International Journal of Serious Games

ISSN: 2384-8766
https://journal.seriousgamessociety.org/

Article

The Impact of Executive Function Games in Moral Decision

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Keywords:
Executive Function
Serious Game
Dual Process Model
Reaction times
Moral Decision

Received: March 2025
Accepted: October 2025
Published: October 2025
DOI: 10.17083/x0dd2228

Abstract

According to the dual process model, moral decision making speed is influenced by cognitive sources. However, there has been a lack of studies examining moral decision reaction times across cognitive dimensions and genders using a modern approach. Unlike previous research that relied on cognitive assessments, this study employed a game-based approach. This study investigated whether inhibitory control, cognitive flexibility, and working memory games affect the reaction times of moral decisions across genders. Its purpose was to examine differences in moral decision reaction times between men and women under different executive function game conditions. A factorial mixed-design experiment was conducted, with the experimental group engaging in game-based stimulations and the control group performing a dot task comparison. A total of 61 law students participated. Our findings indicated overall no differences between groups and genders, however differences in reaction times were observed across cognitive game and gender. This study advances the state of the art by combining serious-games stimulation for executive function with timeline-presented moral stories. The finding provides a new understanding of serious game applications in both mental chronometry and moral studies within dual process framework.

1. Introduction

Moral decisions are judgments made by individuals concerning what is right or wrong in the context of moral issues. These decisions may involve real or hypothetical ethical contexts [1]. Haidt [2], defined moral decisions are individual judgments about what is right and wrong based on the principles of intuition and emotional. Greene [3] defined a moral decision as the process of an individual cognitively evaluating a problem and deciding which is ideal/right and which is not ideal/wrong in a real or hypothetical context. For example utilitarian judgment is a decision-making based on the benefits for the majority, while deontological judgment is decision-making based on nonmaleficence and duty.

Moral decisions are influenced by various factors, which can be broadly catagorized into external and internal factor. External factor include culture [4], ethnicity [5], socioeconomic status (SES) [6], sex [7] and situational factor [8]. Internal factor encompass cognitive aspects [9], emotions [10], psychological disorders [11] and personality traits [12]. The dual process model focuses on cognitive process and how these factors influenced decisions. The dominance of cognitive process makes decision making slow and deliberative [13]. Lahat et al [14] found that executive processes (EF) are related to the decision times of moral decision. Students who actively use their executive functions tend to make moral decisions faster. However, there has been a lack of detailed studies on cognitive process, specifically regarding its dimensions, so influence of each dimension of executive function (e.g. inhibitory control and cognitive flexibility) to the reaction times to moral dilemmas is relatively unknown. Theoretically, these three dimensions have different functions so their impacts on moral decision-making reaction times will also be different.

Inhibitory control is defined as cognitive control to maximize response and resist distractions. This ability improves decision-making time by maintaining focus on goal and effectively eliminating distractions. Distractions mean options that are not particularly relevant. Cognitive flexibility functions refers to the ability to think alternatively; this ability makes decision-making slower due to the shifting focus toward alternative goals and consideration of available options. Meanwhile, working memory is linked to the retention of ongoing information and response to other stimuli in parallel. It may slow down decsion making process because attention and cognitive resources are divided into two parallel tasks: analyzing the ongoing stimulus and recalling the previous response [15].

There were some experimental studies on moral decisions conducted using the partial executive function dimension. Moore's [16] study, involving a working memory task, found that individuals with higher working memory capacity tend to select utilitarian moral decisions and need more time deciding. In contrast, Greene [17] employed cognitive load induction and working memory tasks and, found that utilitarian moral decisions have faster reaction time. Meanwhile, Paxton [18] found that cognitive reflective task increased the frequency of utilitarian moral decisions over deontological (non-utilitarian) decisions. Tremoliere and Bonnefon, [19] conducted a similar study, adding time pressure as variable, and observed a shift toward deontological moral decisions under these conditions. Martin, [20] examined the impact of working memory capacity on moral decisions and found that higher capacity corresponds with a greater likelihood of utilitarian choices.

According to the dual process model, moral decision-making internal factors interact with external factors and, create a dynamic process. This occurs because there are differences between the cognitive processes in men and women. Niazi [21] found that women are statistically more sensitive to harm-related tendencies than men. Armstrong [22], investigating gender differences in moral decision-making, found that women prefer deontological moral choices, while men lean toward utilitarian decisions. Yusoff et al. [23], examined differences in brain activation, particularly in the frontoparietal region, and observed that women showcase greater emotional response than man, who are inclined toward deontological decisions due to their emphatic side. Friesdorf [24], added that men tend to engage the rational brain areas, whereas women more frequently activate emotional regions. This preference suggests that men are generally more utilitarian, while women are more deontological in moral decision-making. However, these studies only examined gender differences in moral decision-making in a general sample.

Olaborede and Van Der Walt [25] conclude that, heuristic decisions in moral issues due to cognitive simplicity are still often found in juries and judges. Heuristic decisions are made because they are more efficient for complex situations including dilemmatic conditions [26]. However, this decision simplifies cognitive process (mental shortcuts), and cannot be considered a decision involving executive function dimensions. Based on this description, we studied law students to gain an understanding of the cognitive processes of men and women in resolving moral dilemmas.

After identifying the importance of internal factors (executive function) and external factors (gender) in moral decision-making, we realized that among men and women with low or unstimulated executive function (EF), such function does not significantly contribute to the moral decision-making. This is because EF is a fundamental component of cognitive processing, and its influence on moral decision-making becomes evident only when it is actively engaged. To explore its relationship with moral decision-making, EF must first be stimulated.

Various techniques have been employed for this purpose, including physical activity or aerobics [27], martial arts [28], coaching sessions [29], and computer-based cognitive task assessments, as demonstrated by Moore and Paxton. Among these approaches, aiming to provide more objective research findings through an innovative method, we opted to develop a novel method—a computer-based stimulation that does not rely on cognitive assessments or tests, but instead takes the form of a serious game.

Serious games (SG) have shown promising potential not only in education [30] and mental health [31], but also in the decision-making process [32]. These games can boost motivation and engagement through immersive gameplay, effectively training and improving decision-making skills. Furthermore, meta-analyses have indicated that games are effective in enhancing critical thinking and engagement [33]. Serious games have been applied to decision-making under stressful conditions [34], organizational decision-making [35], policy integration decisions [36] and strategic conditions during the COVID-19 pandemic [37]. However, there had been no record of serious games' effect on moral decision at the time of the study.

Serious games are highly suitable for executive function stimulation due to their advantages in knowledge transfer. Boendermaker [38], found that serious games can effectively enhance cognitive performance among adolescents. Games engage people with dynamic and interesting challenges, preventing boredom and facilitating easier knowledge transfer [39]. Applying games to cognitive training is a relatively new approach in psychology. Game-based stimulations are considered particularly appropriate, as they are well-adapted to the current era and especially effective with younger populations.

As mentioned earlier, some studies focused on the choice/type of decision but provided little insight into the dynamics of the decision-making process, particularly in terms of reaction time. Moreover, no studies compared each dimension using game stimulation, existing studies often relied on working memory (e.g., the digit span and n-back tasks) and inhibitory control assessments (e.g., the stop-signal and Stroop tasks) for stimulation. Additionally, the influence of cognitive flexibility on the decision-making process was not explored. The knowledge gap addressed by this study was the lack of information on the impact of executive function dimensions (i.e., inhibitory control, cognitive flexibility and working memory), delivered through serious games, on the reaction times of moral decision-making across genders. Therefore, the purpose of this study was to examine the effects of inhibitory control, cognitive flexibility, and working memory on moral decision reaction times in men and women with studying law.

To ensure the validity of the study, we used a control group. The control group was tasked with approximate number system (ANS), which is based on general magnitude system theory. The general magnitude system refers to the human ability to analyze magnitudes across various dimensions, such as size, frequency, and volume [40].Vincent Wals [41], introduced the theory of the general magnitude system, famously called the "Theory of Magnitude". A key manifestation of the general magnitude system is research on the approximate number system

(ANS) by Justin Halberda [42]. The ANS has two main versions: using dots with different colors and quantities, and using groups of dots varying in size. Originally, the ANS was developed to assess mathematical intuition in children, focusing on their capacity to gauge the magnitude of dot groups [43]. The approximate number system is one aspect of cognitive-perceptual functioning, allowing individuals to perceive the magnitude of a set of stimuli by making comparisons, performing arithmetic manipulations, and grouping [44]. The ANS operates through estimation, relying on intuitive processes [45]. A typical ANS task that is widely used is the dot comparison task, where participants compare the number of dots, typically in yellow and blue.

The game stimulation and gender were the independent variables, while the reaction time for moral decision was the dependent variable. Thus, the hypotheses of this study were:

- Reaction time for moral decisions is slower in the experiment group than in the control group.
- The moral decision reaction time is faster in men than in women.
- Moral decision reaction time is faster during inhibitory control game stimulation than cognitive flexibility game stimulation.
- Moral decision reaction time is faster during working memory game stimulation than cognitive flexibility game stimulation.
- Moral decision reaction time is faster during inhibitory control game stimulation than during working memory game stimulation.
- Last, there is an interaction in moral decision reaction time between men and women across the types of executive function game.

2. Related Work

2.1 Executive Function Serious Games

Previous studies on serious game stimulations for executive function utilized various game types and models. Maraver et al. [46], employed a bag-matching color-shape game (based on the Stroop task mechanism) and a robot-target game (based on the go/no-go task mechanism) for inhibitory control training. Maraver also employed games using n-back and search/updating mechanisms for working memory training. However, these studies employed games that modify the stimulus by using different objects to mimic a game-like experience.

Olfers and Band [47], developed the *Brain Shift Overdrive* game to induce and train cognitive flexibility. The game design closely mirrors the original cognitive task, creating a strong resemblance between the serious cognitive flexibility game and the cognitive flexibility tasks used for assessment. This alignment is due to Olfers and Band’s goal of identifying the ERP (event related potential) associated with task switching in gamified computer-based cognitive training. In contrast Parong et al [48] mployed the point-and-click game All You Can ET (AYCET), which has shown effectiveness in improving cognitive flexibility at an individual level. All You Can ET, developed by Jan Plass from New York University [49], uses an alien-concept where players must feed aliens, with the catch that the type of food required changes depending on where the alien’s gaze was directed last. According to Parong et al., this game has been proven effective in enhancing cognitive flexibility in players.

Earhart & Roberts [50] explained that monitoring and focusing on information while simultaneously recalling stored data are the primary tasks of working memory. Ideally, working memory functions as a temporary storage space (storage component) while also processing new information concurrently (process component) [51]. Games like Memory Birds N-Back on iOS, Restaurant Game from Happy Neuron, and Crushstations include mechanisms designed to train and enhance working memory. In this experiment, we used an inhibitory control game, a cognitive flexibility game and a working memoty game each with completely different gameplay to train executive function.

2.2 Sequential two-system model of moral judgment

The sequential model categorizes moral decisions into two types: utilitarian and deontological decisions. Deontological decisions are rule-based and supported by intuition or emotion, while utilitarian decisions rely on reasoning that overrides intuitive. This correction process makes utilitarian decisions take longer to make [13]. Elqayam et al. [52], found that utilitarian decisions are align with reason mechanisms, while deontological decisions are generally more normative.

Previous studies have used reaction time to understand the dynamics of moral decision-making in dilemmatic situations. Andrejevic [53], incorporated caution and moral valence into a set of dictator game scenarios and found that participants slowed their reaction times when judging negatively valenced actions and when expecting updates on the impact of their decisions. Suter and Hertwig [54], manipulated reaction time by providing either a short or a long allocation period and found that deontological decisions taken faster. Suter added that disrupting cognitive control through time manipulation affects the reaction times of moral decisions.

A meta-analysis by Baron and Gürçay [13] concluded that, in moral decision-making, utilitarian decisions took longer, though the effect was small. In the sequential model, the reaction time in moral decisions is influenced by the balance or equivalence within the story or dilemma. However, the sequential model is less robust in term of story difficulty level and participant ability. From a statistical probability perspective, the conflict model is more accurate. However, this study used the sequential model, as it serves as Greene's foundational model, establishing a baseline for evaluating the effectiveness of executive function stimulations via serious games.

This study used a dilemma task to assess moral decisions. The dilemma task is a hypothetical story of moral conflict developed by Greene to measure moral decisions. In this study, reaction times were measured from the moment participant began reading the story until they made a decision. Each dilemma has two options, deontological and utilitarian choices. Thus, the central question of the present study was: do inhibitory control, cognitive flexibility, and working memory games affect the reaction times for utilitarian and deontological moral decision in men and women?

3. Methods and Material

3.1 Game structure validation

3.1.1 Game design

The inhibitory control game adopts the whack-a-mole concept, aiming at improving participants' cognitive control in avoiding distractors and simultaneously responding to the target. Strong cognitive control influence the reaction times of decision making to be faster and efficient. The Whack-a-Mole game (see figure 1) has four types of moles that appear gradually at each level. At Level 1, 2 and 3 the mole and the rabbit appear in usual pattern, but the pace gradually becomes faster. However in Level 4 and 5, the mole suddenly turn into a rabbit for a brief time. This mechanism is a derivative of the stop-signal task paradigm.

The Feeding Wild game represent the cognitive flexibility dimension, aiming at enhancing alternative thinking patterns and adaptability. Strong cognitive flexibility improves alternative strategies and proactive consideration when choosing a response. Feeding Wild has an herbivores and carnivores theme; each level has a mouse-click switch for feeding the animals, from left-clicking for meat and right-clicking for fruit/vegetables and vice versa. Instructions for changing clicks are not provided explicitly. Rather, participants were informed to adapt their response if there is an incompatibility between the food and the animal that appears. This mechanism is intended to encourage participants to develop flexible and adaptive thinking pattern, so they are not rushed to make decisions (e.g heuristic decisions). Each phase or level has rules that differs from levels already completed. This mechanism resembles the wisconsin sorting card task (WCST) paradigm.

The Trap Cave game represents working memory, aiming at improving recall function and storage capacity. High working memory enhances the ability to maintain focus and attention. Trap Cave integrates both the working memory process and storage components by presenting three types of stimuli—animal sequences, colors, and types of animals—that players must remember while simultaneously processing new information. The game has an animal-themed storyline, where animals are trapped inside a cave. There are four types of animals, each available in four different colors. In level 1 a combination of two animals with the same color. Level 2 shows three animals with two different colors. Level 3 has a combination of three animals with three different colors. Level 4 and 5 show a combination of four animals with three colors.

In all games, there is a *kairos* between the feedback score and the next level (see Figures 1 and 2). *Kairos* refers to the concept of a meaningful experience of time and denotes the pause between two sessions [55]. In UX, *kairos* is a marketing term that means transforming the opportunity into the opportune moment in decision-making. In games, *kairos* serves to reduce overload in each dimension and to create a favorable moment for decision making. Levels, on the other hand, are designed to increase player engagement and enhance the gameplay experience. Monotonous levels can make players feel bored and disengaged.

3.1.2 Game framework and executive function dimensions

The game was constructed based on Jan Plass's [56] framework: analyze, production, testing and release. In the analyze phase, consisting of four foundation or component: affective, the motivational, cognitive and social aspect. The affective aspect refers to emotional stimulation through visuals, music, and colors. The motivational aspect refers to the game has a competitive side due to different levels and mechanisms. The cognitive aspect represents the three dimensions of executive function. The social aspect reflects how the game has familiar themes, i.e., animal themes. Diamond in [15] described aspects of inhibitory control, namely attention, cognitive, and response control. The aspects of cognitive flexibility are perspective, priority and outside-the-box thinking. The working memory aspects used in the study were based on Edward Vogel's visual-spatial working memory [57], namely visual representation, active maintenance and working tasks. The game used Construct 2 and hosted on www.psyjs.com. This website can handle the Construct 2 game and the JsPsych library [58]. The database used MySQL and PHP scripts to send the data. The participants played the game by clicking the game validation link and subsequently went to the inform consent page and filled in biographical data (www.psyjs.com).

3.1.3 Game expert validation

Nine participants were involved in the game validation (see Table 1). Each item asked about the suitability of topics such as visuals (how exciting and attractive the graphic color), music (interesting music that supports players' emotions), and psychological aspects (competitive level: the higher, the more difficult); in the game.

Of all the scores, Aiken's V for Whack-a-Mole (inhibitory control dimension), Feeding Wild (cognitive flexibility dimension) and Trap Cave (working memory dimension) were in the adequate range (.77 to .93), meaning that the game appropriately includes executive function aspects in its gameplay.

3.2 Moral dilemma validation

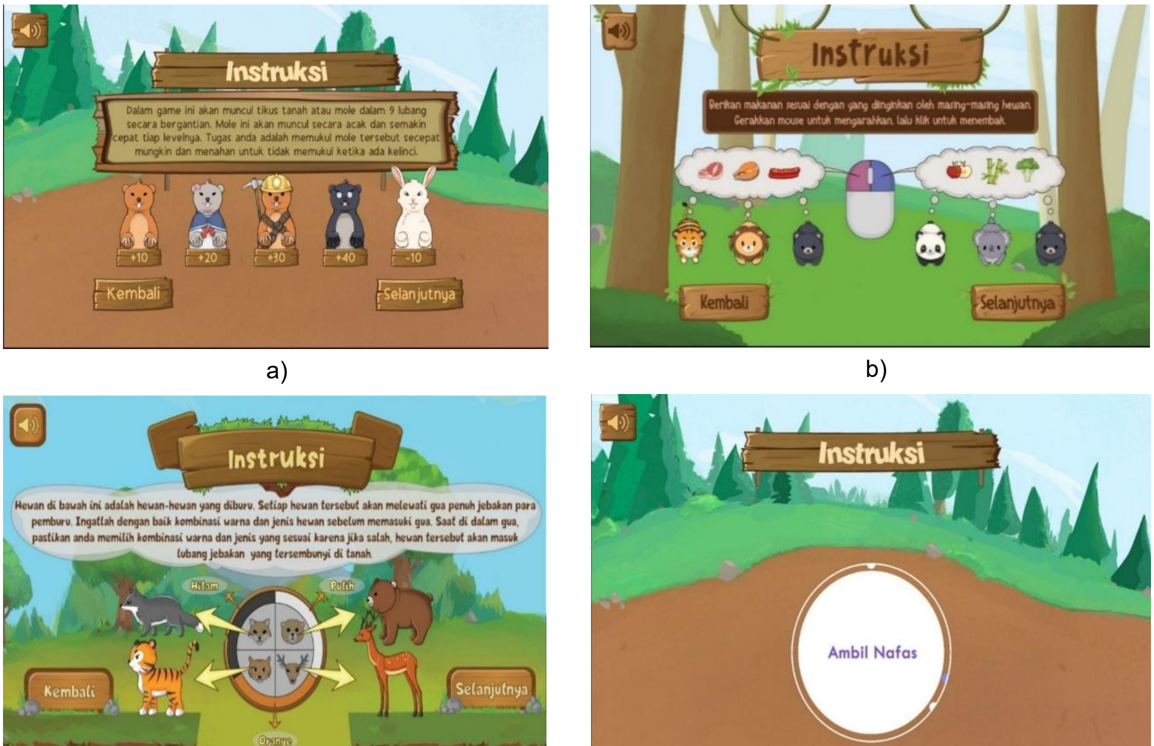
The participants for content validation – consisted of three experts in moral psychology, three in bioethics, and one lecturer who chaired the senate ethics committee. The Aiken's V index in moral stories ranged from .65 to .87, indicating a good content validity.

The construct validation involved 215 participants (men = 84, women = 131). This study used systematic sampling method with the following inclusion criteria: aged 19 – 25 years old, no history of drug use, and had a good circadian rhythm. Participants were paid $1.5 after submission and completing the moral dilemma. The sampling technique used in this study was a convenience sampling method, conducted in three universities. Construct validity, assessed using the partial credit model (PCM), yielded the following results: the raw variance by measure value is 45.2% (>40%), pairwise residual correlations for local independence were below .3, and measurement invariance between genders was confirmed with an Anderson L-R test value of 30.05 (p = .66). These findings indicate that all assumption tests were satisfactorily met. While DIF was detected, its effect size was minimal.

Content and construct validation of the moral stories is essential to ensure accuracy. Cultural differences and vocabulary that differ significantly from the participants' cultures should be revised and adapted. Furthermore, all stories should be reviewed with both male and female groups to identify any that demonstrate a bias in one group over the other.

Table 1. Expert judgment serious game

No.	Gender	Speciality	Age
1	Male	Undergraduate Student with A Concentration In Educational Game Unity	22
2	Male	Undergraduate Student with A Concentration In Educational Game Unity	24
3	Male	Graduate Student with A Concentration in Educational Game	22
4	Female	Game Designer	24
5	Female	Postgraduate Student/Creative Thinking Game Author	43
6	Male	Game Developer/Pact Publishing Learning Construct Author	35
7	Male	Game Developer/Game Designer	23
8	Male	Game Developer/Happy Teeth Creator	24
9	Male	National Indie Game Judge	33



a) b)

Figure 1. Screenshots of executive function games: a) inhibitory control game (Whack-a-Mole); b) cognitive flexibility game (Feeding Wild), c) working memory game (Trap Cave) and d) kairos

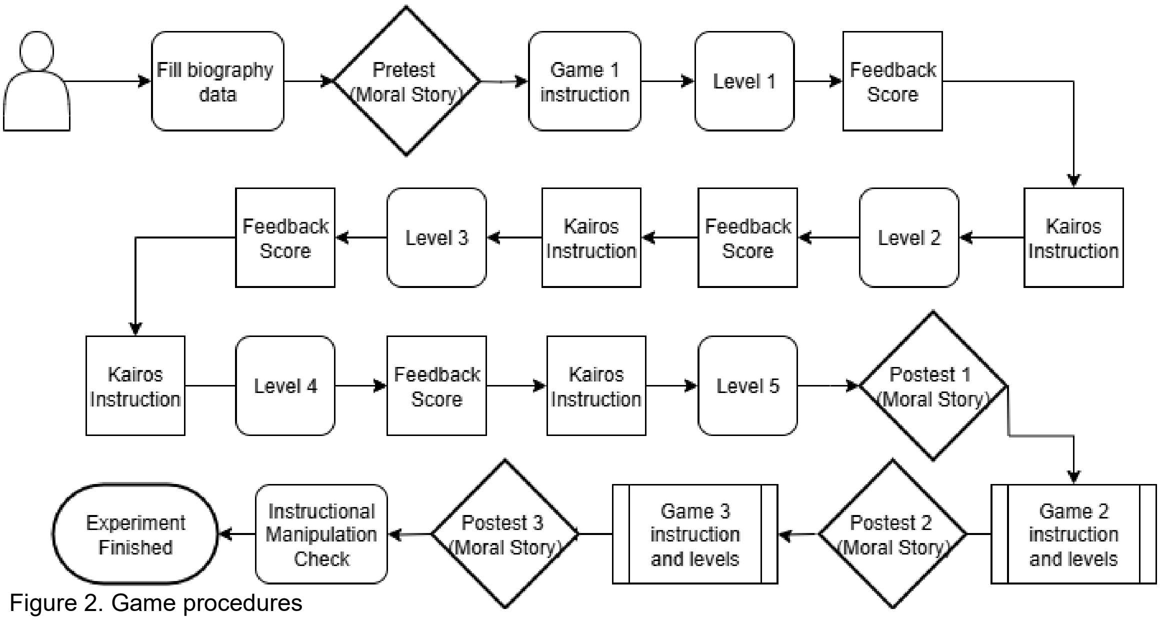


Figure 2. Game procedures

3.3 Participants

The participants in this experiment were law students. The researchers, along with three assistants, recruited participants through social media and by visiting every classroom. Of the 75 participants who responded to the data collection flyer, only 61 were eligible to participate. The control group consisted of 31 participants (men = 17, women = 14), while the experimental group comprised 30 participants (men = 14, women = 16). The experiment was conducted at the Mind, Brain and Behavior Lab, Faculty of Psychology, Universitas Gadjah Mada. Each participant was paid \$3.8 and given merchandises after finishing the experiment. Exclusion criteria were participants who played sadistic and gore games, slept less than 8 hours per day and had physical impairment (auditory and visual).

3.4 Experimental design and procedure

The study design was a factorial mixed-design. Ethical approval was obtained under letter No. 11820/UN1/FPSi.1.3/SD/PT.01.04/2023. The researchers were assisted by three research assistants during the preparation and data collection phases.

The control group received the approximate number system (ANS) as a placebo stimulation (see Figure 4). ANS, derived from the general number theory, refers to the human ability to process magnitudes across various dimensions (e.g., size, frequency and volume) [40]. It is commonly used to assess mathematical intuition in children. In this study, ANS was categorized into three levels: ANS 1 (ratio of 10-40 dots), ANS 2 (ratio of 40-70 dots), and ANS 3 (ratio of 70-100 dots). The ANS stimuli were designed using Canva. The games were counterbalanced to prevent order effect. The results of ANS are not shown here due to limitations in article length.

After arriving, participants were immediately seated at their assigned computers by the assistants. The assistants then instructed them to read the experiment guidelines. Once ready, participants began playing the game, after which all subsequent steps were guided through the computer (see Figure 2). The experiment took approximately 20–30 minutes to complete.

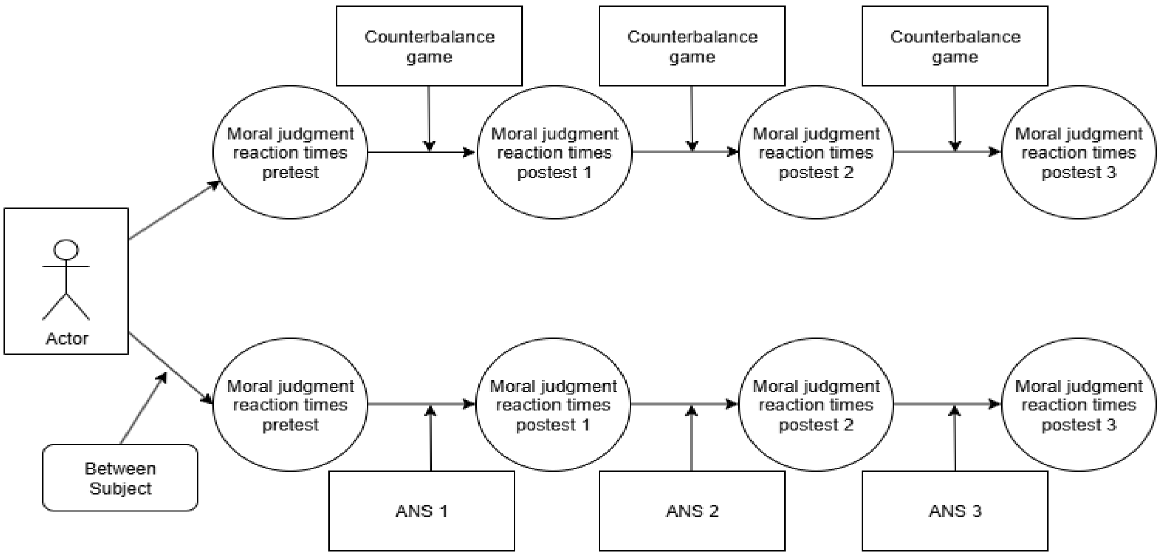


Figure 3. Experiment procedures

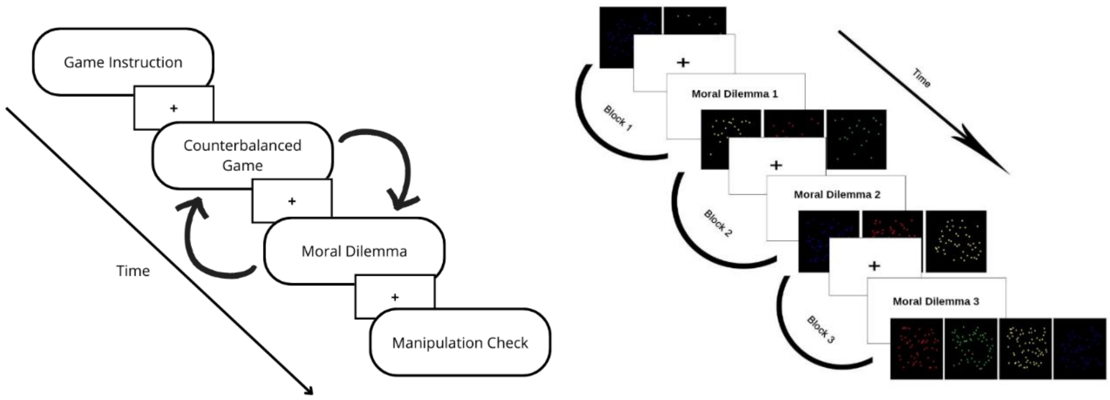


Figure 4. Timeline of game, ANS and moral dilemma

3.5 Statistical analyses

Data analysis was conducted using a mixed-model ANOVA with the `lme4` package [59]. Group factors (experimental vs. control), gender (male vs. female) were between-subject variables. Additionally, game stimulation (Whack-a-Mole vs. Feeding Wild vs. Trap Cave) and ANS placebo stimulation (ANS 1 vs. ANS 2 vs. ANS 3) were treated as within-subject variables, forming a 2×2×3 factorial design.

Table 2. Experiment design

Group	Pretest	Stimulation	Posttest1	Stimulation	Posttest2	Stimulation	Posttest3	Manipulation check
E	O0	X1E	O1	X2E	O2	X3E	O3	OX
C	O0	X1K	O1	X2K	O2	X3K	O3	OX

*E:experiment group, C:control group, X1E, X2E and X3E: counterbalance executive function game, X1K, X2K and X3K :staircase ANS.

4. Result

4.1 Mixed ANOVA for groups, gender and condition

Before participating in the experiment, participants were required to complete the digital version of the Self-Assessment Manikin (SAM) to assess their emotional state, ensuring better control over the study design. The Wilcoxon test indicated no significant differences in emotional arousal (group: p = .23, gender: p = .87), emotional valence (group: p = .63, gender: p = 0.44), or emotional dominance (group: p = .38, gender: p = .47) across groups and genders. Reaction time data were transformed into a log-normal distribution. The goodness of fit was assessed using the Anderson-Darling likelihood ratio test, yielding a good critical value of .68 (AD test = .5; p = .10).

From analysis, there was no significant differences in reaction times of moral decisions between the experimental and control group (F(1,57) = .79; p = .78). Likewise, no gender differences were observed (F(1,57) = 1.36; p = .19). However, a significant effect of the stimulation on the reaction times of moral decision was found (F(7,169) = 13.17; p = .01). The interaction between group and gender was not significant (F(1,57) = .27; p = .60). In contrast, a significant interaction between gender and the stimulation (game and ANS) was observed (F(1,169 = 4.33; p = .01).

Pairwise comparisons showed that in the Whack-a-Mole game, moral decisions were made 0.48 seconds faster than in the pretest condition (Z = -4.45; p = .01). Moral decisions in the Feeding Wild game were 0.76 seconds slower than in the Whack-a-Mole game (Z = 6.49; p = .001). Additionally, the Trap Cave game facilitated moral decisions; participants made decisions 0.45 seconds faster than in the Feeding Wild game (Z = -4.12; p = .01).

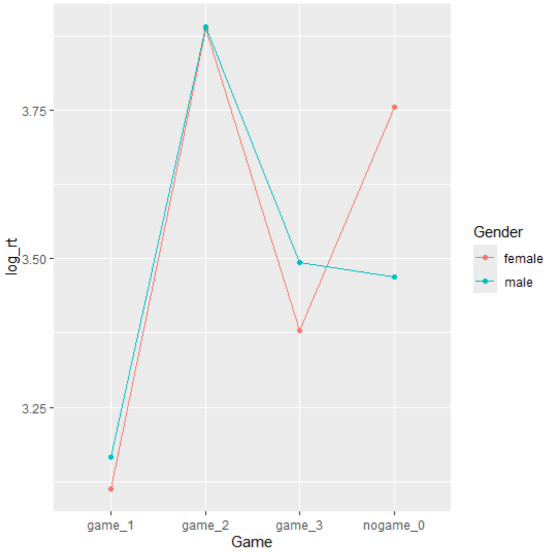
The interaction between gender and game stimulation showed that, among women, moral decision-making in the pretest condition was 0.64 seconds slower than in the Whack-a-Mole game (Z = 4.04; p = .01) (see Table 2). Additionally, women in the Whack-a-Mole game made moral decisions 0.79 seconds faster than in the Feeding Wild game (Z = -5.30; p = .001). The reaction time for moral decisions among women in the Trap Cave game was 0.52 seconds faster than in the Feeding Wild game (Z = -3.47; p = .001).

Among male participants, a difference in moral decision speed was also observed, with decisions in the Feeding Wild game being 0.72 seconds slower than in the Whack-a-Mole game (Z = 4.65; p = .001). Across genders, a significant difference in reaction times was found: women in the Whack-a-Mole game made moral decisions 0.77 seconds faster than men in the Feeding Wild game (Z = -3.69; p = .001).

The ANOVA model was also evaluated using the AIC index. Modeling ANOVA mixed models is essential to ensure that the data is correctly interpreted, leading to an appropriate analysis. This approach also helps researchers explain the observed results. The AIC value for Model 1, which includes groups and gender, is 2,183, while Model 2, incorporating the AIC stimulation, drops to 2,140—a difference of more than 40 (>10).

Table 3. Interaction between gender and game

No.	Gender*Game	estimate	z-value	p-value
1	female*game whack a mole - female*game feeding wild	-.79	-5.30	<.01
2	female*nogame - female* game whack a mole	.64	4.04	.011
3	female*game trap cave – female*game feeding wild	-.52	-3.47	.045
4	male*game feeding wild – male*game whack a mole	.72	4.65	.001
5	female*game whack a mole – male*game feeding wild	-.77	-3.69	.031



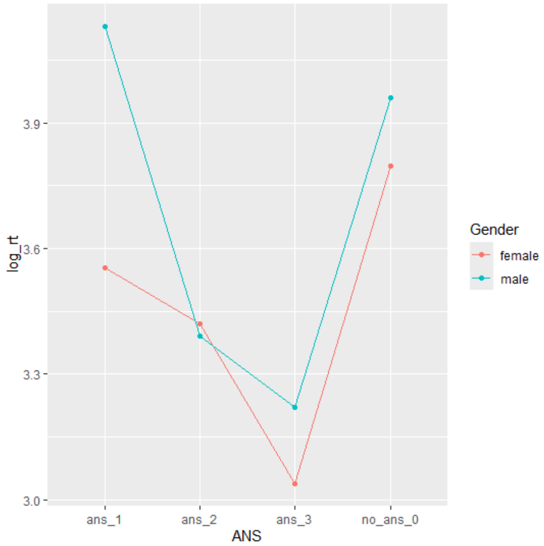


Figure 4. Experiment and control interaction plot

4.2 Linear mixed model in decision type

A linear mixed model was used to analyze decision type (utilitarian vs deontology), due to the presence of nested cells in the deontological decision of the women's group. These decisions of deontology choice were selected only once, resulting in no variance and causing rank deficiency error. We use ezDesign from `ez` packages to examine this pattern [60].

Table 4. Reaction time data

Factor		Mean (sec)	sd (sec)
Game	NoGame	52.48	32.63
	Game 1	27.19	19.94
	Game 2	57.07	28.08
	Game 3	34.81	18.69
ANS	NoANS	54.56	23.30
	ANS 1	54.21	23.49
	ANS 2	31.94	11.71
	ANS 3	24.26	7.95
Gender	Male	44.54	27.65
	Female	38.95	22.03
Group	Experiment	42.35	27.87
	Control	41.25	22.30
Type	Deontology	54.31	25.81
	Utilitarian	33.82	21.22

Table 5. Reaction times missing data in experiment group

No	Groups	Gender	Type	Stimulation/Condition	Var (sec)	Mean (sec)
1	Experiment	Male	Deontology	NoGame	1132.53	65.95
2	Experiment	Female	Deontology	NoGame	700.61	61.35
3	Experiment	Female	Deontology	Game 1	NA	35.34
4	Experiment	Male	Deontology	Game 2	699.23	71.44
5	Experiment	Female	Deontology	Game 2	375.97	51.05
6	Experiment	Male	Deontology	Game 3	34.24	39.70
7	Experiment	Female	Deontology	Game 3	53.05	28.02
8	Experiment	Male	Utilitarian	NoGame	584.03	23.65
9	Experiment	Female	Utilitarian	NoGame	1083.81	43.66
10	Experiment	Male	Utilitarian	Game 1	499.93	28.41
11	Experiment	Female	Utilitarian	Game 1	350.51	25.51
12	Experiment	Male	Utilitarian	Game 2	1843.87	45.09
13	Experiment	Female	Utilitarian	Game 2	791.76	56.44
14	Experiment	Male	Utilitarian	Game 3	797.30	38.01
15	Experiment	Female	Utilitarian	Game 3	206.23	32.74

A generalized linear mixed model was applied, first setting contrasts using effect parameterization. A dummy contrast was set with the cognitive flexibility game, male participants, and deontological as the baseline mean (intercept). Since the reaction times in the inhibitory control game, female participant and deontology judgment showed no variance, it was excluded from analysis (see Table 5). Although not formally analyzed, an interesting finding emerged across all stories, when participants received the inhibitory control game stimulation, deontological choices were difficult to make.

Table 6. GLM results in decision type, gender and game stimulation

	estimate	t-value	p-value
Intercept	1.39	22.92	.001*
Utilitarian	-.17	-2.31	.01*
Female	-.05	-.65	.51
Game 3	-.18	-2.50	.01*
Nogame	-.03	-.58	.56
Utilitarian:Game 3	.21	2.20	.03*
Utilitarian:Female	-.24	-2.31	.02*
Utilitarian:Nogame	-.22	-2.12	.03
Female:Game 3	.09	.93	.32
Female:Nogame	.03	.46	.64
Utilitarian:Female:Game 3	-.32	-2.17	.03*
Utilitarian:Female:Nogame	.09	.66	.49

*game 3 = serious game working memory; nogame = pretest/no serious game

Utilitarian decisions were made 0.17 seconds faster than deontological decisions among men in cognitive flexibility serious game stimulation (t = -2.31; p = .001). Additionally, deontology decisions were 0.18 seconds faster in men, during the working memory serious game stimulation compared to the cognitive flexibility serious game (-2.50; p = .001). Furthermore, the difference in reaction times between utilitarian and deontological decisions was 0.21 seconds longer in the working memory game than the cognitive flexibility game among male participants (t = 2.2; p = .03).

Meanwhile, female participants made utilitarian decisions 0.24 seconds faster during the cognitive flexibility game compared to deontological decisions in men (t =-2.31; p = .02). Finally, utilitarian decisions in women during the working memory game stimulation came out 0.32 seconds faster than deontological decisions in men in the cognitive flexibility game (t = -2.16; p = .03).

4.3 Independent analysis on decision types and serious games

Independence analysis was conducted on the categorical variables of moral decision types and serious games to determine the frequency of decision type (utilitarian vs deontological) within each serious game stimulation. The analysis was performed using the `ggstatsplot` package [61]. The result showed that 44% of deontological decisions occurred during the cognitive flexibility game stimulation (only 2% occurred in the inhibitory control game) (see Figure 6). Conversely, utilitarian decisions dominated in the inhibitory control game (39%, as opposed to only 13% in the cognitive flexibility game). The working memory game exhibited a nearly equal distribution of decision types. The analysis yielded a chi-square value of X-squared = 30.54; p-value = .001, indicating a significant relationship between moral decision type and serious game.

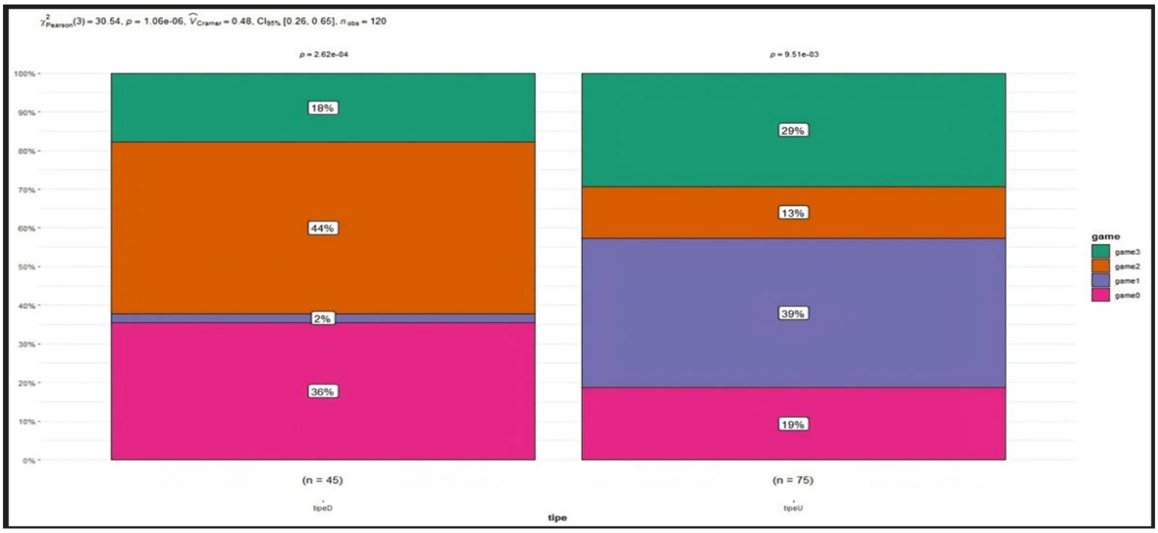


Figure 6. Independent analysis on decision types and serious games

4.4 Reaction times, length of text and decision type

This analysis examined the correlation between reaction times and story length in relation to decisions. A generalized linear model with a binomial distribution was applied, but did not obtain a significant result (see Table 7). The finding indicated no correlation between time spent and the text length on decision types. This strengthens the conclusion that deontological and utilitarian decisions are not influenced by text length or time taken to respond.

Table 7. Reaction times, length and type

	estimate	SE	z-value	p-value
Intercept	3.729	5.308	0.753	0.452
reaction times (rt)	-0.062	0.07	-1.000	0.318
length (text)	-0.007	0.031	-0.256	0.798

5. Discussion

5.1 Moral decision across group, gender and game

5.1.1 Main effect between groups and gender s

Within groups, the specific data patterns in each stimulation were encompassed in a broader data trend. The uniqueness of each stimulation data was masked by the overall group pattern. This was shown by a sum of squares value that appears nearly identical at a general level but revealed significant differences when analyzed at the stimulation level. A similar effect was observed in gender comparisons. This finding could serve as a key reference in experimental studies, emphasizing the importance of proper data interpretation and processing. Regarding gender, Fumagalli et al. [62], reported similar findings. Scheer et al., [63], examined reaction time differences between men and women across a series of tasks. The differences in reaction times were observed at the neuropsychological level, but not at the behavioral level. This underlines the necessity of incorporating a neuropsychological or biomarker approach (e.g., neuroanatomical dissimilarities) in gender-related studies, as relying solely on behavioral data may be insufficient.

5.1.2 Main effects within game stimulations

There are three main effects within thesubject game stimulation: 1) The inhibitory control game influences the acceleration of moral decisions compared to pretest conditions. Consistent with this finding, Xu et al [64], reported that inhibitory control training, speeds up risky decision-making compared to baseline. Similarly, Biggs and Pettijohn [65], found that improvements in inhibitory control are highly beneficial in determining reaction speed for shoot/no-shoot decisions in military contexts.

2) The reaction times of moral decision-making in inhibitory control games are faster than in cognitive flexibility games. The mechanism of inhibitory control emphasizes selective attention and efficiency, requiring a clear separation between responses to disturbances and goal-oriented actions. In contrast, cognitive flexibility is less time-sensitive when it comes to goal achievement, focusing more on exploring new perspectives and alternative thinking. Among the three, cognitive flexibility games have the strongest influence on regulating decision-making speed. In the context of moral decisions, this phenomenon is referred to by some researchers as moral flexibility [66] or moral chameleon [67]. Moral flexibility is defined as a cognitive effort to either break or adhere to rules depending on perceived benefits. It allows individuals to adjust and manipulate their moral compass, making decisions more justifiable in different situations. McHugh et al [68], explored the phenomenon of moral dumbfounding phenomenon and found that individuals who show dumbfounded responses tend to take longer to decide, display uncertain facial expressions, and struggle to articulate a clear rationale. In cases of moral dumbfounding, individuals may have underlying reasons for their choices, but due to the complex interplay of moral flexibility, they find it difficult to justify their decisions.

This finding can be explained through the phenomenon known as the control dilemma. Control dilemma is a condition in which dimensions of executive function are in conflict, resulting in a dilemma when making decisions. Strong inhibitory control makes the decision-making process fast and lessens distractions, whereas strong cognitive flexibility requires decisions to be considered from multiple perspectives [69].

3) The reaction times for moral decisions under the influence of working memory games are significantly different from cognitive flexibility games. This finding aligns with research by Nweze and Nwani [70] who found that cognitive flexibility tasks—specifically switch costs—are negatively correlated with inhibitory control, while mixing costs are correlated with working memory. Mixing costs, also known as global shifting costs (shifts between task levels), and switch costs, or local shifting costs (shifts between trials) [71], play a crucial role in cognitive processing. Mixing costs reflect sustained cognitive processes, indicating how much information is retained in working memory [72]. Through mixing costs, working memory capacity can suppress cognitive flexibility in problem-solving and moral decision-making, which explains why moral decisions are made faster under the stimulation of working memory games. This aligns with findings from Van Stockum and DeCaro [69]. Conversely, through switch trials, cognitive flexibility can reduce the impact of mixing costs from working memory, leading to faster responses. The far transfer effect of serious game-based executive function training has been shown to influence reaction speed. In line with Sala et al. [73], far transfer in executive function training can enhance reaction speed, reasoning, and, on a broader scale, language proficiency.

5.1.3 Interaction effect between gender and game

The inhibitory control and the cognitive flexibility games exhibited strong yet opposite effects across male, female, and mixed-gender groups. Despite these differences, all three cases point to the same conclusion: reaction times in moral decision-making are faster under the influence of the Whack-a-Mole game than the Feeding Wild game. This finding aligns with the concept of the control dilemma in executive function. A control dilemma arises when individuals must choose the appropriate strategy to respond to a stimulus, determining which cognitive resource to prioritize—such as updating, controlling, and adaptability versus stability and goal orientation [74]. This concept suggests that the mechanisms of working memory and cognitive flexibility run parallel, making their effects on moral decision-making speed difficult to distinguish (necessitating a biomarker or neuropsychological approach). However, a clear distinction exists between inhibitory control and cognitive flexibility. In inhibitory control, moral decisions must align with efficiency and the suppression of distractions (combat the distraction), whereas cognitive flexibility emphasizes explorations of new possibilities and adaptations to dynamic situations. This stark contrast makes differentiation relatively straightforward when comparing behavioral patterns. However, a more detailed analysis is not possible, as deontological decision-making in the inhibitory control game was excluded from the analysis.

In table 2, the Trap Cave and Feeding Wild game stimulations showed significant influences, but only in women. It can be seen from the interaction plot that the decision-making speed scores in both games are quite far apart, but not strong enough to settle the differences across genders. It might be caused by the small sample size, because the analysis was stopped before the saturation of the data pattern. It is possible that if the sample was enlarged, the difference in reaction speed in the Whack-a-Mole and Feeding Wild game stimulations in men could be significant. This is also an important finding; that for the male population, assessment of executive function stimulation impacts requires a larger sample size than in women.

In terms of genre, the female group showed a greater interest in executive function serious games featuring the puzzle and point-and-click genres than men. However, despite their lower preference for this genre, the male participants still engaged seriously throughout the experiment. This was likely due to the controlled experimental design in the lab. This finding aligns with research from Hassan et al. [75] and Phan et al. [76].

In addition, heuristic decisions that characterized as extremily fast decisions (results of mental shorcuts, ignoring part of the information) can be suppressed using game stimulation. Excessively fast reaction times decisions (indicate as heuristic decisions) were not found in this study. To create a standard heuristic decisions we used a cut-off formula. The cut-off was carried out using `trimr` packages from Jim Grange [77]. Lower threshold for decision making time is 2,000 ms (2 second) and upper limit of 2.5 SD (90 second). None of the lower threshold were below 2 seconds, however there were seven reaction time records exceeding 90 seconds, ranging from 100 to 120 second.

5.2 Moral decision types across gender and game

Difficulty in making deontological decisions in Whack-a-Mole game might be the most interesting finding of this research (see Figure 4). According to sequence model theory [78], intuition emerges first (Stage 1), supporting deontological decisions. It is followed by cognitive processing (Stage 2), where reasoning-based corrections and choices take place [79]. The cognitive flexibility game further advances this process to the next stage (Stage 3), where individuals, after engaging in cognitive flexibility tasks, reconsider their previous deliberative decisions and opt for a deontological choice. However, at this stage, the decision is no longer purely based on intuition or norms, as described in dual-process model, leading to a longer decision-making time. This finding has two key implication; in both men and women, the Feeding Wild game shifts moral decisions toward deontology, whereas the Whack-a-Mole game increases the frequency of utilitarian decisions (which explains why utilitariansm requires less time). The stronger the influence of cognitive control, the greater the tendency to make beneficial sacrifices. Strong cognitive control suppresses emotional and intuitive responses, treating these features as distractions that do not align with the intended goal.

Second, in the first point, participants had to choose between the two options. Therefore, we believe that deontological choices in Stage 3 have two possible meanings: either participants genuinely chose deontology due to the dominance of executive function, or they had no other choice. To address this, further developments are needed—not in the narrative aspect but in response options. Alternative choices, e.g., virtue ethics and contractualism, could provide deeper insights into the effects of stimulation on executive function in moral decision-making.

In Table 3, utilitarian decisions are not always faster to make compared deontological decisions. Contrary to the previous explanation, the reaction times of utilitarian and deontological decisions depends significantly on gender. For men, utilitarian decisions are faster to make than deontological ones under the Feeding Wild game stimulation. However, under the working memory game stimulation, it takes longer to make utilitarian decisions than deontological ones. In contrast, for women, utilitarian decisions remain consistently faster than deontological ones under both the Feeding Wild and Trap Cave game stimulations. Overall, women tend to make utilitarian decisions more quickly than deontological ones, regardless of the stimulation.

5.3 Limitations and artifact

The deontological decision data could not be analyzed because some participants did not choose deontological options during the Whack-a-Mole game. This finding is both a strength and a limitation of the study. On one hand, it provides new insight into how the Whack-a-Mole game makes deontological decisions more difficult. On the other hand, it presents a drawback, as the absence of data prevents proper analysis.

Additionally, the small sample size lacks sufficient statistical power. The data was also not saturated, meaning it did not fully capture for comprehensive analysis. Since the game was conducted entirely using web, data accuracy was vulnerable to connection disruptions, which could affect reliability.

This study did not incorporate reflection time for the participants' responses. This stage is crucial for a better understanding of how each person interprets the moral story. Reflection serves the same purposes as kairos, a deliberate pause to process and analyze experiences to deepen understanding and improve future action.

Several potential artifacts may arise in experiment study [80]. First, some participants might have prior experience with similar mobile games. Such familiarity with point-and-click mechanics could influence the experiment results, and we did not establish exclusion criteria for this artifact. Second, participants in a laboratory setting may behave differently due to the Hawthorne effect than those in a fully online condition. To address this, we plan to compare the two designs in future research. Third, although the computers had identical specifications, the mouse settings varied. Ideally, for gaming purposes, a mouse operates at around 400 – 800 DPI, whereas a standard mouse for daily tasks (typing, browsing, etc) typically operates at around 800 – 1,600 DPI. This difference in mouse setting could potentially introduce an artifact that led to biases.

5.4 Future research

Future researchers should explore a new approach: integrating moral storytelling into games. Titles like Trolley Problem, Inc., developed by Yogscast Games, can serve as a reference in this regard. Moral narratives are increasingly being incorporated into games, making them more engaging and interactive. A visually appealing design and tactile interaction can enhance user experience and provide fresh variations in gameplay.

Regarding moral standards, Friedrich Nietzsche argued that morality follows specific principles. Interestingly, identity standards in the story appear to have no impact on decision-making speed, suggesting that researchers might instead consider the influence of beauty standards.

6. Conclusions

This study investigated whether inhibitory control, cognitive flexibility, and working memory games affect the response time of moral decisions in men and women. The findings showed that the inhibitory control game had the strongest effect, producing the fastest moral decisions, while the cognitive flexibility game resulted in the slowest moral decision-making. The interaction between gender and game stimulation also reinforced these results: women made faster moral decisions in the inhibitory control game condition than men in the cognitive flexibility game condition. In fact, women in the inhibitory control game condition remained faster than those in the cognitive flexibility game. These results differ from previous studies, likely because in this experiment, the sequence of stimulus-response tasks in the game and the moral scenarios were arranged in a continuous timeline without pauses, allowing the effects to be observed more directly.

Additionally, men and women responded differently to each stimulation. Men tended to prefer activities that relied on intuition (ANS). In contrast, women favored cognitively demanding activities, as they predominantly rely on intuition and feeling. Since each group perceived the unfamiliar aspects of the stimulation as novel, their interests differed accordingly.

Acknowledgments

We would like to express our sincere gratitude to all scientists who gave their valuable feedback and discussion on this study.

We are also deeply grateful to all the participants who generously dedicated their time and efforts to completing this study.

Conflicts of interest

The authors announce there are no conflicts of interest related to the research, writing, or publishing of this article.

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