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The Waiting Game

User Guide for a Delay Discounting Open-Source Software

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Version 01

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Summary

List of links

- Download the software folder (Build-1.2.0.zip) from GitHub using this link. To extract the folder, right-click on it and select "Extract All";

- To obtain the software for Linux and macOS operating systems, please get in touch with the authors.

- For additional information on installation, system requirements, and using the software, refer to section 3.2. Opening the software.

1. Introduction

The Waiting Game is a free, open-source software with game design elements designed to assess delay discounting (DD) performance mediated by an examiner for research purposes. Norms are not provided so performance must not be used for clinical diagnosis purposes. The software includes three tasks matched in visual appearance in which language, instructions, delay durations, and reward type/magnitude can be edited by researchers without prior programming knowledge through a user-friendly interface (an Excel spreadsheet). These features facilitate its adaptation to various sociocultural contexts and research objectives. The software comprises the following games:

1) Imaginary Game: delays are hypothetical (not experienced), and no reward, other than points, is given.

2) Real Game: delays are experienced and the points gained are converted into a material reward chosen by the examiner.

3) Patience Game: delays are experienced, but no reward, other than points, is delivered.

This User Guide aims to:

1) Provide background information and the rationale for the development of these computerized DD tasks;

2) Describe the development of the software;

3) Offer instructions on downloading, administering, editing, and obtaining data/scores from the software.

software.

2. Background

Delay discounting (DD) is a measure of the reduction in the perceived value of rewards when there is a delay in reward delivery (Killeen, 2009). DD tasks are experimental paradigms designed to assess individuals' DD traits and commonly entail making a series of binary choices involving either receiving immediate smaller rewards or larger rewards provided after delays (e.g., choosing between $10 now or $20 in a week) (Reynolds & Schiffbauer, 2005), as depicted in Figure 1.

The set of choices made by the test-takers is then used to determine the rate at which a reward is devalued as a function of time (Tesch & Sanfey, 2008). Choosing to wait longer for higher rewards is indicative of better performance, that is, lower choice impulsivity (Myerson et al., 2001; Scheres et al., 2006).

What do you prefer?

$$ Now Vs. $$$$ Tomorrow

$$ Now Vs. $$$$ After two days

$$ Now Vs. $$$$ After a week

$$$ Now Vs. $$$$ Tomorrow

$$$ Now Vs. $$$$ After two days *And so on...*

Figure 1. Delay discounting tasks usually have a series of trials, each of which offers a binary choice between receiving a smaller reward immediately or a larger one after a delay.

DD is distinct from delay gratification. In delay gratification tasks, there is usually only one binary choice (e.g., receive a marshmallow now or wait for a specified period of time to receive two marshmallows). Additionally, test-takers can decide to wait for this time to receive the larger reward, or to receive the smaller reward *at any moment* during the delay period. In contrast, in DD tasks (Reynolds & Shiffbauer, 2005): 1) choices are made *before* the delays are experienced, with no possibility of changing the choice made during the delay periods; and 2) there are multiple trials (each with different binary choices, although these may be repeated throughout the task). Typically, in the different trials, the reward to be received after different delays (e.g., 5, 10, 20, 40 s) is of a fixed value (e.g., $ 20), while the values of the immediate rewards are always lower than the delayed reward value (e.g., $ 2, $ 5 , $ 10, $ 15).

Although all DD tasks have these characteristics in common, DD paradigms used in the literature may vary in many other respects (Mishra & Lalumière, 2016), as discussed below.

2.1. Paper-and-pencil vs. computer-based application

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 offers better data management, organization, and pre-processing capabilities because responses are automatically recorded and scoring algorithms and equations can be integrated into the program's script (Paul et al., 2005). Additionally, computer-based tasks have the advantage of requiring fewer evaluators to assess a larger number of participants (Schneider, 1991).

Furthermore, automated tasks can enhance motivation through gamification (Turan et al., 2006; Sailer et al., 2017), which involves using game design elements in non-game contexts (Deterding et al., 2011; p. 10). Gamification also reduces task anxiety (Cerrato & Ponticorvo, 2017), which is important because it is known that individuals with low motivation and anxiety may not perform at their full potential (Edwards et al., 2015).

2.2. Differences in DD tasks regarding hypothetical and real delays and rewards

The software presented here contains three DD tasks that were based on others found in the literature considering two principal parameters (delays and rewards), which can be either real or hypothetical. To select the types of DD tasks featured in the software we took into account the following combinations of these parameters (see Reynolds, 2006 and Utsumi et al., 2016): 1) Hypothetical delays/rewards (here called hypothetical task), in which delays are only imagined (not experienced) and rewards are not delivered (e.g., test-takers only gain points); 2) Real delays/rewards (often referred to as "real-time task"), involving experiencing delays and receiving a real (material) reward; and 3) Real delay/Hypothetical reward task, which assesses the capacity to experience delays to gain hypothetical rewards (e.g., points). This was only used once in the literature but exhibited sensitivity in distinguishing impaired tolerance to waiting (delay aversion) in children with attention-deficit/hyperactivity disorder (ADHD) compared to a control group (Utsumi et al., 2016). Another task that is often used in the literature (Reynolds, 2006) involves Hypothetical delays/Real rewards (referred to as "real-reward task"), in which the delays are hypothetical and only one material reward, regardless of the number of trials, is randomly selected, and given to the test-taker.

The theoretical assumption underlying this task is that the prospect of gaining one of the possible rewards prompts test-takers to make choices in all trials as if all rewards were real (Johnson & Bickel, 2002; Madden et al., 2004). However, this paradigm has received criticism due to its reliance on chance rather than on subjective effort (imagining waiting for more time) to attain larger rewards (Kahneman & Tsversky, 1979; Green et al., 1999). Consequently, this task was intentionally omitted from the software presented here.

Table 1 shows different types of DD task paradigms, which differently combine hypothetical and real delays with hypothetical or real rewards.

Table 1. Possible combinations between the delay and reward parameters in different types of delay discounting tasks.

Task type	Common task name	Characteristic of delay	Characteristic of reward
Hypothetical delay/reward	Hypothetical[1]	Only imagined	No real (material) reward
Real delay/reward	Real-time[2]	Experienced	Real (material) reward
Real delay/Hypothetical reward	Hypothetical with Temporal Expectation[3]	Experienced	No real (material) reward (only points)
Hypothetical delay/Real reward*	Real-reward[4]	Only imagined	A real (material) reward is delivered based on probability

Note. tasks often referred to by the following names based on Reynolds (2006)[1,2,4], and Utsumi et al. (2016)[3]; *a Real-reward task was not included in the software.

2.3. Differences between DD tasks regarding length of delays and type/magnitude of rewards

In addition to being paper-and-pencil or computerized tasks and involving hypothetical or real delays and rewards, DD tasks can also differ in terms of delay timeframes and the types or amounts of rewards (Table 2).

Table 2. Delay durations and reward magnitudes commonly used in different delay discounting tasks.

Task type	Delay duration	Reward magnitude
Hypothetical delay/reward	Long (e.g., days to years per trial)	Large (e.g., many dollars per trial)
Real delay/reward	Short (e.g., few seconds to few minutes per trial)	Small (e.g., few cents per trial)
Real delay/Hypothetical reward*	Short	Small
Hypothetical delay/Real reward**	Long	Large

Note. * This type of task involves a scoring system that converts points into material rewards of similarly low monetary values (see Utsumi et al., 2016); ** This type of task was not included in the software.

Most Hypothetical delay/reward tasks manipulate substantial hypothetical rewards, often reaching hundreds of dollars per trial, with lengthy delays that can span days to years. Considering that it is impractical in experimental settings to wait for such a long time to provide rewards and to have sufficiently large funds to do so (Matusiewicz et al., 2013; Robertson & Rasmussen, 2018), our software includes delay lengths and reward magnitudes comparable to those usually used in Real delay/reward paradigms, that is, delays shorter than a minute and small material rewards, usually equivalent to a few cents per trial (see Reynolds, 2006; Jackson & MacKillop, 2016).

Both Hypothetical delay/reward and Real delay/reward tasks often include financial incentives because money possesses a quantifiable and enduring value (Glimcher et al., 2009).

Furthermore, even if low values are used, distinct discounting patterns between clinical and control groups are observed, as well as among individuals with typical development across different ages (Scheres et al., 2014). Presenting real rewards is crucial when investigating choice impulsivity, especially during adolescence, a period of life in which brain systems that shape the trajectory of decision-making and reward sensitivity undergo significant development (Shulman et al., 2016; Ernst, 2014). Hence, delay lengths and magnitudes of rewards were selected from the studies in the literature that have shown the sensitivity of these tasks in identifying impulsivity traits in samples with varying clinical conditions and ages (Scheres et al. 2006, 2008, 2010a, 2010b, 2014; Demurie et al., 2013; Utsumi et al., 2016).

2.4. DD performance across DD tasks

Studies that directly compared the performance in different types of DD tasks often overlooked one or more of the factors mentioned above regarding realness or the magnitudes of rewards and delays. These variations among DD paradigms introduce additional sources of variability in research, making comparisons between performance in DD tasks challenging, including the identification of the specific cognitive abilities involved in the processes of choice making in these different scenarios (Ernst, 2014).

For example, two influential studies in adults (Johnson & Bickel, 2002; Madden et al., 2004) have indicated task equivalence between hypothetical delay/reward and what is known as the “real-reward” conditions (hypothetical delay and in which a chosen reward in a single trial is received by random selection). Both these tasks had identical delays (of up to six months) and rewards (of up to US$ 10 per trial).

However, it is crucial to acknowledge that probabilistic procedures to grant material rewards in the "real-reward" task deviate from the dynamics of DD and may not accurately represent behavior in scenarios in which real gains are unaffected by luck or the risk of loss (Green et al., 1999; Kahneman, 2012).

Therefore, **it is not feasible to confidently claim, based on these studies, that performance in a real-reward task corresponds to that in a hypothetical task or aligns with a real-time task where delays are experienced, and a sum of material rewards from all trials is received regardless of probabilities.**

Research comparing performance in Hypothetical delay/reward and Real delay/reward DD tasks is limited and has produced conflicting results. These disparities may be attributed to various factors, including the age range of study participants and their clinical conditions, the sample size, the number of task trials, and the methodology employed for discount rate computation. For instance, Scheres et al. (2010a) observed similar performance in healthy 18-19-year-olds when comparing performance in these tasks [using area under the curve (AUC) as a measure of DD (for details on metrics, see sections 2.5 and 2.6)], each involving 40 trials with precisely matched delays (up to 60 s) and rewards (maximum of US$ 0.10 per trial). However, in the same study, performance differed when comparing a version of the Hypothetical delay/reward task featuring larger rewards (e.g., US$ 100) and extended delays (e.g., 120 months) with another condition (Hypothetical delay/reward and Real delay/reward tasks with smaller values and shorter delays). This suggests that performance can vary in Hypothetical and Real delay/reward tasks depending on the magnitude of the parameters involved.

In contrast, Miller (2019) did not observe equivalence between these types of task, despite the use of the same short delays and small rewards for both tasks. However, this study involved only five trials to assess nine 7-to-10-year-olds with impulsive traits, using the parameter *k* as a measure of discount (see sections 2.5 and 2.6). Similarly, Lane et al. (2003) showed differences in the performance (using *k*) of healthy 19-37-year-olds in these types of tasks which, however, did not match in terms of delays and rewards.

Together, this overview of the literature indicated that there **is controversy regarding the comparability of performance in Hypothetical and Real delay/reward DD tasks, and that there is a dearth of studies comparing performance in tasks with matching delay lengths and reward magnitudes. Even more limited is the knowledge about the performance of typical adolescents under these different conditions.**

Therefore, the possibility of comparing performance in Hypothetical and Real delay/reward DD tasks can benefit not only from enabling the matching of delay times and rewards but also from using automated DD administration. Our software allows this to be done. **The delay and reward parameters were based on studies in adolescents, but they can be altered to fit different research questions and use in other types of samples (see section 6). Users may also choose to administer only one or two of the three provided DD tasks.**

2.5. Methods for obtaining the subjective value

Certain methods for calculating the discount rate involve determining the Subjective Value (SV) of the larger delayed reward. The SV is the value assigned to a reward by a test-taker when its receipt is contingent upon delays.

When an individual switches their preference from a delayed reward to an immediate one in trials with the same binary options, this means that the cost-benefit ratio has become subjectively equivalent. The SV lies between the values of these two options and is calculated by averaging them. For example, if a person initially chooses to receive $ 0.2 after 30 s instead of $ 0.1 immediately, but then, in the next trial, choses to receive $ 0.1 immediately over waiting 60 s for $ 0.2, the SV for waiting 60 s is the average of these values, i.e., $ 0.15 (Peters et al., 2012).

In most DD tasks, test-takers are presented with repeated identical binary choice options during the task, leading to a laborious and time-consuming calculation of SV (Staubitz et al., 2018). To streamline the SV computation process, many methods have been devised, including the predetermined rules method (Critchfield & Kollins, 2001) and the proportion of delayed reward choices method (Mies et al., 2018).

In the predetermined rules method, binary choices over a specific time (e.g., 5 seconds) made between a larger delayed reward (R$ 20) and increasing values of immediate rewards (e.g., $ 2, $ 5, $ 10, and $ 15) across different trials are arranged in ascending order, as shown in Table 3, with each binary choice repeated twice (trials 1 and 2). To calculate SV this ascending order is considered. Choices can be coded with the letters “W” for instance (Wait for delayed reward) or “NW” (Not Wait, that is, receive the immediate reward) for each trial. The SV is determined for each possible delay length based on a set of rules that assign a value to specific configurations of choices in a given ascending order for each delay.

For instance, choices made when the delay was 10 s can be represented as “WW” (e.g. in both equivalent binary choice trials the test-taker choose to wait to get $ 20 over receiving $ 2 immediately), followed by “WW – WW – NW NW” for the subsequent increasing values of immediate rewards (respectively $ 5, $ 10 and $ 15). Because the shift from preferring to wait 10 s for a higher reward ($ 20) occurred when the immediate reward reached $ 15, the SV is 12.5, which is the mean value between $ 10 and $ 15. Scoring is done by two judges who reach a consensus through discussion in cases of disagreement (Scheres et al., 2006).

However, inconsistencies in choices may occur between the pattern of ascending orders of immediate values in equivalent binary choices (Scheres et al., 2010a). Choice inconsistency can be defined as a set of changes in the pattern of expected discounting throughout successive ascending immediate reward values (Mies et al., 2018).

In the last two columns of Table 3, it is possible to notice that in trial 1 the test-taker only passed over the delayed reward when the immediate reward was $ 10. This makes sense because as the value of the immediate reward increases, waiting for long delays becomes less advantageous. Differently, in trial 2 we can observe that the test-taker’s choices were apparently arbitrary, such as preferring the smallest immediate reward ($ 2) instead of waiting for 20 s to receive the delayed reward, and then foregoing a larger immediate reward ($ 5) to wait for the same delay previously avoided. Taking the responses to the two trials together, the configuration of the choice pairs is W NW – WW – NW NW – NW W. In this case, SV calculation can be accomplished using alternative methods (see Demurie, 2012), which are laborious and challenging to automate. It is also common for inconsistencies be treated as errors, or even treating the entire sequence as missing data, which are artificial adjustments that can distort performance metrics.

Table 3. Example of choices (W = wait for delay reward; NW = not wait, that is, receive the immediate reward) made by one test-taker in a delay discounting task that has two trials with the same binary choices organized in ascending order of reward values.

Immediate rewards values	Delays lengths associated with a $ 20 delayed reward					
	5 s		10 s		20 s	
	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2*
$ 2	W	W	W	W	W	NW
$ 5	W	W	W	W	W	W
$ 10	W	W	W	NW	NW	NW
$ 15	W	W	NW	NW	NW	W

Note. *inconsistent choices

Alternatively, it is possible to use the proportion of delayed reward choices method (Mies et al., 2018) because it can be easily automated and is not influenced by inconsistent choice reversals. This is the method used in the proposed software. To calculate it, all choices made in favor of the larger reward at a particular delay are considered, regardless of their presentation order or the number of trials per binary choice, as shown in Equation 1:

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

Where P represents the proportion of delayed choices for each delay period. The plausible range of SVs is defined as the difference between the highest plausible SV [average of the highest immediate reward ($ 15 in Table 3) and the delayed reward ($ 20)] and the lowest plausible SV [average between $ 0 and the lowest immediate reward ($ 2)].

Then, to calculate the SV of inconsistent choice sequences (e.g., W NW – W W – NW NW – NW W) by the proportional method, when the delay was 20 s, we find 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 delay is 20 s, one can calculate:

$$P = \left(\frac{4}{8}\right) \times 16.5 + 1 \longrightarrow P = 9.25$$

Where 4 is the number of W choices and 8 is the total number of possible choices considering there were two trials for four possible binary choices.

2.6. Methods for obtaining the discount rate

The discount rate of a reward over time is well explained by a hyperbolic function (Peters et al., 2012; van den Bos & McClure, 2013). There are two main DD indexes often used in the literature, but one of them, the parameter *k* (see Mazur, 2000 for instructions on how to calculate it), requires transforming the variable when it has a non-normal distribution (Reynolds, 2006) and/or when it is not hyperboloid. In many cases, this can lead to distortions in performance estimates (Smith & Hantula, 2008).

Thus, the software presented here uses the area under the curve (AUC; Myerson et al., 2001) as the DD performance metric, which is automatically calculated based on SVs of the test-taker's choices for each delay (Reynolds, 2006). To estimate this, the SVs (obtained by the proportion of delayed reward choices method: see above) of each test-takers are plotted on a graph, with delays arranged on the X-axis and SVs on the Y-axis. Figure 2 displays the subjective value of the largest reward as a function of progressively longer delays, which can be used to calculate the AUC. A higher AUC value indicates lower discounting or lower impulsivity.

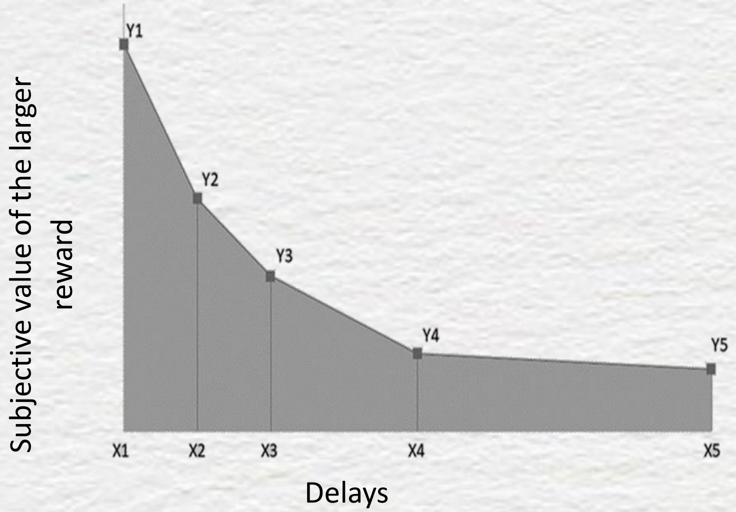


Figure 2. Illustrative graph of the discount function using the area under the curve (AUC) method, where "x" corresponds to progressively longer delays and "y" represents the subjective values (SVs) of the larger devalued reward for each delay. To calculate the AUC, the areas of the trapezoids (highlighted in gray) are computed and shown using Equation 2.

As depicted in Figure 2, the points corresponding to SVs for different delay periods are connected, and a vertical line is drawn from each SV to its corresponding delay time on the X-axis, forming trapezoids. Subsequently, the area of each trapezoid is calculated and summed using the following equation (Myerson et al., 2001):

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

AUC is therefore an index of choice impulsivity (the lower, the more impulsive), which has lower and upper limits. This approach is suitable for assessing non-normal data, which is common in the evaluation of human choice behavior (Reynolds, 2006).

2.7. The current DD tasks

The overview of the literature described above shows conflicting results regarding performance in different types of DD paradigms and highlights the possible difficulties in assessing DD in an automated way by researchers with few resources and who are from countries where English is not the native language.

To address these issues, we built a non-proprietary DD software, in which the DD task parameters and language can be edited, featuring three visually identical types of DD tasks that can be administered individually or together with the same individuals. These tasks have matching delays and rewards, which is beneficial to researchers in comparing performance in different DD paradigms.

The computer-based approach was chosen to prevent application and scoring errors (Paul et al., 2005), with algorithms integrated into the program script for calculating subjective values via the proportional method (Mies et al., 2018) and the area under the curve (Myerson et al., 2001).

These methods are easy to automate and suitable for handling inconsistent choices and non-normal data (Reynolds, 2006). We also incorporated game design elements into the software which has been shown to enhance motivation (Lumsden et al., 2016) and reduce test-related anxiety (Cerrato & Ponticorvo, 2017), both of which can impact performance (Martin & Franzen, 1989; Edwards et al., 2015).

Furthermore, the software is open-access and editable, allowing researchers with limited resources to use it and customize it for experiments in diverse sociocultural contexts (Staubitz et al., 2018). Given that previous DD studies primarily involved samples from developed nations, providing tools for studying DD in different countries is crucial to assess the generalizability of DD performance patterns across diverse populations.

☆☆☆

3. Development and functioning of the software

The Waiting Game is an open-source DD software built using the Unity3D program (developed by Unity Technologies), version 2018.2.21.fl. The code was written in the Rider Integrated Development Environment (IDE) using the C# language (C-Sharp). The graphic design was created using GIMP (a free image editor with modifiable source code) and Photoshop. The software comprises three tasks/games: 1) Imaginary Game (Hypothetical delays/rewards or hypothetical task); 2) Real Game (Real delays/rewards or real-time task); 3) Patience Game (Real delays/Hypothetical rewards).

Our current version of the software, diverging from traditional user interface-based approaches, leveraged Excel spreadsheets for user interactions. This allows users to modify parameters and edit textual information (e.g., instructions and language) in a familiar and accessible environment. It supports English, Brazilian Portuguese, and Spanish, and can be adapted to other languages.

While typical Model-Driven Game Development (MDGD) involves generating software using a domain-specific model (DSM) and/or language (DSL; Zhu & Wang, 2019), our method substitutes the traditional DSL with Excel Spreadsheets. This serves as an effective DSM, enabling users to convert the familiar tabular data into a JSON format file, a standard in various software applications, which is interpreted by our game’s runtime code. This approach aligns with the principles outlined by Kelly and Tolvanen (2008, p. 308), emphasizing the use of models for version control rather than the generated code. Hence, users can tailor the software to their requirements without having to be familiar with C#, JSON, Unity 3D, or the software's underlying coding. The software is free and available for download and use and alter at GitHub *as long as* recognition is given to the authors.

3.1. System requirements

The Waiting Game is compatible with Windows 7 (SP1+) and subsequent versions. It can be installed on computers, notebooks, and tablets. The provided binaries were exclusively for Windows x64.

However, due to Unity being based on Mono, users can promptly recompile the project for any Operating System supported by Unity, such as macOS High Sierra 10.13+ and Linux Ubuntu 20.04 and later versions (Figure 3).

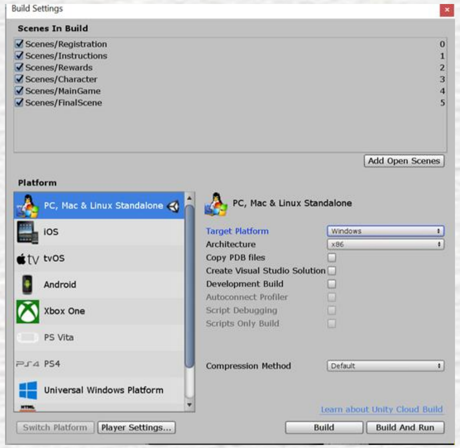


Figure 3. To translate the current project language into that of other operating systems, first download Unity Hub and install Unity version 2018.x (any 2018 version should work). Then, open the folder containing the source files in Unity and navigate to File > Build Settings. If you are not familiar with this procedure and need the project language to be compatible with other operating systems, please contact the authors.

3.2. Opening the software

i) Download the zipped folder from GitHub (Build-1.2.0) here. To unzip the folder, right-click on it and select “Extract All”. Afterwards, you can move the folder to the preferred directory. Access the source code clicking on the same link above. **For instructions to download the software on Linux and macOS operating systems, please get in touch with the authors.**

ii) In the unzipped folder, find the executable file (AR_Project) and run it.

iii) A dialog box will appear, offering choices for screen resolution and graphics (see Figure 4). If you prefer the program to run on Window, click "Windowed." Otherwise, click "Play!" to launch the game in full screen mode. To exit the full screen, you can use the following key combinations: ALT + F4; ALT + TAB; or WINDOWS + D.

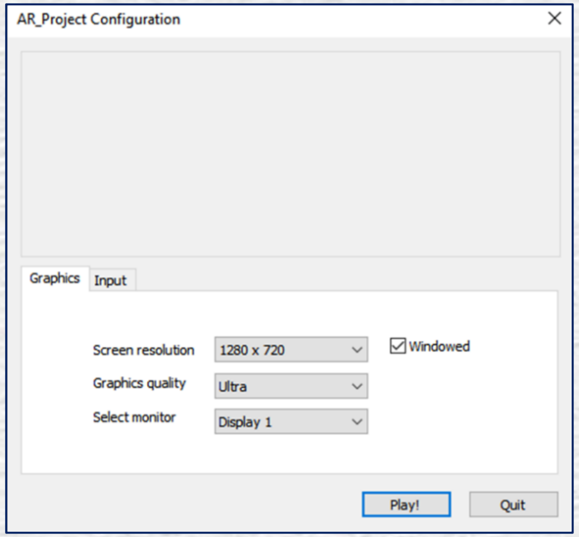


Figure 4. Most modern computers should be able to handle the "Ultra" quality settings without issues. However, if you encounter any problems, you can choose a lower configuration.

3.3. General description of the tasks/games

The Waiting Game includes three distinct DD tasks/games which have the same visual appearance:

- Imaginary Game (Hypothetical delay/reward) – adapted from Demurie et al. (2013). This task prompts test-takers to imagine how long they would hypothetically wait if the total score for this task were proportionally converted into a larger hypothetical material reward, even though they actually only accumulate points;

- Real Game (Real delay/reward) – adapted from Scheres et al. (2006, 2008, 2010a, 2010b, 2014). This task has test-takers wait for rewards in all trials (real delay), knowing that the total score in this task will be proportionally converted into a material (real) reward that is delivered at the end of the task;

- Patience Game (Real delay/Hypothetical reward) – adapted from Utsumi et al. (2016). This task involves experiencing real delays, although there is no real material reward (only points are provided).

Each task (game) of the Waiting Game comprises consecutive trials involving one of three immediate reward options (e.g., 100, 400, and 700 points with zero s delay) and a larger fixed reward (e.g., 1000 points) delivered after one of four delay options (e.g., 7, 15, 30, or 60 s). Each immediate reward is matched three times with each delay, resulting in a total of 36 trials per game. These point values and delays were selected based on prior research involving children/adolescent test-takers (Scheres et al., 2014; Utsumi et al., 2016) and are the same across tasks, enabling researchers who decide to administer all tasks/games to directly compare performance across them as they have matched visuals, reward and delay parameters. However, researchers can choose to administer only one of two of the tasks and all these parameters can be modified using the User Interface, which will be detailed in Section 6. User Interface regarding software editing.

In recognition of the universal appeal of video games across all age groups (ESA, 2022), we incorporated video game-like elements (Deterding et al., 2011) into the Waiting Game software, such as scenarios, avatars, and auditory feedback (Reeves & Read, 2009), which have been found to increase motivation (Turan et al., 2006; Sailer et al., 2017) and alleviate assessment-related anxiety (Martin & Franzen, 1989). These elements are identical in all three DD tasks within the software, except for the Imaginary Game, in which the avatar does not appear because the waiting times are not experienced. For tasks involving real delays, test-takers are represented by avatars designed in a manga style, which is a popular Japanese graphic novel (comic) and anime style known worldwide (Majaw, 2015; Alt, 2020). This aesthetic style is commonly found in video games and is particularly appealing to adolescents.

We aimed to leverage this appeal to enhance motivation for completing the DD tasks, even among clinical populations (e.g., individuals with autism spectrum disorder; Rozema, 2015). The software offers a selection of four manga characters as avatars (two female, one male and one androgynous) to allow for sex/gender identification (see Trepte & Reinecke, 2010).

Delays, rewards, and total scores are always displayed in the same spatial locations to reduce cognitive demands. This approach takes advantage of the fact that individuals tend to implicitly learn environmental patterns, making it easier for them to make predictions (e.g., Garrido et al., 2016) of where to find information presented visually. By maintaining this consistency, we believed test-takers could better concentrate on the demands of the DD tasks themselves.

3.4. General steps to administer the tasks

The software was designed to be administered with the mediation of an examiner, which can be done in in-person testing or online: see Appendix A). The administration comprises six steps outlined in Figure 5, which will be detailed below:

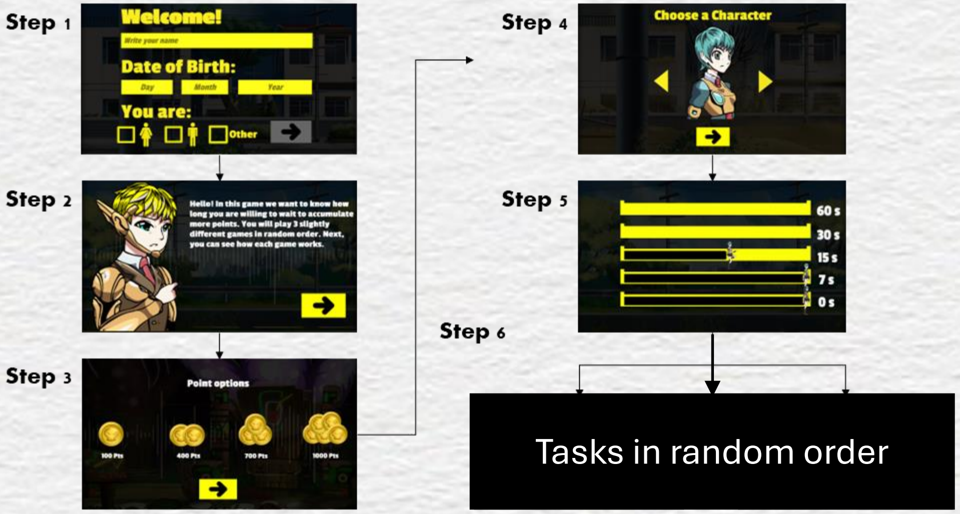


Figure 5. This figure illustrates the steps when running the software: 1) Registration; 2) Initial instructions; 3) Presentation of points; 4) Choosing an avatar; 5) Presentation of delays; and 6) Games, presented in random order: Imaginary Game (Hypothetical delay/reward), Real Game (Real delay/reward) and Patience Game (Real delay/Hypothetical reward).

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/sex. The "Other" choice is provided for individuals who do not identify as male or female. Once the required information is entered, test-takers can advance by clicking on the ARROW (next) positioned in the lower right corner (Figure 6). For those interested in a shortened demonstration of the program's features, entering "debug" in the Name field will bypass the need to have users experience the delays when presenting how the tasks work.

Figure 6. Registration screen.

3.4.2. Initial Instructions

This screen provides instructions about the DD tasks (Figure 7). If the test-takers have questions, additional verbal explanations can be provided, such as: ***"In this activity, you will make several choices between receiving fewer points immediately or waiting for some time to receive more points. The longer you wait, the more points you will accumulate. In one of the games, the points you accumulate will be converted into real prizes [please specify the prize]. The more points you score, the better your chances of receiving a better prize. Before each game, you will be informed if you will receive a real prize or not, okay?"***

Figure 7. Information about the games. In this case, it is informed that the test-taker will play three games, but if the experimenter prefers to use one or two games, it is possible to modify the text through the user interface. See section 6.6. Debug to learn how to select which games to use.

3.4.3. Points Presentation

This screen (Figure 8) aims at familiarizing the test-takers with the point options (100, 400, 700, and 1000) which are displayed from left to right in ascending order of magnitude. These options can be modified using the user interface.

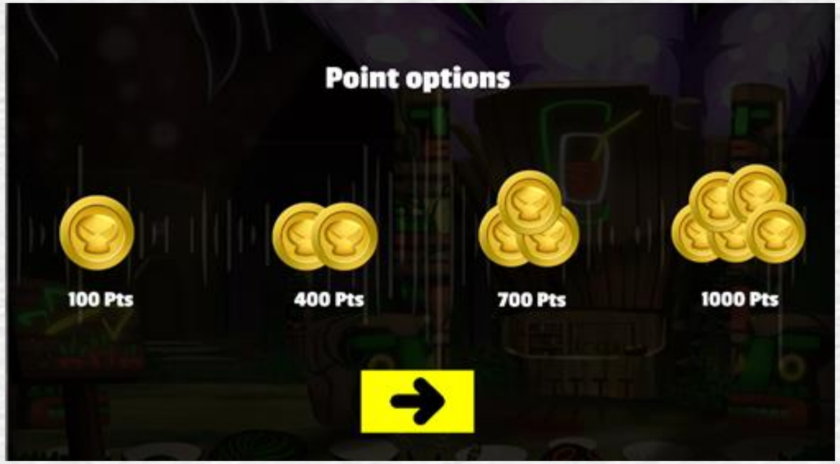
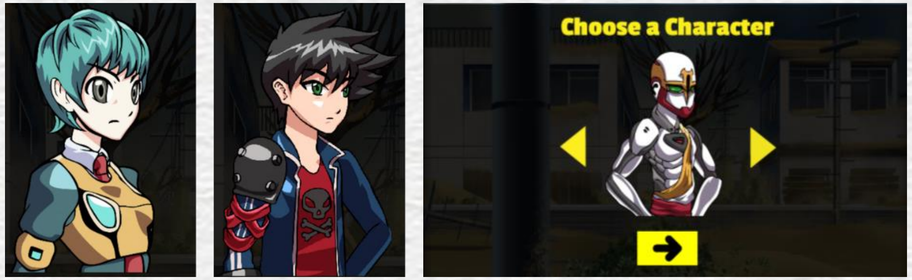


Figure 8. Screen which presents values of points to be gained, which are editable.

3.4.4. Choosing an Avatar

On this screen, the test-taker selects an avatar (a character) from the available options to represent him/her in the games (Figure 9).

The software has four possible avatars, two of which are female, one is male and the other is androgynous (other avatars can be added. See section 6.8. Adding new Avatars). To browse through the avatars, the test-taker can click on the left or right-pointing triangles presented beside the avatars. The test-taker must select the desired avatar by leaving it visible on screen. To proceed to the next step, they must click on the arrow located below the chosen avatar.



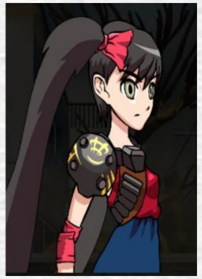


Figure 9. Avatar selection screen (above). To browse through the options and select one of the four avatars on the left, simply click the right or left-pointing triangles, followed by clicking on the arrow below the avatar to continue to the next step.

3.4.5. Presentation of delays

This step is designed to familiarize test-takers with the durations of the delays used in the games. It consists of two screens: the first (Figure 10A) provides information that some delays will be presented, and the second (Figure 10B) displays the delays as five horizontal lanes on the screen, stacked from top to bottom to represent delays of 60, 30, 15, 7, and 0 s. The chosen avatar starts at the bottom lane (representing a zero s delay) and moves from left to right in 0.5 s, serving as a speed reference. Subsequently, the avatar appears positioned on the far left of the lane immediately above the bottom one and moves to the far right in 7 s, and so on. Test-takers are encouraged to experience all delays to establish a real-time reference for their choices.

A

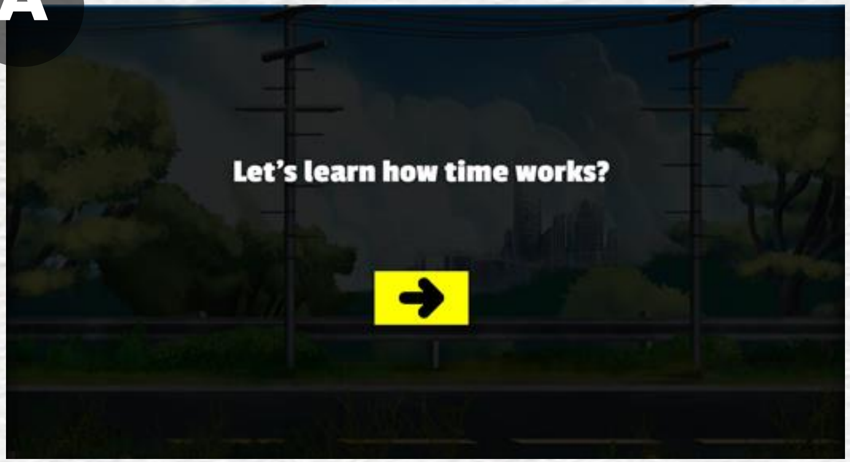


Figure 10. (A) Screen providing information about the delays that will be part of the tasks and will be presented/experienced.

B

(B) This screen displays all the delays that will be part of the tasks, starting with zero s (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 s, and so on.

4. Games

The games themselves are detailed below, but there are some important things to know and attend to while administering any of the tasks in person (see Appendix A for online administration with moderation by a researcher):

1) The Waiting Game includes three games (tasks) that share the same visual appearance as well as the length of delays and reward amounts, although the games differ in terms of whether delays and rewards are hypothetical and/or real. However, it is possible to modify the magnitude/type of these parameters (delay and reward) of the software as a whole through the user interface, as described in section 6. User Interface;

2) The software was built to present all tasks in random order, but researchers may use only one or two of them by defining the tasks in advance in the Debug tab (see section 6.6. Debug);

3) Although all games are preceded by written instructions that were kept at a minimum to contain enough information for performing the tasks, before each game begins, we recommended that extra verbal instructions be provided to ensure test-takers understand what they are supposed to do, especially whether or not they will receive any material reward or prize at the end (examples of what to say are given in the description of each task, below);

4) After written instructions, each game is preceded by 8 practice trials;

5) In the actual games, each of the three values of immediate rewards is paired three times with each of four delay periods (except for zero which represents the possibility of gaining an immediate reward). Hence, each game comprises 36 trials presented in a pseudo-random order (the reason for this is explained in section 5.4. Randomization), which changes in sequence at each administration;

6) The examiner should maintain a neutral stance and closely observe the test-taker's behavior. During the delay periods in the tasks in which they are experienced, some individuals may try to engage in conversation, stand up, or use their cell phones, which must be avoided. Therefore, instruct the test-taker to remain silent, seated, and to turn off their cell phones while playing. The examiner should speak only when necessary and encourage the test-taker to focus on the game. Avoid making comments that could influence the test-taker's choices. If the test-taker has questions, respond briefly and objectively. If the test-taker becomes impatient, they should be allowed a short break of approximately 5 minutes between games. If the test-taker enquiries about the duration of the task, inform them that the entire activity lasts from 15 minutes to just over half an hour if all three games are played. During the games, it is advisable that the examiner maintain some distance from the test-taker to minimize the feeling of being observed;

7) Discontinuation criteria: i) if the test-taker expresses a desire to withdraw from the activity; ii) if there is a noticeable lack of understanding of instructions; iii) if negligence and carelessness with the activity reach a point where data collection becomes infeasible due to aggressive, offensive, and/or destructive behavior.

4.1. Imaginary Game (Hypothetical delays and rewards)

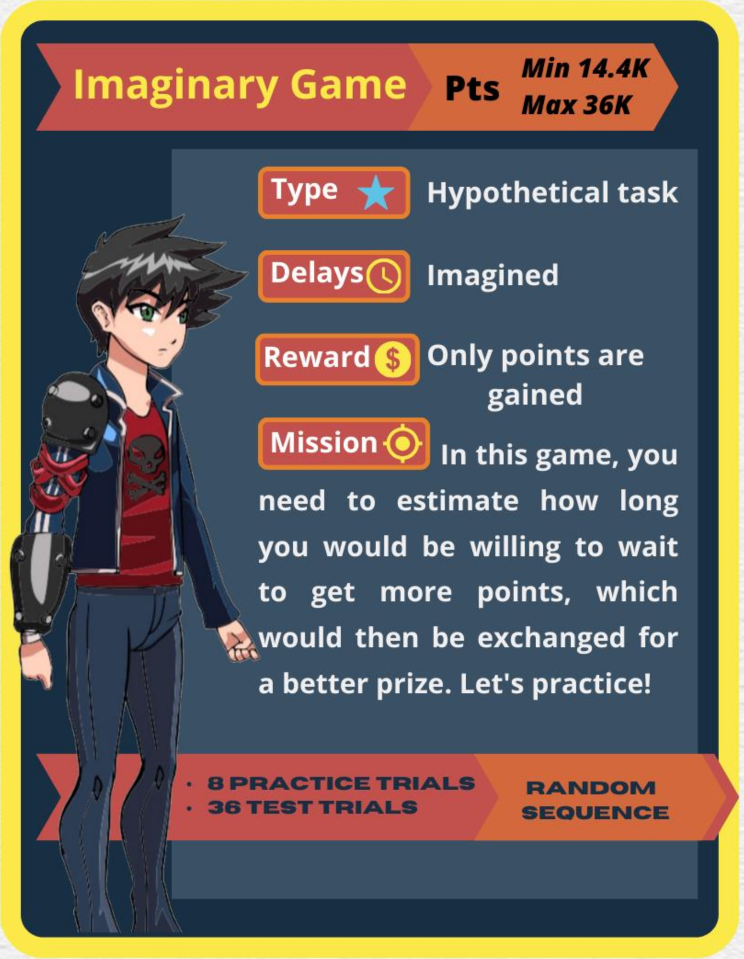
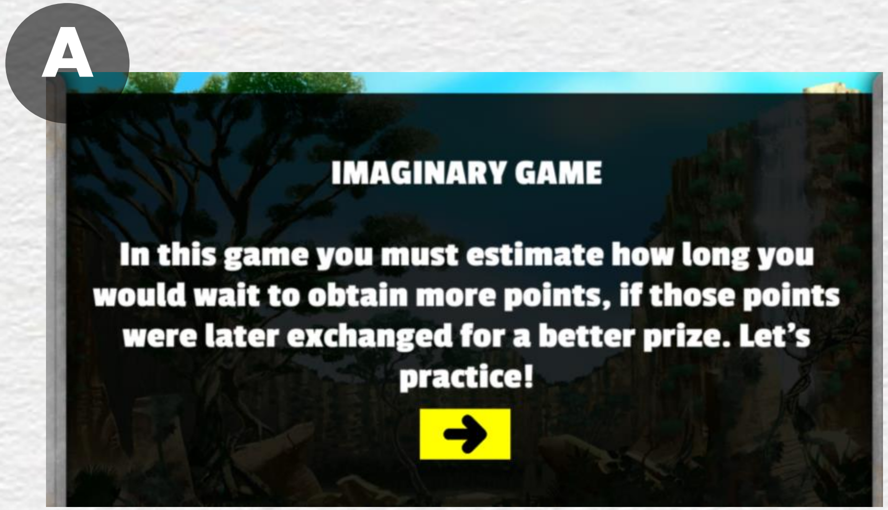


Figure 11A illustrates the screen on which the imaginary game is presented. To select the games that will be part of the experiment, see section 6.6. Debug. Extra verbal information at this point could be something along the lines of:

"In this game, there's no need to wait, and you won't receive a prize at the end of the game. However, try to imagine what you would do if you had to wait to receive a better prize. Before the game begins, you will have the opportunity to practice and understand how it works."

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

"In this game, unlike the last one (or the 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."



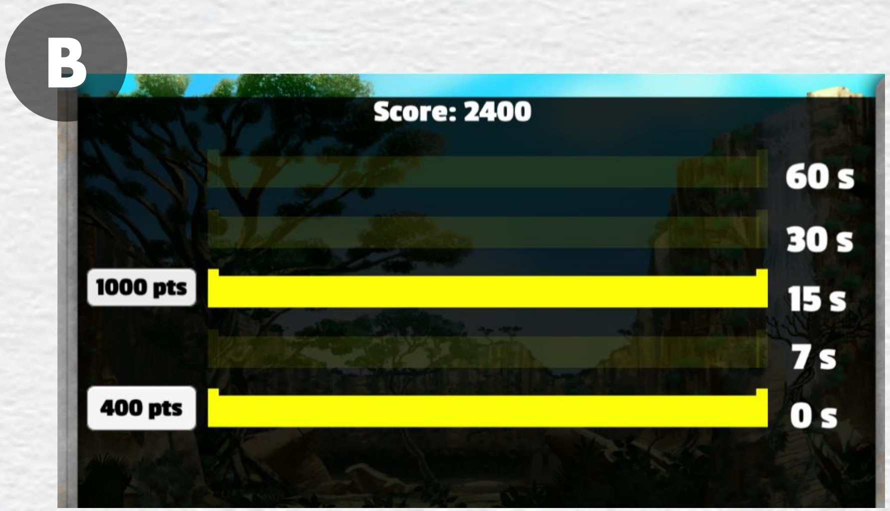


Figure 11. (A) Basic instructions for the Imaginary Game; (B) Practice screen in which the test-taker must choose between waiting 15 s to accumulate 1000 points or receiving 400 points immediately. As it is a hypothetical task, it is important to emphasize that the time intervals are not experienced, and the test-taker will not receive a material reward at the end of the game.

Figure 11B displays one of the practice trial screens. To enhance understanding, the following can be explained verbally:

"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 a higher score or if you prefer to gain a lower score immediately. To make your choice, simply click on the points you want, and they will appear on the scoreboard [point to the scoreboard]. Each time you make a choice, the points will be added to the previous ones and will show up here [on the scoreboard]. See how it works."

Using Figure 11B as an example, the following can be said:

"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 s [point to the corresponding lanes]. In this game, you don't actually have to wait, but it's essential to imagine that if you waited, you would accumulate more points and receive a better prize."

Even if the test-taker understands the instruction, they may still need encouragement to proceed with the practice trials.

After practicing, the first Imaginary Game screen appears. It is essential to ensure that the task-takers understand what they are supposed to do. If necessary, repeat the instructions in a different way. Then, remind the test-takers that they will NOT receive a material reward at the end of the game (Figure 12A). At this point, 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 your choices as if you were going to receive one. You can start."

A screen similar to the one shown in Figure 12B then appears. All games have the same layout, with the only difference being that in the Imaginary Game the avatar does not cross the lane because in this task test-takers do not experience the delays (they are only hypothetical waiting times). Instead of waiting to receive the reward, test-takers must click on the desired score which is automatically added to the scoreboard centered at the top of the screen. The next trial (choice screen) is then presented. After 36 trials, a screen appears showing the total score achieved in the game (Figure 12C).

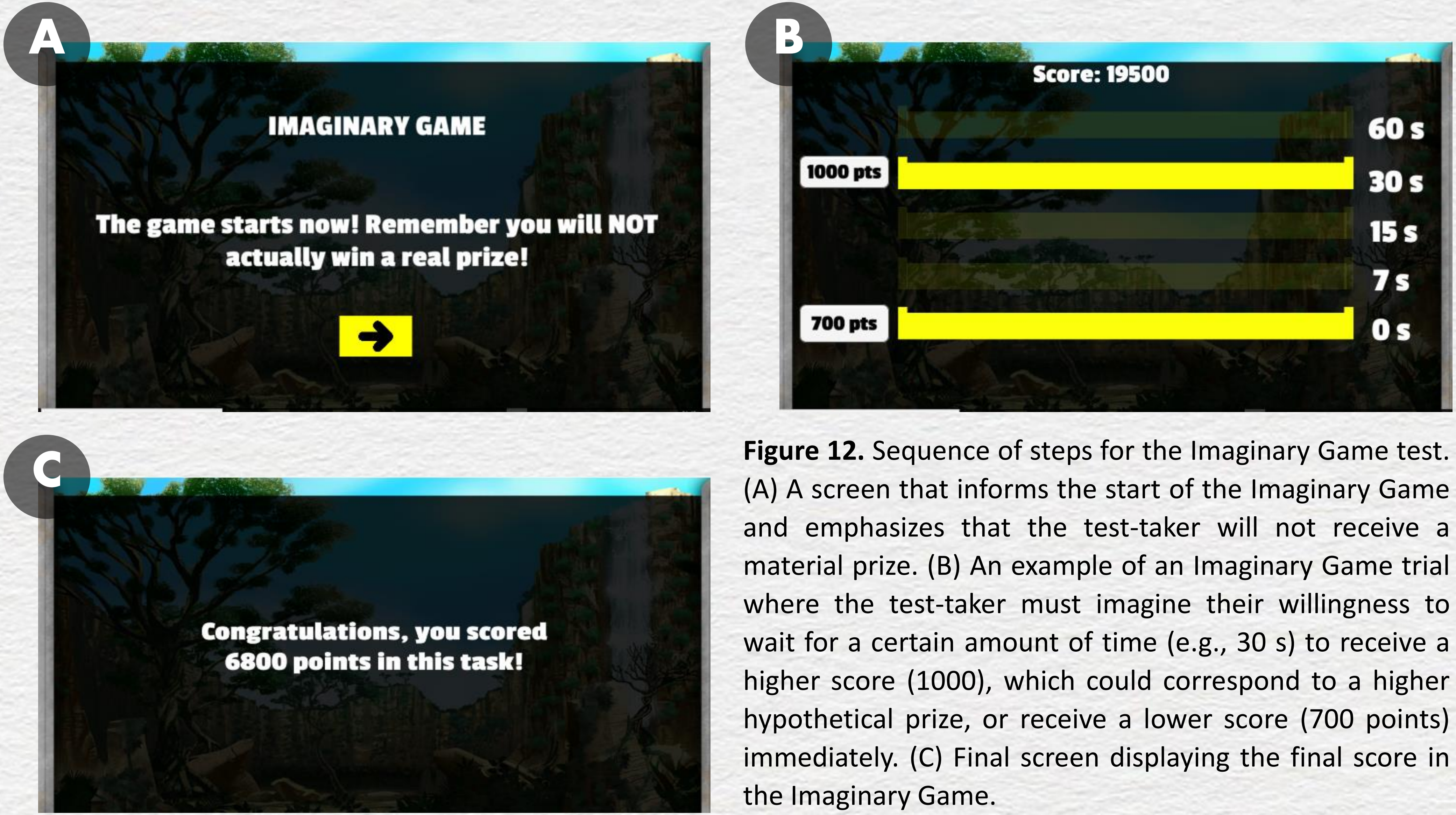


Figure 12. Sequence of steps for the Imaginary Game test. (A) A screen that informs the start of the Imaginary Game and emphasizes that the test-taker will not receive a material prize. (B) An example of an Imaginary Game trial where the test-taker must imagine their willingness to wait for a certain amount of time (e.g., 30 s) to receive a higher score (1000), which could correspond to a higher hypothetical prize, or receive a lower score (700 points) immediately. (C) Final screen displaying the final score in the Imaginary Game.

4.2. Real Game (Real delays and rewards)

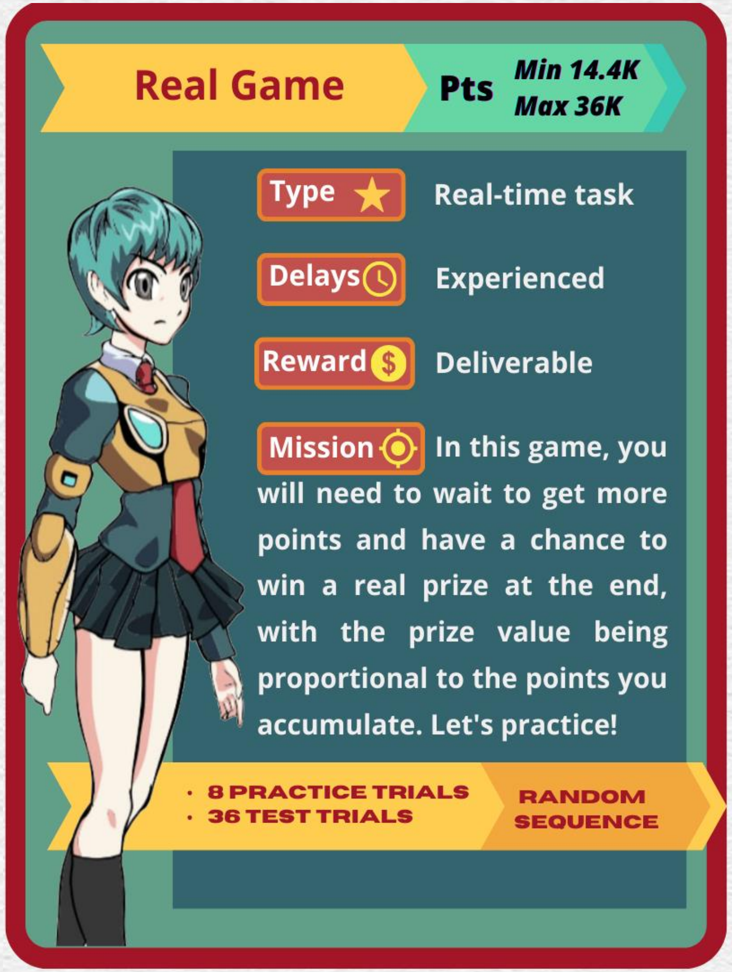


Figure 13A illustrates the screen on which the instructions for this game are presented. To select the games that will be part of the experiment, see section 6.6. Debug. Extra verbal information at this point could be something along the lines of:

"In this game, you need to wait to accumulate more points that will be exchanged for a real prize at the end. To get more points, you must wait for different time intervals. Your material prize will be proportional to the points you accumulate. Before the game begins, you will have the opportunity to practice and understand how it works."

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

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

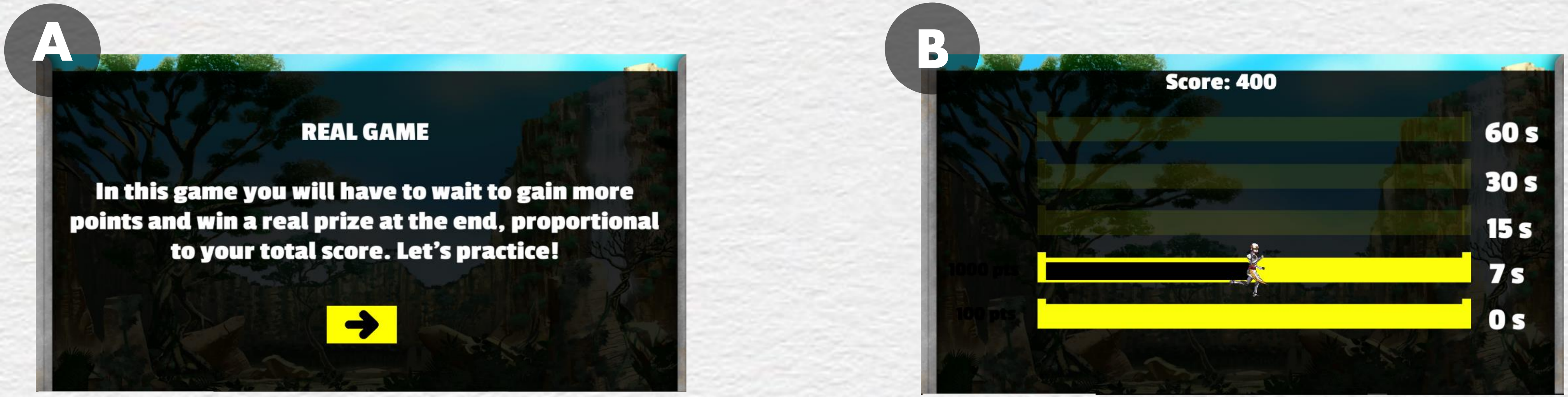


Figure 13. (A) Basic instructions for performing the Real Game; (B) Practice screen in which the test-taker is instructed to choose between an immediate lower score (100) or wait 7 s to receive the highest score and thus increase the chances of the total score being converted into a better material prize.

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 one, where you need to choose if you prefer to wait some time to accumulate a higher score or if you prefer to accumulate a lower score immediately. To make your choice, simply click on the points you want, and they will appear on the scoreboard [point to the scoreboard]. Each time you make a choice, the points will be added to the previous ones and will show up here [on the scoreboard]. See how it works."

Adopting Figure 13B as an example, the examiner can say:

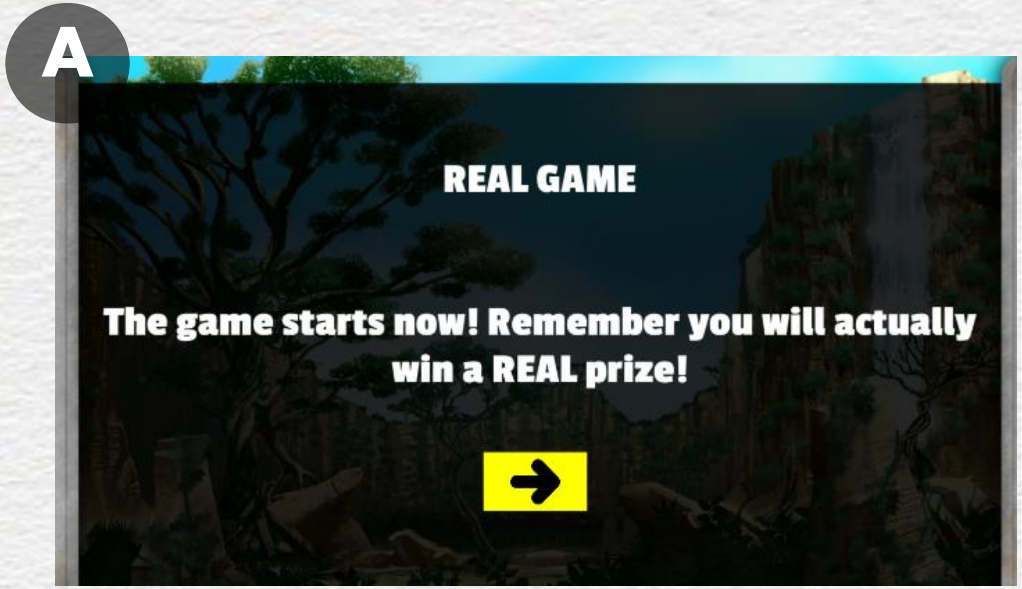
"Take a look at this screen: we have 100 points here [after choosing, the points are shaded], which you can accumulate now, and 1000 points in this other lane, which you will accumulate after waiting 7 seconds [point to corresponding lanes]. In this game, if you press that button [corresponding to the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

Even if the test-taker understands the instruction, they may still need encouragement to proceed with the practice trials.

After practicing, the first Real Game screen appears, and it is essential to ensure that test-takers understand the task. If necessary, repeat the instructions in a different way. Then, remind test-takers that they WILL receive a material reward at the end of the game (Figure 14A). At this point, the examiner can say:

"Now that you have practiced, you can play the game. Remember, in this game, you WILL receive a real prize based on the points you accumulate. You can start."

A screen similar to the one shown in Figure 14B then appears. All games have the same layout, but unlike the Imaginary Game, here the avatar is visible. After 36 trials, a screen appears displaying the total score achieved in the game (Figure 14C).



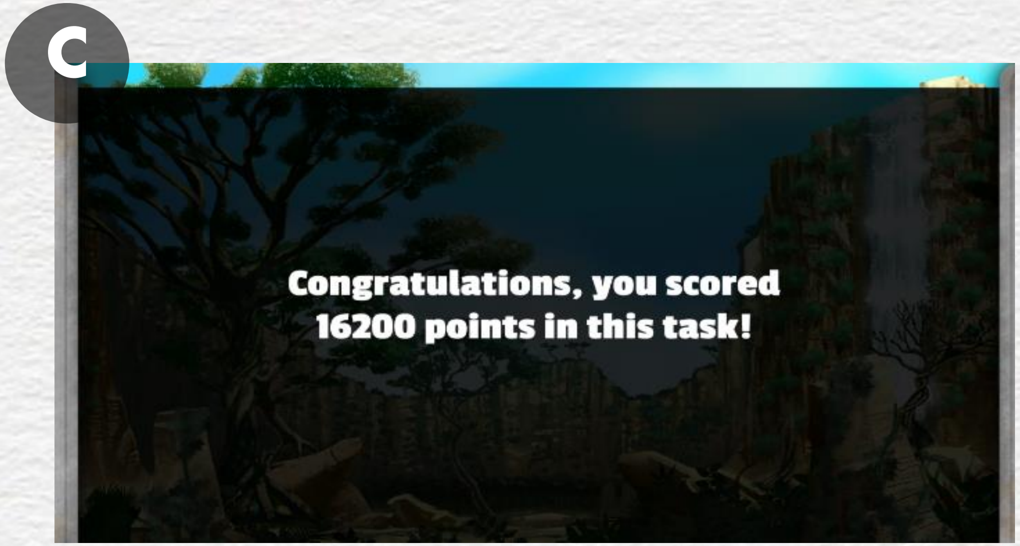


Figure 14. Real Game test step sequence. (A) Screen that informs that the Real Game will start and that the test-taker will receive a material reward; (B) Differently from the Imaginary Game, the avatar appears in this game. The option is given between waiting 60 s to receive the highest score (1000) and receiving 400 points immediately; (C) Final screen displaying the final score. At the end of all games, the score in this game is converted proportionally into a real prize.

4.3. Patience Game (real delays and hypothetical rewards)

The Patience Game was included in the software because it is a type of DD task in which delays are experienced, but no material reward is delivered. It was developed based on a previous study to assess aversion to waiting (Utsumi et al., 2016) and allows the determination of the willingness to wait even when no material reward will be obtained from it. If performance in this task is contrasted to that in the Real delay/reward task, it is possible to investigate differences between the willingness to wait due to high sensitivity to rewards in paradigms in which there are material rewards and the willingness to wait due to difference levels of aversion to waiting in paradigms in which no material gains are given.

In Utsumi et al. (2016), typically developing children were able to wait longer to accumulate points in this task than children with attention-deficit/hyperactivity disorder (ADHD), although no significant distinctions were observed between groups in DD performance in other tasks akin to the Imaginary (Hypothetical delay/reward) and Real (Real delay/reward) games detailed earlier, despite all games featuring identical delay durations and point magnitudes. In other words, higher aversion to waiting in ADHD children was only picked up by the Patience game. Furthermore, performance in the Patience task was the only one to correlate with the Behavior Rating Inventory of Executive Function (BRIEF): better DD performance (higher scores) in this task was linked to lower levels of impulsive traits.

Figure 15A illustrates the screen presenting the instructions of this game. If this game is the first to be presented, the examiner can consider the text below as supplementary verbal information to complement the written instructions:

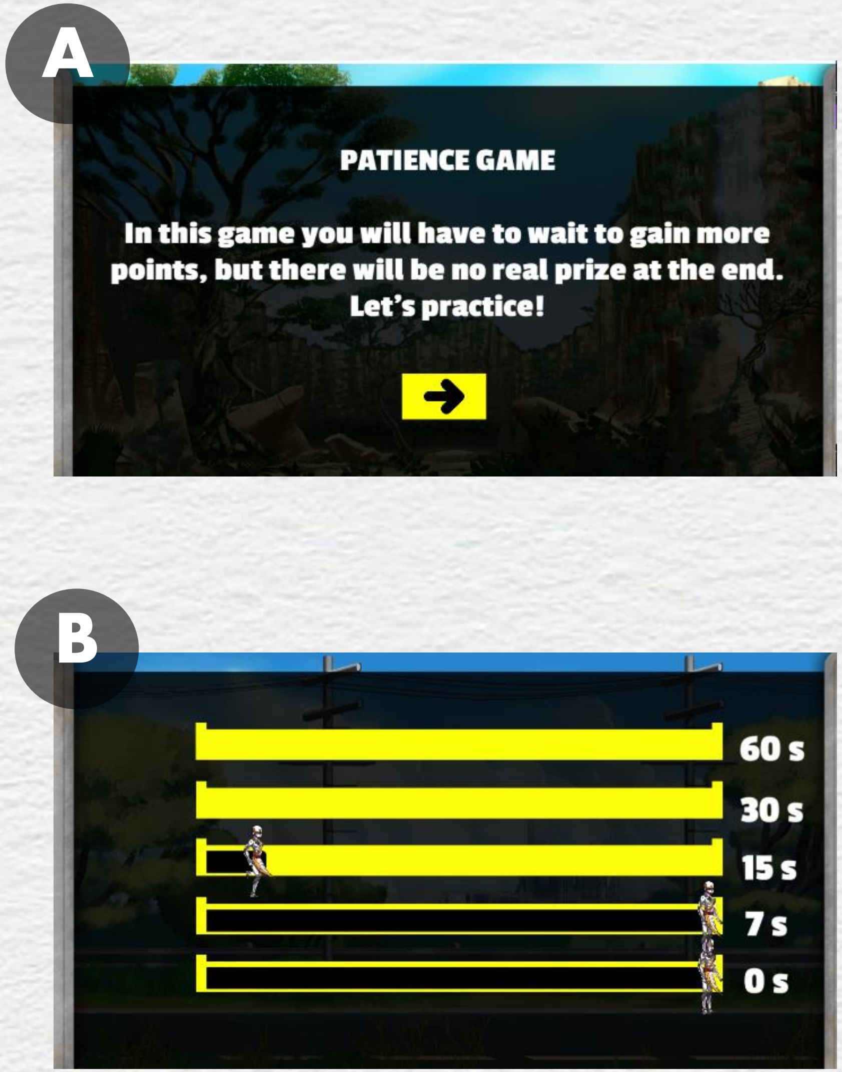


Figure 15. (A) Basic instructions for participating in the Patience Game; (B) Practice screen in which the test-taker is prompted to decide between an immediate lower score (700) or waiting for 15 s to receive the highest score, with the awareness that no material reward will be given.

"In this game, you can choose to wait for different time intervals to accumulate more points, knowing that you won't receive a material prize at the end of the game. To get more points, you'll need to wait for some durations, but please remember that there won't be any material prize. Before the game begins, you will have the opportunity to practice and understand how it works."

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

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

Figure 15B 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 one, where you need to choose whether you prefer to wait some time to accumulate a higher score or prefer to accumulate a lower score immediately. To make your choice, simply click on the points you want, and they will appear on the scoreboard [point to the scoreboard]. Each time you make a choice, the points will be added to the previous ones and will show up here [on the 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 shaded], which you can accumulate now, and 1000 points in this other lane, which you will accumulate after waiting 15 seconds [point to the corresponding lanes]. In this game, if you press that button [corresponding to the larger reward], you will need to really wait for 15 seconds. Remember, in this game you'll not receive a real prize at the end."

Even if the test-taker understands the instruction, they may still need encouragement to proceed with the practice trials.

After practicing, the first Patience Game screen appears, and it is essential to ensure that the test-takers understand the task. If necessary, repeat the instructions in a different way. Then, remind the test-takers that they WILL NOT receive a material reward at the end of the game (Figure 16A). At this point, 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. You can start."

A screen similar to the one shown in Figure 16B then appears. Visually, the Patience Game is identical to Real Game, with the avatar moving along the lanes for the duration of the delay. After 36 trials a screen appears displaying the total score achieved in the game (Figure 16C).

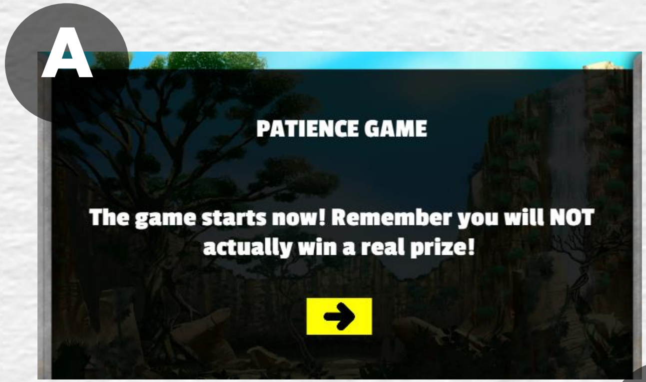
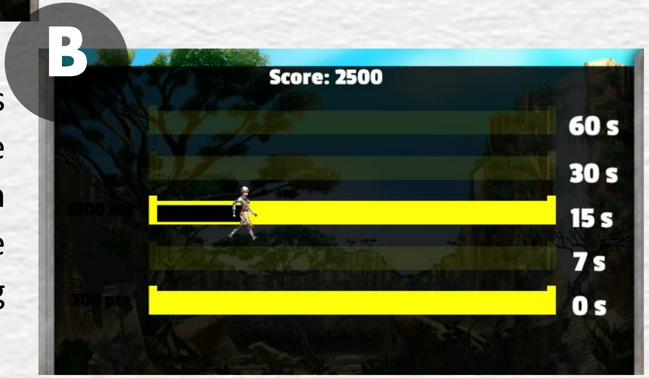
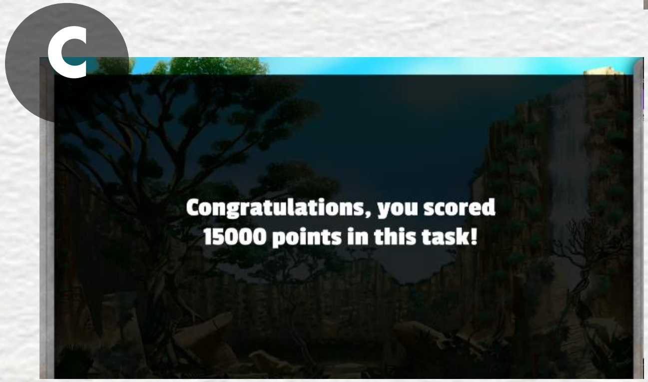


Figure 16. Patience Game test step sequence. (A) Screen that informs the player that the Patience Game will start and that they will NOT receive a material reward.



(B) Visually, the Patience Game is identical to the 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 displaying the final score.

4.4. Reward

At the end of the three games, the total and Real Game scores are displayed (Figure 17); the latter is used to determine the material reward to be provided to the test-taker (see Table 4). The conversion of scores into non-monetary material rewards can be based on a previous study (Utsumi et al., 2016). Alternatively, monetary rewards can be given to the test-taker after completing this task following the guidelines suggested by several authors who conducted Real delay/reward tasks (real-time tasks), such as providing a few cents per trial (e.g., Scheres et al., 2014; Yu & Sonuga-Barke, 2016).

Table 4. 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 difference (i.e., 36,000 – 14,400 = 21,600) was divided into three equal ranges (21,600 / 3 = 7,200), each corresponding to specific monetary values that increases according to the number of points (US$ 0.40 increase per range).

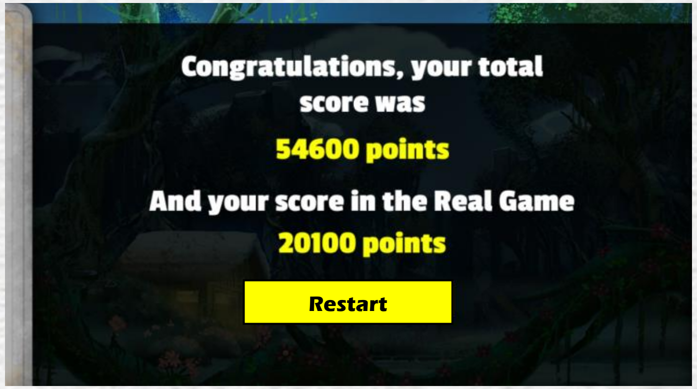


Figure 17. Final screen displaying the total scores. The score in the Real Game is then converted proportionally into a material reward determined by the experimenter. The games can be restarted by clicking on the "Restart" button.

5. Output

There are two types of outputs (output 1 and output 2) generated only after the games have been administered. **Both outputs are in the following directory: Build-1.2.0 > AR_Project_Data > Data.**

5.1. Output 1

This output (Data_OneLine) is a consolidated CSV file, located in Data folder (Figure 19 A). It arranges each test-takers' responses from the three games in a single line. The data of each new test-taker are added beneath the previous entry, including age calculation, game sequence, absolute and normalized scores per game. This streamlined format allows information to be exported to various statistical software for analyses. To split the comma-separated information into separate columns, click on "DATA" in the toolbar, select the data in column A, and then click "Text to Columns". A dialog box will appear; ensure that the "Delimited" option is selected and click "Next". Then, in the delimiters field, click on the comma option, then "Next," and finally, "Finish" (Figure 19 B). Abbreviations are explained in Table 5.

A

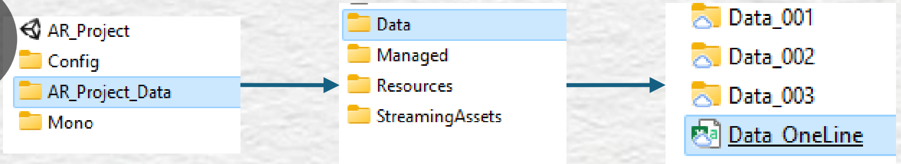
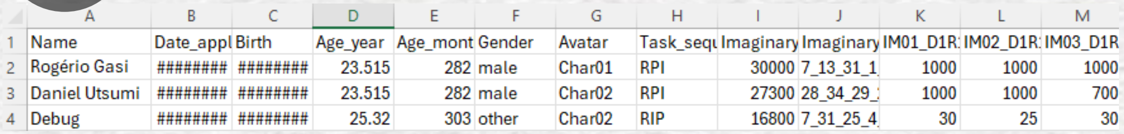


Figure 19. Location and opening of output 1. (A) Locate the Data_OneLine CSV file in the Data folder.

B



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Name	Date_appl	Birth	Age_year	Age_mont	Gender	Avatar	Task_sequ	Imaginary	Imaginary	IM01_D1R	IM02_D1R	IM03_D1R
2	Rogério Gasi	########	########	23.515	282	male	Char01	RPI	30000	7_13_31_1	1000	1000	1000
3	Daniel Utsumi	########	########	23.515	282	male	Char02	RPI	27300	28_34_29_	1000	1000	700
4	Debug	########	########	25.32	303	other	Char02	RIP	16800	7_31_25_4	30	25	30

(B) As mentioned earlier, you need to split the comma-separated information into columns. This output stores the information in a format that facilitates the transposition of raw data to the database. Note that on line 4, it says "Debug", indicating the game's abbreviated presentation mode, as described in section 6.6. Debug. Also, observe that cells K4 to M4 have different option values as they were modified using the user interface, which will be discussed in section 6.2. Rewards.

5.2. Output 2

This output generates individual folders for each test-taker, each containing a CSV file per game. These folders are situated in the data directory and are named in the format Data_number (e.g., Data_001). The number after “data” represents the test-taker’s identification number. Within each folder, there are three CSV files, one for each game (Figure 20). This option is useful for easy access to raw data and allows researchers to observe and organize responses for deriving DD scores using methods other than the ones automatically calculated in the software (e.g., Scheres et al., 2006). Note that scoring methods other than the two that are automated within the software must be manually determined, as described in sections 2.5 and 2.6. For additional information on how to calculate subjective values using the predetermined rules method and AUC manually, we strongly recommend accessing the work of Scheres et al. (2006, 2008, 2010a) and Critchfield & Kollins (2001).

When opening one of the CSV files, it is necessary to separate the information by commas into columns for better visualization. To do this, click on "DATA" in the toolbar, select the data in column A, and then click "Text to Columns." A dialog box will appear; ensure that the “Delimited" option is selected and click "Next." Then, in the delimiters field, click on the comma option, then "Next," and finally, "Finish" (Figure 21).

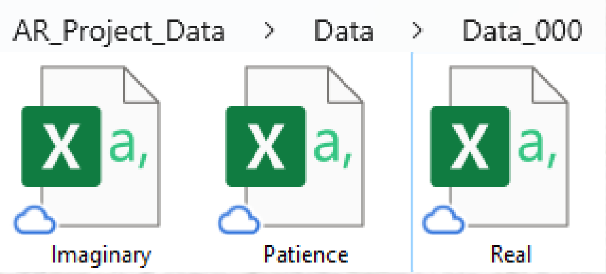


Figure 20. Location of output 2. In this example, the Data_000 folder was opened, which contains three **CSV** files corresponding to the three games completed by a single test-taker.

	A	B	C	D	E	F	G
1	Application_date	############					
2	Name	Daniel Utsumi					
3	Birth	10/10/2000					
4	Gender	male					
5	Avatar	Char02					
6	Total_Score	26400					
7	Type	Trial	Cluster_ID	Smallest_Reward	Time_On_Biggest_Reward	Chosen_Reward	Choose_Time
8	Training	7	E	100	4	100	2.26
9	Training	4	C	700	1	700	1.18
10	Training	6	C	700	1	700	0.45
11	Training	1	A	100	1	100	0.42
12	Training	5	D	400	3	400	0.4
13	Training	8	F	400	4	400	0.43
14	Training	2	B	400	2	400	0.4
15	Training	3	B	400	2	400	0.4
16	Experiment	25	I	700	3	1000	5.7
17	Experiment	10	D	100	2	1000	0.97
18	Experiment	26	I	700	3	1000	0.93
19	Experiment	22	H	400	3	1000	0.91

Figure 21. Visualization of output 2 data after converting information separated by commas into columns. Each file contains the sociodemographic information of the test-taker (name, date of birth, gender, and chosen avatar), date and time of the evaluation, score achieved in the current game, and the choices made by the test-taker. In line 7, column Type, one can differentiate practice trials (Training) from those of the actual game (Experiment). The Trial column shows the order in which the trials were presented, which in this case was randomized. Cluster_ID is the set formed by three identical trials, coded by letters (see section 5.4. Randomization, for a better understanding of how clusters are formed). The Smallest_Reward column refers to the immediate reward offered in the trial; Time_On_Biggest_Reward shows delays of each trial; Chosen_Reward shows the reward chosen by the test-taker; and Choose_Time shows the time elapsed between the presentation of the options for each trial and the test-taker's choice.

Output 2 also allows you to arrange the choices in ascending order. To do this, copy cells A16:G51 and paste them into empty cells (e.g., J1) or another worksheet. Then select the Trial column, click on Sort & Filter in the home toolbar, and choose Smallest to Largest. This ordering enables the manual construction of a matrix similar to that illustrated in Table 3 (see section 2.5. 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. However, this is not necessary, as output 1 provides this and other pre-processed data.

Table 5 provides the abbreviations and their corresponding meanings for Output 2.

Table 5. Abbreviations and their meanings regarding Output 1 (Data_OneLine).

Initials	**Meaning**
I or IM	Imaginary Game (Hypothetical delay/reward task)
P or PT	Patience Game (Real delay/Hypothetical reward task)
R or RL	Real Game (Real delay/reward task)
INITIALSnumb$_1$_Dnumb$_2$Rnumb$_3$ (e.g., IM01_D1R1)	D = delays; R =reward; numb$_1$ = numerical position in ascending order; numb$_2$ = delay ID (e.g., 1 = 7 s, 2 = 15 s; 3 = 30 s; 4 = 60 s); numb$_3$ = reward ID (e.g., 1 = 100 points, 2 = 400 points, 3 = 700 points). Example: IM01_D1R1 = First trial (01) of the Imaginary Game, which involved a 7 s delay and 100 points as a reward.
SVnumb	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 30 s, 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 test-taker in a trial.

Both output types 1 and 2 mentioned so far use the CSV format. **The format in which numbers are presented in the CSV file separates decimals with periods and omits commas when representing thousands. This format complies with international standards for numerical writing and facilitates the separation of comma-separated values into columns, as described earlier. However, in countries like Brazil, decimals are separated by commas, which may alter the way numbers are interpreted by Excel. If you encounter any problems with the results, especially in the DD scores of output 1, please refer to** Appendix B **where we provide a solution to resolve numerical configuration issues.**

If the examiner wants to create their own export type, they can do so by creating a new class that extends the IOutput interface, located at Scripts/Output/. This interface provides information on this when the games end.

Here is a breakdown of the key methods in the interface:

1) StartSession and EndSession: These methods should be used for setting up your export file when a new session starts and ends; **2) SaveUserData and SaveSelectedCharacter:** the software provides information on what to do regarding registration of information about the test-takers; **3) StartExperiments: the software provides information on what to do** when the user finishes the registration process and is about to begin the experiments; **4) SaveExperimentData:** when a new experiment is completed, the SaveExperimentData function provides information on how to save the relevant data; and **5) SaveTotalPoints:** the software provides information on how to save the total points accumulated.

For an example of how this interface is used, you can refer to the package located at /Scripts/Output/CSV. The CSVAllOutputs class within that package uses a Facade pattern to handle both CSV output modes. The /Scripts/Output/OutputFactory.cs file is where to choose which implementation of IOutput is to be used for the specific needs of the examiners.

5.3. Interpreting scores

The scoring of DD performance (available in Output 1) was based on the literature and was incorporated into the Waiting Game through algorithms integrated into the program's script, which automatically calculate: 1) DD subjective values using the proportional method (Mies et al., 2018); and 2) the area under the curve (AUC; Myerson et al., 2001) (for details see section 2.5 and 2.6).

- **Subjective values (based on equation 1, explained in section 2.5):** the absolute SV for each delay in the three tasks can be found in cells DT to EH, while the normalized SV can be found in cells EL to EZ (refer to Table 5). A higher SV indicates a lower discount rate (better performance or lower choice impulsivity). Normalized SVs offer the advantage of expressing the preference for the larger reward in a given delay as a percentage. For example, if RLSV_N2 in output 1 is 0.85, it means that in the Real Game, the test-taker chose the larger reward in 85% of the trials involving a 7 s delay.
- **Area under the curve (based on equation 2, explained in section 2.6):** the absolute AUC values for the three tasks can be found in cells EI to EK, while the normalized AUC values are in cells FA to FC (see Table 5). Higher AUC values indicate lower discounting (better performance or lower choice impulsivity). Normalized AUC values are valuable for interpreting the results as well. For instance, an IMAUC_N of 0.29 represents that in only 29% of all choices made in the Imaginary Game (IM), the test-taker selected the larger reward considering the normalized AUC (AUC_N), indicating a steep discounting pattern throughout the task.

5.4. Randomization

Games are presented in random order, but the sequence of trials in the spreadsheet follows a pseudo-random order, which is consistent with the order presented to the test-taker. However, the sequence of trials changes with each administration while adhering to two essential rules that are necessary for calculating the DD scores:

1) The output must allow the raw data to be rearranged in ascending order. This means that choices involving the lowest score (100) and the shortest delay (7 s) will appear first, followed by choices involving the second lowest score (400) and a 7 s delay, and so on;

2) The order of presentation within a set of identical pairs, referred to as a cluster, must be adhered to. Each choice within a cluster is assigned an ID ranging from 1 to 36, and each cluster, denoted by letters, consists of three identical choice pairs (trials). For example, pairs involving 100 points and 7 s are part of cluster A and are assigned IDs from 1 to 3, whereas pairs involving 400 points and 7 s belong to cluster B with IDs from 4 to 6. While clusters themselves can be randomized, it is crucial to maintain the ID sequence of the trials within each cluster. This rule is especially important when calculating the subjective value (SV) using the predetermined rules method, which corresponds to only output 2 (Figure 21).

To the best of our knowledge, all studies involving DD tasks have employed a fixed pseudo-random presentation mode (e.g., Scheres et al., 2010a). In other words, the presentation appeared to be random but was the same for all test-takers. Differently, in the Waiting Game the sequence of trials for each game varies for each test-taker but maintains certain rules so that the reordering of choices allows the use of non-automated methods of obtaining DD scores, such as the pre-determined rules method (see Figure 22).

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 22. In a true randomization system, a sequence like the one presented in Figure A may occur. However, when reorganizing the IDs in ascending order (B), there is a reversal of positions (highlighted in bold), making it appear as if the test-taker began discounting when, in fact, they only decided in favor of the immediate reward after waiting twice for 7 s to accumulate a total of 2000 points. This reversal alters the subjective value of the reward for a specific delay, as per the predetermined rules method. Hence, it is not possible to completely randomize trials, and the numerical sequence within the cluster cannot be disrupted, 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, this approach reduces the probability of inversions and misinterpretations.

6. User Interface

The most practical way to edit the program's content is through the Excel spreadsheets (User Interface) found in Build-1.2.0 > Config > config (.exe). Within this spreadsheet, there are six tabs: Practices, Tasks, Texts, Rewards, Delays, and Debug. Table 6 summarizes the spreadsheet's editable items.

Table 6. Editable Program Elements, Organized by User Interface Tabs/Spreadsheets.

Tabs	Editable elements
Practices[a]	▪ **Immediate Reward Value:** allows the selection of the value and frequency of the occurrence of the immediate reward during the practice trials. ▪ **Delayed Reward Lane:** allows modification of the lane (that represents the delay) in the practice trials that correspond to the presentation of the higher reward. ▪ **Delayed Reward Value:** the value '4' pertains to the higher reward in the practice trials. It is advised to refrain from altering this value, as an immediate reward should consistently correspond to a higher fixed reward.
Tasks[a]	The editable items on this tab are identical to those found in the Practices tab; however, it is advised to refrain from modifying them. This tab serves to display the associations established between immediate rewards and their corresponding delayed counterparts across the 36 trials. Despite the fact that the pairings of binary choices are arranged in ascending order, the program reorders the trial sequence pseudo-randomly with each administration. … (continues below)

Table 6 (*Continued*)

Tabs	Editable elements
Texts	▪ All text fields can be edited. When adding a new language, input the corresponding language code in cell A5 and then proceed to translate the text from the available default languages (English, Brazilian Portuguese or Spanish). ▪ Reward type can be altered. For instance, within columns Y, Z, and AA (Score, Points, and Points Abbreviated) there are the options to input "Total Value," "Dollars," and "$," respectively.
Rewards	**Value:** All values (rewards) can be modified.
Delays[b]	**Time:** All delays (measured in s) can be altered; however, it is advisable to refrain from altering the minimum delay (zero s), as it represents the immediate reward.
Debug	▪ **Always imaginary first:** for complete randomization of the three tasks/games, keep the FALSE option selected. If the user wants the Imaginary Game to consistently appear first, type TRUE. ▪ **Language:** Enter the language code to choose the language for the texts. ▪ **(Imaginary/Real/Patience) Game Enabled:** Allows you to select the tasks that will be applied when keeping the TRUE option; otherwise type FALSE.

Note. Refrain from altering spreadsheet headers and IDs; [a]Both rewards and delays are assigned numerical values. To understand the association between these numbers and the corresponding reward amounts and delay durations, refer to the Rewards and Delays tabs, respectively; [b]The sequence of lanes should not be modified.

To enhance the comprehensibility of the spreadsheet, the tabs will be described in detail below.

6.1. Texts

This tab contains all the textual information, including written instructions, that appear during the software's execution (Figure 23). Currently, this information is available in three standard languages: English (en), Brazilian Portuguese (pt-br), and Spanish (es) (see Figure 23 A). These texts can be modified, and if researchers want the software to run in one of the three available languages or in another new added language, it is necessary to enter the language code (e.g., *en* for English) in the specified field of the Debug tab (see section 6.6). In Figure 23 B, the rewards are represented as points, but this can be changed to currency. To do so, in columns Y, Z, and AA (Score, Points, and Points Abbreviated), one can enter "Total Value," "Dollars," and "$," respectively.

Insert a new language in cell A5. Don't forget to enter a new language code (e.g., ***it*** for Italian).

Figure 23. Section of the Texts tab in the software's editing spreadsheet. (A) All texts are editable, **except for headers.**(B) In cells Y4 - AA4, it is possible to change the type of reward. Currently, the program uses points, but it is possible to change to the currency of the country where the research is taking place.

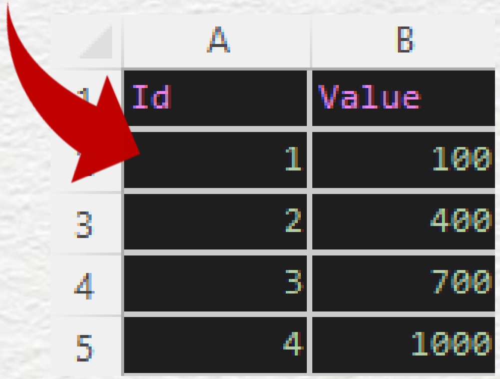
6.2. Rewards

In this tab the IDs and magnitude (Value) of the rewards are presented. In the example of Figure 24, the rewards are represented as points ranging from 100 to 1000. To make changes, simply enter the new values in cells B2 to B5. Please do not alter the IDs, as they are connected to other tabs.

6.3. Delays

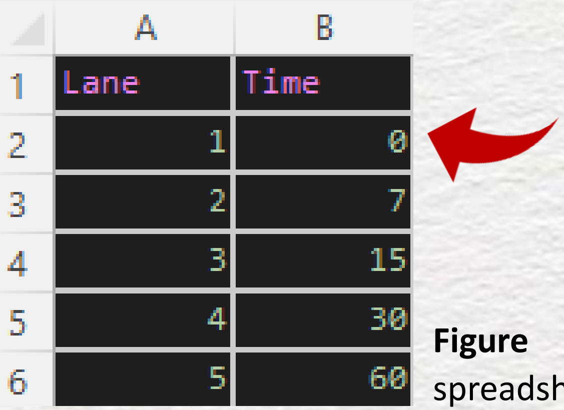
The Delays tab displays the delays (denoted as "time") for each lane, as shown in Figure 25. There are five lanes, with the first lane representing the immediate reward. Therefore, it is not advisable to alter the time for this lane (set to zero s). One can adjust the times for the other lanes, bearing in mind that the unit of measurement is seconds. For instance, if one input 90 in cell B6, it will correspond to 90 s. Please refrain from modifying the lane numbers, as they are interconnected with the other tabs.

Do not modify IDs



	A	B
1	Id	Value
2	1	100
3	2	400
4	3	700
5	4	1000

Figure 24. Prizes tab in the software editing spreadsheet.



	A	B
1	Lane	Time
2	1	0
3	2	7
4	3	15
5	4	30
6	5	60

Altering this time (zero s) is not recommended.

Figure 25. Times tab in the software editing spreadsheet.

6.4. Practices

On this tab, you can find the IDs and numeric codes for the immediate reward value, the lane in which the immediate reward will appear, and the delayed reward value. It is crucial to keep in mind that the lanes correspond to waiting times: the higher the lane number, the longer the delay (refer to Table 7). While the trial sequence is entirely randomized, users have the flexibility to modify the frequency of prize appearances and the lane associated with the larger prize (as illustrated in Figure 26).

Table 7. Mapping of numerical lane codes to delays in the current software version.

Lane	Delays in seconds
1	0
2	7
3	15
4	30
5	60

	A	B	C	D
1	Id	Immediate Reward Value	Delayed Reward Lane	Delayed Reward 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

Do not modify IDs

Figure 26. The Practice tab in the software editing spreadsheet, displaying combinations of rewards (immediate and delayed) along with their associated delays for the delayed reward. The highlighted blue square represents a choice between waiting 7 s for the maximum value or receiving 100 points immediately.

6.5. Tasks (Games)

This tab contains the same elements as the Practice tab but corresponds to the 36 test trials. We strongly advise users not to make any changes to it. Although Figure 27 presents the data organized in ascending order by IDs, the program pseudo-randomizes the sequence of trials while adhering to the scoring rules described above.

Do not modify IDs

	A	B	C	D
1	Id	Immediate Reward Value	Delayed Reward Lane	Delayed Reward Value
2	1	1	2	4
3	2	1	2	4
4	3	1	2	4
5	4	2	2	4
6	5	2	2	4
7	6	2	2	4
8	7	3	2	4
9	8	3	2	4
10	9	3	2	4

Figure 27. Tasks tab displaying the 36 test trials. We advise against altering any of the values.

6.6. Debug

This tab (Figure 28) is crucial for setting the language in which the software will work. To do so, simply enter the language code in cell B2, ensuring that both the language code and texts are available in the Texts tab. In the Debug tab it is also possible to determine whether the software will present the games completely randomly (by filling in cell A2 with FALSE) or whether the Imaginary Game (Hypothetical delay/reward task) will be presented first while the others continue to be presented randomly (by filling in A2 with TRUE). Presenting the Imaginary Game first can be useful to ensure that the test-taker have no prior waiting frame of reference to guide their choices, except for imagining the delays presented on screen.

	A	B	C	D	E
1	Always Imaginary First	Language	Imaginary Game Enabled	Real Game Enabled	Patience Game Enabled
2	FALSE	en	TRUE	TRUE	FALSE

Figure 28. Keep FALSE for "Always Imaginary First" to have the games presented in random order or enter TRUE for the Imaginary Game to always be first. In "Language", enter the language code, as written in the Texts tab. In cells C2 - E2 (“Imaginary/Real/Patience Game Enabled”), the user can choose which games will be applied by keeping the TRUE option; otherwise, type FALSE so that a specific game is omitted from the application.

6.7. Exporting user interface edits

For the software to implement the changes made to the user interface, it is necessary to save the spreadsheet, access the Config folder, and click on the Exporter option (Figure 29 A). This action will result in the import of the new code (JSON) into the program, which will take effect upon subsequent application (Figure 29 B).

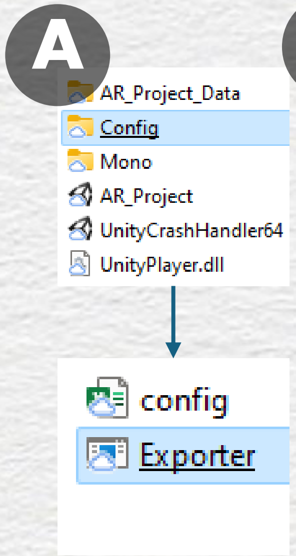


Figure 29. Exporting user interface edits. (A) Firstly, enter the Config folder and click on Exporter. (B) A window similar to the one in the figure will confirm that the export of the new code was successful. Subsequently, the window can be closed, and the new application can proceed. If the protection system attempts to block this action, click on "Run anyway."

6.8. Adding new avatars

The software includes four manga style avatars which are popular among people of all ages, worldwide. It is not possible to add new avatars using the User Interface (Excel spreadsheet), but researchers familiar with programming in C# can do so in the software's source code, freely available at GitHub. Given the ethnic misrepresentation within virtual environments in respect of the expression of racial and cultural identities, this is an issue that should be taken into consideration by researchers who intend to use the Waiting Game, depending on their research questions and/or the characteristics of the to-be-tested samples.

☆☆☆

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Appendix A

Instructions for online administration

The administration of the Waiting Game can be conducted remotely, at low cost, but must be done with the mediation of an examiner. This has advantages compared to in-person testing, including less travel time and travel expenses and the possibility of reaching otherwise inaccessible samples (e.g. patients with reduced mobility, who live far away and/or are vulnerable to infectious diseases). Additionally, it allows people to be tested in a familiar setting, which can be preferred by some test-takers.

However, online testing can involve technical problems like unreliable internet connection. Test takers may also be unfamiliar with and/or uncomfortable with technology and/or not have computers/tablets or access to the internet, which make remote testing impossible.

Moreover, in online testing examiners may fail to notice difficulties that are not clear through vocal communication when participants are unable or unwilling to turn on their cameras, which is common in youngsters. Online testing also poses ethical issues that must be minimized at all costs (i.e. violation of privacy).

To administer the Waiting Game remotely both the examiner and the test-taker must have:

1) An internet connection;

2) Access to remote conferencing application installed that supports screen sharing (e.g., Zoom and Google Meet). For examiners, the conferencing application account must permit meetings longer than 30 min;

3) An operating system compatible with the Waiting Game (Windows, Linux, and macOS).

It is highly recommended that the examiners send the software files to the test-takers in advance, allowing them to play the Waiting Game on their personal computer or tablet when the experiment is conducted. The zipped folder (Build-1.2.0) can be conveniently shared via WhatsApp or email with the test-taker (or their guardian, if they are minors). If the examiner has made any recent modifications to the software, it is essential to verify that the zipped folder contains all the latest updates.

Next, provide the test-taker or their guardian with a link to the remote conference through WhatsApp or email. Once the test-taker joins the virtual room, ask them to enable their microphone and activate their camera. At this moment, assure them that you will explain how they can set up the application on their own computers. This can be done verbally in the conference call.

To start using the software, grant the test-taker permission to share their screen first. For example, in the Zoom meeting room, the researcher should click on the "Security" icon located in the bottom app bar, then select the option "Allow all participants [test-takers] to share screen." Subsequently, the test-taker should be instructed to click on the green "Share screen" icon situated in the app's bottom bar, followed by clicking "Share" in the lower right corner of the options box (as illustrated in Figure 30). For screen sharing in Google Meet, guide the test-taker to click on "Present Now" on the bottom app bar and then select "A tab."

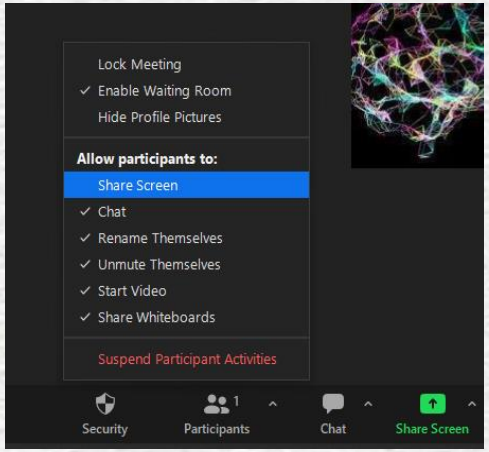


Figure 30. Screen Sharing Procedure in Zoom. To begin, the researcher should click on the "Security" icon located in the app's bottom bar and then choose "Share screen." Subsequently, instruct the test-taker to click on the green "Share screen" icon also found in the app's bottom bar, followed by clicking the blue "Share" button within the options box.

Following this, the test-taker or their guardian should be asked to unzip the Build-1.2.0 folder. They can do this by right-clicking on the folder and choosing the option "Extract all" or "Extract here", or by using a zip/compression software like 7-Zip or WinZip. Once the folder has been successfully unzipped, it is advisable to rename it for clarity (e.g., "DD" followed by the test-taker's initials). To do so, simply ask the test-taker/guardian to right-click on it and select the "rename" option, providing them with the name (We suggest the test-taker's initials). Then follow the administration instructions provided in section 4.

After the test-taker has completed the tasks, they must be assisted to find the data output. To accomplish this, instructions for accessing the "Build-1.2.0" folder > "AR_Project_Data" has to be provided. Inside this folder, the test-taker must be guided to compress the "Data" folder by right-clicking on it, then selecting "Send To," and finally choosing "Compressed (zipped) Folder." Following the compression, it is advisable that this folder be renamed using the test-taker's initials. An alternative method is to instruct the test-taker to compress the entire "Build-1.2.0" folder, using the same procedure outlined above (as shown in Figure 31). Subsequently, the zipped folder can be conveniently sent via WhatsApp or email to the examiner.

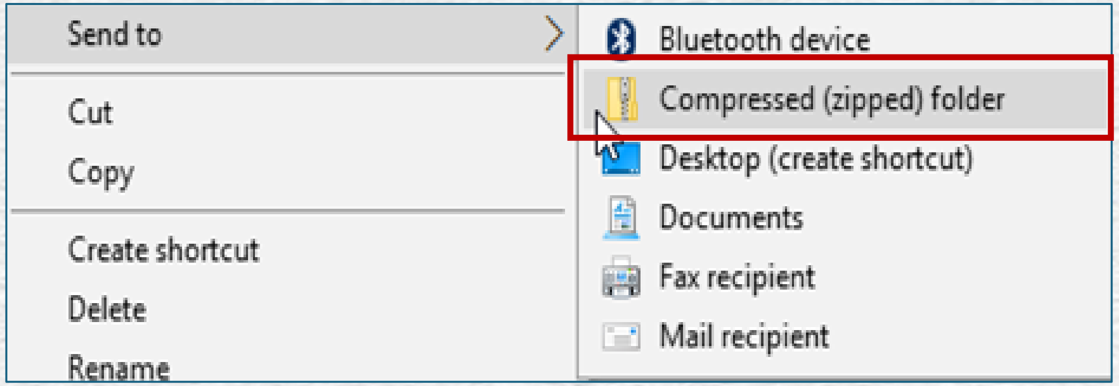


Figure 31. Instructions for compressing the software folder.

Sending the folder via WhatsApp Web or WhatsApp Desktop is convenient as it permits the uploading of large files without the need of generating links or resorting to large file upload websites, such as WeTransfer or MailBigFile. Here is how to accomplish this:

1) Instruct the test-taker to access WhatsApp (Web or Desktop) and open the chat with the examiner.

2) In the chat's textbox, guide them to click on the "paperclip" icon and subsequently select the "File" option.

3) Ask them to choose the zipped folder and proceed to send it to the researcher (as depicted in Figure 32).

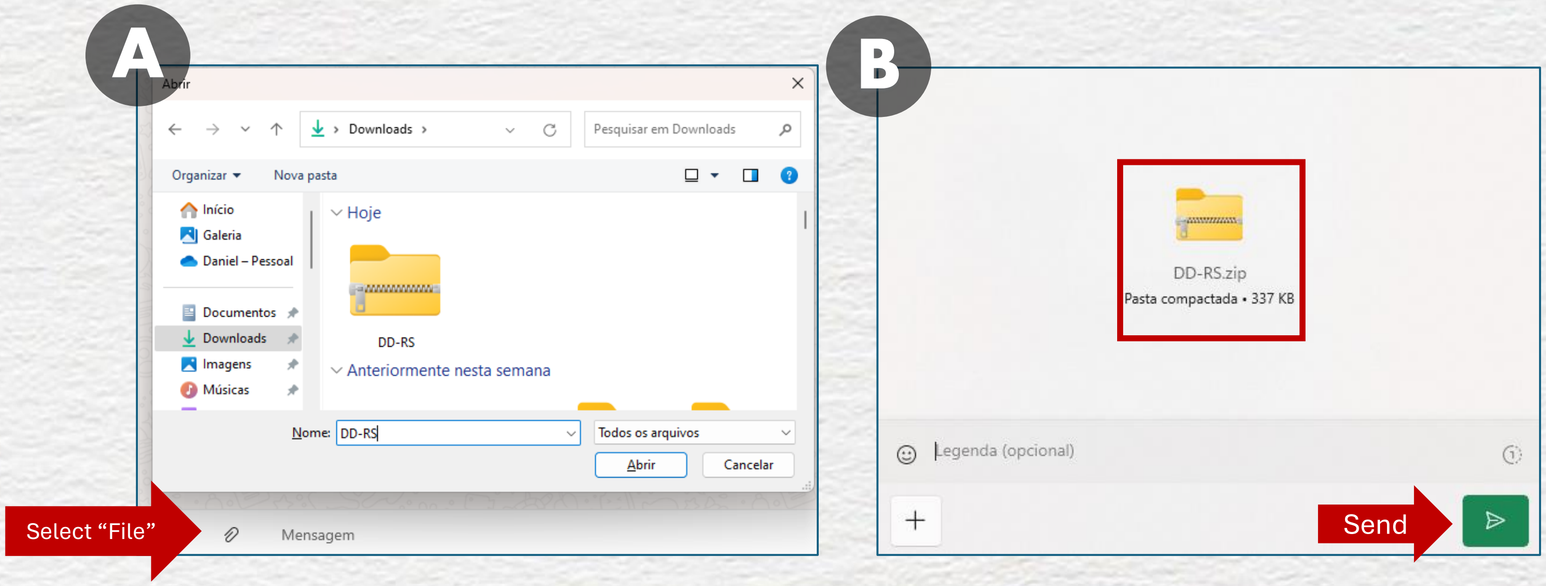


Figure 32. Steps for sending the zipped folder via WhatsApp. (A) Instruct the test-taker to access WhatsApp (Web or Desktop), open the chat with the researcher, and click on the "paperclip" icon, followed by selecting the “File" option. Locate and choose the updated zipped folder (renamed with the test-taker's initials). (B) Verify that the folder name is correct, and then click on the “send” icon.

Appendix B

Troubleshooting number settings in Excel

As mentioned earlier, in certain countries, the writing of numbers differs from that of countries such as the United States. By default, our software employs only periods to denote decimals, a practice generally compatible with international metric standards. However, in countries such as Brazil and France, applications such as Excel are configured to display thousands with periods and decimals with commas, which may lead Excel to distort some results from output 1 (Figure 33).

EI	EJ	EK
IMAUC	RLAUC	PTAUC
2675	1830.556	2408.333
2.675	1.830.556	2.408.333

Figure 33. Cells EI2 to EK2 adequately show the DD scores of the three software tasks, with decimals represented by periods. The cells highlighted in yellow show the same scores that were incorrectly read by Excel, due to differences in the regional settings of the operating system and Excel.

If this is the case, we suggest that users follow the steps below (Figure 34):

Regional Settings in Windows

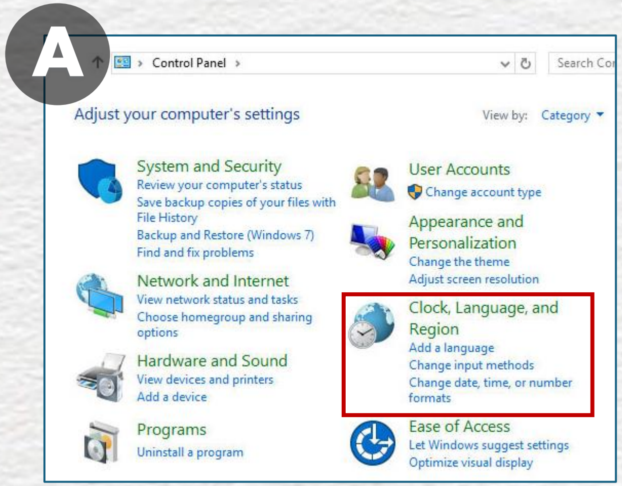


Figure 34. Changing regional number settings. (A) In the computer's Control Panel, click on the “Clock and Region” option;

Regional Settings in Windows

(*continued*)

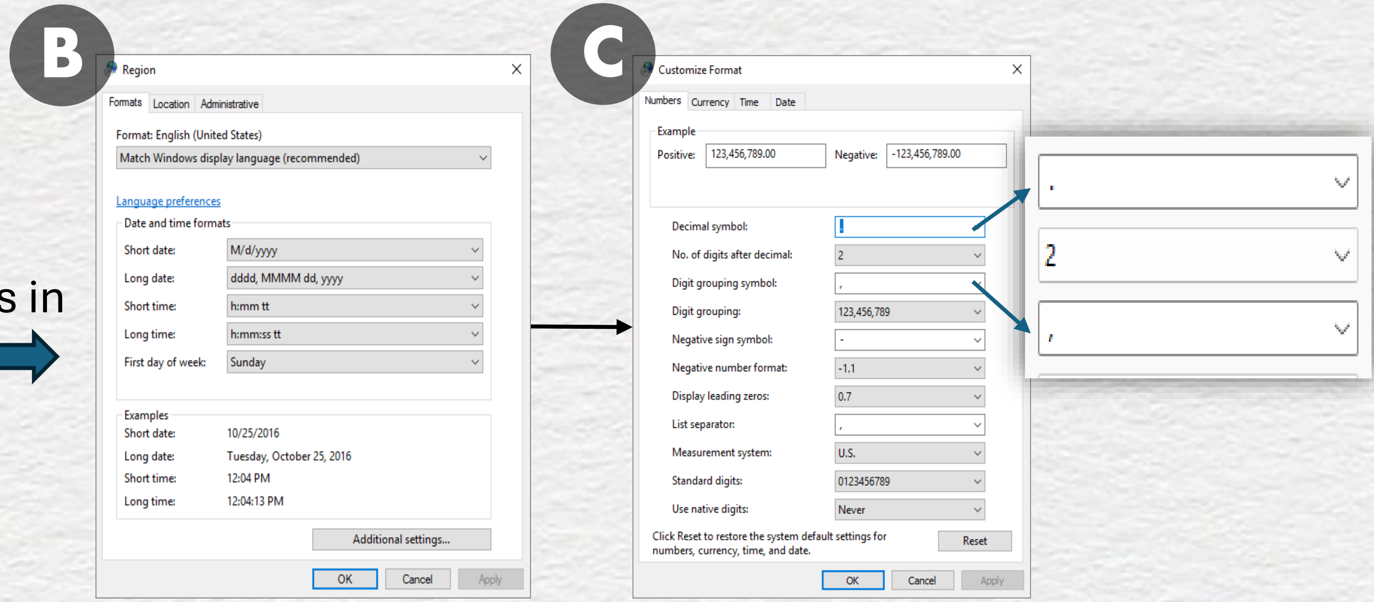
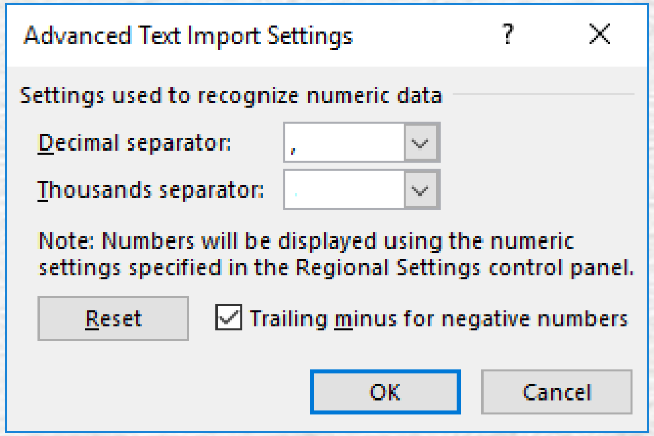


Figure 34 (*continued*). (B) Access "Regional Settings" and click on "Additional settings"; (C) Under the Numbers tab: in the "Decimal symbol" field, replace the comma with a period; in the "Digit grouping symbol" field, replace the period with a comma, and click OK;

Number Settings in Excel



(D) Open Excel and access "Data" on the toolbar, then click on "Text to Columns". Proceed to Step 2, and under "Delimiters", select the Comma option. In Step 3, click on "Advanced". In the "Decimal separator" field, replace the comma with a period; and in the "Thousands separator" field, leave it blank. Click on "OK" and then "Finish". To ensure that the changes are applied, restart your computer.