Effects of Expectation and Speed on Moral Decision-Making

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Effects of Expectation and Speed on Moral Decision-Making

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ABSTRACT

Moral decision-making is one of the most fundamental and ubiquitous forms of decision-making in human society. The current thesis aims to investigate the role of expectation and speed in the cognitive mechanisms underlying moral decision-making.

Previous research has indicated that predictive cues enhance preference and reduce response time for congruent targets during bivalent food evaluation, suggesting a confirmation bias. However, the influence of prior processing on subjective moral evaluation remains less explored.

To explore the expectation effects, we used three different types of predictive cues to elicit directional versus non-predictive prior processing and then asked the participants to perform moral evaluations on a continuous scale from -10 ("very immoral") to +10 ("very moral") with a diverse set of real-world images. Our experimental image database balanced the morality of image content and the volatility of the ratings based on the means and standard deviations in a preliminary study. Ratings, response times, and gaze positions were measured to examine the effects of predictive cues on the moral evaluation of real-world images.

We found that the moral ratings were in line with the expectations induced by the cues. Compared to the non-predictive condition, the moral evaluation in the directional conditions was more polarized. For neutral images, the predictive cues tilted the evaluations to positive versus negative, indicating a decisive liminal influence. High-volatility images were impacted more than low-volatility images in ratings as well as response times. Furthermore, the gaze positions during the interval between the predictive

cue and the image showed a spatial displacement in line with the cue instruction, indicating a response bias.

Speed is one of the crucial components in decision-making, and the speed-accuracy tradeoff establishes a causal link between urgency and reduced accuracy in human perceptual decision-making. Nevertheless, in subjective decision-making without emphasizing accuracy, less is known about how speed specifically relates to the subjective evaluation of visual images.

The second study conducted a set of four experiments to tease apart two alternative hypotheses for the relation between speed and subjective moral evaluation, then explore whether appropriate when extended to other subjective decision-making, for instance, preference evaluation. The hypothesis of the "Speed-Polarization Tradeoff" implies that urgency causes more polarized evaluations. In contrast, the "Ease-of-Processing" hypothesis suggests that any association between speed and polarization is due to the salience of evaluation-relevant image content. The more salient the content, the easier to process, and therefore the faster and more extreme the evaluation. In each experiment, we asked participants to evaluate images on a continuous scale from -10 to +10 and measured their response times; in Experiments 1-3, the participants rated real-world images in terms of morality (from "very immoral," -10, to "very moral," +10); in Experiment 4, the participants rated food images in terms of appetitiveness (from "very disgusting," -10, to "very attractive," +10). In Experiments 1, 3, and 4, we used a cueing procedure to inform the participants on a trial-by-trial basis whether they could make a Self-Paced (SP) evaluation or whether they had to perform a Time-Limited (TL) evaluation within 2 seconds. In Experiment 2, we asked participants to rate the easiness of their SP moral evaluations.

The results showed that compared to the SP conditions, the responses in the TL condition were consistently much faster, indicating that our urgency manipulation was successful. However, comparing the SP versus TL conditions, we found no significant differences in any of the evaluations. Yet, the reported ease of processing of moral evaluation covaried strongly with both the response speed and the polarization of evaluation. The overall pattern of data indicated that, while speed is associated with polarization, urgency does not cause participants to make more extreme evaluations. Instead, the association between speed and polarization reflects the ease of processing. Images that are easy to evaluate evoke faster and more extreme scores than images for which the interpretation is uncertain.

Taken together, the study proved that predictive cues elicit a liminal confirmation bias in moral image evaluation, much in the same way as in bivalent food evaluation; and response speed is associated with, but does not cause, polarization in the moral evaluation of real-world images and in the judgment of food preference, but suggested a critical role for the ease of processing.

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Chapter 1: General Introduction

Expectation in cognition refers to the mental anticipation or prediction of events, outcomes, or stimuli based on previous experiences, knowledge, and contextual cues. It plays a crucial role in shaping perception, attention, memory, and decision-making processes. When it comes to decision-making, people tend to favor information that confirms their preexisting expectations or beliefs, leading to biased judgments and decisions, which we call confirmation bias.

Response speed is also a crucial concept underlying research decision-making for understanding how cognition systems evolve over time and for predicting future states based on past and present behaviors. With respect to expectation, our brain efficiently processes information by providing a framework or set of assumptions about what is likely to happen, and this will be confirmed or reshaped with time process, thus influencing how we interpret and respond to the world around us.

Moral decision-making is one of the most fundamental and ubiquitous forms of decision-making in human society. As one of subjective decision-making, it involves a complex system with parallel and interactive streams of affective processing, including fast, intuitive emotional reactions and slow, controlled evaluations based on reasoning (Malle, 2021; Cameron et al., 2017; Garrigan, Adlam, & Langdon, 2016; Sokol-Hessner et al., 2012; Dane & Pratt, 2007).

Regarding predictive information and fast or slow reactions, previous studies in our laboratory have revealed that participants rated faster for relatively positive or negative food images (Wolf et al., 2018, 2019), and the congruence bias could nudge the evaluation to be faster and more extreme for food images (Ounjai et al., 2018). And the subsequent analyses (Ounjai et al., 2020) indicated that faced with images that did not elicit stable population ratings, the participants tended to rely more on the predictive cues than when faced with images that tended to elicit stable, more extreme ratings (e.g., foods that were clearly appetitive, and liked by almost everyone). Will these findings also manipulate moral decision-making, which is how expectation works in moral decisions, and does the fast response lead to extreme moral or immoral evaluation? The current thesis aims to investigate the role of expectation and decision speed in the cognitive mechanisms underlying moral decision-making.

Bailey and Muldrow (2018) found that direct visual cues with health claims enhanced perceptions of health, taste, and credibility, even for objectively unhealthy foods. Another research has shown that confirmation bias is most prevalent in information search and occurs only for more polarizing topics during information interpretation (Vedejová & Čavojová, 2022). Thus, by this view, confirmation bias should be more significant in those instances of moral decision-making that contain consistent polar contents and could easily motivate emotion. In the case of highly ambiguous evaluative content, people need to mobilize more cognitive resources toward making decisions. By this view, people would be more likely to make decisions that conform to confirmation biases by following predictive cues rather than spending cognitive effort to counteract biases when making difficult decisions.

Thus, in Chapter 2, we continue the line of previous research by investigating the influences of predictive cues in a structurally very similar experimental paradigm, with a very different type of evaluative processing, in the domain of moral decision-making. We aimed to investigate whether a confirmation bias would occur even in an evaluative domain less obviously connected to dopaminergic reward signals, and if so, whether the confirmation bias would operate particularly as a liminal influence, nudging the participant's evaluation under uncertainty or volatility.

An inverse relationship exists between the speed and accuracy of responses in objective decision-making tasks. Similarly, in subjective decision-making, with more time, decision-makers would show higher consistency in their responses. We may have our idiosyncratic preferences, but there should be a system in our proverbial madness. Our tastes would not be random, and even preference reversal would follow some kind of internal logic (Sénémeaud et al., 2013; Lichtenstein & Slovic, 2006; Camerer & Weber, 1992). This logic should give reproducible answers.

One possible argument is that the extra time for information processing should give decision-makers the opportunity to form more precise and more stable object representations of the items under consideration (Curley et al., 2017; Wilson & Schooler, 1991). This would lead to less variability in the evaluation (i.e., a narrower response distribution, with a more minor standard deviation) but not necessarily a change in the mean of the evaluations (i.e., with or without a lateral shift of the response distribution). Therefore, in terms of sequential-sampling models of decision-making, information salience and the clarity of evidence would enable fast processing for extreme evaluations (Quandt et al., 2022; Polanía et al., 2019).

In contrast, speeded responses might be fundamentally different from slow responses – more intuitive, more emotionally charged. Put differently, subjective decision-making might involve a shift in the nature of the underlying evaluation mechanisms as a function of the amount of time available for processing (Kruglanski & Gigerenzer, 2018; Wittmann & Paulus, 2008). This would imply an altered relation between speed and performance in subjective decision-making as compared to the speed-accuracy tradeoff in objective decision-making. Thereby resulting in an inclination towards riskier choices under elevated time pressures (Lin & Jia, 2023; Dror et al., 1999).

Critically, however, the previous studies were not designed to address the relation between speed and subjective evaluation, and thus offer no insights into the underlying mechanisms or conditions that determine any systematic relation unfolds over time.

In Chapter 3, we designed a set of four experiments focusing on the relation between speed and subjective evaluation via directly manipulating speed. We aimed to tease apart two alternative hypotheses. On the one hand, we raise a hypothesis of the "Speed-Polarization Tradeoff," proposing an active, causal link such that faster responses would lead to more extreme evaluations. On the other hand, we propose an alternative hypothesis of "Ease of Processing," suggesting that the salience of evaluation-relevant content influences speed and polarization rather than a direct causal link between them.

The last chapter discussed the findings and implication regarding the effects of expectation and speed on moral decision-making. It also addressed the limitations inherent in the experimental design, paradigm settings, and measurement methods, and proposed directions for future research.

Chapter 2: Predictive Cues Elicit a Liminal Confirmation Bias in the Moral Evaluation of Real-World Images

1 Introduction

Confirmation bias is a well-established phenomenon in the field of psychology, referring to the tendency for individuals to look for the presence of what they expect, or to favor information that supports their existing beliefs or opinions, while disregarding information that contradicts them (Klayman, 1995; Oswald & Grosjean, 2004). It has been demonstrated in various domains and discussed widely on its utility and disutility (Nickerson, 1998). For instance, confirmation biases in political beliefs can lead to attitude polarization, which can hinder the development of rational behavior in a democracy (Taber & Lodge, 2006); as well as in economics (Bisière, 2015; Charness & Dave, 2017; Koriat et al., 2006), science (Kahan et al., 2011), and medicine (Kassin et al., 2013; Mendel et al., 2011). Moreover, Rajsic et al. (2015, 2018) conducted a series of experiments that proved people's pre-existing beliefs can influence their perception and decision-making in visual search tasks.

With respect to subjective evaluation, previous research in our laboratory (Ounjai et al., 2018) showed that bivalent predictive cues have a significant impact on preference ratings for food images. Correct predictions of appetitive or aversive food images produced quick and amplified evaluation scores, while erroneous predictions elicited slower and less extreme evaluation scores. The data from gaze positioning further suggested that the predictive cues produced anticipatory biases in the cued evaluation direction. The entire pattern of data suggested the operation of an active confirmation bias. In the follow-up study (Ounjai et al., 2020) we found that the predictive cues were most influential for food images that overall had relatively moderate rating scores. This finding suggested that the confirmation bias has a specific liminal influence, allowing the evaluation to be nudged in a positive or negative direction, particularly for stimuli near the boundary of neutrality. Here, we aim to further investigate this "liminal confirmation bias," defined as a confirmation bias that operates specifically near the boundary of neutrality in a bivalent evaluation system.

In the present study, we opted to investigate the construct of liminal confirmation bias with a completely different type of human judgment, namely moral evaluation. In doing so, we envisaged a conceptual replication that would not only increase our understanding of confirmatory mechanisms in human judgment, but also make an explicit connection to the study of moral cognition (see Levari et al., 2018, for a similar approach to studying core mechanisms of human judgment).

It should be noted that the study of moral cognition is highly complex with the separable dimensions of decision-making, judgment, and inference (Yu et al., 2019; Ponsi et al., 2021). Here, we focus on moral judgment as the process of evaluating events or behaviors that have a moral component. Moral judgment involves considering personal values, ethical principles, emotional associations, and societal norms (Forsyth, 1980; Turiel, 1983; Bechara, 2004; Greene & Haidt, 2002; Lee & Gino, 2015; Jung et al., 2016).

While some moral evaluations are straightforward, eliciting strong and unambiguous responses (Haidt, 2001), others are difficult to judge, leading to hesitation and multiple viewpoints as seen in the case of dilemmas (Greene et al., 2001; Rom & Conway, 2018).

Confirmation bias may have a distinct impact depending on the type of processing for moral evaluation. One widely held theory suggests that confirmation bias is most pronounced in the case of deeply ingrained, ideological, or emotionally charged views (Nickerson, 1998; Vedejová & Čavojová, 2022). Other researchers argued that confirmation bias particularly takes effect on evaluations with respect to more ambiguous content. Klayman and Ha (1987) found that people tend to seek out information that confirms their initial beliefs when the hypotheses are more complex, contentious, or difficult to evaluate.

However, the extent to which confirmation bias influences moral evaluation remains largely unknown. This study aims to investigate how confirmation bias affects moral evaluations using bivalent predictive cues versus non-predictive cues. We hypothesize that, in line with our prior research on preference judgment using bivalent food images, predictive cues will elicit a congruent bias on moral evaluation such that the ratings align with the predictions. Here, the predictive cues were followed by congruent images in two-thirds of the trials (i.e., moral images after positive predictions; immoral images after negative predictions) or by neutral images in one-third of the trials. Non-predictive cues (in the shape of gray question marks) were followed equally likely by moral, immoral, or neutral images. We expected the ratings of the images to align with the predictions. For neutral images, we expected to observe a liminal confirmation bias such that the ratings would be tilted in the direction indicated by the predictive cues. The response times following predictive cues would be shorter than following non-predictive cues. The gaze positions during the interval between the predictive cue and the real-world image should show a spatial displacement in line with the prediction (i.e., positive predictive cues will lead to a gaze bias toward the positive side of the rating scale and vice versa).

To examine our hypotheses, we opted to use a well-established database of socio-moral images (SMID; Crone et al., 2018) to select a stimulus set that balanced the morality of image content and the volatility of the ratings based on the means and standard deviations in a preliminary study. In our within-subjects design, image type (moral, neutral, immoral), volatility (high-volatility, low-volatility), and predictive cue (directional, non-predictive) were explored as the main factors for confirmation bias in the moral evaluation of real-world images.

2 Methods

2. 1 Participants

A total of N = 30 individuals at Kyushu University (17 males and 13 females with a mean age of 20.83 years old, and a standard deviation of 2.93; 4 left-handed) participated in the study. All participants completed the entire experiment, and the eye tracker and biometric kit successfully captured their physiological responses. The participants had no previous experience in any similar experiment. No participant reported any vision or health issue, or past or present psychological disorder. All participants had normal or corrected-to-normal vision. The Human Ethics Committee of the Faculty of Arts and Science at Kyushu University approved the study. Participants were asked to give their informed consent in writing and fill out a pre-questionnaire prior to the experiment; the informed consent included a no-risk statement and rights protection. Each participant received 1000 yen per hour as monetary compensation for their participation.

2.2 Stimuli and Preliminary Study

To prepare the stimulus set for the present study, we proceeded in three steps. First, we preselected 620 images from SMID (see Figure 1). Then, using these images we conducted a rating experiment to create a bivalent evaluation system with a sample of 14 participants at Kyushu University. Finally, we selected a balanced stimulus set by combining the bivalent evaluation data with the data of standard deviations from SMID. The final distribution of moral content and volatility of the image set is shown in Figure 2. Based on the average pre-rating scores of the images, the three levels of morality were set, respectively, as “Moral” for a rating higher than 2, “Neutral” for a rating between -1 and 1, and “Immoral” for a rating lower than -2; also in this set, the number of high-volatility images (high standard deviation in SMID, SD > 1) equals the number of low-volatility images (low standard deviation in SMID, SD < 1) at the corresponding morality level.

2.2.1 Preselection of 620 images from SMID

Based on the original categorization in the moral domain of SMID, we used code to randomly preselect 620 images from the entire database in an effort to prepare balanced preparatory sets of high and low standard deviation images for each category of Moral, Neutral, and Immoral (see Figure 1). Using the mean moral rating in SMID, the stimulus set is divided into three levels of moral value: low (pink and red; moral mean < 2.5), middle (grey and yellow; moral mean between 2.5 and 3.5), and high (blue and green; moral mean > 3.5). Across the moral spectrum, the images elicited a wide range of variability in ratings, with some images eliciting nearly uniform judgments (with SDs well below 1), and others eliciting substantial variability (SDs of around 1.5). Since more than 98% of the images in SMID showed SDs ranging from 0.5 to 1.5, we used the average (SD = 1) to divide the stimulus set into two volatility categories, with "high volatility" (SD > 1) and "low volatility" (SD < 1). To balance the range of each morality and volatility category, we programmed code to select images that have a moral mean between 1.5 and 4.5 and an SD between 0.7 and 1.3. Specifically, we aimed for a balanced distribution of 30 stimuli in each of the 2 x 3 categories. Thus, red points represent immoral high volatility images; pink points represent immoral low volatility images; yellow points represent neutral high volatility images; gray points represent neutral low volatility images; green points represent moral high volatility images; and blue represents moral low volatility.

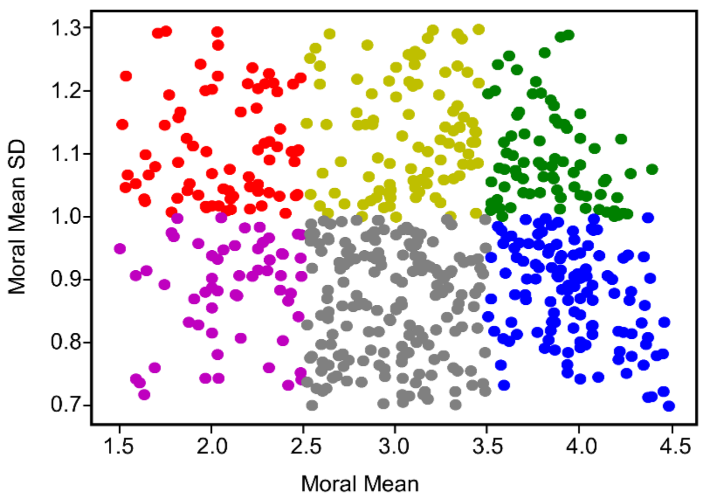

Figure 1. Scatterplot of Moral Mean against Moral Mean Standard Deviation (SD) of 620 images selected from SMID used for the preparatory rating experiment. The colorpoint clusters from up to down and left to right correspond to immoral high volatility images in red, immoral low volatility images in pink, neutral high volatility images in yellow, neutral low volatility images in grey, moral high volatility images in green, and moral low volatility images in blue.

2.2.2 Creating a bivalent evaluation system with a participant sample at Kyushu University

In order to translate the ratings of SMID (ranging from 0 to 5) into a bivalent system with positive and negative poles, as well as to confirm whether the moral categories from SMID were reproducible with a group of participants from a different cultural background as compared to the SMID sample, we conducted a preparatory rating experiment with N = 14 students at the Laboratory of Cognitive Neuroscience of Kyushu University (8 males and 6 females with a mean age of 25.14 years old, and a standard deviation of 3.83). The participants were asked to freely rate the preselected images from the SMID. The images were shown one by one, and the participants could bend the joystick to enter a rating frame; there was no time limitation for viewing or rating, but the participants could not return to the viewing frame once they had moved on to the rating frame. All images were adjusted keeping the original proportions to the same height at 810 pixels, equivalent to three-quarters of the screen (1920 × 1080 pixels), centering on the screen, with 96 dpi for horizontal and vertical resolution. Different from the rating rules of SMID, which ranged from 0-5, the images in our preliminary study were rated for bivalence with respect to moral content, from -10 (extremely immoral) to +10 (extremely moral). In this way, we obtained moral evaluations ranging from -10 to +10 for the 620 preselected SMID images using presentation conditions and working with a sample of participants similar to our main study.

2.2.3 Selecting a balanced stimulus set by combining the data

In the final step toward a balanced stimulus set, we used only images with good reproducibility (i.e., consistent categorization) across the SMID moral ratings and the ratings in our preliminary study. To make the final selections, for each image we used the moral ratings from our preliminary study and the corresponding SDs from the SMID. We randomly selected 180 real-world images by code, aiming for a balanced set with 60 moral images, 60 neutral images, and 60 immoral images. The final distribution of moral content and volatility of the image set is shown in Figure 2.

Based on the average pre-rating scores of the images, the three levels of Image Content were set, respectively, as "Moral" for a rating higher than 2, "Neutral" for a rating between -1 and 1, and "Immoral" for a rating lower than -2; also in this set, the number of high-volatility images (high standard deviation in SMID, SD > 1) equals the number of low-volatility images (low standard deviation in SMID, SD < 1) at the corresponding morality level. Table 1 presents the average moral ratings and SDs as obtained in our preliminary study for each category; the data confirmed that the volatility level was also consistent across the SMID sample and that of our preliminary study.

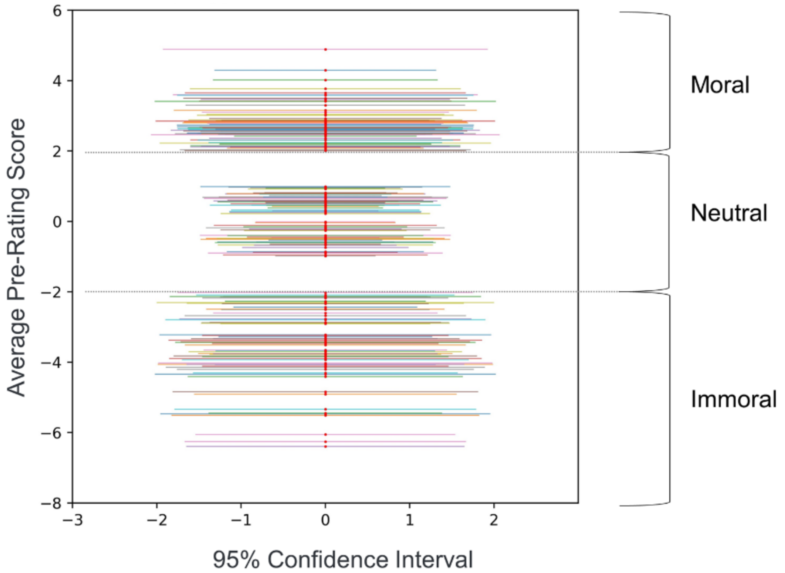

Figure 2. Distribution, volatility, and classification of the experimental image database. The horizontal axis presents the 95% Confidence Interval (CI) of the pre-rating score, and the red dot represents the average pre-rating moral mean for each image. Based on the prior moral evaluations, dashed lines are used to divide the range of moral content into three categories: Moral, Neutral, and Immoral. The entire dataset of moral images was evenly distributed among these three categories.

Table 1. The Average Moral Ratings and SDs for Each Category of Images, Based on the Preliminary Study.

	Moral-HSD	Moral-LSD	Neutral-HSD	Neutral-LSD	Immoral-HSD	Immoral-LSD
Valid	30	30	30	30	30	30
Average Rating	2.850	2.719	0.065	0.121	-3.859	-3.314
SD	3.318	2.584	2.441	1.492	3.410	2.608

2.3 Apparatus

The experiment was run by PsychoPy 3 (version 2021.2.3) connecting with a joystick, an eye tracker (GazePoint GP3, sampling rate of 150 Hz) and a biometric kit (to record GSR and heart rate). All stimuli were presented on a DELL 23.8-inch full high-definition flat-panel monitor with a resolution of 1920 by 1080 pixels and a refresh rate of 60 Hz. A chinrest was mounted at 60 cm from the eye tracker and at 100 cm from the monitor to fix the head location.

2.4 Moral Evaluation Task

The conditions for the moral evaluation task consisted of seven types with three levels of prediction (Positive, Negative, and Unknown) and three levels of morality of the image content (Moral, Neutral, and Immoral) in a total of 180 trials. The experimental design is shown in Figure 3. Directional cues (including Positive and Negative) were used to indicate a valid prediction before stimuli exposure in two-thirds of the trials, while in the remaining third of the trials, the directional cues were followed by neutral images. As for non-predictive cues (Unknown), the content of the following image was equally likely to be Moral, Neutral, or Immoral.

Participants were introduced to the trial structure is illustrated in Figure 4 and the joystick manipulation method to ensure they were familiar with the evaluation task. All trials started with a 2 s cue at the center of the display. Then, a 2.5 s delay with a blank screen was presented before the target image onset. The target image was displayed for 3 s at the center of the screen. Then the participants had to rate the depicted content on a continuous scale from -10 (“very immoral”) to +10 (“very moral”) by bending the joystick in the corresponding direction and clicking the trigger on the joystick to mark the evaluation. The rating had to be completed within 6 s in each trial, or the trial would be aborted and recorded as missing data. At the end of each trial, there was an inter-trial-interval (ITI) of 2 s, with a blank screen.

Before the actual data collection, participants were given detailed task instructions and presented with 10 practice trials to familiarize themselves with the tasks and the operation of the joystick. It was clearly explained that predictive cues were 100% reliable whereas non-predictive cues had no predictive value. No image was presented more than once. The assignment of images to directional versus non-predictive conditions was counterbalanced across participants. All trials were presented in a randomized order for each participant.

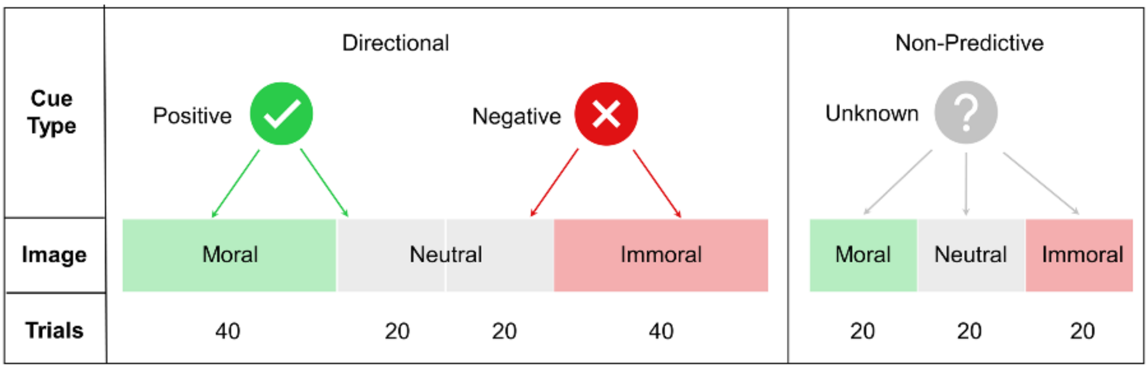

Figure 3. The experimental design consisted of all possible experimental conditions and corresponding trial quantities in the moral evaluation task. Directional cues and non-predictive cue were paired with moral, neutral, and immoral images. Two types of directional cues, namely positive and negative cues, were used to introduce valid outcomes versus neutral outcomes in a fixed ratio of 2:1, ensuring the effectiveness of the directional cue. Additionally, one type of non-predictive cue, referred to as the non-predictive cue, was paired with images from all three categories in equal ratios, thus eliminating any directional effects.

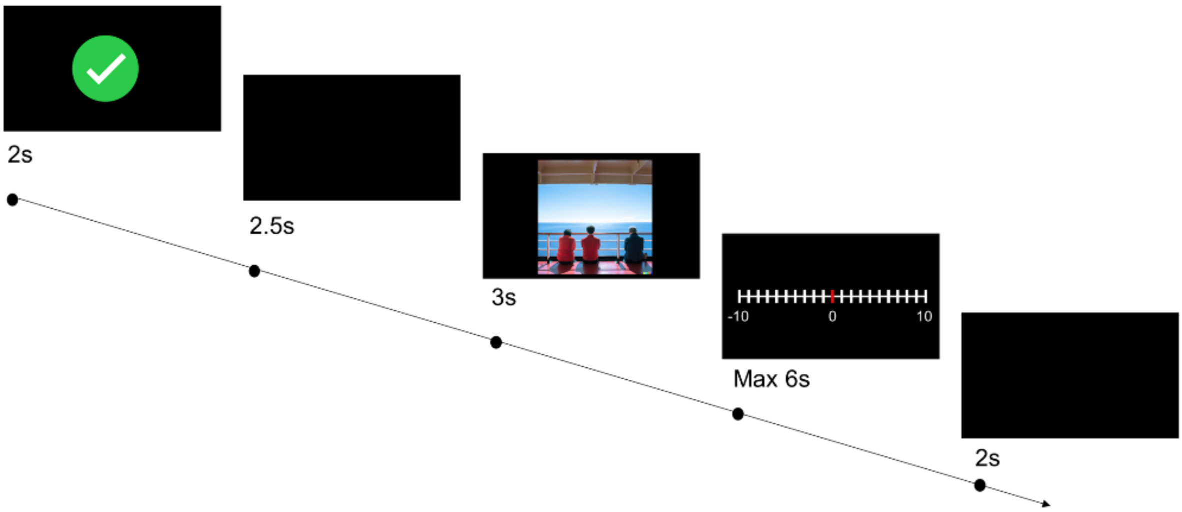

Figure 4. The schematic diagram gives an example of the experimental procedure with a positive-cue trial. Each trial has 5 frames: 2s-cue, 2.5s-delay, 3s-stimuli, Self-paced evaluation (no more than 6s), and 2s-ITI. Participants were provided with a joystick that allowed them to adjust their ratings of immorality or morality on a scale ranging from -10 to +10 by bending in the left or right direction. The initial position of the joystick was set at 0. The non-copyrighted image shown in this example is used only for illustrative purposes and was not part of the actual image database.

3 Results

We conducted a power analysis using the software program G*Power to set the appropriate sample size beforehand. The goal was to obtain .95 power to detect a medium effect size of .25 at the standard .05 alpha error probability. In accordance with the targeted sample size, 30 participants were recruited and completed the entire experiment. All participants completed all trials that provided sufficient data for the present analyses, and their physiological responses were successfully captured by the eye tracker.

3.1 Manual Response Analysis

We focused on the evaluation scores and response times as dependent measures in the manual responses. The evaluation scores were defined as the ratings on a scale from -10 (“very immoral”) to +10 (“very moral”), and the response times were defined as the time from the onset of the scale to the click on the trigger of the joystick. In order to compare cue effects for directional cues versus non-predictive cues across conditions, we took the absolute values of the evaluation scores for all types of images (Figure 5). In this analysis, the objective was to check whether predictive cues elicited more extreme scores than non-predictive cues. When comparing the cue effects for neutral images (Figure 7) across positive direction cues, negative direction cues, and non-predictive cues, we kept the signs of the evaluation scores to check whether the direction of prediction could polarize the evaluation of neutral images. We opted to conduct repeated measure ANOVA to analyze the cue effects for each type of morality content using the JASP software package. Conventional p statistics results were assessed to show significant main effects or interaction effects regarding factors with more than two levels, with the error bars representing the 95% confidence intervals around the means.

3.1.1 Directional Cues versus Non-predictive Cues

Figure 5(A) presents the means and 95% confidence intervals (CI) of the evaluation scores for each volatility (HSD and LSD) as a function of the type of cue (directional or non-predictive) and the morality of the image content, which was moral (left panel), neutral (middle panel), or immoral (right panel). Figure 5(B) shows the corresponding raincloud plots, which are used to illustrate the density and distribution of the data and critical summary statistics (mean and relevant confidence intervals) with minimal redundancy.

To assess the effects statistically, we conducted a 2 × 3 × 2 repeated measure ANOVA with the within-subject factors Cue Type (directional versus non-predictive), Image Content (moral, neutral, or immoral) and Volatility of the evaluation on the image content (high versus low). The results produced a significant main effect of Image Content ($F(2, 58) = 126.214$, $MSE = 3.165$, $\eta^2p = 0.813$, $p < 0.001$). Post-hoc comparisons using Bonferroni correction showed that neutral images obtained significantly lower scores on average (1.084) than both immoral images (4.429, $p < 0.001$) and moral images (4.018, $p < 0.001$), whereas there was no significant difference between moral and immoral images. There was also a significant main effect of Cue Type ($F(1, 29) = 17.204$, $MSE = 1.256$, $\eta^2p = 0.372$, $p < 0.001$), with directional cues producing higher scores on average (3.422) than non-predictive cues (2.932). No significant main effect of Volatility was found ($F(1, 29) = 2.528$, $MSE = 0.409$, $p = 0.123$). There were significant interactions between Image Content and Cue Type ($F(2, 58) =3.214$, $MSE = 0.496$, $\eta^2p = 0.100$, $p < 0.05$); between Image Content and Volatility ($F(2, 58) =10.507$, $MSE = 0.374$, $\eta^2p = 0.266$, $p < 0.001$); and between Cue Type and Volatility ($F(1, 29) = 9.781$, $MSE = 0.180$, $\eta^2p =$

0.252, $p = p < 0.05$). The three-way interaction was not significant ($F(2, 58) = 0.115$, $MSE = 0.557$, $p = 0.892$). Post-hoc comparisons for the significant interactions are reported in detail from Table 2 to Table 4.

Figure 6 shows the means and 95% CI of the response times for directional versus non-predictive cues for each volatility as a function of the morality of the image content. The three-way repeated measure ANOVA produced a significant main effect of Image Content ($F(2, 58) = 27.412$, $MSE = 0.091$, $\eta^2_p = 0.486$, $p < 0.001$). Post-hoc comparisons using Bonferroni correction showed that neutral images produced significantly slower response times (2.238 s) than moral images (1.999 s, $p < 0.001$) and immoral images (1.979 s, $p < 0.001$), whereas there was no significant difference between response times for moral versus immoral images. The main effect of Cue Type was not significant ($F(1, 29) = 0.567$, $MSE = 0.084$, $p = 0.457$), nor was the main effect of Volatility ($F(1, 29) = 3.228$, $MSE = 0.019$, $p = 0.083$). There was a significant interaction between Image Content and Cue Type ($F(2, 58) = 3.193$, $MSE = 0.046$, $\eta^2_p = 0.099$, $p < 0.05$). There was also a significant interaction between Image Content and Volatility ($F(2, 58) = 3.754$, $MSE = 0.057$, $\eta^2_p = 0.115$, $p < 0.05$), but not between Volatility and Cue Type ($F(2, 58) = 1.432$, $MSE = 0.050$, $p = 0.241$). The three-way interaction was not significant ($F(2, 58) = 0.020$, $MSE = 0.032$, $p = 0.980$). Post-hoc comparisons for the significant interactions are reported in detail in Table 5 and Table 6.

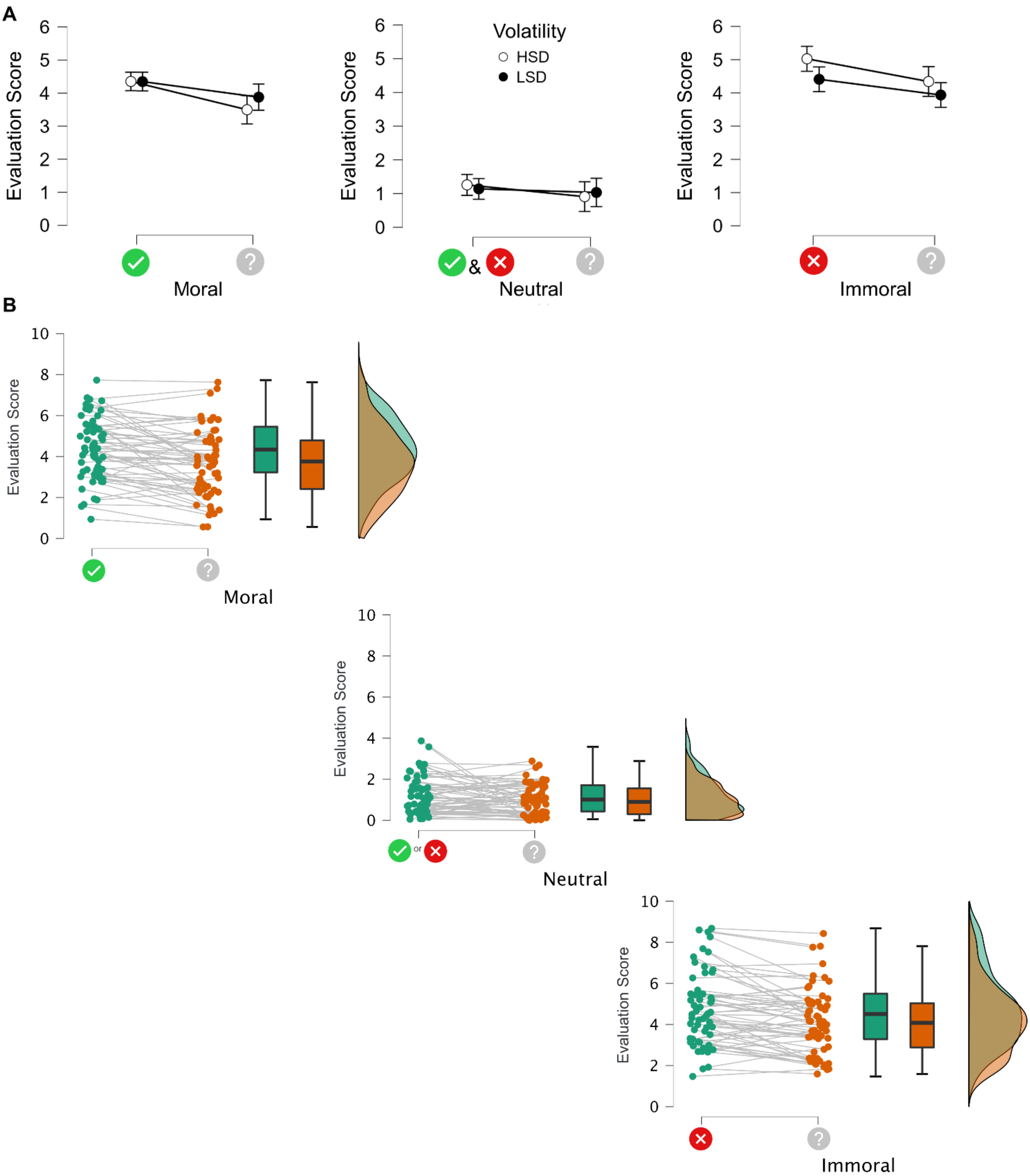

Figure 5. Panel (**A**) Average evaluation scores (absolute values) for each level of

morality of the image content in the directional versus non-predictive condition grouped by volatility split into HSD and LSD. The error bars indicate 95% CI. Panel (**B**) Raincloud plots for each level of morality of the image content in the directional versus non-predictive condition.

Table 2. Analysis of Evaluation Scores for "Directional Cues versus Non-predictive Cues"; Post-Hoc Comparisons with Bonferroni Correction on the Interaction between Image Content and Cue Type.

		Mean Difference	SE	t	p_{bonf}
Immoral, Directional	Neutral, Directional	3.521	0.247	14.254	< .001
	Moral, Directional	0.369	0.247	1.495	1.000
	Immoral, Non-predictive	0.579	0.158	3.662	0.007
	Neutral, Non-predictive	3.749	0.264	14.226	< .001
	Moral, Non-predictive	1.032	0.264	3.917	0.003
Neutral, Directional	Moral, Directional	-3.151	0.247	-12.759	< .001
	Immoral, Non-predictive	-2.942	0.264	-11.164	< .001
	Neutral, Non-predictive	0.228	0.158	1.446	1.000
	Moral, Non-predictive	-2.488	0.264	-9.443	< .001
Moral, Directional	Immoral, Non-predictive	0.209	0.264	0.794	1.000
	Neutral, Non-predictive	3.380	0.264	12.825	< .001
	Moral, Non-predictive	0.663	0.158	4.195	0.001
Immoral, Non-predictive	Neutral, Non-predictive	3.170	0.247	12.836	< .001
	Moral, Non-predictive	0.454	0.247	1.836	1.000
Neutral, Non-predictive	Moral, Non-predictive	-2.717	0.247	-11.000	< .001

Note. P-value adjusted for comparing a family of 15

Note. Results are averaged over the levels of: Volatility

Table 3. Analysis of Evaluation Scores for "Directional Cues versus Non-predictive Cues"; Post-Hoc Comparisons with Bonferroni Correction on the Interaction between Image Content and Volatility.

		Mean Difference	SE	t	p_{bonf}
Immoral, HSD	Neutral, HSD	3.602	0.243	14.834	< .001
	Moral, HSD	0.761	0.243	3.132	0.038
	Immoral, LSD	0.511	0.113	4.509	< .001
	Neutral, LSD	3.600	0.244	14.775	< .001
	Moral, LSD	0.573	0.244	2.353	0.320
Neutral, HSD	Moral, HSD	-2.842	0.243	-11.702	< .001
	Immoral, LSD	-3.091	0.244	-12.687	< .001
	Neutral, LSD	-0.002	0.113	-0.020	1.000
	Moral, LSD	-3.029	0.244	-12.431	< .001
Moral, HSD	Immoral, LSD	-0.249	0.244	-1.024	1.000
	Neutral, LSD	2.839	0.244	11.654	< .001
	Moral, LSD	-0.187	0.113	-1.651	1.000
Immoral, LSD	Neutral, LSD	3.089	0.243	12.720	< .001
	Moral, LSD	0.062	0.243	0.256	1.000
Neutral, LSD	Moral, LSD	-3.027	0.243	-12.463	< .001

Note. P-value adjusted for comparing a family of 15

Note. Results are averaged over the levels of: Cue Type

Table 4. Analysis of Evaluation Scores for "Directional Cues versus Non-predictive Cues"; Post-Hoc Comparisons with Bonferroni Correction on the Interaction between Volatility and Cue Type.

		Mean Difference	SE	t	p_{bonf}
HSD, Directional	LSD, Directional	0.247	0.081	3.054	0.022
	HSD, Non-predictive	0.630	0.126	4.987	< .001
	LSD, Non-predictive	0.597	0.136	4.391	< .001
LSD, Directional	HSD, Non-predictive	0.383	0.136	2.814	0.043
	LSD, Non-predictive	0.350	0.126	2.771	0.052
HSD, Non-predictive	LSD, Non-predictive	-0.033	0.081	-0.405	1.000

Note. P-value adjusted for comparing a family of 6

Note. Results are averaged over the levels of: Image Content

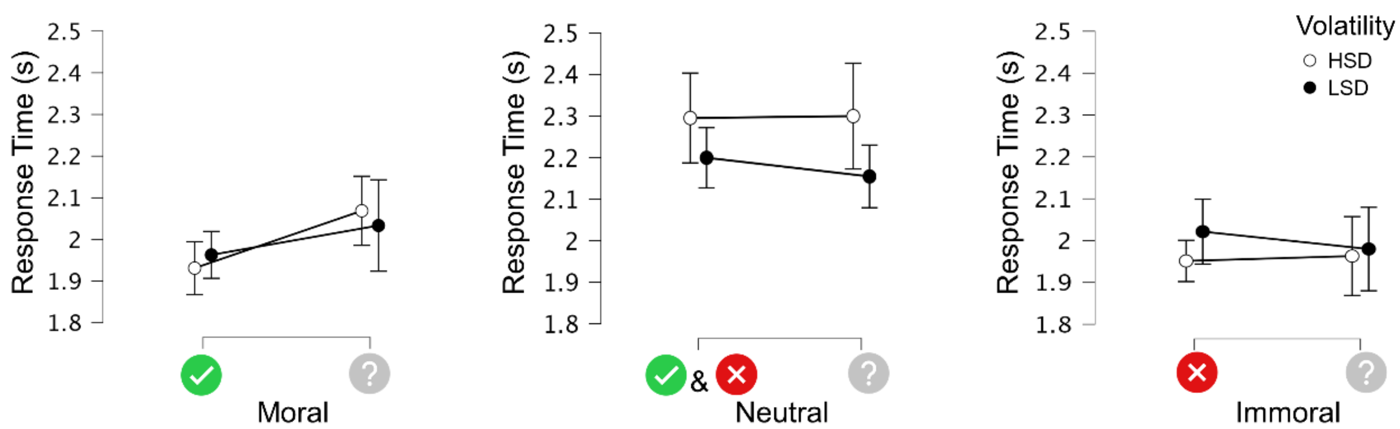

Figure 6. Average response times for each level of morality of the image content in directional versus non-predictive condition grouped by volatility split into HSD and LSD. The error bars indicate 95% CI.

Table 5. Analysis of Response Times for "Directional Cues versus Non-predictive Cues"; Post-Hoc Comparisons with Bonferroni Correction on the Interaction between Image Content and Cue Type.

		Mean Difference	SE	t	p_{bonf}
Immoral, Directional	Neutral, Directional	-0.261	0.048	-5.468	< .001
	Moral, Directional	0.039	0.048	0.825	1.000
	Immoral, Unpredictive	0.015	0.044	0.335	1.000
	Neutral, Unpredictive	-0.241	0.052	-4.639	< .001
	Moral, Unpredictive	-0.065	0.052	-1.243	1.000
Neutral, Directional	Moral, Directional	0.301	0.048	6.293	< .001
	Immoral, Unpredictive	0.276	0.052	5.313	< .001
	Neutral, Unpredictive	0.020	0.044	0.456	1.000
	Moral, Unpredictive	0.197	0.052	3.784	0.004
Moral, Directional	Immoral, Unpredictive	-0.025	0.052	-0.473	1.000
	Neutral, Unpredictive	-0.280	0.052	-5.398	< .001
	Moral, Unpredictive	-0.104	0.044	-2.349	0.320
Immoral, Unpredictive	Neutral, Unpredictive	-0.256	0.048	-5.357	< .001
	Moral, Unpredictive	-0.079	0.048	-1.664	1.000
Neutral, Unpredictive	Moral, Unpredictive	0.176	0.048	3.693	0.005

Note. P-value adjusted for comparing a family of 15

Note. Results are averaged over the levels of: Volatility

Table 6. Analysis of Response Times for "Directional Cues versus Non-predictive Cues"; Post-Hoc Comparisons with Bonferroni Correction on the Interaction between Image Content and Volatility.

		Mean Difference	SE	t	p_{bonf}
Immoral, HSD	Neutral, HSD	-0.341	0.050	-6.859	< .001
	Moral, HSD	-0.043	0.050	-0.859	1.000
	Immoral, LSD	-0.043	0.039	-1.126	1.000
	Neutral, LSD	-0.220	0.045	-4.868	< .001
	Moral, LSD	-0.041	0.045	-0.904	1.000
Neutral, HSD	Moral, HSD	0.298	0.050	6.000	< .001
	Immoral, LSD	0.297	0.045	6.574	< .001
	Neutral, LSD	0.121	0.039	3.125	0.038
	Moral, LSD	0.300	0.045	6.632	< .001
Moral, HSD	Immoral, LSD	-8.013×10^{-4}	0.045	-0.018	1.000
	Neutral, LSD	-0.177	0.045	-3.925	0.002
	Moral, LSD	0.002	0.039	0.047	1.000
Immoral, LSD	Neutral, LSD	-0.177	0.050	-3.556	0.008
	Moral, LSD	0.003	0.050	0.052	1.000
Neutral, LSD	Moral, LSD	0.179	0.050	3.609	0.007

Note. P-value adjusted for comparing a family of 15

Note. Results are averaged over the levels of: Cue Type

3.1.2 Cue Effects for Neutral Images

In order to separate out how the different cues impacted on the ratings of neutral images, we analyzed the signed evaluation scores of high and low-volatility neutral images for the three types of cues, as shown in Figure 7. The 3 × 2 repeated measures ANOVA produced a significant main effect of Cue type ($F(2, 58) = 18.040$, $MSE = 1.948$, $\eta^2 p = 0.384$, $p < 0.001$). Post-hoc comparisons using Bonferroni correction showed that positive predictions produced higher ratings (1.259) than non-predictive cues (0.588, $p < 0.05$) and negative predictions (-0.256, $p < 0.001$); negative predictions also produced significantly lower ratings than non-predictive cues ($p < 0.005$). There was a significant main effect of Volatility ($F(1, 29) = 4.605$, $MSE = 0.595$, $\eta^2 p = 0.137$, $p < 0.05$), with high-volatility images producing lower ratings (0.404) than low-volatility images (0.649). There was no significant interaction between Cue Type and Volatility ($F(2, 58) = 2.035$, $MSE = 0.609$, $p = 0.140$).

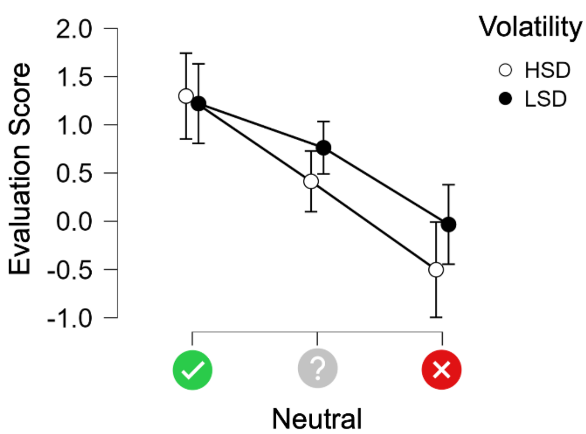

Figure 7. Average evaluation scores for neutral images following the three types of cues grouped by volatility split into HSD and LSD. The error bars indicate 95% CI.

Figure 8 presents the response times for high and low volatility as a function of each type of cue. The 3 × 2 repeated measures ANOVA indicated that Volatility had a significant main effect ($F(1, 29) = 6.646$, $MSE = 0.085$, $\eta^2_p = 0.186$, $p = 0.015$), confirming that high-volatility neutral images (2.297 s) took longer to rate than low-volatility neutral images (2.185 s). There was no significant main effect of Cue Type ($F(2, 58) = 0.173$, $MSE = 0.088$, $p = 0.842$), nor was there a significant interaction between Volatility and Cue Type ($F(2, 58) = 0.242$, $MSE = 0.051$, $p = 0.786$).

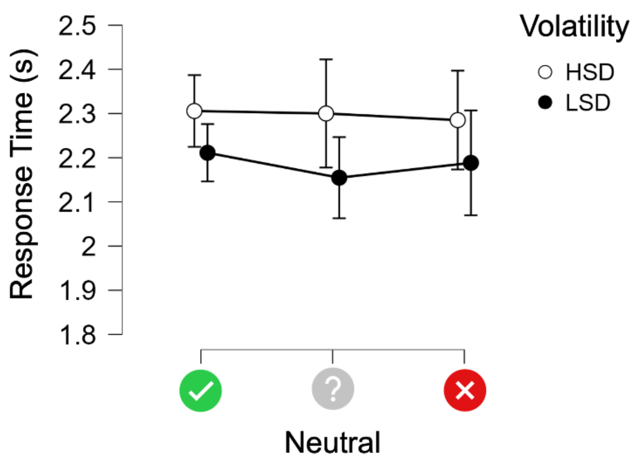

Figure 8. Average response times for neutral images following the three types of cues grouped by volatility split into HSD and LSD. The error bars indicate 95% CI.

3.2 Gaze Displacement Analysis

To examine the hypothesis that the predictive cues would elicit a response bias, we analyzed the average gaze position during the delay period (2.5 s). An active response bias would be visualized by the participant's gaze displacement along the direction associated with the predicted outcome (immoral – left, moral – right). This gaze positioning analysis focused on the period from the disappearance of the cue until the target onset. The data were classified into three conditions according to the Cue Type (positive, non-predictive, and negative).

Figure 9 (A) presents the average horizontal gaze positions during the delay as a function of Cue Type. Our display frame had a width of 1920 pix starting from the left edge, and the cue was presented at the center of the screen with a horizontal coordinate at 960 pix. A one-way repeated measures ANOVA showed that Cue Type produced a significant main effect on gaze position ($F(2, 58) = 7.086$, $MSE = 602.422$, $p < 0.05$). The average horizontal gaze positions shifted to the left or right in the direction congruent with the cue type. Post hoc comparisons with Bonferroni correction showed that positive predictive cues produced more rightward gaze positions (967.496 pix) than non-predictive cues (951.744 pix; $p < 0.05$) and negative predictive cues (944.102 pix; $p < 0.001$). The difference between non-predictive and negative predictive cues was not significant. Figure 9 (B) presents the raincloud for the gaze position of positive, non-predictive, and negative conditions. The average gaze position during the delay after a non-predictive cue appeared to be more dispersive than after a positive or negative cue.

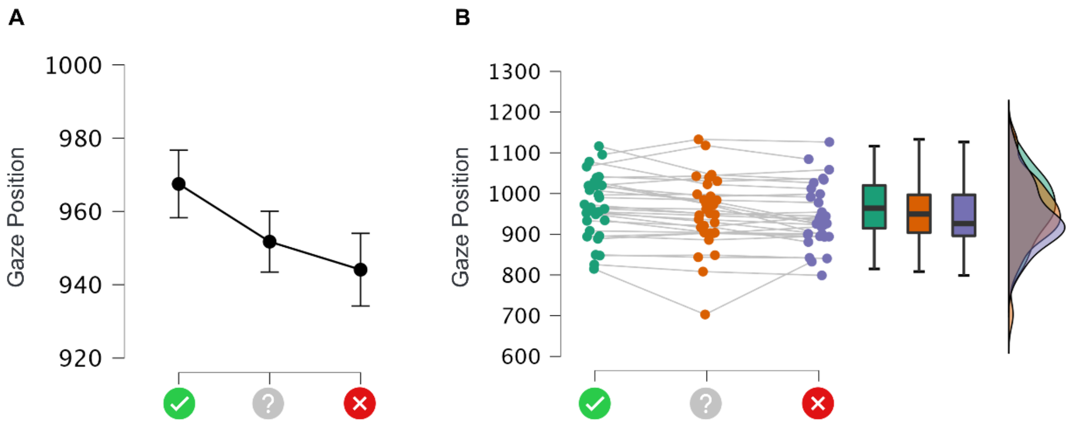

Figure 9. Panel (**A**) Average horizontal gaze positions during the delay period as a function of cue type. The X-axis shows each type of cue. The Y-axis represents the horizontal position on the screen, ranging from 0 to 1,920 pixels from left to right. The error bars indicate 95% CI. Panel (**B**) Raincloud plots for horizontal gaze positions. The dots show the averages per subject for positive prediction in green, for non-predictive cues in orange, and for negative predictions in purple; also shown are boxplots and distribution density plots of the evaluation scores. The error bars indicate 95% CI.

4 Discussion

In the present study, we aimed to investigate whether the confirmation bias influences moral evaluations of real-world images and, if so, under which conditions this bias operates. To this end, we utilized a diverse set of images taken from SMID spanning the moral spectrum (ranging from "moral" to "neutral" to "immoral") and volatility (with a small or large standard deviation in ratings). We asked participants to evaluate these images and rate their evaluations on a continuous scale from +10 to -10.

The current results demonstrate that the moral ratings were in line with the expectations induced by the cue, and that the neutral images required longer deliberation times to make an evaluation than moral or immoral images. We found that the average evaluation score after directional instruction was higher than after non-predictive instruction, especially when evaluating moral images and immoral images, while the response times showed no difference. These results indicated that the Cue Type worked on the moral evaluation procedure by shifting the perceived degree of morality. Moreover, the Cue Type effects on the ratings of high-volatility images were more significant than on low-volatility images. Volatility further produced a significant main effect on response time, with shorter response times for low-volatility images than for high-volatility images. It is most likely that, for high-volatility images, subjects had to spend more effort to process the relation between cue and image to make their evaluation.

Our analysis revealed that directional cues had a substantial effect on images that were clearly moral or immoral, leading to more extreme evaluations due to confirmation bias, corroborating our previous observations of confirmation bias in the evaluation of appetitive and aversive food images (Ounjai et al., 2018; 2020). To examine the operation of a liminal confirmation bias in moral evaluation, we investigated the impact of predictive cues on the evaluation of neutral images which imply a different and more complex evaluation of moral properties. Both positive and negative predictive cues had a marked impact on the moral evaluation score, proving that participants referred to prior expectations in the moral evaluation of the neutral images. To our knowledge, the present findings are the first in the literature on moral cognition to track a decisive liminal influence of confirmation bias, effectively nudging the evaluation of neutral images to the positive or negative direction as a function of the predictive cue.

The gaze positions during the interval between the predictive cue and the image to be rated showed that the positive predictive cues led to a gaze bias toward the positive side of the rating scale, and negative predictive cues had the opposite effect. These spatial displacements reflected the prediction-forming process and were consistent with our previous study on preference decision-making using food images (Ounjai et al., 2018). Future studies could investigate the physiological responses involved in forming the response bias while controlling for individual differences, illumination (Proulx & Egeth, 2008) and color of the cue appearance.

The present effects of confirmation bias in moral evaluation, obtained with predictive cues on a range of real-world images, reflect the judgment processes given a particular level of reliability of the cues. Effectively, the directional predictions (with a check or cross symbol) were paired with moral or immoral images on two-thirds of the occasions, and with neutral images on the remaining third of the occasions. In this regime, the participants would effectively be reinforced into viewing the predictive cues as reliable. Given this perceived reliability, the participants gave more extreme ratings to moral and immoral images, in line with the prediction. These results are in line with the notion that confidence drives confirmation bias in simple decisions: People showed the strongest confirmation bias when they were already confident about the information to be confirmed (Rollwage et al., 2020). In other words, the predictive cues were validated, through experience, as pieces of information that warranted confirmation. Here, it is particularly relevant to note that this confirmation had a decisive impact on liminal cases, that is, neutral images.

The phenomenon of liminal confirmation bias may be structurally similar to that of the prevalence-induced concept change in human judgment (Levari et al., 2018), where ratings are influenced by the expectations set through prior experience. When participants expect half of the stimuli to be of a certain type, they adjust their criteria of categorization to meet that expectation. This implies shifts of judgment near the boundary of neutrality in a binary categorization system. Sometimes the exact same stimulus would be categorized differently depending on the base rate of occurrence. In the present paradigm, the expectation that predictive cues are valid leads the participants to adjust their criteria to the point that neutral images become polarized in line with the prediction.

This observation also raises the question how the base rates of expectation, or the history of reinforcement with the predictive cues, impact the dynamics of confirmation bias. The perceived reliability of the predictive cue may be differentially impacted by clear violations (e.g., a predictive cue followed by an image of the opposite polarity) than by neutral images. Also, there may be a limit to the number of neutral images that can be paired with predictive cues without diminishing the perceived reliability of the predictive cue.

More generally, the present findings of a liminal confirmation bias in the evaluation of real-world images have several important implications for the study of moral cognition. Theoretically, the observation that neutral images become polarized in the context of predictive cues may be connected to the logic of universalization in moral judgment (Levine et al., 2020). Indeed, the liminal confirmation bias functions structurally as a consensus mechanism that offers direction particularly in dilemmas or borderline cases when faced with a binary categorization task. In turn, this critical influence near the boundary of neutrality warrants further investigation to assess its effectiveness in real-world settings (Hertz et al., 2023). The notion that even simple, bivalent cues can serve to swing judgment from neutrality to being morally charged must be regarded as a dual-use type of knowledge that could promote or impede cooperative behavior (Capraro et al., 2019; Balafoutas & Rezaei, 2022). Thus, the present paradigm offers a critical tool for researchers to track the liminal influences of confirmation bias in moral judgment.

Chapter 3: Speed Is Associated with Polarization During Subjective Evaluation: No Tradeoff, But an Effect of the Ease of Processing

1 Introduction

In the study of decision-making, the well-known speed-accuracy tradeoff is arguably one of the most fundamental phenomena (Vargas & Lauwereyns, 2021; Heitz, 2014; Wickelgren, 1977; Luce, 1991). With more time, we make fewer errors. This is true not only for humans across a wide variety of task domains (Fiedler et al., 2021; Onagawa et al.,2019; Yamaguchi, Crump, & Logan, 2013; Link & Tindall, 1971), but even for bees (Chittka et al., 2003) and ants (Franks et al., 2009). In perception and memory tasks as well as economical choices (Kahneman, 2003), it has been shown that decision-makers can adapt to time pressure, but also strategically set the amount of time and effort they invest in processing information for decision-making by weighing the cost of time versus the gain in accuracy. Thus, decision-makers can manipulate the speed-accuracy tradeoff, aiming for optimality in given circumstances (Boureau, Sokol-Hessner, & Daw, 2015; Gluth, Rieskamp, & Buchel, 2012; Bogacz, 2006; Reddi & Carpenter, 2000).

When measuring the accuracy of performance based on perceptual discrimination or memory, researchers rely on objective information that can readily be verified. However, we often make decisions or judgments based on subjective evaluations (Xu, Jin, & Lauwereyns, 2023; Ounjai et al., 2018; Margulis, 2017; Kahneman, 2003). Examples include decisions or judgments based on the perceived attractiveness of faces, foods, music, or works of art, to name the most commonly researched categories (Xu et al., 2020; Ounjai et al., 2018; Margulis, 2017; Shimojo, 2003). Another type of subjective decision is based on moral evaluation, which may be shaped by cultural background and personal experience, with a complexity of processing that does not afford an easy metric of accuracy (Sudo et al., 2021; Malle, 2021; Garrigan, Adlam, & Langdon, 2016). For these diverse types of subjective decision-making, little is known about the relationship between speed and decision performance. The present paper investigates this relationship.

1.1 The Role of Speed in Subjective Evaluation

As a metric of performance in subjective decision-making, the nearest equivalent to accuracy would arguably be the consistency of response, measured across a population of decision-makers (e.g., the level of agreement or consensus) or measured across a sample of decisions for the same items under different conditions (e.g., the level of reproducibility) (Hornsby & Love, 2020; Kahneman, 2003). Evaluations would not be random, and even preference reversal would follow an internal logic that should give reproducible responses (Sénémeaud et al., 2013; Lichtenstein & Slovic, 2006; Camerer & Weber, 1992).

The literature on value-based decision-making suggests that evaluations are based on a sequential sampling process that retrieves information from memory (Shadlen & Shohamy, 2016; Krajbich et al., 2010; Rangel et al., 2008; Weber & Johnson, 2006; Busemeyer & Townsend, 1993). Within this framework, default expectations might be that time constraints introduce random noise in the evaluation, leading to over- or underestimation of a “true” value. Extra time for information processing should give decision-makers the opportunity to form more precise and more stable object representations of the items under consideration (Curley et al., 2017; Wilson & Schooler, 1991). This would lead to a speed-precision tradeoff, with more consistency in the evaluation of slower responses (i.e., a narrower response distribution, with a smaller standard deviation) but not necessarily a change in the mean of the evaluations.

However, given that subjective decision-making involves a complex system with parallel and interactive streams of affective processing, it is possible that speed affects the mean of evaluations. Subjective decision-making includes fast, intuitive emotional reactions and slow, controlled evaluations based on reasoning (Malle, 2021; Bailey & Muldrow, 2018; Cameron et al., 2017; Garrigan, Adlam, & Langdon, 2016; Sokol-Hessner et al., 2012; Dane & Pratt, 2007). Thus, a key question arises: Does time pressure lead to a bias towards emotionally charged information? If more polarizing information would be sampled first, then biased conclusions may occur when the process is halted early under time pressure (Lin & Jia, 2023; Kruglanski & Gigerenzer, 2018; Wittmann & Paulus, 2008; Dror, Basola, & Busemeyer, 1999).

Preliminary evidence in support of an association between speed and polarization has been obtained in our laboratory, with faster responses for food images that receive highly positive or negative ratings than for food images that receive moderate ratings (Wolf et al., 2018, 2019). Also, when participants were given predictive cues indicating the valence of impending food images, we found that the responses were faster and the ratings more extreme when participants were given reliable predictions as compared to neutral or invalid predictions (Ounjai et al., 2018). Critically, however, our previous studies did not directly manipulate speed. Here, we designed a set of four experiments focusing on the role of speed in subjective evaluation by comparing speeded versus non-speeded conditions.

1.2 The Present Study

In the present study, we raise a hypothesis of "Speed-Polarization Tradeoff," proposing an active, causal link such that faster responses would lead to more extreme evaluations. Particularly, time pressure would act as a stressor that reinforces the emotional charge and biases the evaluation toward fast, intuitive emotional reactions (Lin & Jia, 2023; Xu et al., 2020; Bird et al., 2019; Starcke & Brand, 2016; Cyders, 2008; Maule, Hockey, & Bdzola, 2000; Dror, Basola, & Busemeyer, 1999). Consequently, urgency would lead to polarization in the evaluation.

The hypothesis of a speed-polarization tradeoff can be contrasted against a hypothesis of "Ease of Processing." By this account, any connection between speed and polarization would not reflect an active, causal link that can be set strategically by the participant. Instead, the salience of evaluation-relevant content might influence the ease of processing such that images with salient content produce faster responses and more extreme ratings than images whose content is more complex or ambiguous (Andrejević et al., 2022; Quandt et al., 2022; Berberyan et al., 2021; Isham, 2020; Polanía et al., 2019). Urgency, then, would have no effect on the polarization of the evaluation. Instead, the relation between speed and polarization would be governed by the ease of processing.

The introduction of an urgency condition also allowed us to examine the relation between speed and the variability of response across participants. A speed-precision tradeoff should imply that decisions under urgency lead to an increase in variation. However, increased polarization might reduce the variability. If so, a speed-precision tradeoff could be counteracted by any association between speed and polarization, whether it be due to an active speed-polarization tradeoff or the ease of processing.

In each experiment, we asked participants to perform subjective decision-making tasks with visual materials, always judging individual images on a continuous scale from -10 to +10. In Experiments 1 to 3, the visual materials were photos of real-world scenes with a moral evaluation task (similar to Experiment 3 in Sudo et al., 2021). In Experiment 4, the participants were asked to judge food images as a function of preference. In Experiments 1, 3, and 4, we manipulated the urgency of the evaluation task on a trial-by-trial basis, using cues to indicate whether the participants could make a self-paced (SP) evaluation or whether they had to perform a time-limited (TL) evaluation within 2 seconds. In Experiment 2, we did not manipulate urgency, but obtained the participants' self-reported perceptions on the ease of processing for each of their self-paced moral evaluations.

2 Experiments

2.1 Experiment 1: Real-World Images, with Urgency Manipulation

2.1.1 Introduction

In Experiment 1, as an exploratory experiment, we set out to examine the relation between speed and subjective evaluation with moral evaluation of real-world images. Moral evaluation was the appropriate task for present purposes since its underlying mechanisms have been characterized in the greatest detail, with solid evidence for the existence of fast, emotional processes versus slow, deliberative processes (Malle, 2021; Cameron et al., 2017; Garrigan, Adlam, & Langdon, 2016; Van Bavel, FeldmanHall, & Mende-Siedlecki, 2015; Decety & Cacioppo, 2012).

We designed the present experimental paradigm to compare the moral evaluation of real-world images under self-paced viewing versus under time pressure (See Figure 10). We prepared a stimulus set ranging from “very moral” to “very immoral” images based on the Socio-Moral Image Database (SMID) (Crone et al., 2018). We asked participants to rate real-world images on a continuous scale from -10 (“very immoral”) to +10 (“very moral”). To create conditions with and without urgency, we used a cueing procedure (Reuss, H., Kiesel, A., & Kunde, W., 2015; Custers, & Aarts, 2010) to instruct the participants at the beginning of each trial whether they could take as long as they wanted to make the evaluation (Self-Paced condition, SP; left panel of Figure 10) or whether they had to make the evaluation within 2 seconds (Time-Limited condition; TL, right panel of Figure 10). In the TL condition, the trial was aborted and an error message was given when the participant took too long to respond.

Figure 11 presents the alternative predictions from two hypotheses. According to the hypothesis of speed-polarization tradeoff (left panel), speed causes the moral evaluations to be more polarized, and so the ratings under time pressure in the TL condition would be more extreme (i.e., more positive ratings for moral images and more negative ratings for immoral images) than the ratings without time pressure in the SP condition. In contrast, the right panel shows an alternative, ease-of-processing hypothesis, by which there would be no differences in the mean ratings between the SP and TL conditions. According to the ease-of-processing hypothesis, speed does not cause polarization. Instead, fast responses may be correlated with extreme ratings as a function of the ease of processing of moral images. Some images would have a very salient moral content, enabling a fast response with an extreme rating, whereas other images would have a less salient moral content, requiring more time to process and tending to produce more moderate ratings.

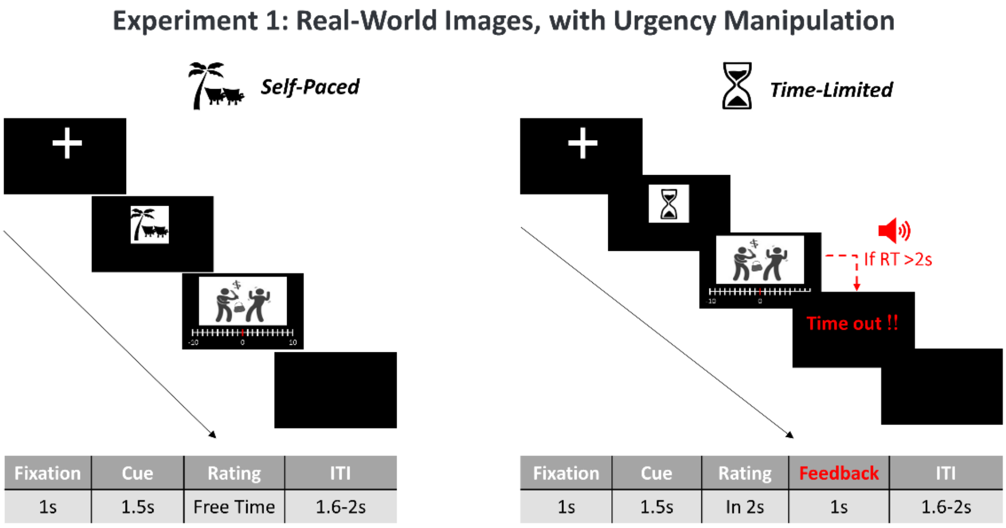

Figure 10. Schematic representation of the paradigm in Experiment 1. The trial structure for the Self-Paced condition is shown on the left; the Time-Limited condition is on the right. Both conditions started with a fixation cross for 1 s, followed by a time-instruction cue for 1.5 s. In Self-Paced trials, the participants were allowed to view the images as long as they liked before indicating their evaluation. In the Time-Limited trials, the participants were required to complete their evaluation within 2 s; if they failed to do so, an error message was presented. Both conditions ended with a random ITI between 1.6 s and 2 s.

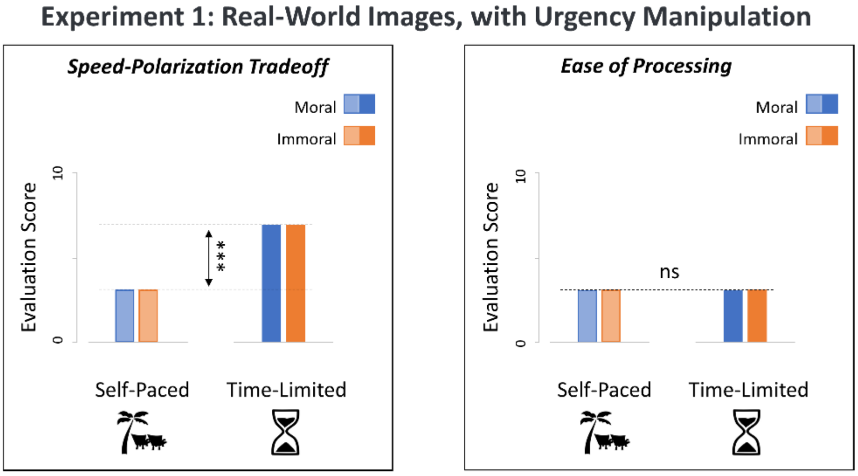

Figure 11. Schematic representation of the alternative predictions from two hypotheses in Experiment 1. Hypothesis I, *Speed-Polarization Tradeoff*, is shown on the left; hypothesis II, *Ease of Processing*, is shown on the right. The hypothesis of speed-polarization tradeoff predicted that the evaluation scores would be more extreme in the Time-Limited condition than in the Self-Paced condition. The ease-of-processing hypothesis implied that the moral evaluations would remain unchanged even under urgency.

2.1.2 Methods

2.1.2.1 Participants

Experiment 1 was conducted as an exploratory study with a sample size comparable to previous studies in our laboratory (Wolf et al., 2018, 2019; Ounjai et al., 2018). Thirty-two students at Kyushu University were recruited as participants; one participant chose to discontinue the experiment midway due to physical discomfort, while another had to be excluded because she had participated in a different experiment using similar images. Thus, the current dataset consisted of data from 30 participants: 15 males and 15 females, with a mean age of 22.67 years old, and a standard deviation of 1.81. The participants had no previous experience in any similar experiment. They were asked to use their right hand to manipulate the joystick during the experiment though 2 participants were left-handed. No participant reported any vision or health issues or past or present psychological disorders. The Human Ethics Committee of the Faculty of Arts and Science at Kyushu University approved the study. Informed consent was obtained in writing from each participant before the experiment; the informed consent included a no-risk statement and rights protection. Each participant received 1000 yen as monetary compensation for their participation. The experiment consisted of a single session of approximately 1 hour.

2.1.2.2 Apparatus and Stimuli

The visual stimuli were presented in a normally-lit room on a 23.8-inch full high-definition flat-panel monitor with a 1920 × 1080 pixels display resolution. The participants were seated in front of the monitor at a comfortable distance of their own choosing (with no head or chin restraint). The manual responses were recorded using a joystick (Logitech, Switzerland; model no. 963290-0403).

All events and recordings were controlled through code written in PsychoPy (version 1.90.3) (Peirce, 2008; Peirce, 2007). The target visual stimuli consisted of 160 real-world images selected from the SMID. The images provided content ranging from very moral (i.e., morally acceptable) to very immoral (i.e., morally offensive), depicting war scenes, weapons, accidents, landscapes, and various types of social interaction. Based on the original categorization in the moral domain of SMID, we preselected a balanced set of moral and immoral images. For confirmation, we conducted a preparatory rating experiment with 10 students in the lab, asking them to rate the preselected images with respect to their moral content from -10 (extremely immoral) to +10 (extremely moral). All images were resized (while maintaining the aspect ratio) to fit the entire height within a 1920×1080 pixels frame prior to preparatory rating. We were able to select a set with 80 moral images and 80 immoral images. During the experiment, each target stimulus was presented against a black background together with an evaluation scale underneath the image. The stimulus was scaled down by one-third and centered in the middle of the upper two-thirds of the screen; the evaluation scale was centered in the middle of the lower third of the screen.

Time-instruction cues were used to indicate on a trial-by-trial basis whether the participant should perform the moral evaluation at their own pace or within 2 s (see Figure 10). The time-instruction cues were two monochrome icons: an icon of beach landscape with a palm tree for the self-paced (SP) condition; an icon of a sand clock with a short low beep sound for the time-limited (TL) condition. The time-instruction cues were presented centered in the middle of the upper third of the screen, with their sizes fixed at 376 × 376 pixels.

2.1.2.3 Procedure

An experimental session lasted approximately 1 hour. The experimental session was divided into 4 blocks of 40 trials, with breaks between the blocks. Participants were asked to give their informed consent in writing and fill out a pre-questionnaire prior to the experiment. Before the actual data collection, participants were given detailed task instructions and presented with 20 practice trials to familiarize themselves with the time instructions and the operation of the joystick.

All trials started with a 1-s fixation screen, in which a fixation cross was centered at the middle of the top third of the display (see Figure 10). Then, a time-instruction cue was presented, centered at the same position as the fixation cross, for a period of 1.5 s, to indicate whether it was an SP trial or a TL trial. In the case of a TL cue, the visual presentation was accompanied by a low beep sound to increase the sense of urgency. Following the 1.5 s presentation of the time-instruction cue, the target image was displayed together with the evaluation scale until the participant had completed their moral evaluation, or for a maximal duration of 2 s in a TL trial. Participants were asked to rate the depicted content in each image on a continuous scale from -10 ("very immoral") to +10 ("very moral") by bending the joystick in the corresponding direction and clicking the trigger on the joystick to mark the evaluation. The registered values were continuous, up to eight digits after the decimal point. The starting point for the evaluation was 0 and then the participants had to bend the joystick to the left or right.

The moral evaluation task was explained at the beginning of the experiment, but not shown in words during the trials; instead, only the evaluation scale was shown in each trial. The participants were instructed to perform their ratings by asking themselves for each image "How morally acceptable is this?" An evaluation of +10 should reflect the most morally acceptable case; conversely, a value of -10 should reflect the complete opposite, that is, the least morally acceptable case. In a TL trial, in case the participant missed the 2 s deadline, a high beep was presented together with the message "Time out!!" displayed in red, centered at the middle of the upper third of the screen. At the end of each trial, there was an inter-trial-interval (ITI) of between 1.6 and 2 s, with a blank screen.

An experimental session consisted of 160 trials, divided into 4 conditions, with 2 levels of time control (SP, TL) and 2 levels of morality of the image content (moral, immoral). No image was presented more than once. All trials were presented in pseudorandom order and each block contained an equal number of trials for each condition. The assignment of images to SP versus TL conditions was counterbalanced across participants.

2.1.3 Results

The present data set included data from 30 participants, each presented with a total of 160 trials, separated into 4 conditions with 40 trials each, corresponding to the 2 × 2 design with the factors of Time Control (Self-Paced versus Time-Limited) and Morality of the image content (Moral versus Immoral). All participants completed all trials in the SP condition; on average, all participants completed 94.54% of the trials in the TL condition (standard deviation, S.D. = 4.76). In the remaining 5.46% of the TL trials, the participants failed to respond within the deadline of 2 s. No participant missed more than

20% of the TL trials. The number of completed trials provided sufficient data for the present analyses.

We focused on the evaluation scores and response times as dependent measures and performed statistical analysis using the JASP software package. Throughout the study, alpha level was set at 0.05 and post-hoc testing was conducted with Bonferroni correction. The evaluation scores were defined as the ratings on a scale from -10 ("very immoral") to +10 ("very moral"), as confirmed by the participants when clicking the trigger on the joystick. The response times were defined as the time from the onset of the target image to the click on the joystick.

2.1.3.1 Analysis of average evaluation scores

Figure 12 presents the means and 95% confidence intervals for the signed evaluation scores (left panel) and for the response times (right panel) as a function of the morality of the image content and the time control condition. This analysis was based on the averaged data for each participant in each condition (N = 30). We conducted a two-way repeated-measures ANOVA using morality of the image content (i.e., Moral versus Immoral) and time control (i.e., SP versus TL) as within-subjects factors. To be able to compare the evaluation scores for moral and immoral images in terms of their polarization (i.e., distance from zero), we used unsigned evaluation scores (i.e., absolute values) in this analysis.

There were no significant main effects for time control ($F(1, 29) = 0.482$, $p = 0.493$, $\eta^2_p = 0.016$) or morality of the image content ($F(1, 29) = 0.516$, $p = 0.478$, $\eta^2_p = 0.017$), but we obtained a statistically significant interaction between the two factors ($F(1, 29) = 6.600$, $p = 0.016$, $\eta^2_p = 0.185$). The effect of time control for moral images (5.428 for SP versus 5.244 for TL) appeared to go in the opposite direction as compared to that for immoral images (5.345 for SP versus 5.682 for TL), but post-hoc comparisons indicated there was no significant difference in any pair of unsigned evaluation scores.

We also conducted a two-way repeated-measures ANOVA based on the response times, using morality of the image content (moral versus immoral) and time control (self-paced versus time-limited) as within-subjects factors. The results showed a significant main effect for time control ($F(1, 29) = 62.065$, $p < 0.001$, $\eta^2_p = 0.682$), but not for morality of the image content ($F(1, 29) = 3.206$, $p = 0.084$, $\eta^2_p = 0.100$), nor was there a statistically significant interaction between the two factors ($F(1, 29) = 3.975$, $p = 0.056$, $\eta^2_p = 0.121$). Post-hoc pairwise comparisons indicated that the response times following the SP cue for moral images (2.677 s) and for immoral images (2.909 s) were both significantly longer than following the TL cue (1.240 s for moral images and 1.236 for immoral images) with p values < 0.001. It proves that our time control manipulation successfully induced participants to speed up their responses when given a deadline of 2 s. Importantly, despite this solid increase in response speed, the participants' average evaluation scores did not change.

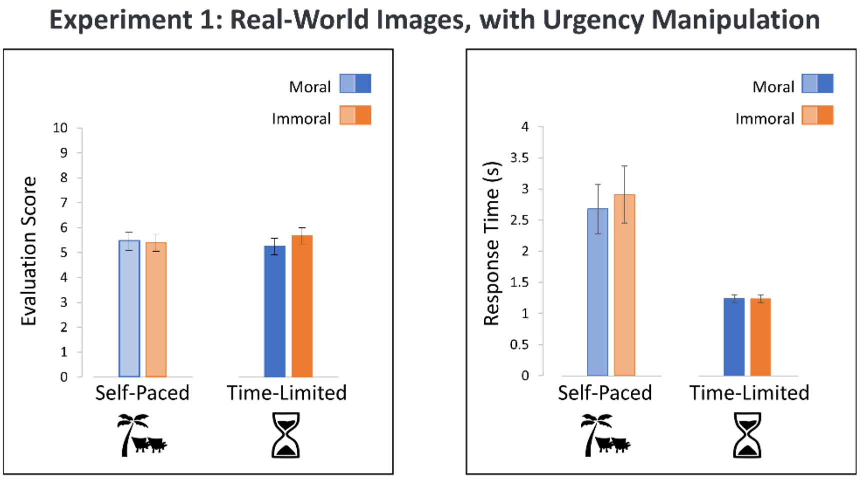

Figure 12. Average evaluation scores (left panel; absolute values) and response times (right panel) of Experiment 1 for each participant in each condition (N = 30). The blue bars show the data with moral images; the orange bars represent the data with immoral images. The bars from the Time-Limited conditions are shown in a darker shade than the bars from the Self-Paced conditions. The error bars reflect the 95% confidence interval around the mean.

2.1.3.2 Median-split analysis

In previous research on preference formation with respect to food, we observed a robust association between response speed and polarized evaluation, such that extreme evaluation scores were consistently associated with fast response times (Wolf et al., 2019; Wolf et al., 2018; Ounjai et al., 2018). To examine whether such an association between speed and polarization also exists for the moral evaluations in the present paradigm, we performed a median-split analysis, separating the fast responses from the slow responses for each participant in each condition. Figure 13 presents the averages and confidence intervals of the evaluation scores, comparing fast versus slow responses, for each of the 4 conditions.

We conducted a three-way repeated-measures ANOVA based on the averaged evaluation scores for each participant (N = 30), using morality of the image content (moral versus immoral), time control (self-paced versus time-limited), and response speed (fast versus slow) as within-subjects factors. Again, to be able to compare the evaluation scores for moral and immoral images directly, we used unsigned evaluation scores in the repeated-measures ANOVA.

The results indicated that only response speed showed a significant main effect ($F (1, 29) = 39.998$, $p < 0.001$, $\eta^2_p = 0.580$), whereas the F values for the other main effects were less than 1. The analysis showed a significant interaction between response speed and time control ($F (1, 29) = 26.217$, $p < 0.001$, $\eta^2_p = 0.475$). Post-hoc analysis revealed that response speed had a significant effect on evaluation in the SP conditions by making them more extreme while the effect was not present in the TL conditions.

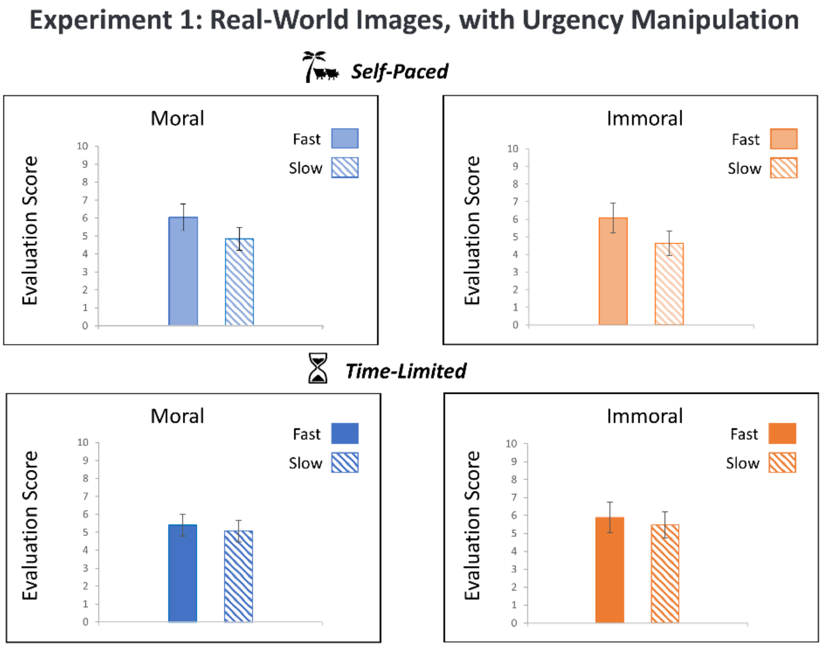

Figure 13. Median-split comparisons between evaluation scores (absolute values) with fast responses versus slow responses in Experiment 1, separately for each condition in the 2 × 2 design with the factors Time Control (Self-Paced and Time-limited) and Morality (Moral and Immoral), based on the averaged data for each participant (N = 30). The error bars reflect the 95% confidence interval around the mean.

2.1.3.3 Analysis of the level of variation

The hypothesis of a speed-precision tradeoff implies that the evaluations should become less precise (i.e., more variable) in a speeded condition. To test this hypothesis, we computed the standard deviation of the unsigned evaluation scores for each participant in each condition. These participant-based standard deviations were then analyzed in a two-way repeated-measures ANOVA, using morality of the image content (moral versus immoral) and time control (self-paced versus time-limited) as within-subjects factors.

There were significant main effects on the participants' standard deviations due to time control ($F(1, 29) = 13.283$, $p < 0.001$, $\eta^2_p = 0.314$) as well as morality of the image content ($F(1, 29) = 12.633$, $p < 0.001$, $\eta^2_p = 0.303$). The interaction between the two factors was not significant ($F(1, 29) = 1.421$, $p = 0.243$, $\eta^2_p = 0.047$). In contrast to the hypothesis of a speed-precision tradeoff, the standard deviations were smaller in the time-limited condition (average SD = 2.119) than in the self-paced condition (average SD = 2.419). Images with moral content (2.103) also generated smaller standard deviations than images with immoral content (2.435).

2.1.3.4 Correlation analysis

To gain further insights into the present data patterns as a function of response speed and the time control conditions, we performed item-based analyses, computing for each image (N = 160) the average evaluation score and response time in the SP condition versus the TL condition. Figure 14 presents the scatter plot with histograms and a linear regression line (with a 95% confidence interval) for the item-based correlation between unsigned evaluation scores in the SP condition versus the TL condition. Pearson's *r* value was 0.694 ($R^2 = 0.481$; $p < 0.001$), indicating very strong evidence supporting a positive correlation. Thus, the moral evaluation scores for the real-world images were very similar across the SP and TL conditions.

Figure 15 presents the scatter plots with histograms and smooth regression lines (with a 95% confidence interval) for the item-based correlations between the evaluation scores and the response times in the SP condition (left panel) and in the TL condition (right panel). For the SP condition, Pearson's *r* value was -0.523 ($R^2 = 0.274$; $p < 0.001$); for the TL condition, Pearson's *r* value was -0.291 ($R^2 = 0.085$; $p < 0.001$). Thus, in both conditions, items that elicited more polarized evaluation scores were processed faster.

Experiment 1: Real-World Images, with Urgency Manipulation

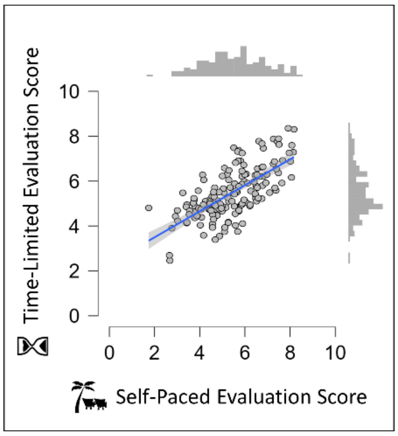

Figure 14. Item-based scatter plot with histograms and linear regression line for the correlation analysis (N = 160) between the evaluation scores (absolute values) in the Self-Paced versus Time-Limited conditions in Experiment 1.

Experiment 1: Real-World Images, with Urgency Manipulation

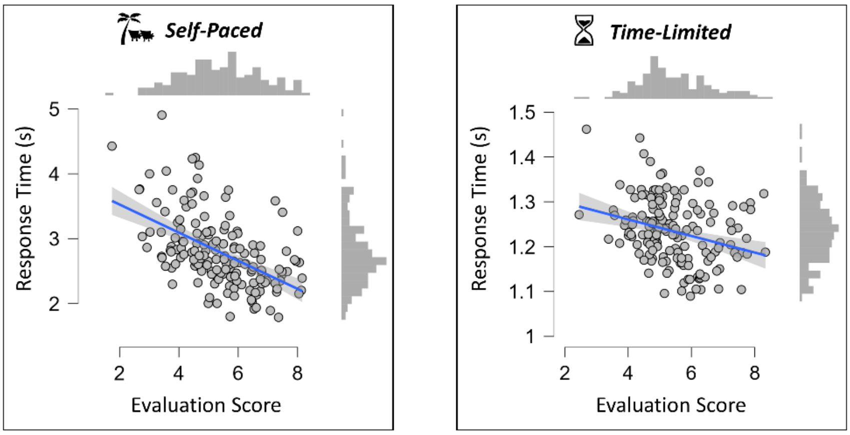

Figure 15. Item-based scatter plots with histograms for the correlation analysis (N = 160) between the evaluation scores (absolute values) and response times in Experiment 1. The left panel shows the data in the Self-Paced condition; the right panel shows the data in the Time-Limited condition. The trends are indicated with smooth regression lines and their 95% confidence intervals.

2.1.4 Discussion

In Experiment 1, we set out to examine the role of speed in subjective evaluation using real-world images ranging from "very moral" to "very immoral" taken from SMID, and asked participants to give ratings to reflect their evaluation on a continuous scale from -10 to +10, either with or without time pressure.

We found that the response speed was much faster in the time-limited condition than in the self-paced condition, proving that our manipulation of urgency was successful. However, the urgency did not affect the means of moral evaluations, with ratings for moral and immoral images that were unchanged in the time-limited versus the self-paced condition. Within conditions, however, a median-split analysis separating fast from slow responses showed that fast responses were associated with more extreme ratings than slow responses only in the SP condition. Thus, while urgency produced increased speed in responding, it also abolished the difference between mean evaluations for fast versus slow responses within the TL condition.

In line with the latter finding, the standard deviations of the moral evaluations tended to be larger in the self-paced condition than in the time-limited condition. This observation appears to run against the hypothesis of a speed-precision tradeoff. However, our measures of precision are not based on within-participant measures of consistency for the same stimuli. In the present paradigm, we opted to avoid repeated presentations, concerned that stimulus repetition might alter the evaluation process (introducing priming and/or familiarity effects). As a consequence, we were not able to measure within-person consistency in evaluation. To study within-person consistency would require a careful research design to control for effects of repetition, order, and time control, adding a level of complexity to be addressed in future investigations.

With the present paradigm, we were able to conduct an item-based analysis, examining the consistency in evaluation for the same images among different participants. The item-based analysis of the data underscored that the ratings given to the images were highly consistent across the time-limited and self-paced conditions, and that extreme ratings (“very moral” and “very immoral”) were associated with faster responses than more moderate ratings.

An additional caveat with the present study is that the joystick we used has an asymmetric handle design and weight distribution that likely implies an uneven resistance of movement across the range, with the largest resistance for initial movements. This may make moderate evaluations more motorically challenging, causing increased response times and thus introducing a confounding factor.

Taken together, the findings in Experiment 1 were compatible with the ease-of-processing hypothesis. However, we did not actually assess the ease of processing of the evaluations. Experiment 2 was designed to provide more direct evidence in support of the ease-of-processing hypothesis.

2.2 Experiment 2: Real-World Images, with Easiness Rating

2.2.1 Introduction

The data pattern in Experiment 1 established that, while speed is associated with polarization of evaluation, this is not due to an active tradeoff. Instead, we hypothesized that the association between speed and polarization is due to the ease of processing. Following on from the exploratory investigation in Experiment 1, we pre-registered

Experiments 2, 3 and 4 of the present study as confirmatory research at OSF (https://osf.io/8fjrk). In Experiment 2 we aimed to examine the ease-of-processing hypothesis by effectively tracking the participants' self-reported easiness of the moral evaluations on a trial-by-trial basis, under self-paced viewing.

Additionally, we changed the image pool based on the SMID to create a more continuous distribution, including the middle range, and categorizing the images as "moral," "moderate," or "immoral." As in Experiment 1, we asked participants to rate real-world images on a continuous scale from -10 ("very immoral") to +10 ("very moral"). In every trial, immediately after performing the moral evaluation, the participants had to rate the easiness of that evaluation. To avoid confusion between the two kinds of assessments, we used horizontal response mapping for the moral evaluation and vertical response mapping for the easiness rating.

2.2.2 Methods

2.2.2.1 Participants

Experiments 2, 3, and 4 were designed and pre-registered in parallel following on from the exploratory Experiment 1. Before data collection, a power analysis using G*Power determined the appropriate sample size for a repeated-measures ANOVA of one group with four measurements to achieve 95% power, detect a medium effect size of 0.25, and maintain a standard alpha error probability of 0.05. The indicated sample size was 36. For consistency, we applied this sample size for each of the three pre-registered experiments. Accordingly, thirty-six students (18 males and 18 females with a mean age of 21.22 years old and a standard deviation of 3.42) at Kyushu University were recruited as participants and completed experiment 2. The participants had no previous experience in any similar experiment. During the experiment, they were asked to use their right hand to manipulate the joystick. Only 1 participant was left-handed. No participant reported issues of health or vision, or past or present psychological disorders. We obtained informed consent in writing from each participant before the experiment, including a no-risk statement and rights protection. Each participant received 1000 yen as monetary compensation for their participation. The experiment consisted of a single session of approximately 1 hour.

2.2.2.2 Apparatus and Stimuli

The experimental set-up was the same as in Experiment 1, except that we used an upgraded version of PsychoPy 3 (version 2021.2.3) and added an eye tracker (GazePoint GP3) and a biometric kit (with the function of recording GSR and heart rate) to record the participant's eye movements and biometric data (not analyzed in the present study). Participants could respond by joystick in the horizontal and vertical direction to give a corresponding score on the left-right and up-down scale showing on the screen. A chinrest with a forehead bar was used to fix the head location at 60 cm from the eye tracker and at 100 cm from the monitor. Participants were able to adjust the chair height for a comfortable posture to avoid movement during the experiment.

The visual stimuli used in this study comprised a total of 180 real-world images consisting for more than two thirds of images used in Experiment 1, while replacing and adding images carefully selected from the SMID to ensure well-balanced moral, neutral, and immoral categories, encompassing a wide range of content.

2.2.2.3 Procedure

The experimental session was divided into 4 blocks of 45 trials, with stimuli randomly presented in each trial and breaks between the blocks. Before the actual data collection, participants were given detailed task instructions and presented with 10 practice trials to familiarize themselves with the operation of the joystick.

All trials started with a 1-s fixation screen, in which a fixation cross was centered at the middle of the top third of the display. A 0.5 s blank screen was shown before the moral evaluation of the image. In the moral evaluation frame, each target stimulus was presented against a black background together with an evaluation scale underneath the image. All images were adjusted keeping the original proportions to the same height at 600 pixels with 96 dpi for horizontal and vertical resolution. The stimulus was centered in the middle of the upper two-thirds of the screen; the evaluation scale was centered in the middle of the lower third of the screen. Participants were asked to rate the depicted content in each image on a continuous left-right scale. The response mapping for the moral evaluation was counterbalanced across participants: Either from -10 ("very immoral") at the left to +10 ("very moral") at the right, or opposite, from +10 ("very moral") at the left to -10 ("very immoral") at the right. The participants had to bend the joystick in the direction of their evaluation and click the trigger on the joystick to mark the evaluation.

The moral evaluation task was explained at the beginning of the experiment, but not shown in words during the trials; instead, only the moral evaluation scale with the labels of the two polar ends was shown in each trial. As in Experiment 1, the participants were instructed to perform the moral evaluation by asking themselves for each image "How morally acceptable is this?" After the moral evaluation, the participants were asked to rate the easiness of the moral evaluation on an up-down scale. For this judgment, the participants were instructed to ask themselves for each image "How easy was it to give the moral evaluation for this?" The response mapping for the easiness rating was also counterbalanced across participants: Either from 0 ("very difficult") at the bottom to 100 ("very easy") at the top, or opposite, from 100 ("very easy") at the bottom to 0 ("very difficult") at the top. The easiness rating marker started from 50, the middle of the scale. The question "How easy was it to rate the morality?" was displayed above the scaler in each trial. At the end of each trial, there was an inter-trial interval (ITI) of between 1.5 and 2.0 s, with a blank screen.

2.2.3 Results

A total of 36 participants were recruited, and each participant completed 180 trials. They were divided into 4 groups to counterbalance the left-right scale for the moral evaluations and the up-down scale for the easiness ratings.

We focused on the moral evaluation scores, the response times of the moral evaluations, and the easiness ratings as dependent measures. The responses were recorded when the participants clicked the trigger on the joystick. The response times of the moral evaluations were defined as the time from the onset of the target image to the click on the joystick.Preliminary analysis to check the counterbalancing showed there were no significant group differences in any of the dependent measures, indicating that the scale directions did not impact on the participants' performance.

To gain insights into the present data patterns as a function of response speed, we performed item-based analyses, computing for each image (N = 180) the average unsigned moral evaluation, the easiness rating, and the response time of the moral evaluation across participants.

Figure 16 presents the scatter plot with histograms and smooth regression line (with a 95% confidence interval) for the correlation between the moral evaluations and the response times. The Pearson's *r* value was -0.543, with $R^2 = 0.295$ ($p < 0.001$), confirming that the responses tended to be faster for items that elicited more polarized evaluation scores.

Figure 17 presents the scatter plot with histograms and linear regression line (with a 95% confidence interval) for the correlation between the unsigned moral evaluations and the easiness ratings. The Pearson's *r* value was 0.878, with $R^2 = 0.771$ ($p < 0.001$), indicating that items that elicited more polarized evaluation scores were strongly associated with higher easiness ratings.

In contrast to the opposite correlation in Figures 16 and 17, the correlation between easiness ratings and response times proved to be highly significant. Figure 18 presents the scatter plot with histograms and linear regression (with a 95% confidence interval) for the correlation between response times and easiness ratings (Pearson's $r = -0.678$, $R^2 = 0.460$, $p < 0.001$). The easier the images were to rate, the faster were the response times.

Experiment 2: Real-World Images, with Easiness Rating

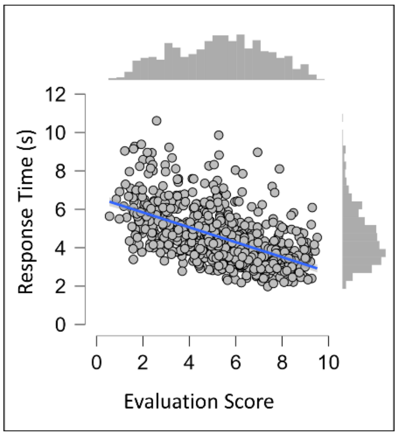

Figure 16 Item-based scatter plot with histograms for the correlation analysis (N = 720) between the moral evaluation scores (absolute values) and response times in Experiment 2, with smooth regression line and its 95% confidence interval.

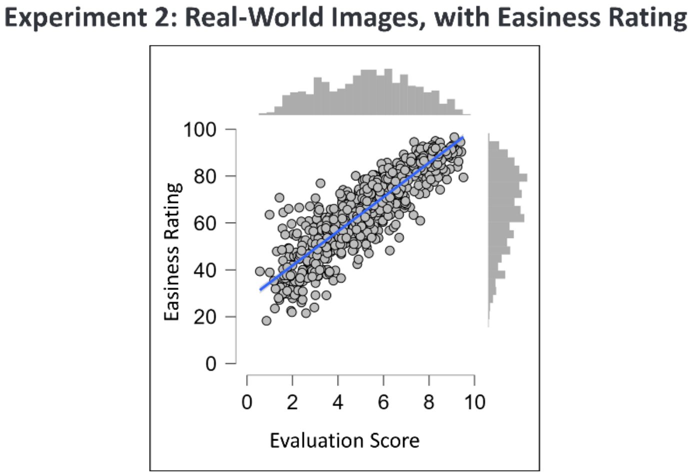

Figure 17 Item-based scatter plot with histograms for the correlation analysis (N = 720) between the moral evaluation scores (absolute values) and the easiness rating in Experiment 2, with smooth regression line and its 95% confidence interval.

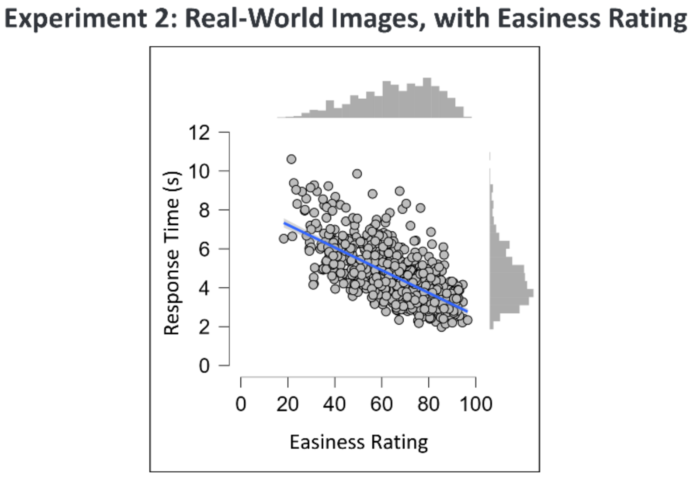

Figure 18 Item-based scatter plot with histograms for the correlation analysis (N = 720) between the easiness rating and response times of moral evaluation in Experiment 2, with linear regression line and its 95% confidence interval.

2.2.4 Discussion

In experiment 2, we set out to provide more direct evidence in favor of the ease-of-processing hypothesis by tracking the participants' self-reported easiness of the moral evaluations on a trial-by-trial basis, under self-paced viewing. The results showed a clear correlation between the easiness ratings and the response times. Easier ratings were performed faster. Notably, the easier ratings also showed a significant correlation to the moral evaluations. The more extreme evaluation scores were associated with higher ratings of easiness. Taken together, the data in Experiments 1 and 2 are best accommodated by the ease-of-processing hypothesis to explain the association between speed and polarization of the moral evaluations.

However, Experiment 2 utilized a slightly modified stimulus set. Thus, we decided to conduct a third experiment in an effort to establish the reproducibility of the findings, and to test the time-limited condition with the stimulus set of Experiment 2.

2.3 Experiment 3: Replication of Experiment 1, with Balanced Stimulus Set

2.3.1 Introduction

In Experiment 2 we used a more balanced stimulus set than in Experiment 1, with a better distribution of images across the spectrum from very moral to very immoral. We reasoned it was necessary to replicate Experiment 1 with the balanced stimulus set to properly rule out the hypothesis of a speed-polarization tradeoff. It remained possible that we had failed to obtain evidence for a tradeoff in Experiment 1 due to the unbalanced stimulus set, if urgency would affect especially the evaluation of images in the middle range, not close to either end of the moral scale. Compared to the clearly moral or immoral images, which are associated with more stable and concentrated evaluations, the middle range of images might be more ambiguous or volatile, and therefore more susceptible to polarization of evaluation under time pressure. Then, Experiment 3 was conducted as a replication of Experiment 1, in all aspects comparable, but with a new group of participants and a balanced set of stimuli.

2.3.2 Methods

2.3.2.1 Participants

A total of N = 36 individuals at Kyushu University (18 males and 18 females with a mean age of 20.92 years old, and a standard deviation of 3.50) met the participation criteria outlined in the preregistration. All participants completed the entire experiment. The participants had no previous experience in any similar experiment. They were asked to use their right hand to manipulate the joystick during the experiment, and 2 participants were left-handed. No participant reported any vision or health issue, or past or present psychological disorder according to their pre-questionnaire before the experiment. All participants had normal or corrected-to-normal vision. The Human Ethics Committee of the Faculty of Arts and Science at Kyushu University approved the study. Informed consent was obtained in writing from each participant before the experiment; the informed consent included a no-risk statement and rights protection. Each participant received 1000 yen per hour as monetary compensation for their participation. The experiment consisted of a single session of approximately 1 hour.

2.3.2.2 Stimuli, Apparatus, and Procedure

The target visual stimuli and apparatus were the same as those in Experiment 2. The experimental paradigm was the same as in Experiment 1 (see Figure 10). An experimental session consisted of 180 trials, divided into four blocks of 45 trials, with two levels of time instruction (SP, TL) and three levels of morality of the image content (moral, neutral, immoral). No image was presented more than once, and all trials were presented in pseudorandom order to ensure that each block of 45 trials contained the same distribution of trials per condition. The assignment of images to SP versus TL conditions was counterbalanced across participants.

2.3.3 Results

The present data set included data from 36 subjects, each presented with a total of 180 trials corresponding to the 2 × 3 design with the factors of Time Instruction (SP versus TL) and Morality of the image content (Moral versus Neutral versus Immoral). All participants completed all trials in the SP condition; on average, all participants completed 94.78% of the trials in the TL condition (standard deviation, S.D. = 4.79). In the remaining 5.32% of the TL trials, the participants failed to respond within the deadline of 2 s. No participant missed more than 20% of the TL trials. The number of completed trials provided sufficient data for the present analyses.

Similar to Experiment 1, we focused on the evaluation scores and response times as dependent measures and performed conventional p statistics using the JASP software package.

2.3.3.1 Overall analysis

Figure 19 presents the means and 95% confidence intervals for the signed evaluation scores (left panel) and for the response times (right panel) as a function of the morality of the image content and the time control condition. This analysis was based on the averaged data for each participant in each condition ($N = 36$).

To be able to compare the evaluation scores across categories of image content in terms of their polarization (i.e., distance from zero), we used unsigned evaluation scores (i.e., absolute values) in a repeated measures ANOVA with the within-subjects factors time control (i.e., SP versus TL) and the morality of the image content (i.e., moral versus neutral versus immoral).

There was a significant main effect of the morality of the image content ($F(2, 70) = 120.078$, $p < 0.001$, $\eta^2_p = 0.774$). Post-hoc pairwise comparisons showed significant differences at $p < 0.001$ among all three types of images. The effect of time control was not significant, with $F < 1$. A statistically significant interaction was obtained between the two factors ($F(2, 70) = 11.439$, $p < 0.001$, $\eta^2_p = 0.246$). Post-hoc pairwise comparisons showed significant differences as a function of time control for moral images (higher evaluation score with the SP cue than the TL cue) and neutral images (lower evaluation score with the SP cue than the TL cue), but not for immoral images.

We also conducted a repeated-measures ANOVA based on the response times, using the same factors as used in the statistical analysis of the evaluation score. The results showed significant main effects for time control ($F(1, 35) = 65.278$, $p < 0.001$, $\eta^2_p = 0.651$) and morality of the image content ($F(2, 70) = 29.670$, $p < 0.001$, $\eta^2_p = 0.459$). Post-hoc pairwise comparisons showed that neutral stimuli produced significantly longer response times than moral as well as immoral stimuli. There was also a statistically significant interaction between the two factors ($F(2, 70) = 22.332$, $p < 0.001$, $\eta^2_p = 0.390$). Post-hoc pairwise comparisons showed the pattern of differences among the image categories was due to the SP condition, whereas in the TL condition, there were no significant differences.

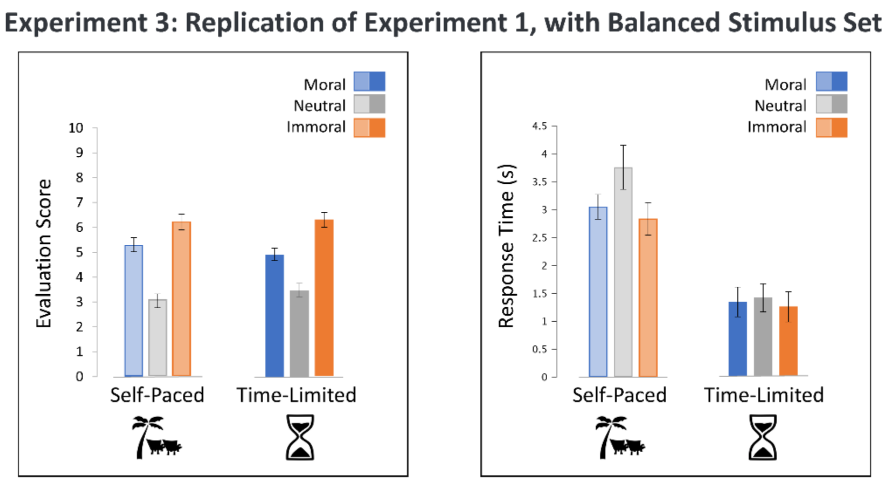

Figure 19. Average evaluation scores (left panel; absolute values) and response times (right panel) for each participant in each condition (N = 36) of Experiment 3. The blue bars show the data with moral images; the gray bars show the data with neutral images; the orange bars represent the data with immoral images. The bars from the Time-Limited conditions are shown in a darker shade than the bars from the Self-Paced conditions. The error bars reflect the 95% confidence interval around the mean.

2.3.3.2 Median-split analysis

Figure 20 presents the averages and 95% confidence intervals of the evaluation scores, comparing fast versus slow responses for each of the 2 × 3 conditions. As in Experiment 1, we also conducted the median split by response time on the corresponding condition and analyzed within-subjects effects of a three-way repeated-measures ANOVA based on the averaged evaluation scores for each participant (N = 36), using morality of the image content, time control, and response speed (fast versus slow).

Again, to be able to compare the evaluation scores for moral and immoral images directly, we inversed the sign for the data with immoral evaluation. Significant main effects were obtained with morality of the image content ($F(2, 70) = 119.746$, $p < 0.001$, $\eta^2_p = 0.774$) and response speed ($F(1, 35) = 70.682$, $p < 0.001$, $\eta^2_p = 0.669$), but not time control ($F < 1$). Within conditions, fast responses consistently produced more extreme evaluation scores (5.282) than slow responses (4.448), but the instruction to perform time-limited evaluations did not induce polarization. As already established by the 2 x 2 repeated measures ANOVA without the median split, there was a significant interaction between the morality of the image content and time control ($F(2, 70) = 11.390$, $p < 0.001$, $\eta^2_p = 0.246$). No other interactions were statistically significant (all F values < 2).

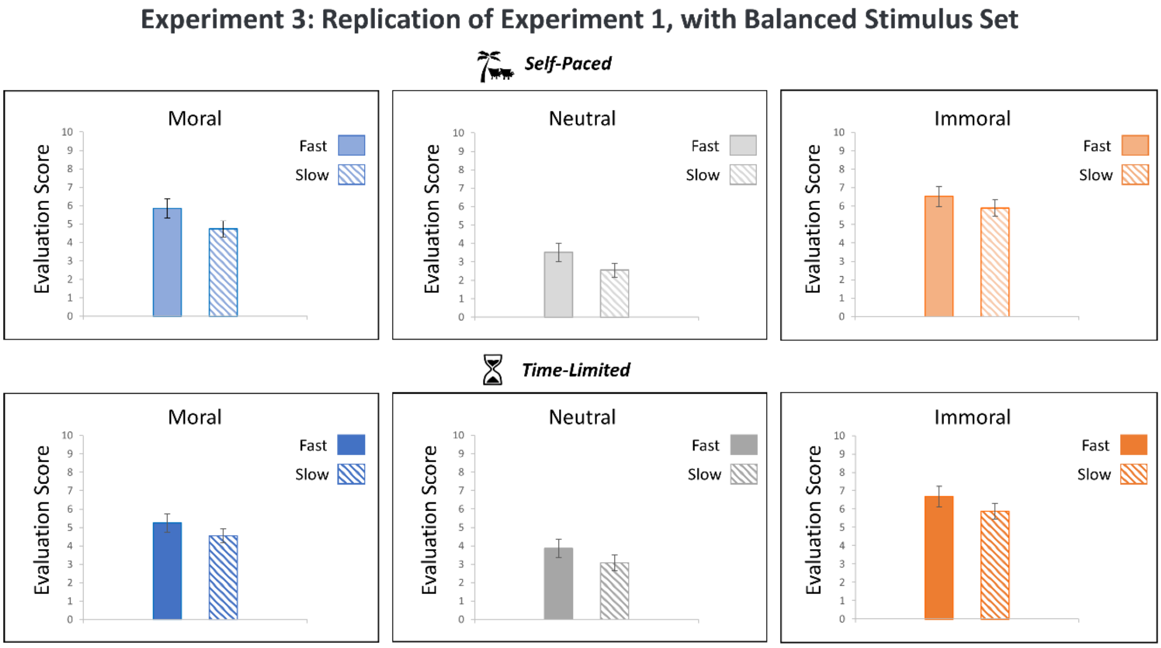

Figure 20. Median-split comparisons between evaluation scores (absolute values) with fast responses versus slow responses in Experiment 3, separately for each condition in the 2 × 3 design with the factors Time Instruction (Self-paced versus Time-limited) and Morality (Moral versus Neutral versus Immoral), based on the averaged data for each participant (N = 36). The error bars reflect the 95% confidence interval around the mean.

2.3.3.3 Analysis of the level of variation

As in Experiment 1, we computed the standard deviation of the unsigned evaluation scores for each participant in each condition. These participant-based standard deviations were then analyzed in a two-way repeated-measures ANOVA, using morality of the image content (moral, neutral, or immoral) and time control (self-paced versus time-limited) as within-subjects factors.

There was a significant main effect of the factor time control ($F (1, 35) = 9.674$, $p = 0.004$, $\eta^2_p = 0.217$), with larger standard deviations in the SP condition than in the TL condition. There was also a significant main effect on the participants' standard deviations from the morality of the image content ($F (2, 70) = 5.573$, $p = 0.006$, $\eta^2_p = 0.137$). Post-hoc pairwise comparisons showed significant differences only with neutral images, producing smaller standard deviations than immoral images as well as moral images. The interaction between morality of the image content and time control was also significant ($F (2, 70) = 3.413$, $p = 0.039$, $\eta^2_p = 0.089$). Post-hoc pairwise comparisons showed that for moral images there was a significant difference in standard deviations as a function of time control, but not for immoral and neutral images.

2.3.3.4 Correlation analysis

Figure 21 presents the scatter plot with histograms and a linear regression line (with 95% confidence interval) for the item-based correlation between unsigned evaluation scores in the SP condition versus the TL condition. Pearson's *r* value was 0.886 ($R^2 = 0.784$; $p < 0.001$). As with the results in Experiment 1, the unsigned evaluation scores for the real-world images were very similar across the SP and TL conditions.

Figure 22 presents the scatter plots with histograms and linear regression lines (with a 95% confidence interval) for the item-based correlations between the unsigned evaluation scores and the response times in the SP condition (left panel) and in the TL condition (right panel). For the SP condition, Pearson's *r* value was -0.549 ($R^2 = 0.302$; $p < 0.001$). For the TL condition, Pearson's *r* value at -0.658 ($R^2 = 0.433$; $p < 0.001$). Thus, in both cases, the significant negative correlation confirmed the association between fast responses and more polarized evaluation scores.

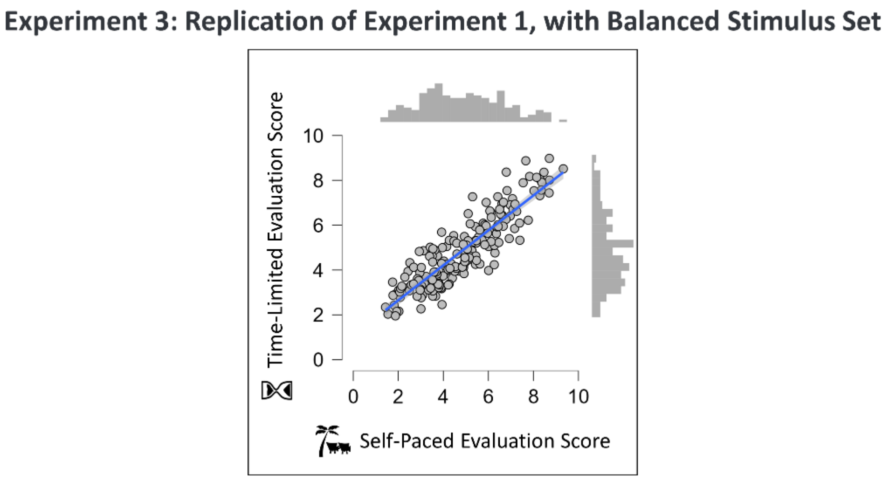

Figure 21. Item-based scatter plot with histograms and linear regression line for the correlation analysis (N = 180) between the evaluation scores (absolute values) in the Self-Paced versus Time-Limited conditions in Experiment 3.

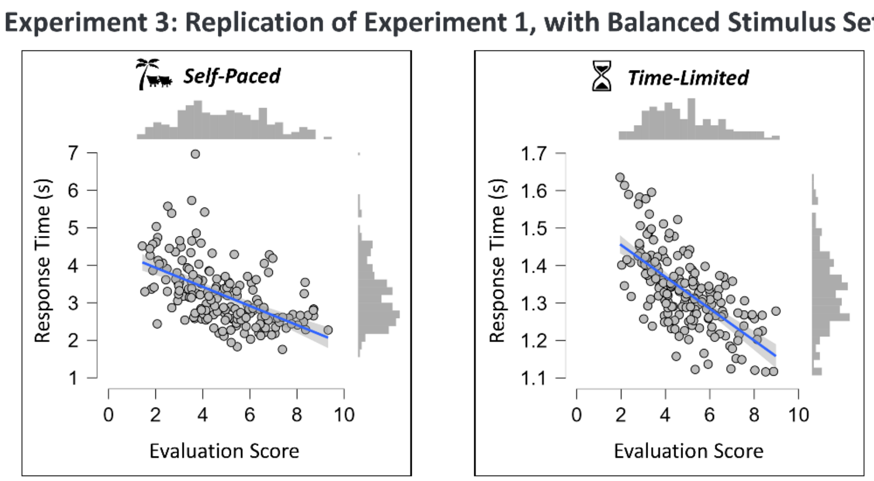

Figure 22. Item-based scatter plots with histograms for the correlation analysis (N = 180) between the evaluation scores (absolute values) and response times in Experiment 3. The left panel shows the data in the Self-Paced condition; the right panel shows the data in the Time-Limited condition. The trends are indicated with smooth regression lines and their 95% confidence intervals.

.3.4 Discussion

In Experiment 3, we introduced neutral images and aimed to replicate the findings of Experiment 1. The response speed was again much faster in the time-limited condition than in the self-paced condition; the greatest difference in response speed as a function of urgency was obtained with the neutral images. However, despite the successful speed manipulation, overall urgency did not affect the means of the evaluation scores. Zooming in on the type of image, however, a relatively small but significant difference was obtained for the moral images, with lower evaluation scores in the time-limited condition than in the self-paced condition, that is, in the direction opposite to the hypothesis of a speed-polarization tradeoff. For neutral images, the evaluation scores increased under time pressure.

Within conditions, a median-split analysis separating fast from slow responses for all image categories showed that fast responses were associated with more extreme ratings than slow responses. Item-based analysis gave solid evidence that the evaluation scores remained consistent regardless of the time-control condition. Yet, images that were rated to have extreme moral or immoral content generated quicker responses than images with moderate ratings.

As in Experiment 1, the standard deviations of the moral evaluations tended to be larger in the self-paced condition than in the time-limited condition, in contrast to the hypothesis of a speed-precision tradeoff. Again, this observation is subject to the caveat that we did not measure within-person consistency in evaluation.

Taken together, the data pattern in Experiment 3 is consistent with the ease-of-processing hypothesis but not the hypothesis of a speed-polarization tradeoff.

2.4 Experiment 4: Food Images, with Urgency Manipulation

2.4.1 Introduction

The previous experiments provided a solid pattern of findings favoring the ease-of-processing hypothesis to explain the association between speed and polarization in moral evaluation. However, moral decision-making is only one instance of subjective evaluation that cannot readily be measured in terms of accuracy. To test whether the findings with moral evaluation can be generalized to other types of subjective evaluation, we designed Experiment 4 as a conceptual replication, using a completely different type of evaluative processing based on preference, particularly with respect to food.

Similar to Experiment 3, we used a balanced distribution of "Appetitive", "Neutral", and "Aversive" images based on the Things object concept and object image database (THINGS database) (Heart et al., 2019) and the FoodCast research image database (FRIDa) (Foroni et al., 2013). We asked participants to rate food images on a continuous scale from -10 ("very disgusting") to +10 ("very attractive") following the Self-Paced or the Time-limited time instructions.

2.4.2 Methods

2.4.2.1 Participants

A total of N = 36 individuals at Kyushu University (21 males and 15 females with a mean age of 21.25 years old and a standard deviation of 2.37) met the participation criteria outlined in the pre-registration. All participants completed the entire experiment. The participants had no previous experience in any similar experiment. They were asked to use their right hand to manipulate the joystick during the experiment, and all participants were right-handed. No participant reported any vision or health issue, or past or present psychological disorder according to their pre-questionnaire prior to the experiment. All participants had normal or corrected-to-normal vision. The Human Ethics Committee of the Faculty of Arts and Science at Kyushu University approved the study. Informed consent was obtained in writing from each participant before the experiment; the informed consent included a no-risk statement and rights protection. Each participant received 1000 yen per hour as monetary compensation for their participation. The experiment consisted of a single session of approximately 1 hour.

2.4.2.2 Apparatus, Stimuli and Procedure

The apparatus and experimental paradigm were the same as in Experiment 3. An experimental session consisted of 180 trials, divided into four blocks of 45 trials, with two levels of time instruction (SP, TL) and three levels of appetitiveness of the image content (appetitive, neutral, aversive). No image was presented more than once, and all trials were presented in pseudorandom order to ensure that each block of 45 trials contained the same distribution of trials per condition. The assignment of images to SP versus TL conditions was counterbalanced across participants.

The target visual stimuli consisted of 180 food images selected from THINGS database (Heart et al., 2019) and FRIDa (Foroni et al., 2013). The categories of appetitive and aversive were consistent with FRIDa used in research of evaluative processing (Ounjai et al., 2018), which included strongly aversive and appetitive food images. To complete the food image database distribution, we supplemented neutral and slightly aversive images based on the original categorization in the food domain of the THINGS database. The images provided content ranging from appetitive to aversive, depicting desserts, gourmet meals, fruit, vegetables, indulgent foods (e.g., chocolates, cakes, ice creams), unadorned foods (e.g., plain white rice, unseasoned vegetables), and spoiled or rotten food. We preselected a balanced set of neutral images and slightly aversive images. For confirmation, we conducted a preparatory rating experiment with ten students in the lab, asking them to rate the preselected images with respect to their preference from -10 (extremely disgusting) to +10 (extremely attractive). The participants were instructed to perform the food evaluation by asking themselves for each image "How attractive is this food?" Each target stimulus was reformatted for the experiment without changing the aspect ratio to maintain the same height at 600 pixels with 96 dpi for horizontal and vertical resolution.

2.4.3 Results

The present data set included data from 36 subjects, each presented with a total of 180 trials corresponding to the 2 × 3 design with the factors of Time Instruction (SP versus TL) and Food categories (Appetitive versus Neutral versus Aversive). All participants completed all trials in the SP condition; on average, all participants completed 94.04% of the trials in the TL condition (standard deviation, S.D. = 3.04). In the remaining 5.96% of the TL trials, the participants failed to respond within the deadline of 2 s. No participant missed more than 20% of the TL trials. The number of completed trials provided sufficient data for the present analyses.

We conducted the same statistical methods as in Experiment 3 to analyze the data, focusing on the evaluation scores and response times as dependent measures.

2.4.3.1 Overall analysis

Figure 23 presents the means and 95% confidence intervals for the signed evaluation scores (left panel) and response times (right panel) as a function of the food categories and the time control condition. This analysis was based on the averaged data for each participant in each condition (N = 36).

Concerning the evaluation scores, repeated measures ANOVA was performed to analyze the within-subjects effect of the time control (i.e., SP versus TL) and the categories of the food image content (i.e., appetitive versus neutral versus aversive). To facilitate a comparative analysis of the evaluation scores in terms of their polarization (i.e., distance from zero), we used unsigned evaluation scores (i.e., absolute values). There was a significant main effect of the categories of the food image content ($F(2, 70) = 95.820$, $p < 0.001$, $\eta^2_p = 0.732$). Post-hoc pairwise comparisons showed significant differences among all three categories, with neutral images receiving the least polarized scores and aversive images receiving the most polarized scores. The effect of time control was not significant ($F(1, 35) = 1.486$, $p = 0.231$, $\eta^2_p = 0.041$), nor was there a statistically significant interaction between the two factors ($F(2, 70) = 1.549$, $p = 0.220$, $\eta^2_p = 0.042$).

The results of repeated-measures ANOVA on the response times showed significant main effects for time control ($F(1, 35) = 114.211$, $p < 0.001$, $\eta^2_p = 0.765$) and food categories ($F(2, 70) = 31.581$, $p < 0.001$, $\eta^2_p = 0.474$). Post-hoc pairwise comparisons indicated that the response times for the three categories of food images were all significantly different from each other. There was also a statistically significant interaction between the two factors ($F(2, 70) = 12.312$, $p < 0.001$, $\eta^2_p = 0.260$). Post-hoc pairwise comparisons proved that the pattern of differences among image categories was due to the SP condition, whereas in the TL condition there were no such differences.

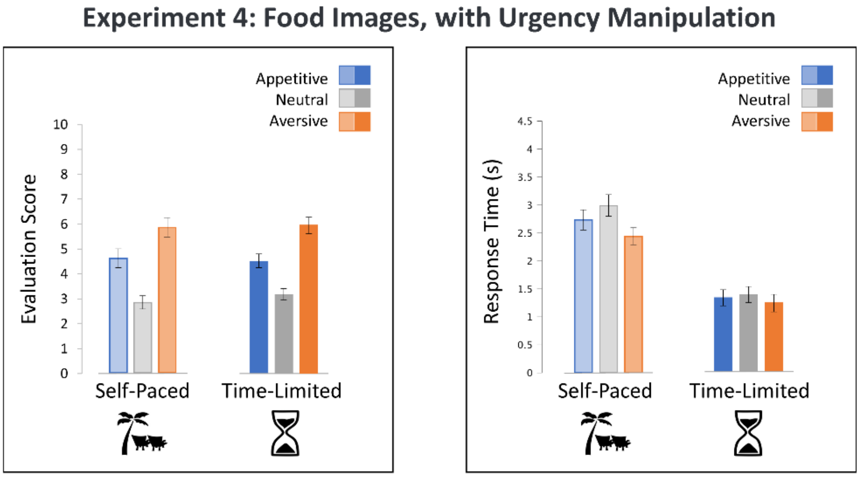

Figure 23. Average evaluation scores (left panel; absolute values) and response times (right panel) for each participant in each condition (N = 36) of Experiment 4. The blue bars show the data with appetitive images; the gray bars show the data with neutral images; the orange bars represent the data with aversive images. The bars from the TL conditions are shown in a darker shade than those from the SP conditions. The error bars reflect the 95% confidence interval around the mean.

2.4.3.2 Median-split analysis

As in Experiment 3, we also conducted a median-split analysis by response time. Figure 24 presents the signed averages and confidence intervals of the evaluation scores, comparing fast versus slow responses for each of the 2 × 3 conditions. The three-way within-subjects repeated-measures ANOVA was based on the averaged unsigned evaluation scores for each participant (N = 36), using food categories, time control, and response speed (fast versus slow).

Significant main effects were obtained with food categories ($F(2, 70) = 95.643$, $p < 0.001$, $\eta^2_p = 0.732$) and response speed ($F(1, 35) = 156.090$, $p < 0.001$, $\eta^2_p = 0.817$), but the effect of time control was not significant ($F(1, 35) = 1.245$, $p = 0.272$, $\eta^2_p = 0.034$).

There was a significant interaction between food categories and response speed ($F(2, 70) = 17.252$, $p < 0.001$, $\eta^2_p = 0.330$) and also a significant three-way interaction ($F(2, 70) = 3.578$, $p = 0.033$, $\eta^2_p = 0.093$. Overall, fast responses were consistently associated with more polarized scores within conditions, but time-limited cues did not affect the evaluation scores differently as compared to self-paced cues.

2.4.3.3 Analysis of the level of variation

As in Experiments 1 and 3, we computed the standard deviation of the unsigned evaluation scores for each participant in each condition. These participant-based standard deviations were then analyzed in a two-way repeated-measures ANOVA, using food categories (appetitive versus neutral versus aversive) and time control (self-paced versus time-limited) as within-subjects factors.

There was a significant main effect on the participants' standard deviations from the food categories (F (2, 70) = 62.980, p < 0.001, η^2_p = 0.643). Post-hoc pairwise comparisons showed significant differences among all three categories. The factor time control also produced a significant main effect (F (1, 35) = 7.246, p = 0.011, η^2_p = 0.172) with larger standard deviations in the self-paced condition (average SD = 2.478) than in the time-limited condition (average SD = 2.329). There was no interaction between the two factors (F (2, 70) = 1.894, p = 0.158, η^2_p = 0.051).

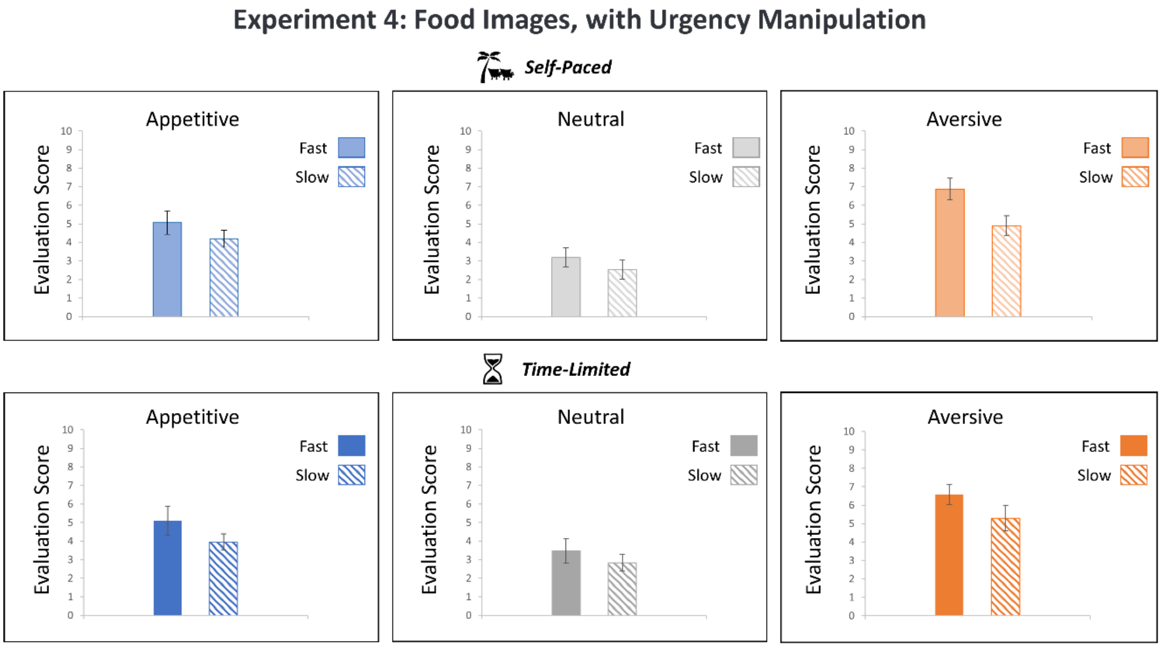

Figure 24. Median-split comparisons between evaluation scores (absolute values) with fast responses versus slow responses, separately for each condition in the 2 × 3 design with the factors Time Instruction (Self-paced versus Time-limited) and Food Categories (Appetitive versus Neutral versus Aversive) in Experiment 4, based on the averaged data for each participant (N = 36). The error bars reflect the 95% confidence interval around the mean.

2.4.3.4 Correlation analysis

Figure 25 presents the scatter plot with histograms and a linear regression line (with 95% confidence interval) for the item-based correlation between unsigned evaluation scores in the SP condition versus the TL condition. Pearson's *r* value was 0.867 (R^2 = 0.752; $p < 0.001$). As with the results of moral evaluation, the scores for food images were very similar across the SP and TL conditions.

Figure 26 presents the scatter plots with histograms and linear regression lines (with 95% confidence interval) for the item-based correlations between the unsigned evaluation scores and the response times in the SP condition (left panel) and in the TL condition (right panel). In both cases, the linear trends were significant, with a Pearson's *r* value of -0.508 in the SP condition (R^2 = 0.258; $p < 0.001$) and -0.674 in the TL condition (R^2 = 0.454; $p < 0.001$). Once again, faster responses were associated with more polarized evaluations in both time control conditions.

Experiment 4: Food Images, with Urgency Manipulation

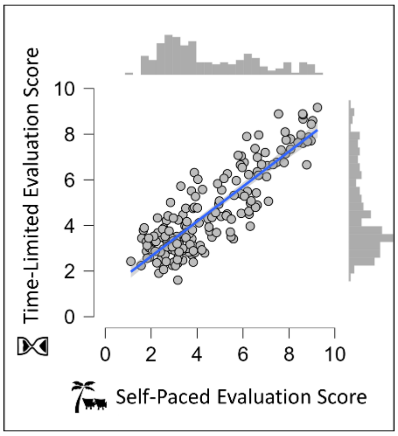

Figure 25. Item-based scatter plot with histograms and linear regression line for the correlation analysis (N = 180) between the evaluation scores (absolute values) in the Self-Paced versus Time-Limited conditions of Experiment 4.

Experiment 4: Food Images, with Urgency Manipulation

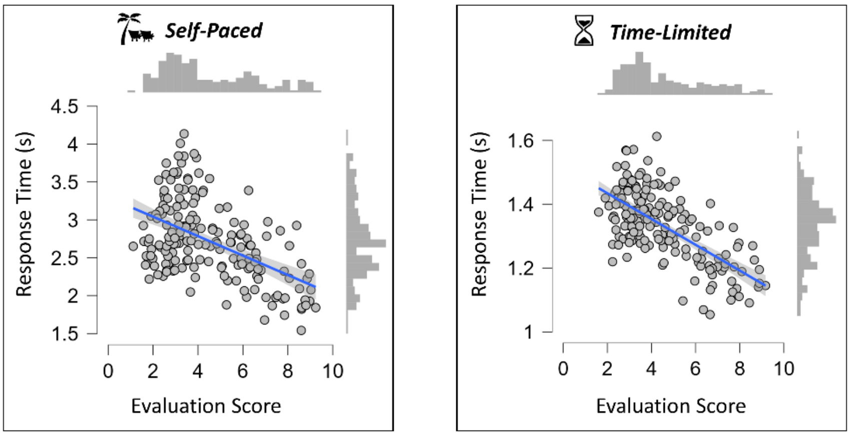

Figure 26. Item-based scatter plots with histograms for the correlation analysis (N = 180) between the evaluation scores (absolute values) and response times in Experiment 4. The left panel shows the data in the Self-Paced condition; the right panel shows the data in the Time-Limited condition. The trends are indicated with smooth regression lines and their 95% confidence intervals.

2.4.4 Discussion

In Experiment 4, we used food images in a preference evaluation task for a conceptual replication of our findings on the association between speed and polarization in moral decision-making. Consistent with our previous findings, the response speed was much faster in the time-limited condition than in the self-paced condition also when evaluating the appetitiveness of food images, proving that our urgency manipulation was very effective. However, despite the significant time pressure, the preference evaluations remained unchanged in the time-limited condition versus the self-paced condition. Thus, urgency does not lead to polarization in the preference evaluation of food images.

Within conditions, a median-split analysis separating fast from slow responses for the food images showed that fast responses were consistently associated with more polarized ratings than slow responses. This was also confirmed in the item-based correlation analysis. In all these respects, the results of Experiment 4 matched with those of Experiment 3, proving that the findings with moral evaluation are generalizable to an entirely different kind of subjective evaluation, based on food preference.

There was also no evidence in favor of a speed-precision tradeoff. Indeed, the standard deviations of the preference evaluations tended to be larger in the self-paced condition than in the time-limited condition.

3 General Discussion

In this study, we set out to examine the relationship between response speed and subjective evaluation with moral evaluations of images depicting real-world scenes, and preference evaluations of food images. We used images with very polarized content as well as neutral content taken from the SMID (Crone et al., 2018), THINGS database

(Baker, 2019) and FRIDa (Foroni et al., 2013). To contrast the hypotheses of a speed-polarization tradeoff versus the ease of processing, we used a cueing procedure to manipulate the urgency of response in Experiments 1, 3, and 4; we asked participants to evaluate the images on a continuous scale from -10 to +10, either with or without time pressure. In Experiment 2 we asked the participants also to give a self-reported measure of the ease of processing for each image. Across the four experiments, we consistently found that extreme evaluation scores were associated with relatively fast responses. Yet, urgency via time pressure made response speed much faster without nudging the subjective evaluations to polarization. The findings rule out a speed-polarization tradeoff, and instead are better explained by an account in terms of the ease of processing.

To examine the possibility of a speed-precision tradeoff, we also examined the levels of variation in SP versus TL conditions in Experiments 1, 3, and 4. Overall, the evidence suggested that time pressure did not cause more noise in the evaluations. Indeed, in Experiments 1, 3, and 4, the data pointed to significant effects in the opposite direction.

Speed does not cause polarization, but it remains possible that, with insufficient time to process the contents of the images, the normal association between fast responses and extreme ratings would break down. People may resort to relatively safe choices under urgency to accommodate the incomplete information processing for decision-making (Wu et al., 2022; Maule, Hockey, & Bdzola, 2000; Dror, Basola, & Busemeyer, 1999). Accordingly, one hypothesis would be that, if participants are not given enough time to recognize the image content, they may respond with moderate or neutral ratings. This view is compatible with the ease-of-processing hypothesis: With additional time pressure, it would become more difficult to perform the evaluations, possibly leading to reduced polarization. Other ways to manipulate the ease of processing would be to either degrade the visual images or to add a dual-task requirement. In all such cases, the more difficult processing should, if it has any effect at all, lead to slowed, more moderate evaluations rather than polarization.

In the present study, we tracked commonalities in evaluation mechanisms across very different tasks, with moral evaluation versus food preference estimation. The findings corroborate our recent conceptual replication of the mechanisms of confirmation bias in subjective judgement (Ma & Lauwereyns, 2024, studying moral evaluation with a paradigm modeled after Ounjai et al., 2018, on food preference estimation; see also Levari et al., 2018, for a similar conceptual replication across very different judgment tasks). More generally, there may be a need in the literature to combine lines of research that are traditionally kept separate (e.g., perceptual decision-making versus value-based decision-making).

In sum, the present paradigm established that response speed is associated with, but does not cause, polarization in the moral evaluation of real-world images and in the judgment of food preference. The data did not reflect a speed-polarization tradeoff but suggested a critical role for the ease of processing.

Chapter 4: Overall Discussion

This thesis studies the role of expectation and speed in moral decision-making using a set of experiments on subjective evaluation. In this chapter, we will discuss the impacts, limitations, and possible future research based on the results of these two studies.

In Chapter 2, we designed an expectation paradigm via three types of predictive cues, investigating how confirmation bias manipulates directional versus non-predictive moral evaluation. Moral ratings aligned with expectations set by cues verified effective confirmation bias, showing more polarization in directional conditions compared to non-predictive ones. And gaze positions during the cue-image interval shifted according to cue instructions, indicating a response bias. The predictive cues were pre-cue to form a prediction before the stimulation of targets, thus our gaze data suggested that the confirmation bias here is at the level of post-perception decision processes. Each decision was made according to predicting, image contents, and processing information that confirms pre-existing expectations. In order to isolate ocular motility factors caused by prediction, confirmation bias, or stimuli, one possible approach is replacing the pre-cue with the post-cue. We could put the cue after stimuli and insert delay after stimuli, cue, and evaluation frames, in this way, gaze movements are able to reflect prediction or decision revealing the cognition change and distinguishing confirmation bias by perception or post-decisional processing, respectively. Especially when images are paired with valid, unknown, or invalid cues, we can explore whether participants will reinforce their original decision or ignore the evidence.

Predictive cues influenced neutral images toward positive or negative evaluations, with high-volatility images affected more in both ratings and response times. This phenomenon is similar to pre-valence-induced concept change (David E. Levari et al., 2018) where prior experience shapes judgment criteria. These findings were verified from low-level perception of color to higher-level judgments of ethics, there is a robust tendency for perceptual and judgmental standards to “creep” when they ought not to. Adapt to our research, when facing neutral images following positive or negative predictions, ethical or unethical requests became rare, so participants began to see innocuous requests as ethical or unethical.

In addition, we confirmed the previous results on food evaluation and obtained new findings on moral judgment, which has significance in exploring the universality of cognitive phenomenon. Regarding the replicable results obtained in two different decision-making, perception-based versus value-based, this finding could be extended to other types of decision-making or even non-human populations.

In Chapter 3, we directly manipulated speed via time pressures in a series of experiments testing two hypotheses on the relationship between speed and subjective moral evaluation and examined their applicability to other subjective decisions like preference evaluations. From the present data, there appears to be no direct analogue of the speed-accuracy tradeoff for subjective decision-making. The level of variation in the moral evaluations also remained unchanged in the Time-Limited versus Self-Paced condition, ruling out any notion of a speed-precision tradeoff. But results suggest a critical role for “Ease-of-Processing,” indicating that faster and more extreme evaluations result from the salience of evaluation-relevant image content.

Here, we note the caveat that our present tests of precision or consistency are based on measurements across participants. Future investigations should test for consistency by multiple repetitions of judgment for the same items with the same participants, while carefully controlling for factors such as familiarity and repetition priming.

Interestingly in this regard, to the extent that time pressure did have an effect on the evaluations, it went in the opposite direction of the proposed speed-polarization tradeoff, particularly for positive evaluation, that is, for real-world images with morally acceptable content in Experiment 3, and appetitive food images in Experiment 4. The data suggested different or asymmetric weights for positive, neutral, or negative aspects depending on the evaluation context (Klaassen et al., 2021; Maule, Hockey, & Bdzola, 2000). The negative evaluation may be driven by content that is relatively more arousing, with negative emotional reactions influenced by autonomic nervous system activity via the anterior cingulate cortex (Hewig et al., 2011). Here it is relevant to note that the extreme negative evaluations tended to be faster than their positive counterparts, significantly so in Experiment 4. The implication is that the negative evaluations could be completed within the given time limit, whereas this may not always have been the case for positive evaluations. When there was not enough time, the evaluations drifted to the middle, an effect of moderation rather than polarization.

Given that time pressure acts as a stressor that takes a high amount of cognitive effort (Silvestrini, & Gendolla, 2019; Bijleveld, Custers, & Aarts, 2010), people may resort to relatively safe judgments or choices under urgency to accommodate the situation when they do not have enough time to complete the required information processing for decision-making. Future studies should be converging operations to examine the role of ease of processing in subjective evaluation.

Although we did not find a direct analogue of the speed-accuracy tradeoff in the present study, it is possible that speed causes indirect changes in subjective evaluation performance. Given that the participants were able to reach the same moral evaluations or food preference judgments in less than half the time, comparing the Time-Limited versus Self-Paced conditions, it seems reasonable to suggest that a large component of the response time in the self-paced condition reflected post-decisional processing, or cognitive processing aimed at further information extraction, beyond the amount needed to reach the subjective evaluation. Recent research on the so-called "moral pop-out" in a lexical decision task with moral and non-moral words has suggested that moral content is prioritized in conscious awareness after perceptual encoding but before memory processing, with discriminatory brain activity as early as 200 ms after stimulus onset (Gantman et al., 2020). In line with this observation, in the present paradigm participants may have been able to assess the evaluation-relevant content well before proceeding to respond, particularly in the self-paced viewing condition.

It is possible that, without time pressure, the natural tendency would be to continue exploring the image content even after moral or food-preference categorization, engaging in intrinsically-motivated or curiosity-driven (Berlyne, 1966) associative information processing and continued semantic inference. If so, it is possible that there would be a tradeoff between speed and the level of processing (Craik, 2002; Craik & Lockhart, 1972), or a speed-memory tradeoff. That is to say, under time pressure, participants would not be able to create detailed episodic memories of the images. If tested, then, participants might show poorer recall and recognition performance for images evaluated under time pressure than for those evaluated in a self-paced condition.

Another consideration with respect to the notion of a speed-precision tradeoff is that in the present study we used only one level of time pressure, requiring the participants to respond within 2 s in the time-limited condition. While this level of time pressure was strong enough to more than double the speed of responding, the item-based correlations indicated that 2 s was, in most cases, long enough for the participants to achieve very similar subjective evaluations across the self-paced and time-limited conditions. Future research (e.g., using tachistoscopic presentations) should examine how urgency affects the moral evaluation when the given viewing time falls below the minimal amount needed to complete the normal categorization. Moreover, we could combine these two studies, setting predictive cues in a time-limited paradigm to investigate how urgency affects confirmation bias.

One technical limitation in the present study is our usage of a joystick that might have an unbalanced resistance across the movement range. While it is unlikely to have impacted the comparisons between SP and TL conditions, it potentially introduced a confounding factor within conditions. Future work should address this issue by implementing different response modes (e.g., using a gamepad with dual sticks, or switching from a continuous categorization to a binary forced choice).

Finally, all eye movements on each specific task were analyzed and will be demonstrated in other paper, while the biometric data collected during the moral evaluation process are currently under analysis, prompting an intriguing inquiry into correlation between decisions and the temporal responses of eye movements, heart rate, and skin resistance levels.

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APPENDIX : Ethics Statement

The research protocols for this study align with the ethical principles outlined in the Declaration of Helsinki, a cornerstone document in research involving human subjects. Approval for the study was granted by the Human Ethics Committee of the Faculty of Arts and Science at Kyushu University, with reference to Issue No. 202201.

All participants provided explicit informed consent in writing, demonstrating their understanding and willingness to participate in the study. The consent process clarified the nature and purpose of the research, as well as the rights and responsibilities of the participants. The study prioritizes confidentiality, and measures have been implemented to protect the anonymity of subjects. The research adheres to ethical guidelines, and potential risks and benefits were carefully considered. This commitment to ethical standards underscores the integrity and validity of the research outcomes. The researcher affirms compliance with the stipulated ethical protocols, ensuring the well-being and rights of participants were paramount throughout the study.