spreadsheet** so that they can freely modify the contents (see Figure 22). In this spreadsheet, there are six tabs: Training, Trials, Texts, Rewards, Time and Debug.

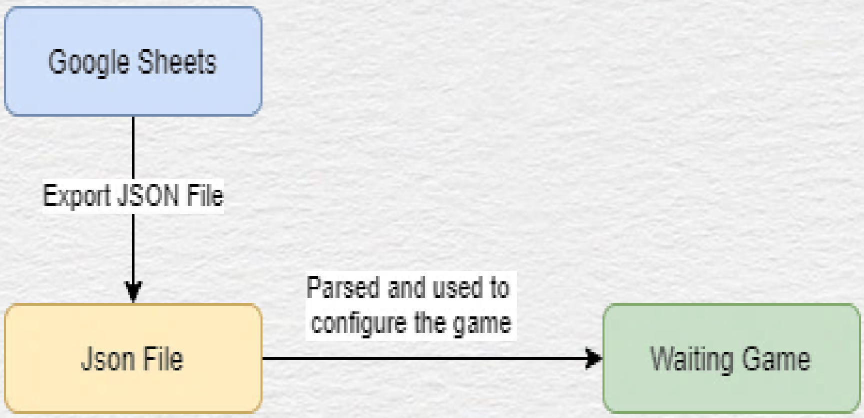



**Figure 22.** Flow chart that illustrates the path to edit the content of the programme. Edits made in the Google spreadsheet (domain-specific model; DSM) generate a JSON file (domain-specific language; DSL), which needs to be saved as it is the code that replaces the prior one in the Config file, located in AR_Project_Data>StreamingAssets.

Table 5 summarizes the spreadsheet's editable items.

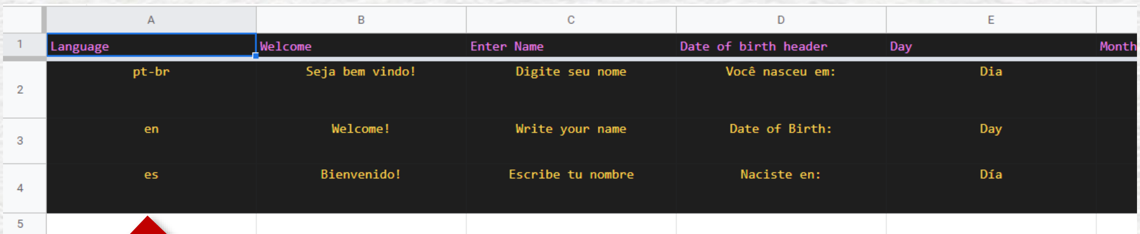
**Table 5.** Editable programme items, organized by User Interface tabs (Google Spreadsheets).

| Tabs | Editable items | Important |
|---|---|---|
| **Trainings** | **Immediate prize value:** It is possible to choose the value and the number of times an immediate reward will appear in the practice step;<br><br>**Second prize lane:** It is possible to determine the lane (delay) in which the larger reward will appear;<br><br>**Second prize value:** This value (4) corresponds to the larger reward. Changing it is not recommended as an immediate reward will always be paired with the larger fixed reward. | **In all cases, changing spreadsheet headers and IDs is not recommended.**<br><br>Rewards and delays are numbered. To know the correspondence between the numbers and the amount of reward and length of delays, access the tabs Prizes and Times, respectively. |
| **Experiments** | The editable items on this tab are the same as for Trainings, but it is recommended not to change them. This tab is used to view the matches made between immediate rewards and the delayed one over the 36 trials. Although the pairings are in ascending order, at each application the programme pseudo-randomizes the order of trials. | To know the correspondence between the numbers and the amount of reward and length of delays, access the tabs Prizes and Times, respectively. |
| **Texts** | All text fields are editable. To enter a new language, enter the language code in cell A4 and translate the texts from the default languages provided (English, Brazilian Portuguese and Spanish);<br><br>It is also possible to change the reward type. For example, in columns X, Y and Z (Score, Points and Points Abbreviated) it is possible to enter "Total Value", "Dollars" and "$", respectively. | |
| **Prizes** | **Value:** All values can be modified. | |
| **Times** | **Tempo:** All delays (in seconds) can be modified, but it is recommended not to change the zero time, as this corresponds to the immediate reward. | The sequence of lanes must not be modified. |
| **Debug** | Always imaginary first: For the complete randomization of the tasks/games, keep the FALSE option selected. If you want the Imaginary Game to always be first, type TRUE;<br><br>Language: Insert the language code to select the language of the texts. | |

In order to make the spreadsheet easier to understand, the tabs will be detailed next.

## 6.1. Texts

This tab contains all texts that appear during the execution of the programme (Figure 23). There are currently three standard languages: English, Brazilian Portuguese and Spanish. If necessary, the texts can be modified. For example, in this version the rewards are points, but it is possible to change it to your country's currency. Thus, in columns X, Y and Z (Score, Points and Points Abbreviated) it is possible to enter "Total Value", "Dollars" and "$", respectively. Note that in column A the language codes of these languages are presented (en, pt-br, es). In case of inclusion of a new language, it is necessary to write the texts in line 5 and insert the language code in column A.



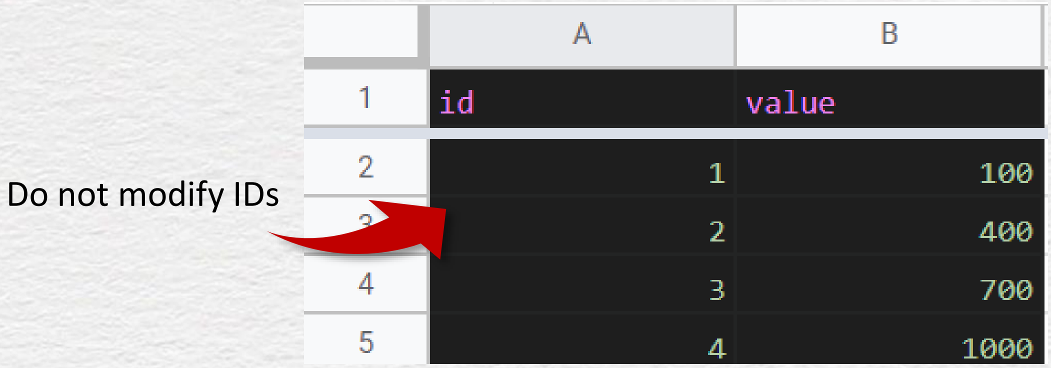
| | A | B | C | D | E | |
|---|---|---|---|---|---|---|
| 1 | Language | Welcome | Enter Name | Date of birth header | Day | Month |
| 2 | pt-br | Seja bem vindo! | Digite seu nome | Você nasceu em: | Dia | |
| 3 | en | Welcome! | Write your name | Date of Birth: | Day | |
| 4 | es | Bienvenido! | Escribe tu nombre | Naciste en: | Día | |
| 5 | | | | | | |

**Figure 23.** Part of the Texts tab of the programme's editing spreadsheet.

Insert new language on cell A4. Do not forget to enter a new language code (e.g., **it** for Italian).

## 6.2. Prizes (rewards)

In this tab the IDs and magnitude (Value) of the rewards are presented (Figure 24). In this version, the rewards are points ranging from 100 to 1000. To modify, just enter the new values from cells B2 to B5. Do not modify IDs as they are linked to other tabs.

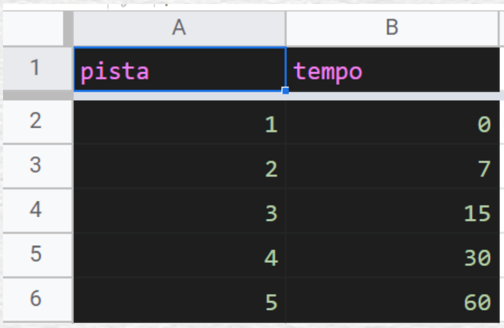



| | A | B |
|---|---|---|
| 1 | id | value |
| 2 | 1 | 100 |
| 3 | 2 | 400 |
| 4 | 3 | 700 |
| 5 | 4 | 1000 |

**Figure 24.** Tab Prizes of the programme editing spreadsheet.

## 6.3. Times (delays)

The tab Times presents the delays (delays) by lane, denominated in the spreadsheet by "tempo" and "pista", respectively (Figure 25). There are 5 lanes, the first one corresponding to the immediate reward. Therefore, it is not recommended to change the time of this lane (zero sec.). The other lanes can be modified, remembering that the unit of measure is seconds. For example, if you enter in cell B6 90, this will correspond to 1 minute and 30 seconds. Do not modify the lane numbers as they are linked to the other tabs.



| | A | B |
|---|---|---|
| 1 | pista | tempo |
| 2 | 1 | 0 |
| 3 | 2 | 7 |
| 4 | 3 | 15 |
| 5 | 4 | 30 |
| 6 | 5 | 60 |

It is not recommended that this time (zero sec.) be altered.

**Figure 25.** Tab Times of the programme editing spreadsheet.

## 6.4. Trainings (practice trials)

On this tab the IDs and numeric codes for the value of the immediate prize, lane in which the immediate prize will appear and the value of the second prize are displayed. It is important to remember that the lanes represent the waiting time: the higher the lane, the longer the delay (see Table 6). The trial sequence is completely randomized, but you can change the number of times a prize will appear, and the lane associated with the bigger prize (Figure 26).

**Table 6.** Correspondence between numerical code of lanes and delays in the current programme version

| Lane | Delay in seconds |
|---|---|
| 1 | 0 |
| 2 | 7 |
| 3 | 15 |
| 4 | 30 |
| 5 | 60 |

Do not modify IDs

| | A | B | C | D |
|---|---|---|---|---|
| 1 | Id | Immediate Prize Value | Second Prize Lane | Second Prize Value |
| 2 | 1 | 1 | 2 | 4 |
| 3 | 2 | 2 | 3 | 4 |
| 4 | 3 | 2 | 3 | 4 |
| 5 | 4 | 3 | 2 | 4 |
| 6 | 5 | 2 | 4 | 4 |
| 7 | 6 | 3 | 2 | 4 |
| 8 | 7 | 1 | 5 | 4 |
| 9 | 8 | 2 | 5 | 4 |

**Figure 26.** The training (practice trial) tab of the programme editing spreadsheet where combinations between rewards (immediate and delayed) and delays associated with delayed reward are shown. The blue square highlights a combination that represents the choice between the maximum value associated with waiting 30 seconds versus receiving 100 points immediately.

## 6.5. Experiments (games/tasks)

This tab contains the same elements as the Training tab, but corresponds to the 36 test trials. We recommend users to not change it. Although Figure 27 presents the data organized in ascending order by IDs, the programme pseudo-randomizes the sequence of trials, complying with the rules described above for scoring.

Do not modify IDs

| | A | B | C | D |
|---|---|---|---|---|
| 1 | Id | Immediate Prize Value | Second Prize Lane | Second Prize Value |
| 2 | 1 | 1 | 2 | 4 |
| 3 | 2 | 1 | 2 | 4 |
| 4 | 3 | 1 | 3 | 4 |
| 5 | 4 | 2 | 3 | 4 |
| 6 | 5 | 2 | 4 | 4 |
| 7 | 6 | 2 | 4 | 4 |
| 8 | 7 | 3 | 5 | 4 |
| 9 | 8 | 3 | 5 | 4 |

**Figure 27.** Experiments tab where the 36 test trials are shown. It is not recommended to change any value.

## 6.6. Debug

This tab is essential for changing or adding a new language. To do this, just write the language code in cell B2. Make sure the code language and texts are on the Texts tab. Column A shows an option for those who want the Imaginary Game (hypothetical task) to always be presented first. To do this, just type "TRUE" cell A2, otherwise the tasks will be presented in a completely random way (Figure 28) and automatic scoring will not be possible.

| | A | B |
|---|---|---|
| 1 | Always Imaginary First | Language |
| 2 | FALSE | en |

**Figure 28.** Debug Tab.

## 6.7. JSON Export

Changes made to the Google Spreadsheet are automatically saved. To export and run the changes, it is necessary to click Export JSON and then Export JSON for Unity Project (Figure 29A), located in the taskbar. A dialog will open with the script (figure 29B). Select all, copy (e.g., press CTRL+C on the keyboard) and open the programme's StreamingAssets folder. Open the Config file, select all the text and then click paste (CTRL+V) (Figure 29C). This will cause the old script to be replaced with the new one. Then save and close the Config file. Contact the authors if you need any assistance.

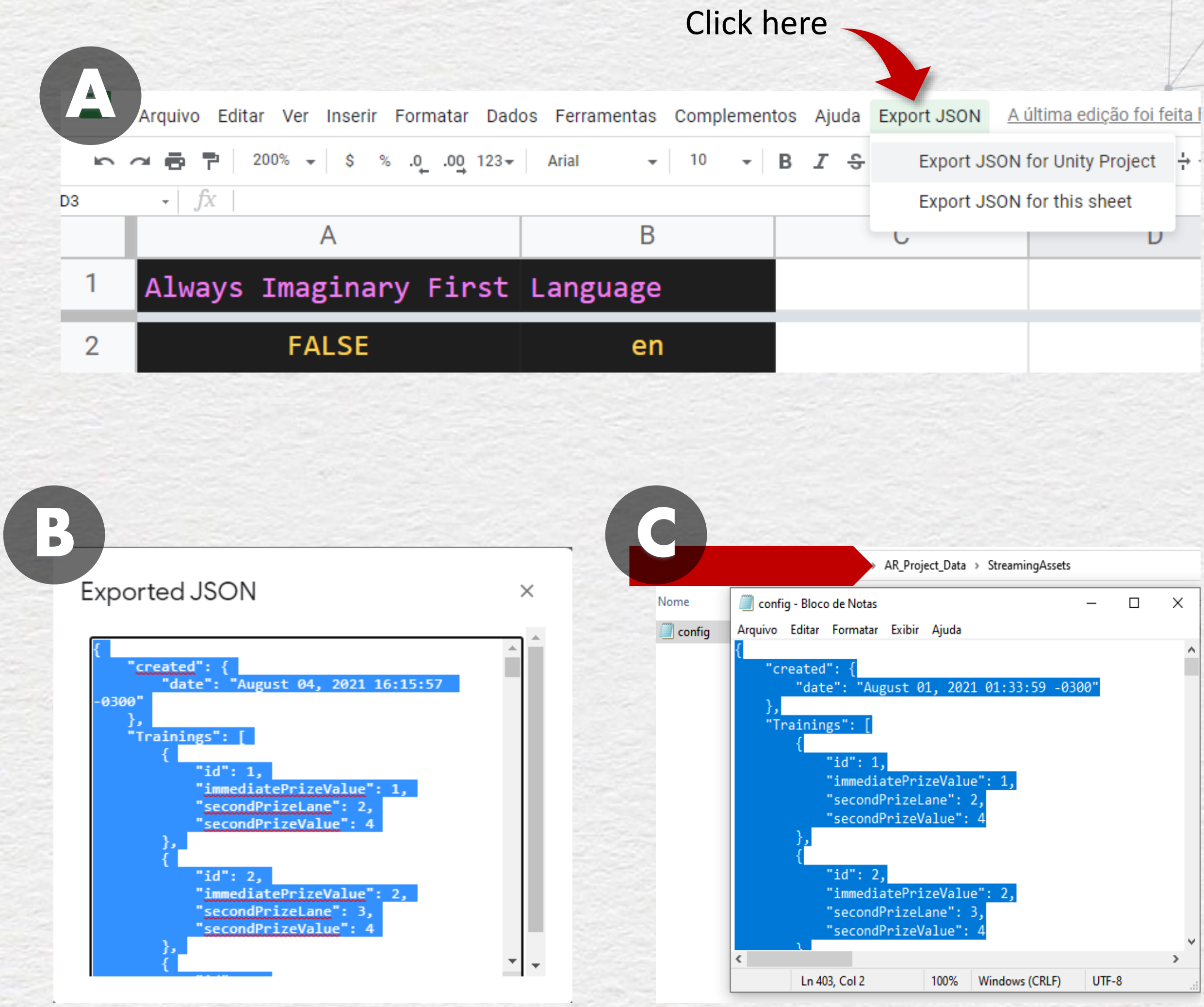



**Figure 29.** Procedure to export the JSON to the StreamingAssets folder of the programme.

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# Apendix A - Instructions for online administration

The Waiting Game administration can be done remotely. To this end, it is necessary to ensure that both the researcher and the test-taker have:

1) Internet connection;
2) Installed remote conferencing app that allows screen sharing (e.g., Zoom and Google Meet). For researchers, the app account must allow meetings longer than 30 minutes;
3) Software compatible operating system (Windows, Linux and macOS).

In order to ensure that the test-taker is not harmed by unstable connections, it is strongly recommended that the programme files be sent to the test-taker in advance so that s(he) can play the Waiting Game on his/her own computer or tablet. The zipped folder DD_1.0.3-6 can be sent via WhatApp or email to the test-taker (or guardian, in the case of minors). If the programme has been edited by the researcher, it is necessary to make sure that the zipped folder contains the updated changes.

After that, the link to the remote conference is sent to the test-taker or guardian via WhatsApp or email. Once the participant is in the room, ask him/her to enable the microphone and preferably the camera. At this point, it is important to give him/her general instructions about what will be done.

To start the programme, allow the test-taker to share their screen first. In meeting room on Zoom, the researcher must click on the “Security” icon, located on the bottom app bar, and on the option “Allow participant to share screen”. Then, the participant is asked to click on the green “Share screen” icon on the bottom app bar and then on “Share”, located in the lower right corner of the options box (Figure S1). To share the screen on Google Meet, the participant is instructed to click on “Present Now” on the bottom app bar, and then on “A tab”.

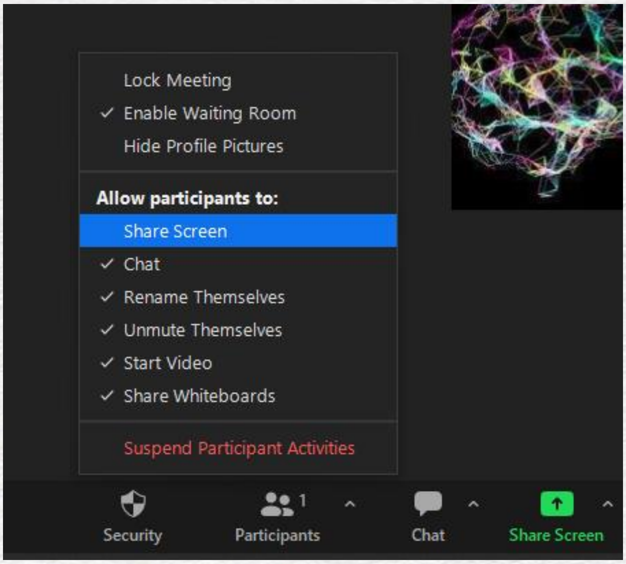


**Figure S1.** Procedure for enabling screen sharing on Zoom. First, the researcher needs to click on the "Security" icon on the bottom bar of the app and then select “Share screen". Next, the test-taker is asked to click on the green "Share screen" icon on the bottom bar of the app and then on the blue "Share" button in the options box.

Next, ask the test-taker or the guardian to unzip the DD_1.0.3-6 folder, right clicking on the folder and selecting the option “Extract all" or “Extract here" or using a zip/compression software, such as 7-Zip or WinZip. After unzipping the folder, it is recommended to rename it (e.g., DD followed by the test-taker's initials) by right clicking on the unzipped folder and selecting the "rename" option. Then follow the administration instructions in chapter 4. Games.

At the end of the application, it is fundamental that the researcher guides the test-taker to send the data output. To this end, instruct him/her to access DD_1.0.3-6 > AR_Project_Data. Inside this folder, ask the test-taker to compress the Data folder by right-clicking it, then "Send To" and finally "Compressed (zipped) Folder". After zipping, it is recommended to rename the folder with test-taker's initials. An alternative to this procedure is to ask the test-taker to compress the DD_1.0.3-6 folder, adopting the same procedure described above (Figure S2). Next, the folder can be sent via WhatsApp or email.

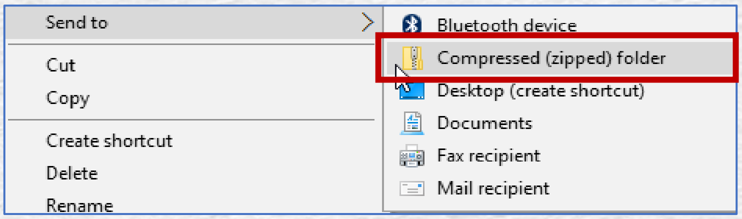


**Figure S2.** Instructions to zip the programme folder.

Sending the folder via WhatsApp Web or WhatsApp Desktop is useful because it allows uploading large files without needing link generation or using large file upload websites (over 20 GB), such as WeTransfer or MailBigFile. To do so, ask the test-taker to access Whatsapp (Web or Desktop) and open the chat with the researcher. In the textbox, ask him/her to click on the “paperclip" icon and then on the “File” option. Ask him/her to select the zipped folder and then send it to researcher (Figure S3).

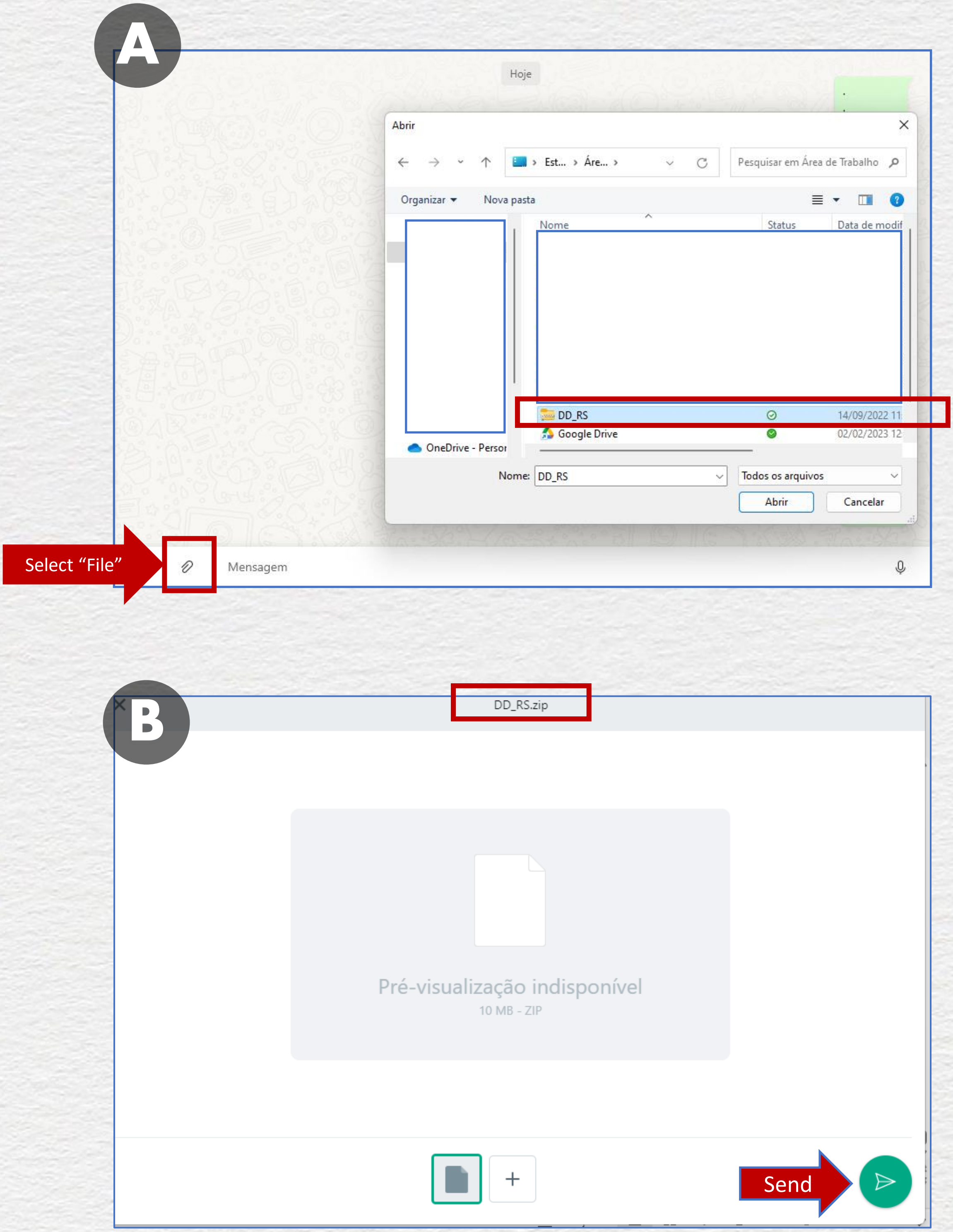


**Figure S3.** Procedure for sending the zipped folder by WhatsApp. First ask the test-taker to access WhatsApp (Web or Desktop), open the chat with the researcher, click on the "paperclip" icon and then the “File" option. Locate and select the updated zipped folder (renamed with test-taker's initials); (B) Make sure the folder name is correct and then click on “send” icon.