CARDINAL STEFAN WYSZYNSKI UNIVERSITY IN WARSAW

FACULTY OF CHRISTIAN PHILOSOPHY

Patrycja Didyk

Student ID: 4084

Cognitive Processes in Choice-Induced Preference Change: A Comparison of Hindsight Bias and Cognitive Dissonance

Procesy poznawcze w zmianie preferencji wywołanej wyborem: Porównanie zjawiska mądrości po fakcie i dysonansu poznawczego

Supervisor:

dr hab. Marek Nieznański, prof. UKSW

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Table of Contents

Podziękowania

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Abstract

The present dissertation investigates the cognitive mechanisms underlying choice-induced preference change (CIPC). First, we examined the role of memory processes as proposed in the dual-recollection theory. Second, we examined whether the structure and nature of the cognitive processes underlying the reduction of cognitive dissonance (CD) are analogous to those involved in hindsight bias (HB). CIPC is often measure by free-choice paradigm (FCP), which typically has three parts (Rating – Choice – Rating, RCR). The first part is to evaluate the items (e.g., travel destinations, food) according to their desirability, then the second part is the forced-choice task between similarly rated objects. The last part is the re-rating of the same items to see if subjects' preferences have changed. Usually, a shift in preferences consists in increasing the rating of the chosen item and decreasing the assessment of the rejected item. This phenomenon is also known as spread of alternatives, since the difference in desirability between chosen and rejected items spreads.

Experiment 1 (RCR: Desirability, $N = 24$; RRC: Desirability, $N = 24$; RCR: Safety, $N = 24$) and Experiment 2 ($N = 55$) examined the role of processes in dual recollection theory in memory task performance for specific target items, depending on whether the CIPC effect had occurred for those items. Experiment 1 showed that recollection of choice was lowest for chosen objects with opposite-to-choice change in desirability rating, while familiarity was lowest for chosen objects with consistent with choice change in rating. These differences were not observed for the safety rating and for the control procedure with choice made after ratings. In Experiment 2, we manipulated choice difficulty (close vs. distant pairs of options) to address the lack of spread observed for rejected items in the previous study. In the close pairs condition, we found a consistent shift in ratings corresponding to choice, but did not observe significant differences in the parameters representing context recollection. In the distant pairs condition, we observed consistent changes in ratings only for chosen items. However, we

found that context recollection was best for (chosen or rejected) targets with no change in ratings. Additionally, data from Experiment 2 were used to explore the applicability of the multinomial processing tree model of hindsight bias to CIPC in FCP. This model assumes that latent processes of recollection, reconstruction bias and guessing can contribute to the change in rating. The results showed that the reconstruction bias was significantly higher in the close pairs condition than in the distant pairs condition. Experiment 3 ($N = 81$) directly compared the latent cognitive processes underlying HB and CD within a FCP. In the CD condition, participants re-rated previously chosen and rejected items and in the HB condition, participants attempted to recall their original ratings. The results suggested a similarity in the underlying cognitive processes of hindsight bias and cognitive dissonance, however, the sample size was insufficient to draw firm conclusions.

Experiment 4 ($N = 227$) replicated comparisons between CD and HB with a new type of material - artwork and included an instructional manipulation further differentiating CD and HB conditions: participants in the CD condition rated artworks based on personal preference, while participants in the HB condition adopted the third person perspective of an art expert. The results showed that changes consistent with choice were significant and the spread index differed significantly between the two experimental conditions, with a greater spread observed in the CD than in HB. In the final experiment ($N = 107$), participants reflected on their choice by selecting evaluative attributes of the chosen and rejected artworks. The manipulation was designed to either align with, contradict their choice or to remain neutral. This design aimed to test whether the spread of alternatives varied across evaluation types and whether CIPC could be modulated differently in CD and HB conditions, however, the manipulation did not produce the expected effect. Together, the five experiments offer novel insights into the interplay of memory, decision-making, and self-relevance in shaping

post-choice preferences, and contribute to a broader understanding of the mechanisms linking cognitive dissonance and hindsight bias.

Keywords: choice-induced preference change, free-choice paradigm, cognitive dissonance, hindsight bias, dual-recollection theory

Streszczenie

Niniejsza rozprawa podejmuje problematykę mechanizmów poznawczych leżących u podstaw zjawiska zmiany preferencji po dokonaniu wyboru (*choice-induced preference change*, CIPC). Po pierwsze, zbadano rolę procesów pamięciowych postulowanych w teorii podwójnego przypominania (*dual-recollection theory*). Po drugie, sprawdzono, czy struktura i charakter procesów poznawczych związanych z redukcją dysonansu poznawczego (*cognitive dissonance*, CD) są analogiczne do tych, które występują w złudzeniu mądrości po fakcie (*hindsight bias*, HB).

CIPC jest najczęściej badane za pomocą paradygmatu swobodnego wyboru (*free-choice paradigm,* FCP), który składa się z trzech etapów (Ocena - Wybór - Ocena; *Rating - Choice - Rating,* RCR). W pierwszym etapie uczestnicy oceniają obiekty (np. kierunki podróży, jedzenie) pod względem ich atrakcyjności. W drugim etapie dokonują wymuszonego wyboru pomiędzy obiektami o podobnych ocenach. W etapie trzecim ponownie oceniają te same obiekty, aby sprawdzić, czy ich preferencje uległy zmianie. Zazwyczaj zmiana preferencji polega na podwyższeniu oceny obiektu wybranego i obniżeniu oceny obiektu odrzuconego. Zjawisko to określa się jako oddalanie się alternatyw (*spread of alternatives*), ponieważ różnica w atrakcyjności między obiektem wybranym a odrzuconym powiększa się.

Eksperyment 1 (RCR: atrakcyjność, $N = 24$; RRC: atrakcyjność, $N = 24$; RCR: bezpieczeństwo, $N = 24$) oraz Eksperyment 2 ($N = 55$) badały rolę procesów określonych w teorii podwójnego przypominania w zadaniach pamięciowych dla poszczególnych obiektów, w zależności od tego, czy wystąpił dla nich efekt CIPC. W Eksperymencie 1 wykazano, że parametr przypominania sobie wyboru był najniższy w przypadku obiektów wybranych, dla których ocena atrakcyjności zmieniła się przeciwnie do dokonanego wyboru, natomiast parametr znajomości (*familiarity*) był najniższy dla obiektów wybranych, w przypadku

których zmiana oceny była zgodna z wyborem. Nie zaobserwowano takich różnic w przypadku ocen bezpieczeństwa ani w procedurze kontrolnej, w której wybór następował po ocenach. W Eksperymencie 2 manipulowano trudnością wyboru (pary bliskie kontra pary odległe), aby wyjaśnić zaobserwowany wcześniej brak efektu CIPC dla obiektów odrzuconych. W warunku par bliskich stwierdzono spójny ze wskazanym wyborem kierunek zmian ocen, lecz nie zaobserwowano istotnych różnic w parametrach reprezentujących przypominanie kontekstowe. W warunku par odległych spójne zmiany ocen wystąpiły wyłącznie dla obiektów wybranych. Co istotne, parametr przypominania kontekstowego był najlepszy dla obiektów (wybranych lub odrzuconych), dla których nie odnotowano zmian w ocenach. Ponadto dane z Eksperymentu 2 wykorzystano do sprawdzenia użyteczności wielomianowego modelu złudzenia mądrości po fakcie dla CIPC mierzonego w FCP. Model ten zakłada, że na zmianę ocen mogą wpływać procesy ukryte, takie jak przypominanie, tendencyjna rekonstrukcja oraz zgadywanie. Wyniki wskazały, że zniekształcona rekonstrukcja miała istotnie wyższy udział w zmianie oceny w warunku par bliskich niż w warunku par odległych.

Eksperyment 3 ($N = 81$) bezpośrednio porównał ukryte procesy poznawcze leżące u podstaw HB i CD mierzone w FCP. W warunku CD uczestnicy ponownie oceniali wcześniej wybrane i odrzucone obiekty, natomiast w warunku HB próbowali odtworzyć z pamięci swoje pierwotne oceny. Wyniki sugerowały podobieństwo procesów poznawczych odpowiedzialnych za złudzenie mądrości po fakcie i dysonansu poznawczego, choć liczebność próby była zbyt mała, aby wyciągnąć jednoznaczne wnioski.

Eksperyment 4 ($N = 227$) powtórzył porównanie CD i HB, stosując nowy typ materiału - dzieła sztuki oraz wprowadzając manipulację instrukcją bardziej różnicującą warunki CD i HB. Uczestnicy w warunku CD oceniali dzieła sztuki według własnych preferencji, natomiast w warunku HB przyjmowali perspektywę eksperta sztuki. Wyniki

wykazały istotne zmiany zgodne z wyborem oraz istotną różnicę w indeksie rozszerzenia pomiędzy warunkami, przy czym efekt był silniejszy w warunku CD niż w HB.

W ostatnim eksperymencie (N = 107) uczestnicy dokonywali refleksji nad wyborem, przypisując określone cechy wartościujące obiektom wybranym i odrzuconym. Manipulacja polegała na tym, że cechy te były zgodne z wyborem, sprzeczne z nim bądź neutralne. Celem było sprawdzenie, czy oddalanie się alternatyw różni się w zależności od rodzaju ewaluacji oraz czy efekt CIPC można modulować w warunkach CD i HB w odmienny sposób. Manipulacja ta nie przyniosła jednak oczekiwanych rezultatów. Pięć przeprowadzonych eksperymentów razem dostarcza nowej wiedzy na temat wzajemnych zależności między pamięcią, podejmowaniem decyzji a znaczeniem udziału „ja" w kształtowaniu preferencji po dokonanym wyborze oraz wnosi istotny wkład w szersze zrozumienie mechanizmów łączących dysonans poznawczy i złudzenie mądrości po fakcie.

Słowa kluczowe: zmiana preferencji wywołana wyborem, paradygmat swobodnego wyboru, dysonans poznawczy, złudzenie mądrości po fakcie, teoria podwójnego przypominania

"Human life occurs only once, and the reason we cannot determine which of our decisions are good and which bad is that in a given situation we can make only one decision; we are not granted a second, third, or fourth life in which to compare various decisions."

Milan Kundera, The Unbearable Lightness of Being

Introduction

How can we make a good decision? How do we choose the one - the perfect option we will never regret? As Milan Kundera wrote in his classic novel *The Unbearable Lightness of Being*, we are not given a second life to compare the outcomes of the path we didn't take. Our judgment and decision-making are often marked by uncertainty and constrained by limited information related to the choices we face. We must frequently act without knowing all the consequences, relying on incomplete data, intuition, or assumptions to guide us.

While we make numerous decisions every day, the significance of those decisions can vary greatly. Choosing what to eat for breakfast is not equivalent in weight to deciding whether to buy a house. Judgment usually constitutes a crucial initial step in the decision-making process, shaping how we interpret available information and assess our options. It refers to the evaluation of an event or situation based on incomplete information. In contrast, decisions are often evaluated based on their outcomes or consequences (Eysenck & Keane, 2020). Research on judgment and decision-making by Tversky and Kahneman (e.g., 1973, 1974, 1986) offers valuable insights into the nature of human rationality. Their findings demonstrate that intuitive thinking - even among experts - often overrides deliberate, rational analysis (Kahneman, 2012). They compared cognitive biases to the subjective assessment of physical quantities, such as distance or size. These assessments are typically based on data of limited validity and processed using heuristic rules.

For example, the perceived distance of an object is often judged by its clarity: the clearer the object appears, the closer we assume it to be. Under poor visibility, when contours are blurred, we tend to overestimate distance. Conversely, in clear conditions, we may underestimate the distance simply because the object appears more sharply defined. These same mechanisms of biased judgment can also apply to the assessment of probabilities and decision-making under uncertainty (Tversky & Kahneman, 1974).

Later, Kahneman (2012) extend the idea that there are two systems at work in our mind. The names - System 1 and System 2 - are based on the work of Keith Stanovich and Richard West (2000). Kahneman characterizes System 1 as an automatic and rapid process that operates without much energy or conscious control. However, System 2 divides attention between important tasks. This process involves the subjective feeling of decisions and conscious action. Our sense of self is typically associated with System 2.

Both systems work together, minimizing the cognitive effort while optimizing effectiveness. System 2 is effortful, and is able to detect and correct the mistakes generated by System 1. Although decision making often begins with the fast, intuitive process of System 1, when it becomes more complex, System 2 takes over. System 1 performs well when dealing with simple tasks, and the answers it provides are often correct. However, it is also susceptible to systematic, biased error. System 1 operates quickly and intuitively and it does not adhere to the principles of logic or statistical reasoning. And since it reflects automatic cognitive processes, we are generally unable to consciously suppress it.

Due to the characteristics of System 1, we are prone to relying on heuristics. Shan and Oppenheimer (2008) proposed that the goal of using heuristics is to make judgments while minimizing cognitive effort. They identified five aspects of heuristics: 1) examining fewer cues - less information must be acknowledged, 2) reducing the difficulty associated with retrieving and storing cue values - by retrieving accessible information, 3) simplifying the weighting of cues, 4) integrating less information overall, and 5) examining fewer alternatives. Similarly, Gigerenzer and Gaissmaier (2011) defined heuristic as a "strategy that ignores part of the information, with the goal of making decisions more quickly, frugally, and/or accurately than more complex methods" (p. 454).

In contrast, normative decision models, for example multi-attribute utility theory (see Jansen, 2011), states that decision-maker chooses the option that yields the greatest utility

from a number of possible alternatives. According to this model, individuals detect all relevant attributes, assign utility values to each attribute and then choose the option with the highest utility score. However, applying this approach in real life is often unrealistic. It requires complete knowledge of all available options and the ability to evaluate them thoroughly. In practice, individuals often lack full information and are constrained by the limits of cognitive resources (e.g. short-term memory capacity) (Eysenck & Keane, 2020).

Another factor contributing to the complexity of decision-making is changing nature of human preferences. While multi-attribute utility theory presents the preferences as stable, research suggests otherwise. For example, Fischer and Greitemeyer (2010) presented a model of selective exposure which shows the tendency to prefer information consistent with one's beliefs over inconsistent information. This tendency correlates with higher need to defend personal position. This effect was also demonstrated by Simon et al. (2004), in their study, participants' preferences shifted to cohere with the choice.

The shift in preferences is also known as choice-induced preference change (CIPC) or spread of alternatives. It is defined as the tendency to increase the rating of chosen items and decrease the rating of rejected ones (Salti et al., 2014). Studies by Chammat et al. (2017) and Salti et al. (2014) employed the free-choice paradigm (FCP), in which participants first rated a set of travel destinations, then made choices between similarly rated options. After making their choices, participants re-evaluated the selected destinations as more attractive and the rejected ones as less attractive. These results have been interpreted as a form of cognitive dissonance (CD) reduction.

Cognitive dissonance theory (Festinger, 1957) challenges the assumption that humans process information in a purely logical and rational manner. It might be understood as a theory of cognitive balance, in which the reduction of dissonance is a process that consistently guides cognitive activity toward greater coherence and consistency (Joule, 1986).

A similar need for coherence can be observed in the phenomenon of hindsight bias (HB). This cognitive bias arises because people are motivated to perceive past events as more predictable than they actually were. In an effort to "make sense" of the past, individuals may forget, de-emphasize, or reinterpret information that cannot be easily integrated into the dominant narrative (Fischhoff & Beyth, 1975).

In my dissertation, I explored the choice-induced preference change. First, I aimed to identify which memory processes from dual-process theory of recollection memory are involved in the reduction of cognitive dissonance. Second, I examined whether the structure and nature of the cognitive processes underlying the reduction of cognitive dissonance are analogous to those involved in hindsight bias.

The theoretical context of the research project

"Thus, dissonance theory does not rest upon the assumption that man is a rational animal; rather, it suggests that man is a rationalizing animal - that he attempts to appear rational to others and to himself" (Aronson, 1969, p.3)

Theory of cognitive dissonance

Leon Festinger introduced the theory of cognitive dissonance in 1957, describing how individuals experience discomfort when holding two conflicting cognitions. He defined cognitions as elements of knowledge: what people know about themselves, their behaviours, and their surroundings. Festinger used the term knowledge broadly, encompassing opinions, desires, personal experiences, and values. When two cognitions are unrelated, they are irrelevant to each other. If they are related, they can be either consonant (consistent) or dissonant (inconsistent). The presence of dissonance creates psychological discomfort, which motivates individuals to reduce it and restore consonance. To achieve this, people may change their attitudes, beliefs, or behaviours. Additionally, they tend to avoid information or situations that could increase dissonance.

The best-known example of two cognitions creating dissonance is the smoker example. A smoker learns that smoking is harmful to health. The cognition "I smoke" is dissonant with the cognition "Smoking harms my health." The knowledge that smoking is unhealthy conflicts with the act of continuing the addiction. To resolve this discomfort, a person might choose to quit smoking. Then, the cognition: "I'm quitting smoking because is unhealthy" is consonant with cognition "Smoking harms my health". While this change would reduce dissonance, research suggests that people rarely alter their behaviour simply due to

new information. Instead, they are more likely to seek counterarguments to refute the information that makes them feel uncomfortable.

Dissonance after making the decision

When a person makes a decision, they choose one option over another. Dissonance does not exist between two options themselves; rather, it arises when we are forced to choose between them. Festinger (1957) described this process as the relationship between cognition and behaviour. When someone selects Option 1 and, in doing so, rejects Option 2, all the cognitive elements that led to choosing Option 1 align with the decision (they are consonant). However, the cognitive elements that could have justified choosing Option 2 are now in conflict with the chosen decision, creating dissonance. To illustrate this more clearly, imagine debating between two travel destinations. When considering Spain and Italy, we weigh the positive and negative aspects of each country. The reasons that convinced us to choose Spain over Italy are in harmony with our decision (consonant). However, Italy also had positive qualities, and those now stand in contrast to our choice (dissonant). Furthermore, while Spain may have been the better choice for us, it also has its downsides. Once a decision is made, we must deal with its consequences. This means accepting the negative aspects of our chosen option while also coming to terms with the loss of the positive aspects of the rejected option. Festinger emphasized that dissonance is stronger when the rejected option is particularly attractive. This happens because, even after making a decision, we continue to recall the appealing qualities of the option we did not choose. The more attractive the rejected option is compared to the chosen one, the greater the proportion of conflicting cognitive elements in relation to the final decision. The magnitude of dissonance increases with the number and importance of these conflicting elements. As a result, dissonance becomes more noticeable in significant and difficult decisions. Festinger wrote: “Two elements are in dissonant relationship if, considering these two alone, the obverse of one element would follow from the other. To state

it a bit more formally, x and y are dissonant if not-x follows from y" (Festinger, 1957, p. 26). If two elements are in a dissonant relationship, the intensity of dissonance depends on their significance - the more important these elements are or the greater the value a person assigns to them, the stronger the dissonance will be.

Festinger (1957) mentioned the importance of individual assessment of the elements, but he focused on the overall number of cognitions that contributes to the magnitude of dissonance. The dissonance varies in magnitude and it depends on the proportion of relevant elements that are dissonant with behavioural elements (Mills & Ross, 1964). Specifically, the intensity of dissonance depends on the proportion of dissonant to consonant cognitions. If the number or importance of dissonant cognitions increases while the number and importance of consonant cognitions remain constant, the magnitude of dissonance will rise. Conversely, if the number or importance of consonant cognitions increases while dissonant cognitions remain constant, the magnitude of dissonance will decrease. In Festinger's work, the measure of elements is orientated by a special cognition - behaviour. Joule (1986) commented on this dissonance ratio and presented it as an equation: "the total amount of dissonance is a function of D divided by D + C (where D is the number of dissonances involving a given cognition, and C the total number of consonances)" (p. 66). So, in the smoker example, D represents cognitions about the danger of smoking and C represents rationalization of the smoker's behaviour. The behaviour (smoking cigarettes) is the particular, special cognition to which cognition C and D relates to.

Later, Beauvois and Joule (2019) expanded on the concept of the dissonance ratio, illustrating how cognitions within the ratio are determined by their relationship to the generative cognition and how this, in turn, influences the magnitude of dissonance. The goal of the reduction of dissonance is not increasing the number of consistent cognitions, but rather

the rationalization of behaviour that produces the cognition which is the most resistant to change, which Beauvois and Joule (2019) called generative cognition.

Reduction of cognitive dissonance

The mere presence of dissonance creates a desire to reduce it. Festinger (1957) identified three main strategies for reducing dissonance. The first approach is to **change one of the dissonant cognitions**, which can be achieved by altering behaviour or attitude. For example, a smoker could reduce dissonance by quitting smoking. However, change is not always possible. Modifying behaviour or attitude may be too difficult or it can come with significant emotional and cognitive costs. The second strategy focuses on reducing dissonance by **modifying environmental cognitions** - that is, shaping one's environment in a way that minimizes conflicting thoughts. This can include seeking social validation for one's behaviour or beliefs, and avoiding situations, information that might intensify the dissonance, or trivializing dissonant behaviour (Cancino-Montecinos et al., 2020). The third strategy is **adding new cognitions**. In this case, the smoker might rationalize their behaviour by convincing themselves that smoking is no worse than other everyday risks, such as driving a car. They might also actively seek out research that downplays or contradicts the health risks of smoking.

Different studies have expanded on the reduction strategy. For example, Simon et al. (1995) distinguished trivialization which can be described as decreasing the importance of the elements that are involved in the dissonant relations. Gosling et al. (2006) further contributed by emphasizing the role of denial of responsibility as a reduction mechanism. It reduces dissonance through a mechanism of disengagement from one's own behaviour. A person does not experience a negative affect because they are not conscious of the inconsistency between their attitude and their behaviour. Their findings suggest that, when given a chance, individuals will deny their responsibility for their actions.

Festinger (1957) viewed the tendency to avoid additional dissonance as an inherent response to the presence of dissonance itself. However, Mills (2019) challenged this assumption, arguing that the magnitude of dissonance does not necessarily correspond to a stronger tendency to avoid new, potentially dissonant information. In an earlier experiment (1965), Mills examined how the level of existing dissonance affects interest in both consonant and dissonant information. The results showed that participants were more inclined to seek out information that supported their decision (consonant information) rather than actively avoiding information that favoured the rejected option. Mills (2019) also proposed that the desirability (or undesirability) of a decision's consequences should be incorporated into dissonance theory. According to this perspective, the formulation of dissonance should involve three key cognitions: a) a cognition about behaviour, b) a cognition about a consequence of the behaviour, c) a cognition about the desirability (or undesirable) of the consequences. In relation to the smoker example, Mills presented that smoker should feel the greater dissonance if he thinks there is a 100% probability that smoking causes cancer rather than there is only 1% probability of the disease. He stated that this proposition better explains why dissonance is sometimes reduced by changing an attitude or belief.

Cancino-Montecinos et al. (2020) presented a general model of dissonance reduction. They proposed that the reduction of dissonance is a reduction of negative feelings so it might be referred as an emotion-regulation process. However, reduction strategies related to cognitive restructuring are not related to full-blown emotions but rather affect-like discomfort. This might happen in free-choice paradigm and effort justification paradigm, as the participants are able to resolve the situation of dissonance.

Different explanations of cognitive dissonance

In 1972, Bem proposed the **self-perception theory** as a challenge to Festinger’s assumptions. This theory suggests that the effects of dissonance stem from rational conclusions drawn by

observing one's own behaviour. Festinger and Carlsmith's (1959) experiment illustrates this idea: if we see someone writing an essay in support of violent behaviour and learn that they are receiving only a small payment (e.g., 2 złoty) for doing so, we are likely to assume that they genuinely agree with the controversial stance. Since the reward is too insignificant to serve as a strong motivational factor, we conclude that their writing reflects their true beliefs. According to Bem, we apply the same reasoning to ourselves, forming our beliefs based on the most recent behaviours we remember and the information available in our memory. He argued that the reduction was due to the nonmotivational process, merely by adjusting the attitude by observing the behaviour.

In the experiment of Zanna and Cooper (1974), participants attributed their dissonance-produced arousal to the pill they were given before writing counter-attitudinal essay. They believed that the given pill was a part of a different study investigating the drug's effect on short-term memory. It was mentioned that the pill's side effects could cause feeling of tension. The results showed that participants experienced less dissonance when they could attribute their well-being to the external agent. However, the group that was told that the pill would relax them, had experienced greater dissonance and attitude change, as there was no external reason for their behaviour. The external agent allows subjects to justify their behaviour without adjusting their attitudes (Fazio et al., 1977). However, these results are difficult to explain using self-perception theory. Bem's theory states that attitude change does not result from motivation to reduce the discomfort caused by CD. The new attitude emerges, if a person's behaviour is more extreme than the initial attitude (but it does not have to be a contradictory attitude). So, reducing this discomfort by attributing it to a pill, would not affect attitude change. Other studies (e.g., Elliot & Devine, 1994; Harmon-Jones et al., 1996), which demonstrated that dissonance is accompanied by physiological arousal and that cognitive changes are motivated by the need to reduce psychological discomfort, further contributed to

the view that self-perception alone cannot account for these findings. However, the study by Fazio et al. (1977) proposed a reconciliation between self-perception and dissonance theories, presenting them as complementary rather than competing.

In 1988, Steele explained dissonance reduction through **self-affirmation theory**. This theory suggests that thoughts and actions are driven by the motivation to maintain a positive self-image. Inconsistent information threatens sense of moral and adaptive integrity. The strength of the self-affirmation drive depends on the level of threat posed by the information. Steele proposed that a smoker, for example, could reduce dissonance by affirming other aspects of their life, such as being a good husband or a dedicated employee, thereby preserving their overall sense of self-worth.

Another explanation emphasizing the significant role of the ego was presented by Aronson in 1969. He introduced the **self-consistency theory**, arguing that people experience dissonance when their behaviour contradicts their self-concept. However, in contrast to self-affirmation theory, this model continues to emphasize the importance of the need for consistency. Most individuals hold a positive self-concept, perceiving themselves as reasonable and wise. According to Aronson, dissonance arises when they are persuaded or induced (e.g., through the induced-compliance paradigm) to act in ways that conflict with this self-perception. He emphasized the self-concept as a central factor in dissonance processes, as people generally strive to maintain a consistent and positive sense of self. Dissonance reduction involves self-justification, as individuals seek to reconcile feelings of immorality, confusion, or embarrassment triggered by their actions or decisions. The more personally involved someone is in a behaviour and the less external justification they have for it, the stronger their cognitive dissonance and the greater their need for self-justification. For example, a person who lies to others will experience dissonance because their actions threaten their self-concept as a good and moral individual (Aronson, 2019). Self-affirmation and self-

consistency theories share similarities but make opposing predictions regarding how individuals with low and high self-esteem will reduce dissonance. Self-affirmation theory suggests that people with low self-esteem will rationalize more, as they have fewer resources to defend against threatening information (Nail et al., 2001; Nail et al., 2004) In contrast, self-consistency theory predicts that individuals with high self-esteem will rationalize more, as their positive self-concept is in conflict with their behaviour (Aronson et al., 2019).

Gawronski and Brannon (2019) provided a broader understanding of cognitive dissonance by adding the concept of **cognitive inconsistency**. They understand inconsistency (or consistency) as a "property of the relation between cognitive elements" and dissonance as the "aversive feeling that is assumed to arise from inconsistent cognitive elements" (p. 92). The dissonance in Festinger's definition is limited to discrepancies between attitudes and behaviours. Cognitive (in)consistency is described as propositional beliefs with subjective assumption of positive or negative truth about relations between elements. This process often results from more than just two propositional beliefs, unlike Festinger's original dissonance theory, which focused on the conflict between two opposing elements. They presented an example: *Canadians are friendly; Uli is unfriendly; Uli is Canadian*. The inconsistency can be reduced by updating the belief. It can be changed by adding an exception (e.g. *Some Canadians are unfriendly*).

Cooper and Fazio (1984) presented the **New Look model** that focuses on the consequences of actions, not just the mere inconsistency between beliefs and behaviour. According to their theory, cognitive dissonance is a state of arousal caused by feeling responsible for producing the aversive event. The arousal then becomes the motivation to reduce dissonance, serving as the driving force behind attitude or behaviour change (see also Cooper, 2019). The theory is often examined using induced-compliance paradigm which is discussed later in the text.

Also, the **action-based model** first proposed by Harmon-Jones (1999) and later elaborated in the revised edition (Harmon-Jones and Harmon-Jones, 2019), highlights that cognitive inconsistency can cause the negative affective state and a motivation to reduce it. The theory suggests that cognitions usually guide behaviour and if they are inconsistent with each other, dissonance arises because effective action cannot happen. The emotional state acts as a motivator to restore coherence. The model distinguishes between the inconsistency itself - referred to as "cognitive discrepancy"- and the resulting unpleasant emotional state, termed "dissonance." It is this aversive emotional state that drives the motivation to resolve the discrepancy.

Another explanation presents the **impression management theory**, which roots cognitive dissonance in the social influence process. The theory posits that individuals are motivated to control how they are perceived by others (Tedeschi et al., 1971). A person may behave in ways that does not align with their personal values in order to appear more attractive or gain greater acceptance within a group. The discrepancy between internal beliefs and behaviour can create dissonance, especially in social situations when the need of positive impression is increased (Rosenfeld et al., 1984).

Measures of cognitive dissonance

There are several popular experimental paradigms in the literature that are used to measure cognitive dissonance. The first, and also probably the most popular one is the **induced-compliance paradigm.** In this experimental setting, participants are induced to act contrary to an attitude. In Festinger and Carlsmith (1959) experiment, participants were given either 1$ (low justification) or $20 (high justification) to tell a fellow participant that a given task, which was actually very boring, is interesting and they would perform it again in future if they had a chance to. The experiment engaged participants in counter-attitudinal behaviour.

The results showed that participants who received low justification experienced dissonance and changed their attitudes because of the inconsistency between the belief that the task was boring and their behaviour - claiming that the task was interesting. People who received 20$ did not experience dissonance, as the money justified their behaviour. The less money they received, the more positive attitude they had (Harmon-Jones & Mills, 2019). In 1970, Cooper and Worchel replicated and extended Festinger and Carlsmith's study by introducing a new condition in which participants shared their experience with another person waiting to take part in the study. In the "confederate-not-convinced" condition, the confederate was instructed to remain unconvinced and express the view that the psychological experiments were not interesting. The results showed that attitude change occurred only in the condition where the confederate believed the participant. This finding was interpreted as evidence that dissonance-related attitude change occurs only when individuals feel personally responsible for producing an aversive consequence - supporting the New Look model proposed by Cooper and Fazio (1984). However, Harmon-Jones et al. (1996) and Harmon-Jones (2000) using induced compliance paradigm tested whether attitude change could occur even in the absence of aversive consequences. The results confirmed the hypothesis, the attitude change can take place when cognitive inconsistency is present even without the production of aversive consequences.

The belief-disconfirmation paradigm is based on Festinger, Riecked and Schachter's (1956) field-study. The scientists acted as observers in a doomsday cult whose members believed a prophecy about a flood that would engulf the continent. The group believed that the information about the flood was delivered from outer space and the members were the chosen ones, destined to be saved from the flood by a flying saucer. When the predicted flood did not occur, members who experienced the disconfirmation alone tended to abandon their beliefs. However, those who remained within the group, generated a new explanation: the

woman who had initially announced the prophecy claimed that their faith and unity had averted the disaster, and they were saved by divine intervention. Following the disconfirmation, group members engaged in proselytizing. This paradigm demonstrates that when a central and deeply held belief is disconfirmed, it generates cognitive dissonance. To resolve this internal conflict, individuals may strengthen their belief rather than abandon it. Similar findings were reported by Batson (1975), who found that students who had publicly committed to a religious belief, and were subsequently confronted with disconfirming evidence, showed a significant increase in the intensity of their belief.

The effort-justification paradigm was used for the first time by Aronson and Mills (1959). Participants were invited to join a discussion group. They were randomly assigned to two conditions: severe initiation and mild initiation. In the severe condition, subject took part in an embarrassing activity to join the group, whereas in the mild condition, the activity was not as embarrassing. However, the discussion group was quite boring. The results showed that participants who performed the embarrassing activity, evaluated the group more positively than the ones in the mild condition. Dissonance occurs when a person engages in an unpleasant activity to obtain a certain outcome. The greater the effort in the unpleasant activity, the greater dissonance that can arise. To reduce it, a person may overestimate the value of the outcome of this activity, saying that a boring group discussion was very interesting. The next paradigm, introduced by Stone et al. (1994), is known as the **induced-hypocrisy paradigm**. A study on AIDS prevention demonstrated that individuals who were made aware of their own hypocrisy engaged in compensatory behaviour as a way to amend their inconsistency.

Finally, a popular measure of cognitive dissonance is the **free-choice paradigm (FCP)** presented by Brehm (1956). A typical FCP experiment has three parts. The first is to evaluate the item (e.g., a travel destination, food, electrical items) according to the desire to

have them. The second part is the forced-choice task between two similarly assessed items. The third phase is a reassessment of all items to see if our preferences have changed. The second part has the manipulation consistent with Festinger's assumption, as the hardest choice, the greater cognitive dissonance. In the Brehm's study participants were asked to rate articles (e.g. an automatic coffee-maker, toaster, portable radio) on a scale from one to eight, where one meant "definitely not at all desirable" and eight - "extremely desirable". Participants were instructed to rate the desirability based not only on the attractiveness, but also on how much they needed the object. In the next part of the experiment, the products were presented in pairs based on participants' ratings. In the condition with high cognitive dissonance, pairs included close in rating objects, the difference in rating was only ½ or 1 and ½ scale-points lower. In the low dissonance condition, the difference was always 3 scale-points lower. Next, the participants were asked to rate the objects again. Before this second evaluation, they were given time to read more about the products. This second rating was explained as a way to assess how evaluations might change after further consideration. The results supported the prediction that choosing between two options creates dissonance. To reduce this discomfort, participants tended to enhance the desirability of the chosen option while devaluing the rejected one. However, FCP has been also criticized as biased by a statistical artifact (for reviews see: Enisman et al., 2021; Izuma & Murayama, 2013). Chen and Risen (2010) suggested that the CIPC effect that is observed in the FCP may not follow the subject's genuine preferences change. Since ratings are inherently noisy measures of preferences, changes in ratings may be attributed to a regression to the mean. For example, when two options (e.g., A and B) receive similar initial ratings, it could be due to an underestimation of preference for A or an overestimation for B leading to the selecting A in the choice phase. So, an apparent CIPC effect might emerge even when actual preferences remain stable. This critique was later moderated by counterarguments presented by Alós-

Ferrer and Shi (2015) and meta-analysis of Enisman et al. (2021). Nonetheless, it is widely acknowledged that some form of control procedure (such as the Rating-Rating-Choice design) is essential for properly interpreting results from FCP experiments (e.g., Chammat et al., 2017; Enisman et al., 2021).

Beginnings of Hindsight Bias Research

In the 1967, Elaine Walster wrote an article "'Second Guessing' Important Events", in which she presented the idea that people have tendency to overestimate their prediction after they learnt about consequences of the event. Walster conducted two experiments in which participants were asked to predict the outcomes of another person's decision to buy a house. In one experimental condition - financial gain - participants were told that a valuable mineral had been discovered on the buyer's land, resulting in a potential profit from the purchase. In the second condition - financial loss - participants were told that, due to mud damage, a large part of the house required renovation. Within both conditions, the magnitude of gain or loss was manipulated (e.g., $20, $700, or $22,000). The results from both experiments showed that the better the actual outcome was reported to be, the more confident participants were that they would have predicted a positive result. The same pattern was observed for negative outcomes: the worse the loss, the more confident participants were that they would have anticipated it. Walster interpretated these results as evidence that people have a need to view the world predictable and controllable.

Then, in 1975 Baruch Fischhoff and Ruth Beyth published a paper about phenomenon they called "I knew it would happen". In their study, they asked students to assess the probabilities of several possible outcomes of the visits of President Nixon to China or to Union Of Soviet Socialist Republics, before the events have happened. The students assigned each potential outcome a probability value ranging from 0 to 100%. This assessment can be referred as original judgment (OJ). After the visits had taken place, the researchers asked the

students to recall their initial assessments. If students could not remember their original answers, they were asked to estimate the probability they believed they had assigned earlier. This response is called - recollection of the original judgment (ROJ). Students were also asked to indicate whether they believed each outcome had actually occurred. This step aimed to determine what each participant thought had happened. The results supported the hypothesis that the knowledge of outcomes of the trips maybe associated with bias in prediction recollection or reconstruction. The difference between ROJ and OJ were bigger for the outcomes that have had happened. Conversely, for events that did not happen, ROJ values were smaller compared to OJ.

Fischhoff further explained *hindsight bias* as the tendency to project newly acquired knowledge onto past events, while the person simultaneously denying that this outcome information has influenced their judgment. When individuals are asked to reassess an event after knowing the outcome, they tend to give biased judgments, yet fail to acknowledge that the available information has shaped their response. They underestimate the effect of this information on their assessment and believe they knew about it all along (Fischhoff, 1977). In 1980 Fischhoff wrote “in trying to reconstruct our foresightful state of mind, we will remain anchored in our hindsightful perspective, leaving the reported outcome too likely looking” (p. 85).

Fischhoff (1975) conducted an experiment in which participants were asked to assess the outcomes of the Gurkhas-British war. Subjects were first given a brief description outlining the strengths and weaknesses of both sides involved in the conflict. Then, each experimental group was presented with a different version of how the war had supposedly ended. Afterward, participants were asked to estimate the probability of four possible outcomes of the conflict, as if they were unaware of the actual result. Each group rated the outcome they had been told was the actual result as the most likely. Fischoff (1975) explain

the results as a process of “creeping determinism”. The outcome information is immediately and **automatically assimilated** into person’s knowledge about the events preceding the outcome. This process is fast and unconscious. The outcome knowledge “creeps” into the subject’s mental representation of the events (Hawkins & Hastie, 1990). This mechanism works as a desire of “making sense of the past”. When we are trying to understand particular outcome of the situation, then we increase the value of data and reasons which fit into coherent explanatory of what really happened. The information which did not fit into the explanatory is forgotten or reinterpreted.

Fischhoff and Beth (1975) provided an example of drawing the balls from a container with unspecified number of blue and red balls. The process was described as sampling with replacement, meaning each ball was returned to the container after being drawn. The first 4 draws were evenly distributed - 2 blue balls and 2 red balls. The fifth draw ball was blue. Before the fifth drawing, the probability of blue ball was 50% (as to the prior experience). Now, the probability of drawing the blue ball will be higher than 50%, this means that the probability after the fact is higher than predicted probability. In real life situation, this increase in probability reduce our discomfort with the surprisingness of what has happened. Rather than reflecting a process of "learning from the past," it reinforces the attitude of having known it all along.

Assessment of hindsight bias

The classic way to assess hindsight bias is to present participants with questions that require numerical answers. There are two possible experimental design: memory and hypothetical (Pohl, 2007).

In the memory design, participants give their answers, then receive feedback (e.g., outcome information, solution) and are asked to recall their answer which they gave earlier as exactly as possible and ignore the information from feedback.

In the hypothetical design, participants first receive feedback in numerical form. Then, they are asked to estimate what they would have predicted if they had not been given the feedback, essentially, they are asked to respond hypothetically. In the studies about anchoring (Tversky & Kahneman, 1974), the experimental design is very similar with a difference that participants first are asked to indicate whether the correct answer lies above or below given number before they proposed their answer.

The materials used in experiments have been highly diversified. Pohl (2007) divided it into three groups: *assertion* when participants have to judge if the statement is true or false and assign a confidence score (e.g., Fischhoff, 1975, Fischhoff & Beth, 1975, Musch, 2003) or two-alternative-forced-choice (2AFC) where subjects are choosing the correct answer between two options and then asses the confidence score of their rating (e.g., Fischhoff, 1977, Hoffrage et al., 2000). The next one is *event or episode* where participants are asked to establish the probability for each of possible outcomes of this event (e.g., Sanna et al., 2002). In the last category, Pohl put *unknown quantity.* The answers can be given in percentage, rating or numerical value. The most popular example are questions about general knowledge, for example "How high is the Statue of Liberty?" (e.g., Calvillo, 2012, Pohl & Hell, 1996, Erdfelder & Buchner, 1998).

Explanations of hindsight bias

The literature presents several models that explain or describe the mechanisms underlying hindsight bias. Hawkins and Hastie (1990) presented four general strategies that explain the hindsight bias responses: 1) recollection of the old belief which is the simplest response strategy and involves searching long-term memory for the old belief and respond consistently with its implication; 2) anchoring on current, post-outcome belief and then adjusting the response according to it, 3) re-judgement which involves reconstruction of the prior judgement, and 4) motivated response adjustment, in which subject wants to appear

competent. Blank et al. (2008) distinguished three components of hindsight bias which focus on phenomenological distinctions of this effect. The first component is called the *impression of necessity*. People perceive the outcome as something that was inevitable, even though they did not anticipate it beforehand. Within this category, Blank et al. (2008) also include the concept of *creeping determinism*. The second component is the *impression of foreseeability*. This refers to the feeling of "I knew it would happen." It reflects a reaction in which individuals, despite not knowing the actual outcome in advance, retrospectively perceive themselves as having predicted it all along. The third component involves *memory distortions*. This can be observed in the mentioned before memory design; when asked to recall their initial assessment made prior to a given event, participants provide responses that are altered by the knowledge they have acquired afterward (e.g., Erdfelder & Buchner, 1998). In Roese and Vohs' (2012) model, the components of Blank et al.'s (2008) model are referred to as levels of hindsight bias. For any level of hindsight bias to occur, one of three types of components must be present: cognitive (recollection, knowledge updating, sense-making), metacognitive (fluency) and motivational (need for closure, self-esteem).

Roese and Vohs (2012) describe cognitive inputs as operations shaped by memory processes. When asked to recall a prior judgement, individuals attempt to retrieve their original response before receiving feedback (Erdfelder & Buchner, 1998). According to Hawkins and Hastie (1990), in such cases, people search their long-term memory for their old belief and respond consistently with its implications. However, the recollection process can be affected by knowledge of the outcome. Outcome information may interfere with accurate recall by altering or erasing the original memory trace, or by making recall more difficult (Erdfelder & Buchner, 1998). The effect of hindsight bias can be reduced when participants are able to accurately reconstruct their original response. Hell et al. (1988) demonstrated that

when participants were asked to generate reasons for their initial response, the memory trace for the OJ was strengthened, thereby reducing the magnitude of hindsight bias.

To further understand these mechanisms, Erdfelder and Buchner (1998) introduced a multinomial processing tree model to distinguish between recollection and reconstruction biases in hindsight judgments. This model estimates probabilities of latent processes based on discrete observable event frequencies (Batchelder & Riefer, 1990; Schmidt et al., 2023). In their 13-parameter hindsight-bias model, Erdfelder & Buchner (1998) defined recollection bias as the distortion or reduced accessibility of the memory trace for the original judgement due to outcome knowledge, while reconstruction bias was linked to re-judgment processes, such as anchoring on current beliefs and adjusting past estimates to fit newly acquired outcome information (Dehn & Erdfelder, 1998).

The **anchoring on the current belief and adjustment** of the answer explanation is based on the anchoring phenomenon described by Tversky and Kahneman (1974). In their classic study, they asked subjects to estimate the percentage of African countries in the United Nations. Before giving the answer, the researcher spined a wheel of fortune which presented a certain number. The subjects were asked to determine whether the number of African countries were lower or higher than the value on the spinning wheel. Their answers were influenced by the anchor (the value from the spinning wheel). The median estimated percentage of African countries was 25% when the anchor was 10 and 45% when the anchor was 65. In hindsight bias, the outcome knowledge we learn after giving the first judgement serves as the anchor. When asked to recollect their first response, participants are anchoring on the new information and then adjust their answer with the influence of the uncertainty they had making OJ. The hindsight bias can be produced by imperfect adjustments process (Erdfelder & Buchner, 1998).

In the model SARA (Selective Activation, Reconstruction, and Anchoring) the anchoring effect that contributes to hindsight bias is interpreted as an automatic process, which can be hardly influenced intentionally. The model proposes two mechanisms: 1) “selective activation” which represents the change in long-term memory caused by the anchor (the authors compare this process to the Fischhoff’s (1975) explanation of immediate integration into existing knowledge) and 2) “biased reconstruction” which occurs when people use the anchor as the basis for reconstructing an original answer. Both mechanisms can evoke hindsight bias (Pohl et al., 2003).

The third explanation attributes hindsight bias to a **rejudgment** strategy, which consists of several subtasks: sampling evidence, interpreting the evidence, and integrating the implications of the evidence. This strategy is trying to repeat the judgmental process that led to the OJ (Erdfelder & Buchner, 1998). People seek evidence from both their environment and memory when making judgments. In hindsight bias paradigm, when the outcome of judged situation is known, evidence which does not fit the outcome becomes less accessible. Then, after we find some information, they are often incomplete and insufficient for making an accurate judgment. As a result, people must estimate the data to a satisfactory level and derive implications to reach a final judgment (Hawkins & Hastie, 1990).

The RAFT model (Reconstruction After Feedback With Take The Best) proposed by Hoffrage et al. (2000) combines rejudgment with another strategy - **knowledge updating**. According to the model, if the original answer cannot be retrieved from memory, it is reconstructed by re-evaluating the problem. While outcome information is incorporated into existing knowledge, it does not directly alter the memory trace of the original judgment. Instead, it serves as a basis for knowledge updating. Roese and Vohs (2012) defined knowledge updating as: "the integration of new information into existing memory structures" (p. 414). This process makes the past appear more coherent and comprehensible, creating a

sense of clarity. Sense-making involves a more elaborate process of knowledge updating, stemming from humans' natural tendency to predict future events. However, it results in bias because we often overlook the role of randomness in life. By constructing causal explanations, we create a narrative that shapes the story of our lives. As Roese and Vohs (2012) stated, "the essence of sensemaking, rooted in oversimplified causal inference, is thus severely compromised from the start of the inferential journey, thereby constituting yet another facet of hindsight bias" (p. 415). Recollection and knowledge updating manifest in memory distortion, while sense-making corresponds to the inevitability/necessity components - both of which are mentioned in Rose and Vohs's model as well as in Blank et al.'s (2008) approach.

Another process contributing to the formation of hindsight bias is **metacognition**, which involves awareness and regulation of one's own thoughts (Flavell, 1979). Metacognitive inputs refer to conscious explanations generated to support judgments. The easier it is to reach a conclusion about an outcome, the stronger the hindsight bias becomes. Metacognitive inputs align with foreseeability, explaining why people misattribute subjective ease to objective truth and certainty. Sanna and Schwarz (2007) presented a metacognitive model of hindsight bias in which they emphasized the role of subject's subjective experience. They stated that metacognitive experiences can either reinforce or contradict the implications of thought content itself. Thought content refers to "what comes to mind" when we see the outcome, while metacognitive experiences are the sensations and awareness that accompany our thinking process and they play significant role in hindsight bias (for review see: Sanna & Schwarz, 2004). For example, when the outcome information is known and it seems familiar, subject may overestimate its inevitability and generate stronger effect of hindsight bias. However, when the outcomes are highly surprising, they feel unfamiliar, the bias is weaker (Sanna & Schwarz, 2007).

In a series of studies (Sanna et al., 2002; Sanna et al., 2002; Sanna & Schwarz, 2003, 2004), participants were asked to generate reasons supporting or opposing a specific event's outcome - for example, the outcome of the British-Gurkha War (as in Fischhoff's original 1975 study), a football game, the 2000 U.S. Presidential election, or an upcoming real-life exam. Since considering alternative outcomes can help reduce hindsight bias (Fischhoff, 1980, Hell et al., 1988), this task was intended to explore its debiasing effect. However, the impact depended on the number of reasons generated and whether the alternative outcomes were positive or negative. Studies by Sanna et al. (2002) and Sanna and Schwarz (2003) found that listing many alternatives actually strengthened hindsight bias. Generating numerous counterfactual reasons is cognitively demanding, leading individuals to believe that there were fewer plausible ways the event could have unfolded differently. However, the results from Sanna and Schwarz (2004) study showed that when students were listing 3 reasons about passing the exam (e.g., success = easy task) the hindsight bias effect was equivalent to listing 12 reasons about fail the exam (e.g., failure = difficult task). Moreover, when they were listing 12 reasons about success and 3 about failure, the effect was the same. The authors highlighted the interaction between thought content and accessibility experience. When thoughts about failure were more accessible, they helped to counteract the hindsight bias that typically follows a successful outcome.

The last explanation of mechanisms of hindsight bias is about **motivational aspects**. Here, the focus is shifted onto self-oriented outcomes of hindsight bias. In the Roese and Vohs's (2003) model, motivational inputs are related to the level of foreseeability ("I knew it would happen"). When we state that the outcome is exactly what we could predict, hindsight bias seems to stem from presenting the world as predictable and safe (cf. Walster, 1967). There are some studies that showed that a need for control is positively correlated with the magnitude of hindsight bias (Musch, 2003, Tykocinski, 2001) or protecting one's self-esteem

(Bernstein et al., 2015, Campbell & Tesser, 1983, Pezzo, 2011). In Campbell and Tesser's study (1983) participants were asked to answer almanac questions intended to measure the hindsight bias, but they also were asked to complete personality tests which assess dogmatism and intolerance for ambiguity, and a test which measure person's desire to maintain a high level of public esteem. The results showed the positive correlation between hindsight bias and subject's motives.

Tykocinski (2001) proposed an alternative explanation for why people adjust their second judgment after learning the outcome of a situation. He introduced the concept of "retroactive pessimism," which Bernstein et al. (2015) described as an attempt to manage feelings of disappointment. This relates to the inevitability component of hindsight bias, often expressed as "It had to happen." Individuals tend to perceive negative outcomes as more likely and positive outcomes as less probable. Szpitalak (2017) points out that a retroactive pessimist, as opposed to a defensive pessimist, will evaluate an event after it has happened and say they knew all along that it would fail. For example, in Tykocinski's (2001) study on the 1999 Israeli prime minister election, participants who initially supported the losing candidate later overestimated the likelihood of the winner's victory. However, the study of Mark et al. (2003) (and also Louie, 1999, Louie et al., 2000, Mark and Mellor, 1991) showed that negative outcomes can sometimes be perceived as less foreseeable, leading to a reaction of "I couldn't have seen it coming". This is linked to defensive processing, which serves as a protection mechanism against the consequences of poor decisions. Pezzo and Pezzo (2007) described motivated sense-making as an attempt to rationalize an outcome by attributing inconsistencies either to external factors (retroactive pessimism) or internal factors (defensive processing). Hawkins and Hastie (1990) argued that this motivational strategy helps individuals maintain a positive self-image, with people adjusting their recollection of judgments (ROJ) to appear more intelligent and knowledgeable.

Memory processes in hindsight bias

The previously mention model SARA (Pohl et al., 2003) and the work of Erdfelder and Buchner (1998) identify memory processes involved in hindsight bias. SARA proposes two mechanisms behind hindsight bias: *selective activation* which enhances the retrieval of information related to anchor as it becomes more accessible in memory due to the change in associative patter and *bias reconstruction* which occurs when anchor plays a role of retrieval cue, influencing the memory search. Additionally, Erdfelder and Buchner (1998) have also proposed two but different processes: *recollection bias* defined as "the effect of outcome knowledge on the direct-recall strategy" and *reconstruction bias* which they explain as "the effect of outcome knowledge on the strategies of rejudgment or of anchoring on the current belief and adjustment" (p. 389). Both approaches share some similarities in understanding how underlying memory processes work in hindsight bias.

In Erdfelder and Buchner's (1998) approach, when participants are asked about their original prediction of an event, they first try to recall the information from episodic memory. This process represents recollection stage and if it is successful, hindsight bias does not occur. However, if recall is not successful, participants will generate prediction based on their current knowledge (Erdfelder et al., 2007). The recollection process can be disrupted, either through distortion of the memory trace by external information or by reduced access to the memory trace itself. When this happens, the answer must be reconstructed. The reconstruction process can follow two paths: an unbiased reconstruction, where participants accurately recreate their original answer, or a biased reconstruction, where participants adopt the feedback (correct answer) as their own response (Pohl et al., 2018).

Erdfelder and Buchner (1998) presented the multinomial processing tree model for hindsight bias (HB13) which measure separately recollection and reconstruction processes. In the model, recollection bias is denoted by the difference between probability of recollecting

the original judgement of a control item and of an experimental item (r_c - r_e). In the experimental condition, participants are provided with feedback (correct judgements) and in control condition they are not. Reconstruction bias is measured by parameter *b* which denotes the probability of biased reconstruction of original answer. The reconstructed judgment will vary around the correct judgement (feedback or anchor). The unbiased reconstruction (with probability 1-*b*) will vary around the original answer (Erdfelder et al., 2007).

The SARA model shares its basic architecture with the associative memory model SAM (Search of Associative Memory; Shiffrin & Raaijmakers, 1992). Both models assume that events are stored in memory as separate *images* - units of information associated with a specific question. For example, in response to the almanac question *"How old was Goethe when he died?"*, the image set might include general knowledge about life expectancy or a mental image of Goethe as an old man. These individually stored pieces of information form an image set tied to a particular question and are kept in long-term memory. The images within this set are interconnected - the more similar two images are, the stronger their mutual association.

The fundamental process in the model is called sampling. Sampling refers to a cyclical process of searching and retrieving information. In this process, relevant information is drawn from long-term memory and made available for further processing in working memory. The search is guided by cues currently present in working memory. Typically, the initial cue is the considered question. Once an image is retrieved and transferred into working memory, it serves as an additional cue for subsequent retrieval cycles. As a result, the sampling process becomes more focused and constrained by the images already retrieved.

The retrieval of images into working memory strengthens the association for cues that have been together in working memory. Pohl et al. (2003) explained that the likelihood of retrieving a specific image depends on its overall activation level - determined by the strength

of association between that image and each cue. So, the associations of retrieved images to currently available cues (like an anchor) are increased which leads to a higher retrieval probability of these images in later sampling processes. However, if the sampling process fails to retrieve any relevant images into working memory, the guessing process takes over. This process relies on general knowledge and cues that were initially present in working memory. For instance, when estimating Goethe's age at death, the guessing process randomly draws a number close to the average life expectancy for adults, drawing from broad, non-specific information rather than specific memory traces.

When participants are asked to recall their original estimate and if an anchor is retrieved but not recognized as such, it functions like any other image in working memory, serving as an additional retrieval cue. When the anchor remains in working memory, it can guide the ongoing memory search and contribute to hindsight bias. Because of its strong association with numerically similar memories, the anchor increases the likelihood of retrieving these related images - ultimately distorting the reconstruction of the original estimate (Pohl et al., 2003).

Both approaches share some similarities in understanding processes behind hindsight bias. They both use a cognitive modelling framework and present that hindsight bias is not a unitary phenomenon. Erdfelder and Buchner (1998) and Pohl et al. (2003) both argue that hindsight bias consists of multiple components. They emphasize the interplay of memory, judgement and outcome knowledge. In both the role of outcome knowledge - anchor in SARA model and feedback (correct judgement) in HB13 - impair the retrieval process of original judgement.

The presence of hindsight bias and its dependence on memory processes have been supported by numerous studies. The bias has been shown to positively correlate with the depth of encoding of the feedback (or anchor), meaning the more deeply the anchor is

processed, the stronger the bias effect (Wood, 1978). Additionally, when participants already know the correct answer to a question, the bias tends to be minimal (Christensen-Szalanski & Wilham, 1991) or when participants can recall their original answer with high strength, precision, and detail, the likelihood of hindsight bias is also reduced (Hell et al., 1988).

Knowledge updating in hindsight bias

To the discussion of memory activity in hindsight bias, Hardt et al. (2010) added that the changes of strength of associations in long-term memory induces states of plasticity which contributed to process of reconsolidation. The whole process plays a role of knowledge updating which allows memory to be adaptive, but it can also modify memory and produce memory distortions. They stated that consolidation and reconsolidation could explain process behind hindsight bias.

As Squire et al. (2015) define it, memory consolidation refers to "the process by which a temporary, labile memory is transformed into a more stable, long-lasting form" (p. 1). In the early stages, memories are more dependent on the hippocampus, although from the beginning, learning material is encoded simultaneously in both the hippocampus and the neocortex. As consolidation progresses, the hippocampus becomes less critical for the storage and retrieval of memories. Through this process, memories are reorganized and gradually stabilized in distributed regions of the neocortex (McKenzie & Eichenbaum, 2011).

However, when memory traces are reactivated, they can become modifiable. This process is known as reconsolidation - it occurs when a memory is retrieved and temporarily enters a state of plasticity. During this window, the memory can be updated or altered in various ways (for example, by incorporating new information). This post-retrieval plasticity allows for the modulation of memory strength, enabling both the strengthening and weakening of different elements of the memory (Elsey et al., 2018). In this way,

reconsolidation supports memory updating, allowing previously stored memories to be recalibrated in light of new experiences (Hardt et al., 2010).

In the case of hindsight bias, Hardt et al. (2010) argue that it results from the malleability of memory characterized by retrieval-induced distortions. They interpret the distortion of original judgement as a part of memory-updating process that, under normal circumstances, produces adaptive behaviour. When participants are presented with what they perceive as the correct answer to a question they were initially uncertain about, it is natural for them to modify their original response accordingly.

Underlying processes in choice-induced preference change

Choice-induced preference change has generated much debate about its underlying mechanisms. The literature usually presents two types of explanations regarding the role of self-based and non-self based metacognitive processes (e.g., Chammat et al., 2017; Egan et al., 2010; Salti et al., 2014).

Non-self based models explain choice-induced preference change as an effect of low - level processes, without involving episodic memory and executive control. These theories do not involve the self, as choice-induced preference change is a result of an automatic cognitive mechanism. Lieberman et al. (2001), in experiment 1, found that amnesic patients demonstrated as much behaviour-induced attitude change as did the age-matched healthy controls, though their memory for preferred items was severely impaired. In the same paper, the experiment 2, showed that the CIPC effect occurred both in cognitive-load and no-load conditions suggesting that this process is relatively automatic. Additionally, the study of Coppin et al. (2010) showed that an overvaluation of the chosen odour and a devaluation of the rejected odour occurred both for the forgotten and the remembered targets, which was interpreted as resulting from implicit mechanisms. In line with this, Sharot et al. (2012) found that the choices altered the preferences both immediately after being made and after a long

delay of 2.5-3 years. Since such a long delay should likely limits memory for the choice, their findings also support the idea that preference change does not rely on remembering the choice itself. Also, Silver et al. (2020) showed that CIPC does not require experience in making decisions, it is not based on metacognitive abilities and there is no need for a developed sense of self. In a series of seven experiments using FCP on preverbal infants, they found that infants experience choice-induce preference changes similar to adults. The results showed that after selecting between two equally attractive objects, the infants devalued the unchosen toy.

However, the explanations proposed by self-based models focus on contradiction between self and decision and demonstrate the role of explicit memory for the spread of alternatives in FCP. These theories and studies state that people change their preferences to preserve congruity in their choices and to see themselves in positive light (Egan et al., 2010). So, to reduce the cognitive dissonance, subjects would minimalize the unpleasant feeling by holding to their first choices and to do so they need to remember what they have chosen.

For example, Tandetnik et al. (2021) indicate that patients with frontal lobe lesions and executive functions deficits do not change their subjective preferences in the free choice task, even when they do remember their previous choices while patients without executive problems change their preference to maintain coherence with their past remembered choices. In the study of Salti et al. (2014) participants were asked to evaluate how much they would like to spend their vacation in destinations that were presented as picture and name of the country. The spread turned out to be larger for the remembered items than for the forgotten items and, in the experimental RCR (rating-choice-rating) sequence, than in the control RRC (rating-rating-choice) sequence, which suggests that the FCP measures a real change in preference. Researchers also found a strong association between the spread and the memory of choice. Additionally, Chammat et al. (2017) carried out similar experiments using an fMRI with healthy controls and neurological patients. The results showed the activity of the left

hippocampus associated with episodic memory retrieval during the second rating where the spread probably occurs.

Nevertheless, it is not clear when the change of preference really happens. Voigt et al. (2019) were the first to report that the change in preferences is associated with neural activity occurring earlier than previously thought - during the difficult decision. They also showed the eye-tracking results which revealed that fixation durations predict choices as well as future evaluations. However, the authors do not rule out the contribution of dissonance reduction after the decision has been made. In their study, in addition to the fMRI and eye-tracking analysis, a memory test was used, and the results showed that the change of preferences occurred only for the choices that were remembered. Therefore, Voigt et al. suggest that there may be a shift in preferences during and after the decision is made.

Also, the study by Lee and Daunizeau (2020) seem to support the findings presented above, however they argue that it is possible to discuss about CIPC without referring to the reduction of cognitive dissonance. According to them, post-choice cognitive dissonance reduction theory (CDRT) could be distinguished from CIPC. They propose that CIPC occurs during the choice phase and can be interpreted without invoking the theory of cognitive dissonance reduction (Festinger, 1957). In their study, participants were asked after each stage of FCP if they were sure of their answers, as to check their level of uncertainty regarding value rating. The results showed that every choice is made until internal value representation refinements allow choice confidence to reach a satisfying level. This suggests that CIPC is driven by value reassessment that occurs during the choice itself, rather than being a product of post-choice rationalization or memory processes.

The Dual Recollection Theory

Research in cognitive psychology and neuropsychology has identified two distinct processes involved in recognition: recollection and familiarity. Recollection refers to recognition that is based on the conscious retrieval of contextual details related to a prior event or person. In contrast, familiarity is characterized as a more automatic process, involving a sense of knowing without being fully aware of when or where the event occurred or the person was encountered (Yonelinas, 2002).

Recollection and familiarity are treated as memory processes or different kinds of memory storage. These two processes are postulated by the dual-process models. In one of these models (Jacoby, 1991) recollection is assumed to be an analytical, consciously controlled process, whereas familiarity is defined as a relatively automatic process that is related to a prior experience. Tulving (1985) associated recollection with *autonoetic* (self-knowing) consciousness, for example, the ability to mentally recreate a specific event. While familiarity was linked to *noetic* (knowing) consciousness, in which an individual recognizes an event without recalling any contextual details related to it.

The remember/know procedure (Migo et al., 2012; Tulving, 1985) is a widely used method for investigating dual-process theories of recognition memory. In this paradigm, participants are asked to respond *I remember* when they can consciously recall details associated with the original learning episode, and *I know* when the information feels familiar but they cannot retrieve specific contextual details. 'Remember' responses are interpreted as evidence of recollection, whereas 'know' responses are taken to reflect the familiarity process.

One of the most influential dual-process theories of memory is fuzzy-trace theory (FTT), developed by Brainerd and Reyna (1990). This theory proposes that when information is encoded in memory, two parallel traces are formed: a verbatim trace and a gist trace. The verbatim trace stores detailed, precise information about a stimulus (Brainerd & Reyna,

2004). For instance, recalling the specific letters that composed a word or the exact shape of a stimulus relies on verbatim trace retrieval. In contrast, the gist trace encodes the general meaning of items and their relationships to other stimuli (Obidziński, 2019). It also includes related contextual or semantic information, forming a hierarchical structure of meaning, in which gist representations vary in their level of abstraction (Reyna, 2012).

While the verbatim trace represents the literal characteristics of the experienced stimulus - such as the font used for a word on a study list - the gist trace reflects the interpretation or understanding of the stimulus (Brainerd & Reyna, 2004). In decision-making, verbatim traces are linked to analytical thinking, offering greater precision, whereas gist traces are associated with intuitive thinking, which is faster and cognitively less demanding (Reyna, 2012).

The retrieval of the verbatim trace is associated with the conscious recall of a specific target, often described as “re-experiencing” the stimulus under particular conditions. This process allows for recollection rejection, which involves recognizing that a given item is merely similar to - but not identical with - a studied item. As a result, participants may explicitly reject it, stating that there is “no identity” between the two stimuli (Nieznański, 2015).

In contrast, the retrieval of gist is linked to a more general form of memory experience - familiarity. Familiarity provides information related to the stimulus, but it lacks the vivid, context-specific detail of re-experiencing. When the gist trace is especially strong, it can lead to phantom recollection - a false but vivid memory experience in which information not actually presented is mistakenly recalled as if it were a studied item (Brainerd & Reyna, 2002; Brainerd et al., 2001).

Based on fuzzy-trace theory, the conjoint recognition paradigm was developed (Brainerd et al., 1999, 2001). This paradigm includes three types of test stimuli: targets, related distractors, and unrelated distractors.

During the learning phase, participants study a list of stimuli. In the subsequent testing phase, they are given one of three types of instructions:

1. accept targets and reject both related and unrelated distractors,
2. accept related distractors and reject targets and unrelated distractors, or
3. accept both targets and related distractors while rejecting unrelated distractors.

This procedure is used to estimate parameters in a multinomial dual-recollection model, which includes nine parameters reflecting the retrieval of verbatim traces, gist traces, and guessing bias.

Later, Brainerd et al. (2014) showed that the recollection process can be differentiated into context recollection and target recollection. Context recollection focuses on information in the "background" during the learning phase. Brainerd et al. (2014) give an example, when the word *flute* is included in the learning list, it can trigger the recall of one's favourite piece played on the flute which can be a helpful cue during the test phase, when one needs to recall the target. Other examples of context information may be the appearance of the test room, colour, size of visual presentation, gender, accent and volume of the voice during presentation. The subjective impressions related to target are also important, for example, with the word *soup*, we may feel hungry or recall the taste of our favourite soup (Brainerd et al., 2015). Target recollection is a retrieval of a "pure" stimulus, i.e. a given word in the learning phase, ignoring contextual details. The participant is able to reject words that have a similar meaning or look similar (related distractors) (Brainerd et al., 2014). Lampinen and Odegard (2006) give an example when the word *puppy* appears in the list of to-be-remember words, the individual may not correctly recognize the word *dog* during the test. This mistake

can be avoided by target recollection and recollection rejection, that was mentioned in fuzzy-trace theory. The participant will reject the word *dog* because they will remember that it was a *puppy*.

Description of the research problem

The main research objective was to explore the underlying mechanisms involved in choice-induced preference change (CIPC). First, we examined the role of memory processes as proposed in the dual-recollection theory. Second, we examined whether the structure and nature of the cognitive processes underlying the reduction of cognitive dissonance are analogous to those involved in hindsight bias.

CIPC refers to the tendency to alter one's preferences after making a decision between similarly valued options. This phenomenon has generated much debate about the underlying mechanisms. The most widely accepted explanation is grounded in cognitive dissonance theory (Festinger, 1957), which posits that individuals modify their preferences to reduce the psychological discomfort that arises from holding inconsistent cognitions (e.g., Chammat et al., 2017; Enisman et al., 2021; Salti et al., 2014). These self-based models focus on the contradiction between one’s self and one’s decision (Egan et al., 2010). The state of dissonance stems from inconsistency between current behaviour and previous remembered decisions. To reduce it, we may to give a higher rating to something we have recently chosen or, conversely, a lower rating to something we have rejected. This proposed mechanism implies the contribution of high-level cognitive processes and conscious memory for choice (Salti et al, 2014).

Alternative approaches argue that the CIPC effect results from more general cognitive processing that do not engage the self-concept or meta-representations (non-self-based models, Egan et al., 2010). In this class of theories, the CIPC effect results from low-level processes and happens as a result of an automatic cognitive mechanism that does not involve episodic memory. This conception is supported by reports of the CIPC effect in amnesic patients (Lieberman et al., 2001), in young infants, and even in non-human primates (Egan et al., 2010). Moreover, it is also possible that preferences are updated online during the choice,

therefore, the revaluation is based on this adjusted preference and does not need remembering the choice (Voigt et al., 2019). Despite these insights, the effect of CIPC has never been studied from the perspective of dual recollection theory (Brainerd et al., 2014, 2015).

CIPC has been mostly studied by using free-choice paradigm in research about cognitive dissonance (e.g. Salti et al., 2014; Chammat et al., 2017). However, hindsight bias is measured by similar three-parts design. Both distortions have two types of ratings and feedback or choice that divide them. In cognitive dissonance the choice influences the second rating which can be interpreted as the change of preferences. In hindsight bias, feedback (outside information) influences the second rating and can be understood as an update of our knowledge. Both hindsight bias and cognitive dissonance have been described as self-serving biases. One explanation for the reduction of cognitive dissonance is the motivation to maintain a positive self-image (Bem, 1972; Steele, 1988, Aronson, 1969), and hindsight bias has been attributed to self-protection mechanisms (Roese & Vohs, 2012; Much & Wagner, 2007; Pezzo, 2003, 2011). Additionally, there are some analogies in cognitive processes postulated as contributing to these phenomena. Fischhoff (1975) hypothesized that the hindsight bias effect is automatic and unconscious, however, many researchers postulate that also memory processes as recollection and reconstruction bias are involved in hindsight bias (e.g., Dehn & Erdeflder, 1998, Erdfelder & Buchner, 1998). Research on choice-induced preference change conducted from the perspective of cognitive dissonance theory, debates if the effect involves high-levels processes such as episodic memory and executive functions required in conflict detection (e.g. Tandetnik et al., 2021, Salti et al., 2014, Chammat et al., 2017) or low-level processes that occur unconsciously and independently of memory and executive control (e.g. Lieberman et al., 2001, Egan et al., 2007).

Despite these analogies, hindsight bias and cognitive dissonance have never been studied together, and hindsight bias has never been considered as a possible explanation for

choice-induced preference change in FCP. In my research (Experiment 2, 3,4,5), I aimed to explore whether the cognitive processes involved in hindsight bias are analogous to processes involved in cognitive dissonance reduction.

Overview of the research

Experiments 1 and 2 focused on identifying which memory processes, as postulated by dual-recollection theory, contribute to the CIPC effect[1]. However, the FCP results from Experiment 2 were also used to preliminarily validate the multinomial processing tree model for hindsight bias developed by Erdfelder and Buchner (1998) with its modification proposed by Dehn and Erdfelder (1998).

The aim of Experiment 1 was to examine the role of dual-recollection processes in memory task performance for specific target items, depending on whether the CIPC effect had occurred for those items. In Experiment 2, we addressed a key limitation of the RCR-desirability procedure used in Experiment 1 namely, the lack of a significant effect on the Spread index. While Experiment 1 showed choice-consistent changes in ratings for chosen items, no such effect was observed for rejected items. To investigate this further, we manipulated choice difficulty by presenting participants with either closely matched pairs (i.e., similarly rated countries) or distantly rated pairs. The results of Experiment 2 were then used to examine whether the cognitive processes underlying CIPC are analogous to those observed in hindsight bias.

The aim of Experiment 3 was to examine whether the latent processes underlying hindsight bias also accurately account for performance in the free-choice paradigm typically used to study cognitive dissonance. The experiment included two corresponding conditions each with its control groups and aimed to measure the reduction of cognitive dissonance and

[1] The results of these experiments have been published (Didyk & Nieznański, 2024), see Appendix 2 for information about authors' involvement.

hindsight bias within the free-choice paradigm. In the cognitive dissonance condition, during second rating, participants were asked to rate again items, whereas in the hindsight bias condition, they were asked to recall their first rating (as in the memory design, Pohl, 2007).

Experiment 4 also included two corresponding conditions each with its control groups. In this study, we changed the stimulus material from countries to paintings and introduced a manipulation of task instructions. In the CD condition, participants were asked to rate the paintings from their personal perspective. In contrast, in the HB condition, participants were instructed to adopt the role of an art expert and evaluate the paintings based on their attractiveness from an expert's point of view.

In the final experiment, we introduced a manipulation designed to influence participants' evaluation of their choices. Participants were asked to reflect on either: a) the positive attributes of the chosen painting and the negative attributes of the rejected painting (manipulation of choice-consistent evaluation), b) the positive attributes of the rejected painting and the negative attributes of the chosen painting (manipulation of choice-inconsistent evaluation), or c) respond to neutral questions about both the chosen and rejected items (control condition). We expected that the spread of alternatives would vary across conditions, particularly in the manipulation of choice-consistent evaluation, and that the effect would differ between conditions involving hindsight bias and cognitive dissonance.

The main research questions and hypotheses

The aim of this dissertation was to investigate the cognitive mechanisms underlying choice-induced preference change. This section outlines the specific research questions and hypotheses formulated for each experiment.

Experiment 1

Research questions for Experiment 1:

1. Is the CIPC effect a self-based process accompanied by conscious memory processes (context and target recollection), or a non-self-based process accompanied by unconscious/automatic memory processes (e.g., familiarity)?

1a. Is context recollection (i.e. remembering of choice) more likely for items that show a choice induced preference change?

1b. Is target recollection more likely for items that show a choice induced preference change?

1c. Does familiarity contribute to choice-induced preference change?

2. Does making a choice indicate spread of alternatives?

2a. Does the spread of alternatives occur when choice is made **before** desirability rating?

2b. Does the spread of alternatives occur when choice is made **after** desirability rating?

2c. Does the spread of alternatives occur when choice and rating do not involve self-motives?

In exploration mode, we will separately investigate how the aforementioned processes unfold for the options that were rejected in the choice phase and for those that were chosen.

Hypotheses for Experiment 1:

H1: The CIPC effect is a self-based process accompanied by conscious memory of choice.

H1a: Context recollection is higher for items that show a choice-consistent preference change than for other items.

H1b: Target recollection is higher for items that show a choice-consistent preference change than for other items.

H1c: Familiarity is different for items that show a choice-consistent preference change than for other items.

H2: The spread of alternatives occurs for preferences, when second rating is made after the self-based choice.

H2a: The spread of alternatives is higher when choice is made before the second rating than when the choice is made after the second rating.

H2b: The spread of alternatives is higher when choice involves the self (desirability rating) than when it does not involve the self (safety rating).

Experiment 2

Research questions for Experiment 2:

1. Is the spread of alternatives more pronounced after choices between similarly attractive options (Close pairs) than between options that differ in initial rating (Distant pairs)?
2. Are the differences in spread of alternatives between conditions with paired close and distant in attractiveness options accompanied by differences in memory for choice?

Hypotheses for Experiment 2:

H1: The spread of alternatives differs between similarly attractive options and options with more distant ratings.

H1a. The spread of alternatives occurs for preferences when the second rating is a self-based choice between options that were initially rated as similarly attractive.

H1b. The spread of alternatives is higher after choices between similarly attractive options than between options with more distant initial ratings.

H2: There are differences in spread of alternatives between conditions with paired close and distant in attractiveness options accompanied by differences in memory for choice.

H2a. In the close pairs condition, context recollection is higher for items that show a choice-consistent preference change than for other items.

H2b. The higher spread of alternatives in the close pairs condition than in the distant pairs condition is accompanied by higher context recollection in the close pairs condition than in the distant pairs condition.

Experiment 3

Research question for Experiment 3:

1. Does the spread of alternatives occur when second rating is presented as a recall task, following memory-based design in the hindsight bias studies?
2. Are there differences in contribution of reconstruction bias to preference change between procedures with repeated rating (as in standard FCP paradigm for reduction of cognitive dissonance) and those involving recall of the rating (as in hindsight bias research)?

Hypotheses for Experiment 3:

H1: The spread of alternatives for preferences occurs when the second rating involves recalling the initial rating after a choice.

H2a: Reconstruction bias contributes to preference change in the repeated rating (in the CD condition).

H2b: Reconstruction bias contributes to change of the recalled rating (in the HB condition).

Experiment 4

Research questions for Experiment 4:

1. Does the spread of alternatives occur for aesthetic preferences in the same way as it does for desirability-based preferences?
2. Does the spread of alternatives occur when the second rating is presented as a recall task and preferences are expressed from the perspective of another person (i.e., not involving the self)?
3. Are there differences in spread of alternatives between self-based re-rating procedure and non-self-based recall procedure?
4. Does the contribution of latent cognitive processes differ between the self-based re-rating procedure and the non-self-based recall procedure?

Hypotheses for Experiment 4:

H1: The spread of alternatives occurs for aesthetic preferences when second rating is made after the self-based choice.

H2: The spread of alternatives occurs for aesthetic preferences when the second rating is presented as a recall task following a choice made from another-person perspective.

H3: The spread of alternatives for aesthetic judgments differs between self-based re-rating and non-self-based recall.

H4: The latent cognitive processes differ between the self-based re-rating procedure and the non-self-based recall procedure.

H4a: Reconstruction bias contributes to preference change for the second rating (in the CD condition) and for recall of the first rating (in the HB condition).

H4b: There is a difference in contribution of reconstruction bias between the self-based re-rating condition and the non-self-based recall condition.

Experiment 5

Research questions for Experiment 5:

1. Does reflecting on the positive versus negative aspects of chosen and rejected options influence the magnitude of the spread of alternatives?
2. Do the effects of this reflective manipulation differ between the self-based re-rating procedure and the non-self-based recall procedure?

Hypotheses for Experiment 5:

H1: In the self-based re-rating condition, reflecting on the **positive** attributes of **chosen** options and the **negative** attributes of **rejected** options results in a *lower* spread of alternatives compared to reflecting on the **positive** attributes of **rejected** options and the **negative** attributes of **chosen** options.

H2: In the non-self-based recall condition, reflecting on the **positive** attributes of **chosen** options and the **negative** attributes of **rejected** options results in a *higher* spread of alternatives compared to reflecting on the **positive** attributes of rejected options and the **negative** attributes of chosen options.

RESEARCH

Ethics Statement

All experiments have been approved by Ethical Board for Scientific Research of the Institute of Psychology at Cardinal Stefan Wyszynski University in Warsaw RDpsy-U-02/03/2021 (see Appendix 1). All the subjects gave their written informed consents. Participants were informed that the study is anonymous and is solely for scientific purposes. At any time, they could withdraw from participation and had the opportunity to ask questions. Research participants were also provided with the experimenter's email address in case they wished to contact them after the study.

Experiment 1

In Experiment 1, participants completed a free-choice paradigm followed by a conjoint recognition memory test, which referred to targets and their corresponding choices from the Choice phase. The primary aim was to examine how memory processes, as outlined in dual-recollection theory (Brainerd et al., 2015), contribute to performance on a memory task specifically for targets depending on whether or not the CIPC effect occurred for these targets.

The memory processes under investigation differ in terms of the accompanying conscious states: context recollection and target recollection involve the conscious reinstatement of details from the study episode, whereas familiarity is considered a more automatic process. Based on self-based models and prior research demonstrating the role of episodic memory in cognitive dissonance reduction (e.g., Salti et al., 2014; Chammat et al., 2017), it can be expected that conscious reinstatement of a prior choice during the memory task is associated with choice-consistent changes in item ratings.

It was assumed that items for which participants were able to retrieve recollective details during the memory test - whether selected or rejected - were likely also recollected during the second rating phase, and that this recollection influenced their updated evaluation. According to cognitive dissonance theory (Festinger, 1957) and self-perception theory (Bem, 1972), recollecting that an item was chosen should lead to an increase in its second rating, while recollecting that an item was rejected should lead to a decrease in its rating. In contrast, non-self-based models predict that conscious reinstatement of the choice episode is not necessary for the CIPC effect. These models allow for either a lack of memory involvement or the engagement of only automatic processes, such as familiarity. Additionally, differences in memory processes might emerge during the decision-making phase, for example due to asymmetrical allocation of attention to chosen versus rejected items (Voigt et al., 2019).

Performance was assessed using the experimental RCR procedure and the control RRC procedure, both of which employed the same stimulus material and rating dimension (i.e., desirability of tourist destinations). It was expected to observe a spread of alternatives in the RCR condition, but not in the RRC condition. Since the RRC procedure does not involve a choice between options, any rating changes cannot be attributed to choice-induced mechanisms. Consequently, context recollection and familiarity should not differ between targets with changed versus unchanged ratings in the RRC condition.

In addition, the third condition was introduced. It followed the same sequence of stages as the RCR desirability-rating procedure but differed in the dimension being evaluated. Using the same materials, participants were asked to rate the safety of the tourist destinations rather than their desirability. Safety ratings reflect factual beliefs about the economic, political, or environmental conditions in a given country, rather than personal preferences. Therefore, this safety-rating RCR condition should result in reduced levels of cognitive

dissonance, as participants do not perceive a personal stake - such as gain or loss - in choosing one similarly rated destination as safer than another.

In the present study, several hypotheses were formulated to explore the role of memory processes in CIPC and to assess whether the effect is best explained by self-based or non-self-based models.

First, it was hypothesized that CIPC is primarily a self-based process that depends on the conscious recollection of prior choices. This hypothesis is supported by the expectation that memory processes, specifically context recollection will occur more frequently for items that show a choice-consistent change in preference, compared to those that do not. That is, when participants remember the choice they made, they are more likely to update their rating in line with that choice.

Second, it was hypothesized that the spread of alternatives would occur only when the second rating follows a self-based choice. In support of this, we posited that the spread is greater when the choice occurs before the second rating (as in the RCR procedure), compared to when choice is made after the second rating (as in the RRC procedure). Additionally, we expected that the spread is more pronounced in conditions where the ratings and choice are self-referential (based on personal desirability), than in situations where they are non-self-referential (based on perceived safety). This assumption reflects the idea that preference change is more likely to occur when an individual is required to make a difficult decision that is personally relevant. Additionally, we are going to test the role of a more automatic memory process (i.e., familiarity) in the CPIC, as literature suggests this effect occurs also in amnesic patients and infants or in conditions that eliminate or reduce the contribution of controlled memory processes (i.e., recollection) (Coppin et al., 2010; Egan et al., 2010; Lieberman et al., 2001; Sharot et al. 2012).

Methods

Experiment 1 consists of three experiments that are not directly compared with each other. They are presented together because the experiments used the same materials and methodological approach. The differences in recruitment methods across experiments are due to the COVID-19 pandemic. The first experiment (RCR with destination ratings) was conducted in-person, subsequent experiments (RRC desirability-rating and RCR safety-rating) were conducted online, as in-person sessions were no longer possible.

This limitation is not believed to compromise the validity of Experiment 1, as the study focused on within-participant comparisons (i.e., memory for rejected vs. chosen countries) conducted separately within each group. However, for completeness, we also compared the mean spread between experiments. These comparisons are presented in the supplementary materials (see File 2).

Sample

In the RCR desirability-rating condition, 24 participants, aged 19 to 55 (19 women; age $M = 26.2$, $SD = 8.6$), were recruited via a snowball procedure and through social networks. The results of one person were excluded from the analyses since her answers in the memory test were not reliable (all negative responses for one type of questions). In the RRC desirability-rating control condition, 24 participants were recruited online via social media, aged 22 to 34 (15 women, age $M = 25.2$, $SD = 2.8$). Finally, in the RCR safety-rating condition, 24 participants aged 20 to 30 (15 women, age $M = 22.4$, $SD = 1.9$), were recruited online via social media and received a voucher to a popular bookstore worth 50 PLN (ca. $13) for volunteering. A post hoc sensitivity analysis showed that, with a sample of 24 participants, it was possible to detect medium-to-large effect size $d = 0.6$, with power 1- beta = 0.80, in a one-sample *t*-test of difference (of spread) from constant (zero).

Materials

The materials and procedure in many aspects followed those used by Chammat et al. (2017). In order to prepare the materials, a pilot study was conducted with 105 participants in the form of a survey on the countries that are most desired as a travel destination. Participants rated 119 countries, of which 23 with extreme ratings were excluded. Based on the ratings received, the countries with the closest arithmetic means of ratings were matched into pairs for the FCP Choice phase. Another pilot study was conducted to prepare materials for the RCR safety-rating procedure. This time 108 participants were asked to rate countries according to the level of security and the hospitality of the citizens. The additional material (instructions, material from pilot study, real distance between countries, raw data) is available online: https://osf.io/g7tzs/ (files names: Experiment 1, Pilot study).

Procedure

The RCR-desirability procedure (see Figure 1) was carried out individually, in person, on the researcher's computer using the E-Prime program 2.0 (Psychology Software Tools, Pittsburgh, PA). The first part of the procedure was Rating 1 and it consisted of 60 names of countries that are potential travel destinations. Each country's name appeared one at a time on the screen for 1000 ms and was preceded by a 1000 ms fixation point. They were written in Times New Roman, 20 pt., bold, positioned in the centre of the screen. At the beginning of Rating 1, there were 4 buffer items that were best and worst rated in the pilot study. Buffers did not appear in the later parts of the study and were not included in the analyses. The participants were instructed that their task was to evaluate how much they would like to visit a given country (e.g., if they won the lottery). They answered using a scale from 1 to 8, where "1" means that they do not want to go there at all, and "8" means that they dream of visiting this country. The participants selected a given rating by pressing the relevant number on a computer keyboard.

Then, they went on to the Choice part, where they were instructed to indicate, for each pair, which of the two countries they would like to visit more. The two paired countries had similar ratings according to the pilot study; each pair was displayed for 2000 ms. The two stimuli appeared next to each other on the slide. After the slide disappeared, the participants had to choose one of the countries. There were 30 such pairs presented in the Choice phase. The Rating 2 part involved the reassessment of 60 countries and the instruction was the same as in the Rating 1 phase. Finally, the participants approached the conjoint recognition memory test where the names of 96 countries (36 new items and 60 targets) were displayed one after another on a computer screen, in random order. The participants were instructed to answer Yes or No to one of the following questions:

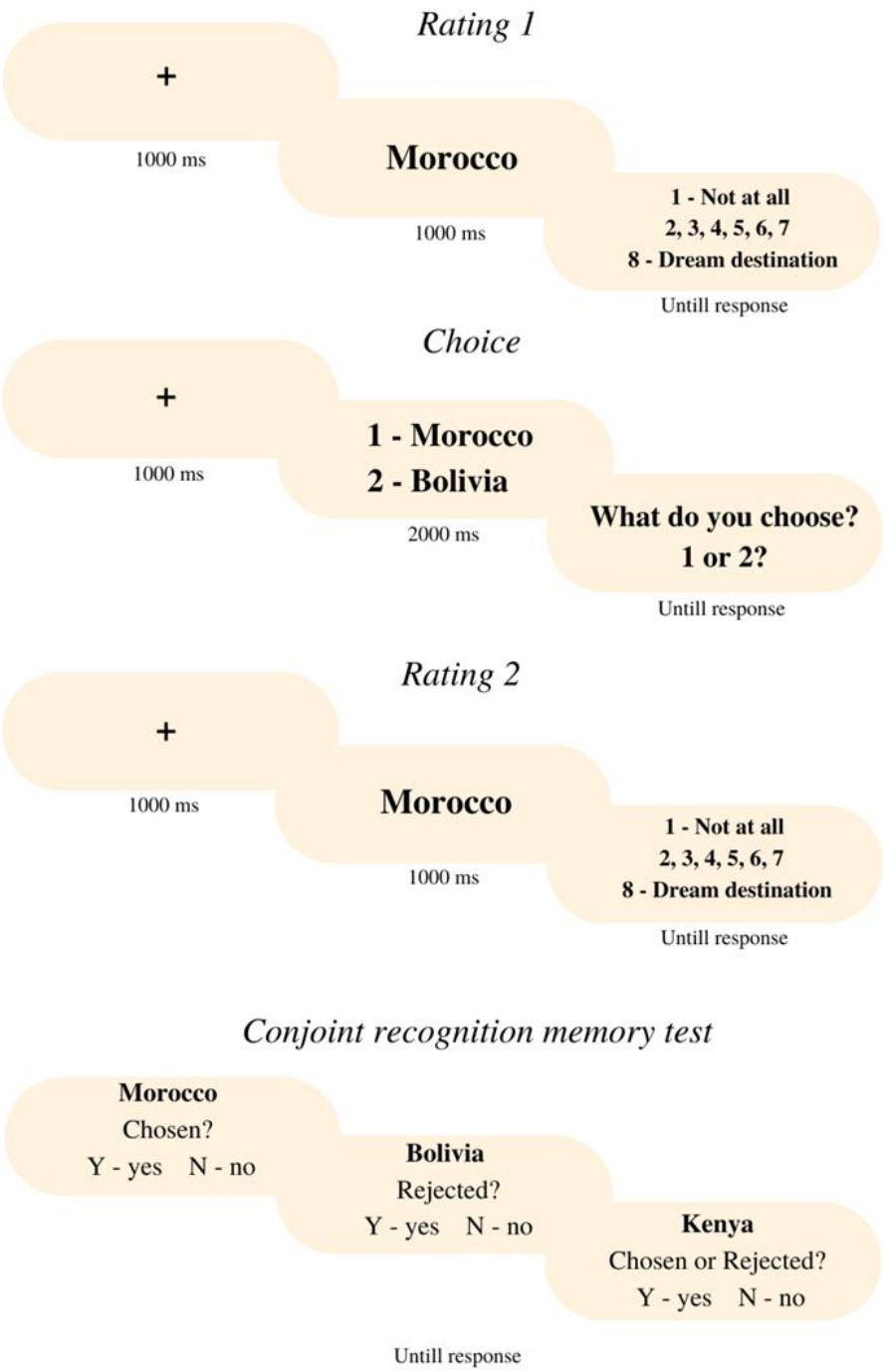
a) Did you choose this country when it was paired with the other country?

b) Did you reject this country when it was paired with the other country?

c) Did you choose or reject this country (was it in any pair of countries)?”

Figure 1

The procedure used in the RCR-desirability condition of the free-choice paradigm



The first control condition was identical to the RCR-desirability procedure with the exception of the order of the phases (RRC, rating - rating - choice), and it was conducted online using *OpenSesame* software (Mathôt et al., 2011).

The RCR-safety condition was identical to the RCR-desirability condition with the following exceptions: the used materials from the second pilot study (with safety ratings), the

ratings referred to a safety attribute, this experiment was built in *OpenSesame*, and it was conducted online. The participants were asked to rate a scale from 1 to 8 how safe the country that appeared on the screen is by taking into consideration the hospitality of the citizens and the security of the country. In the Choice part of the study, the participants were instructed to indicate which of the two countries in the pair is safer, in their opinion.

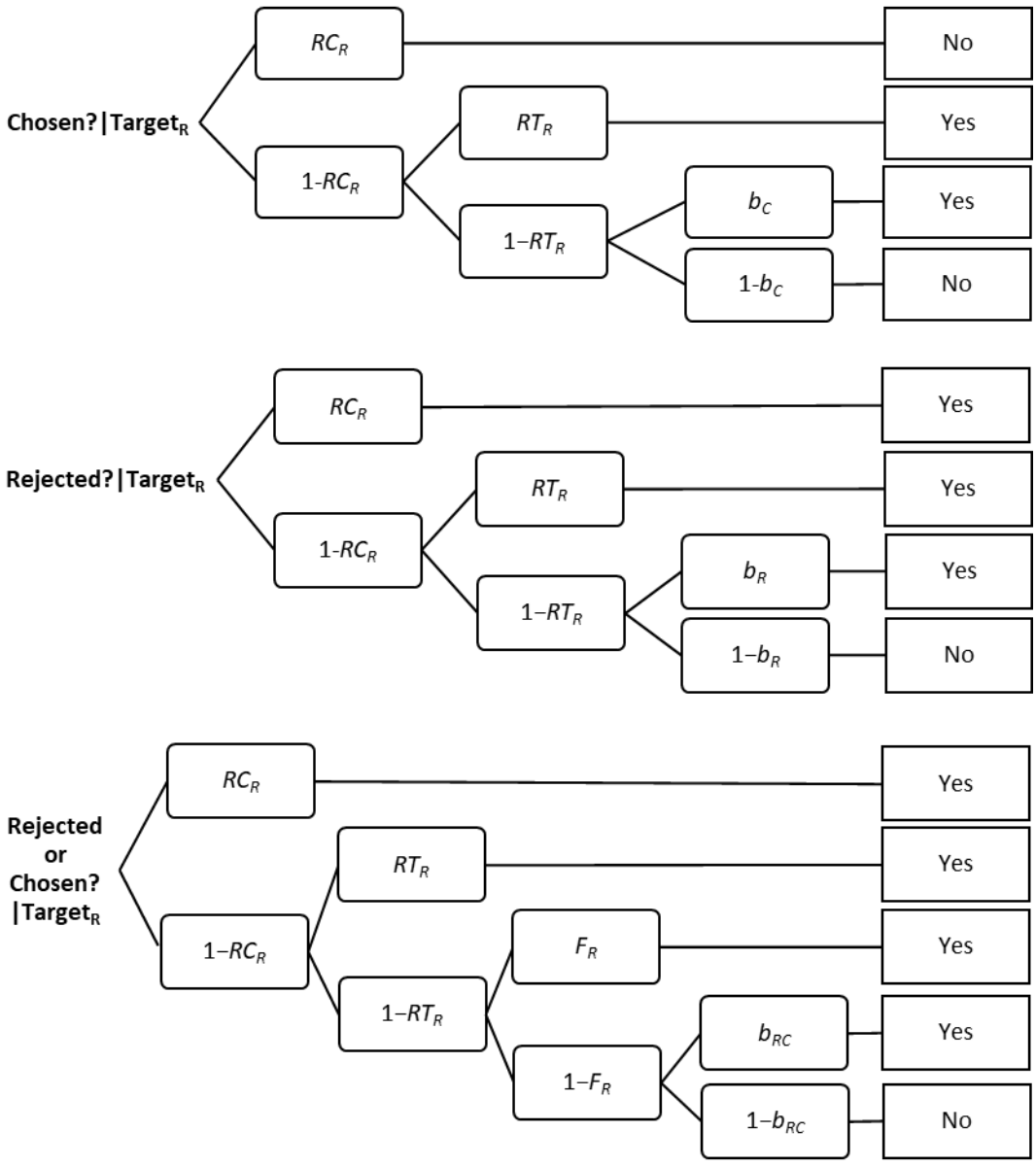
Multinomial dual recollection processing tree model

The dual-recollection multinomial processing tree model was used as the measurement model (Brainerd et al., 2015). Multinomial modelling is a statistical methodology that can be applied to categorical data, and its great advantage is its capability of disentangling and measuring the separate contribution of underlying latent cognitive processes to task performance (for reviews see: Batchelder & Riefer, 1999; Erdfelder et al., 2009). Figure 2 presents a part of the dual recollection multinomial model adapted for the memory for choice task. Here, the context is determined by the decision (rejected vs. chosen) made for each target by the participants. In the current study, three types of question probes in the memory test (Rejected?, Chosen?, Rejected or Chosen?) were crossed with three types of cues - names of countries that were: 1) rejected or 2) chosen in the Choice phase, or 3) nonstudied distractors. In Figure 2, only the model of processing of rejected targets is shown as an example. On the left are the cue types used at test with the specified question probes. On the right are the participants' observable responses (accept or reject) that are connected with the question probes and the item types by the branches of the processing trees. When a target is congruent with the question probe (R?|Target_R), the target cues are accepted if context recollection (RC_R) or target recollection (RT_R) is successful and, if neither are successful, response bias (b_R) can produce a "yes" response. When a target type is incongruent with the question probe (C?|Target_R), the target cues are rejected if context recollection is successful, but are accepted if context recollection fails ($1-RC_R$) and target recollection (RT_R) is

successful, and a "yes" response may also be produced by the response bias (b_C). On probes with the RorC? question, the participants respond "yes" if context recollection, target recollection or familiarity (F_R) are successful, and if all of these retrieval processes fail, the response bias (b_{RC}) can produce acceptance (see Nieznański, 2020 and Niedziałkowska & Nieznański, 2021, for similar model adaptation).

Figure 2

A part of the multinomial dual-recollection model for targets rejected during a choice task (based on Brainerd et al., 2015, Figure 1)



The computations were carried out on raw frequencies of each response category aggregated over the participants and categorised according to the change in rating in the FCP (for response frequencies see file 1 in the supplementary materials). The goodness of fit of the model to the empirical data was tested with the log-likelihood ratio statistic (G^2), which is distributed asymptotically as a χ^2 distribution. At α level of 0.05, $G^2(1) = 3.84$ indicates a critical value. For multiple comparisons in pairs (i.e., when three types of targets are compared with each other), an adjustment procedure was required to preserve the probability of Type I error. We note each time the sequential Holm rejection procedure indicated that the result would not remain significant after applying the alpha correction.

All computations were carried out with the *Multitree* computer program (Moshagen, 2010). A post-hoc power analysis was conducted for the most important hypotheses concerning the differences in context recollection across targets categorised depending on choice-consistency of their change in rating. Assuming significance level $\alpha = 0.05$, and power $1 - \beta = 0.80$, analysis revealed that the number of observations gathered in the RCR desirability condition, was sufficient to detect an effect of size $w = 0.06$, which corresponds to the difference of 0.325 between the RC_C parameters for targets with consistent vs. opposite change in rating and the difference of 0.275 between the RC_C parameters for targets with consistent vs. no change in rating. Similarly, for context recollection of rejected targets, the gathered number of observations was sufficient to detect an effect of size $w = 0.06$, which corresponds to the difference of 0.35 between the RC_R parameters for targets with consistent vs. opposite change in rating, and the difference of 0.32 between the RC_R parameters for targets with consistent vs. no change in rating.

Results of Experiment 1

Spreading of alternatives

Table 1 presents the mean differences between the second and the first rating, separately for the chosen and the rejected items, as well as the overall index of the spreading of alternatives:

$$Spread = (Rating2_{Chosen} - Rating1_{Chosen}) - (Rating2_{Rejected} - Rating1_{Rejected}).$$

The value of the *Spread* index above zero means a change in rating that is consistent with the choice.

Table 1

Mean spread of alternatives and the results of one-sample test of difference from 0

	Mean (SD)	95% CI	One-sample test	Effect size
Study 1, RCR: Desirability				
R2 - R1 for chosen	0.190 (0.371)	[.034, .347]	$t(23) = 2.512$, $p = .019$	$d = .513$
R2 - R1 for rejected	0.012 (0.418)	[–.164, .186]	$t(23) = 0.142$, $p = .889$	$d = .029$
Spread	0.177 (0.516)	[–.041, .395]	$t(23) = 1.676$, $p = .107$	$d = .342$
Study 1, RRC: Desirability				
R2 - R1 for chosen	**–0.326** (.750)	[–.643, –.009]	$t(23) = 2.130$, $p = .044$	$d = .435$
R2 - R1 for rejected	**0.394** (.684)	[.105, .683]	$t(23) = 2.824$, $p = .010$	$d = .576$
Spread	**–0.720** (1.023)	[–1.148, –.291]	$t(23) = 3.474$, $p = .002$	$d = .709$
Study 1, RCR: Safety				
R2 - R1 for chosen	–0.024 (.417)	[–.200, .152]	$t(23) = 0.284$, $p = .779$	$d = .058$
R2 - R1 for rejected	–0.047 (.504)	[–.260, .166]	$t(23) = 0.458$, $p = .652$	$d = .093$
Spread	0.023 (.387)	[–.140, .186]	$t(23) = 0.290$, $p = .774$	$d = .059$

Note. Means significantly different from 0 after applying the Holm sequential rejective procedure are in bold font.

The results of the one-sample *t*-test, showed that the spread index was not significantly different from zero in both RCR conditions. Looking separately at the change in ratings for the rejected and the chosen items, a marked change (but nonsignificant after correction for multiple testing) occurred only for the chosen items in the RCR-desirability condition. In the RRC condition, the differences in ratings were in the opposite direction than implicated by the choice; but in this condition, the choice phase comes after the second rating, so in fact, participants rejected items for which they had increased ratings and chose items for which they had decreased ratings. These results suggest that the cognitive dissonance reduction could possibly have affected the second rating solely for chosen items in the RCR desirability condition since only in this case did the participants change their ratings noticeably and consistently with their choice.

Memory for choice and changes in ratings

Each item was categorized for each participant separately, according to the following criteria: 1) whether it was rejected or accepted at the Choice phase of the FCP; 2) which question probe this item received (R?, C? or RorC?); and 3) whether the rating for this target changed consistently or in the opposite direction with respect to the choice or if it did not change at all.

Rating-Choice-Rating Procedure - desirability rating

The multinomial model parameter estimates are shown in the upper part of Table 2. Among the memory parameters, the context recollection and the familiarity of the chosen targets differed significantly across the targets categorized according to their change in rating. Comparisons in pairs showed that the context recollection of the chosen target parameter (RC_C) was significantly lower for the opposite-change targets then for the consistent-change ones, $\Delta G^2(1) = 7.78$, $p = .005$, and for the no-change targets, $\Delta G^2(1) = 9.47$, $p = .002$. In

contrast, the familiarity of the chosen targets parameter (F_C) was significantly higher for the opposite-change targets than for the consistent-change ones, $\Delta G^2(1) = 13.48$, $p < .001$, and the no-change targets, $\Delta G^2(1) = 4.63$, $p = .031$ (but the latter difference would not remain significant after applying the alpha adjustment).

When the parameters were compared according to whether the targets were chosen or rejected, in the case of opposite-choice targets, the familiarity parameter for the rejected targets was lower than for the chosen targets, $\Delta G^2(1) = 5.46$, $p = .019$ (nonsignificant after alpha correction). Finally, for the response bias parameters, we found that the participants were more prone to guess "yes" when they were asked "Did you reject it?" than "Did you choose it?", $\Delta G^2(1) = 23.38$, $p < .001$.

Table 2

Multinomial model parameter estimates (standard errors) obtained in Experiment 1

Parameter	Choice consistent change in rating	No change in rating*	Opposite to choice change in rating	Comparison
RCR: Desirability rating				
RT_C	.46 (.070)	.42 (.063)	.38 (.062)	$\Delta G^2(2) = .63$, $p = .728$
RT_R	.37 (.066)	.30 (.054)	.36 (.061)	$\Delta G^2(2) = .84$, $p = .658$
RC_C	**.35 (.071)**	**.37 (.063)**	**.03 (.093)**	**$\Delta G^2(2) = 10.70$, $p = .005$**
RC_R	.28 (.088)	.32 (.072)	.24 (.088)	$\Delta G^2(2) = .52$, $p = .773$
F_C	**.03 (.227)**	**.48 (.133)**	**.83 (.086)**	**$\Delta G^2(2) = 13.67$, $p = .001$**
F_R	.40 (.176)	.52 (.126)	.43 (.150)	$\Delta G^2(2) = .39$, $p = .821$
b_C		.08 (.016)		
b_R		.23 (.025)		
b_{RC}		.18 (.022)		
RRC: Desirability rating				
RT_C	.47 (.068)	.38 (.078)	.55 (.057)	$\Delta G^2(2) = 2.98$, $p = .225$
RT_R	.38 (.072)	.22 (.058)	.29 (.053)	$\Delta G^2(2) = 2.94$, $p = .230$
RC_C	.40 (.075)	.47 (.076)	.38 (.064)	$\Delta G^2(2) = 0.88$, $p = .645$
RC_R	.46 (.078)	.38 (.080)	.41 (.064)	$\Delta G^2(2) = 0.53$, $p = .769$
F_C	.43 (.178)	.46 (.164)	.45 (.171)	$\Delta G^2(2) = 0.01$, $p = .994$
F_R	.33 (.204)	**.76 (.089)**	**.14 (.161)**	**$\Delta G^2(2) = 11.26$, $p = .004$**
b_C		.03 (.10)		
b_R		.08 (.16)		

b_{RC}		.03 (.11)		
RCR: Safety rating				
RT_C	.41 (.054)	.51 (.049)	.43 (.050)	$\Delta G^2(2) = 2.42$, $p = .298$
RT_R	.41 (.061)	.43 (.051)	.36 (.056)	$\Delta G^2(2) = 0.86$, $p = .650$
RC_C	.11 (0.086)	.23 (.070)	.11 (.080)	$\Delta G^2(2) = 1.70$, $p = .426$
RC_R	.31 (0.077)	.19 (.077)	.19 (.084)	$\Delta G^2(2) = 1.68$, $p = .432$
F_C	.65 (0.107)	.57 (.124)	.67 (.098)	$\Delta G^2(2) = 0.43$, $p = .805$
F_R	.43 (0.149)	.55 (.114)	.54 (.118)	$\Delta G^2(2) = 0.49$, $p = .784$
b_C		.08 (.016)		
b_R		.10 (.018)		
b_{RC}		.10 (.018)		

Note. RT_C - target recollection for chosen targets, RT_R - target recollection for rejected targets, RC_C - context recollection for chosen targets, RC_R - context recollection for rejected targets, F_C - familiarity for chosen targets, F_R - familiarity for rejected targets, b_C - bias toward "yes" response for "Did you choose it?" questions, b_R - bias toward "yes" response for "Did you reject it?" questions, b_{RC} - bias toward "yes" response for "Did you reject or choose it?" questions. Significant results are in bold font. * Items with a maximal rating (1 or 8) which cannot change were excluded from analyses.

Rating-Rating-Choice Procedure - desirability rating

As can be seen in the middle part of Table 2, only in the case of the familiarity of the rejected targets parameter (F_R) a significant difference was detected. When compared in pairs, the familiarity parameter for the no-change targets was significantly higher than for the opposite-change targets, $\Delta G^2(1) = 11.19$, $p = .008$, and the consistent-change targets, $\Delta G^2(1) = 4.78$, $p = .028$ (the latter nonsignificant after alpha correction).

When the parameters were compared according to whether the targets were chosen or rejected, in the case of the opposite-choice targets, the target recollection parameter for the rejected targets was significantly lower than for the chosen targets, $\Delta G^2(1) = 11.18$, $p < .001$. As for the RCR-desirability procedure, the participants were also more prone to guess "yes" when asked "Did you reject it?" than "Did you choose it?", $\Delta G^2(1) = 7.98$, $p = .005$.

Rating-Choice-Rating Procedure - safety rating

As shown in the bottom part of Table 2, no parameter differed significantly across the types of targets. When the parameters were compared according to whether the targets were chosen or rejected, there was also no difference.

Discussion of Experiment 1

In Experiment 1, we found that desirability ratings changed consistently with choice only in the case of chosen travel destinations in the RCR condition. However, for rejected targets, no significant change was detected in this condition. For chosen targets (but not for rejected ones) we found that the context recollection parameter from the dual-recollection model (Brainerd et al., 2014, 2015) was close to zero for targets that changed their rating in the opposite to choice direction, and it was significantly higher for targets with no change or consistent change in desirability rating than for opposite-to-choice targets. This result suggests that remembering that a target was chosen as more desirable at least suppressed subjects from decreasing their second rating.

When participants' ratings were based on their knowledge about the countries' safety, their changes in ratings were not biased and resulted in a non significantly different from zero mean spread of alternatives. As predicted, it seems that ratings that do not engage the participants' attitudes or preferences do not induce a noticeable dissonance that needs to be reduced. Consistently with this result, we found no differences in memory parameters across types of targets.

In the case of the RRC control procedure, we found a significant change in participants' ratings, but in the opposite direction than the choice made in the last stage of the RRC procedure. This result is unexpected and suggests that an unknown factor operates when subjects assess the desirability of tourist destinations in two consecutive rating sessions before

the Choice phase. Perhaps the impact of this factor is offset by the reduction of dissonance in the RCR procedure.

The results concerning the contribution of familiarity suggest that this more automatic component of memory significantly differs depending on the target type. In the RCR-desirability condition, for chosen targets, we observed nearly null contribution of familiarity to recognition of choice-consistent targets, whereas it was significantly higher for opposite-change targets. Such a pattern of results was not found for rejected targets.

Non-self based models predict that higher-level cognition is not involved in the CIPC effect, which does not preclude that an automatic process such as familiarity may be involved in this effect. We observed the differences in familiarity among targets depending on their category, but in the opposite direction to what was observed for context recollection, since the chosen targets for which the choice-induced preference change was observed were least familiar. It suggests that a higher level of familiarity may be associated with a lower level of CIPC. Moreover, we observed some differences in familiarity contribution in the RRC control procedure.

Experiment 2

In Experiment 2, we addressed the main ambiguity of the RCR-desirability procedure of Experiment 1, namely the lack of effect on the Spread index. We found marked choice-consistent changes in ratings only for chosen items, but not for rejected items. Also, we found significant differences in context recollection only for chosen items. This suggests the possibility that an increase in context recollection might also be observed in the case of rejected items, if spread effects occurred for those items. The literature on FCP (Brehm, 1956) indicates that the magnitude of the dissonance and the consequent spread effects are greater the more closely the alternatives approach equal desirability. In Experiment 1, we did not

control for how close in rating the countries paired in the choice phase were for individual participants, assuming that matching based on group ratings is sufficient to obtain the CIPC effect. Therefore, in Experiment 2, we directly manipulated how close in rating the paired countries are. We expected that pairing countries that are similarly attractive would lead to a high spread of alternatives effect, while matching pairs with distant ratings would lead to a lack of spread; these differences in spread size should be followed by differences in memory performance, provided memory is indeed involved in a mechanism of the CIPC effect. An additional aim of the study was to preliminarily test the applicability of the model of cognitive processes involved in hindsight bias in analysing the processes involved in FCP.

Methods

Sample

In Experiment 2, 55 participants (43 women; age $M = 20.6$, $SD = 2.85$), were recruited via a snowball procedure mostly among first year psychology students. The experiments were conducted in the laboratory of the Chair of Cognitive Psychology at UKSW. Each session involved either up to five participants simultaneously or was conducted individually using the researcher's computer. Students received a voucher to a popular bookstore worth 50 PLN (ca. $13) for volunteering. The participants were randomly assigned to the distant pairs condition (19 women; age $M = 19.6$, $SD = 0.971$), and to the close pairs condition (24 women; age $M = 21.5$, $SD = 3.67$). The results of two persons from the distant pairs condition were excluded from the analyses, because of technical difficulties with computers during the experiment. A post hoc power analysis showed that, with a sample of 27 participants, it was possible to detect medium effect size $d = 0.56$, with power 1- beta = 0.80, in a one-sample two-tailed *t*-test of difference of spread from zero (G*Power 3; Faul et al., 2007).

Materials and procedure

The materials and procedure were similar to the RCR-desirability condition of Experiment 1, with the main exception that the pairs in the Choice phase were matched on the basis of each person's individual ratings from the Rating 1 phase. In the distant pairs condition, the algorithm matched countries in such a way as to maximise the difference in the ratings of the paired countries, and in the close pairs condition, conversely, the ratings were as similar as possible.

The procedure was programmed in the PsychoPy software (Peirce, et.al., 2019). The additional material (the code of the experiments, instructions, raw data) is available online: https://osf.io/g7tzs/ (file name: Experiment 2).

Multinomial processing tree model for hindsight bias

In order to test an assumption that the structure and nature of the cognitive processes underlying choice-induced preference change are analogous to the processes underlying hindsight bias, we generalized a multinomial processing tree model developed to measure the latent processes contributing to HB performance to a free-choice paradigm. This attempt was derived from two main considerations. First, the choice between two options that participants make during the choice phase in FCP can be conceptualized as a self-generated "correct answer". Except that rather than being given this answer, as in the HB experiments, in FCP participants are asked to choose the "correct answer", that is, to consider all the pros and cons on their own and come to a conclusion about which option is better. Second, although in the HB paradigm participants are asked to recall their original judgment, they are often unable to do so and reconstruct that judgment on the basis of their current knowledge. The same can happen in FCP; although participants are asked to make their judgments once again, sometimes they probably recall their first judgment. Thus, in both paradigms, the processes of

recollection and reconstruction contribute to task performance. Arguably, these processes may influence performance with varying effectiveness, with the recollection component being more important in the HB experiments than in FCP, because participants are explicitly asked to recall their original judgment, and with the reconstruction process being more important in FCP than in HB experiments, because participants are explicitly asked for reassessment.

A measurement model that seems to be appropriate for applying to both paradigms is the multinomial processing tree model for hindsight bias developed by Erdfelder and Buchner (1998) with its modification proposed by Dehn and Erdfelder (1998). This model is based on the recollection-reconstruction theory of HB. This theory assumes that during the second judgment, participants first try to recollect their original judgment, but correct recollections may be inhibited since the outcome knowledge interferes with retrieval of the original judgment. If recollection is not successful, in the second stage, participants try to reconstruct the original judgment. The reconstruction process may be biased because the correct answer may function as an anchor to which the participant adjusts the reconstructed judgment. Alternatively, outcome information may alter the participants' knowledge, so that reassessment must be based on this updated knowledge (Coolin et al., 2014; Erdfelder et al., 2007; Gross et al., 2023).

Erdfelder and Buchner (1998) developed a multinomial processing tree model that disentangles the impact of recollection bias from the impact of reconstruction bias on the HB task performance. This model assumes 13 parameters, so it is called the HB13 model. Among the most important parameters in this model are the r_C and r_E parameters, which represent the probability of recollecting the original judgment in the control and experimental conditions, respectively. Another key parameter is b, which represents the probability of biased reconstruction given unsuccessful recollection, while the parameter g represents guessing strategy for unrecollected and unreconstructed items. The HB13 model contains several other

parameters that can be dropped when the outcome information is not unique for each item and is given in a simple binary format (e.g., true vs. false) instead of a more detailed (e.g., numerical) information. Such simplifications were introduced in the Hindsight Bias Difference Score model by Dehn and Erdfelder (1998). They ignored the possibility of source confusion between the original answer and the outcome information, and they did not take into account chance hits of the original answer. In comparison with Dehn and Erdfelder (1998) model, which was focused on the analysis of the magnitude of difference between recalled answer and the original answer, we did not differentiated responses depending on the size of deviation between these answers, which allowed for some further simplifications in the model. We also introduced a modification in the model for control condition that takes into account the specificity of FCP.

Figure 3

Multinomial processing tree model for Free Choice Paradigm, adapted from Hindsight Bias Difference Score model by Dehn and Erdfelder (1998)

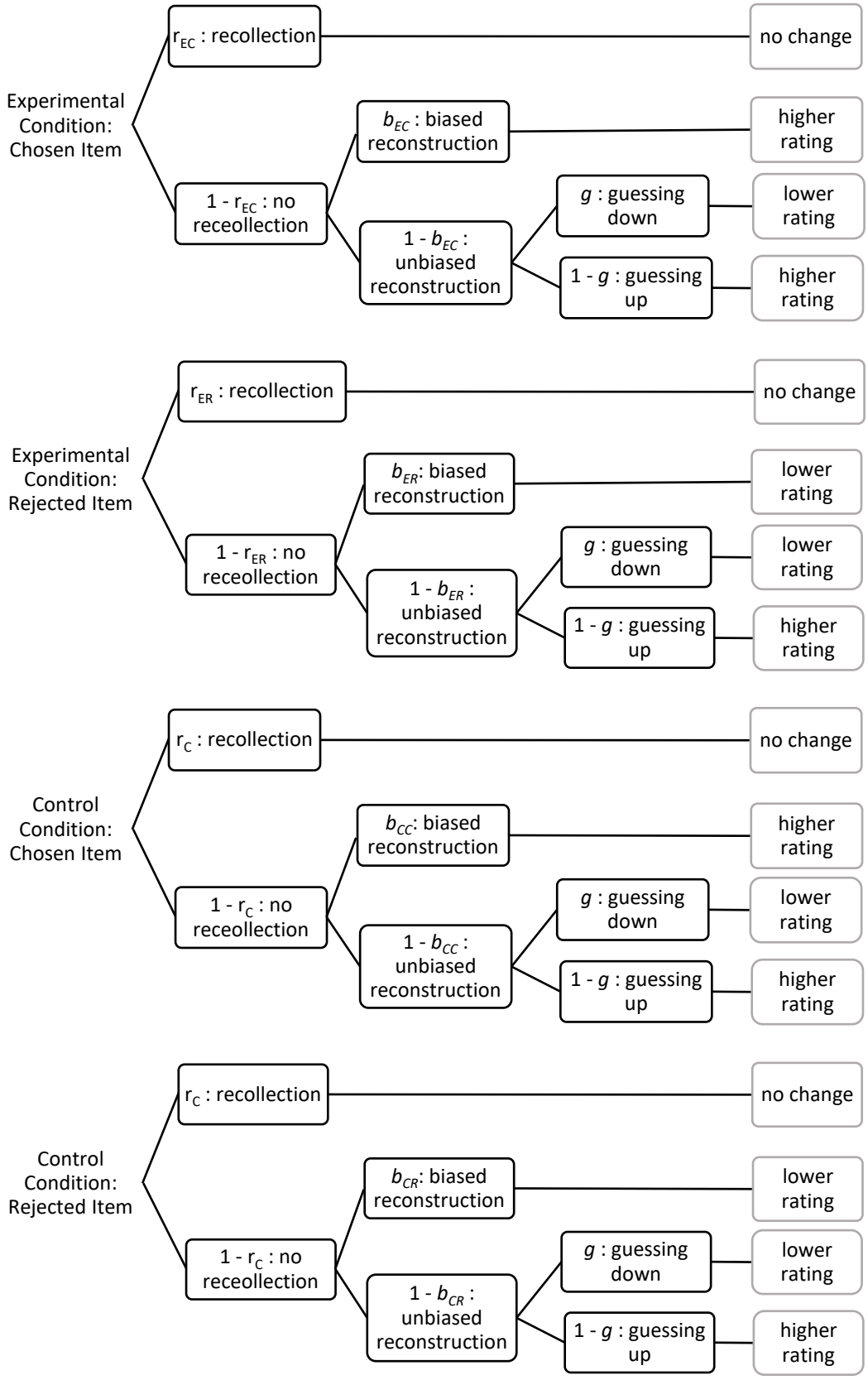

Experimental Condition: Chosen Item
r_{EC} : recollection
no change
1 - r_{EC} : no receollection
b_{EC} : biased reconstruction
higher rating
1 - b_{EC} : unbiased reconstruction
g : guessing down
lower rating
1 - g : guessing up
higher rating
Experimental Condition: Rejected Item
r_{ER} : recollection
no change
1 - r_{ER} : no receollection
b_{ER}: biased reconstruction
lower rating
1 - b_{ER} : unbiased reconstruction
g : guessing down
lower rating
1 - g : guessing up
higher rating
Control Condition: Chosen Item
r_C : recollection
no change
1 - r_C : no receollection
b_{CC}: biased reconstruction
higher rating
1 - b_{CC} : unbiased reconstruction
g : guessing down
lower rating
1 - g : guessing up
higher rating
Control Condition: Rejected Item
r_C : recollection
no change
1 - r_C : no receollection
b_{CR}: biased reconstruction
lower rating
1 - b_{CR} : unbiased reconstruction
g : guessing down
lower rating
1 - g : guessing up
higher rating

Figure 3 depicts multinomial processing tree model adapted to the Free Choice Paradigm. The model contains seven parameters $\{r_C, r_{EC}, r_{ER}, b_C, b_{EC}, b_{ER}, g\}$ and eight free response categories. In the experimental condition, we distinguished between parameters representing processing of items that were chosen vs. rejected in the choice phase. We assumed that it is possible that the feedback information the participants generate for themselves by decision in this phase may influence their knowledge about or preference for chosen and rejected item in a different way. For example, it is possible that rejecting an item results in a kind of inhibition process, as it is observed in tasks with negated items (e.g., Mayo et al., 2014) or even as in the item-method directed forgetting task (e.g., Zacks et al., 1996). It is also possible that acceptance or rejection of an option differently affects adaptation processes of accommodation and assimilation (cf., Fiedler & Hütter, 2013). In the model for the experimental condition, the r_{EC} and r_{ER} parameters represent recollection of the original rating, for chosen and rejected items, respectively, and this process results in no change in rating. Conditional on the failure to recollect the original rating, the parameters b_{EC} and b_{ER} represent probability of biased reconstruction, for chosen and rejected items, respectively. This means giving a higher rating for chosen items, and lower rating for rejected items. When reconstruction is not biased, the parameter g represents responding tendency to give a lower rating, and 1 - g represents responding tendency to give a higher rating.

In the control condition, the parameter r_C is the probability of original judgment recollection, leading to no change in rating at second judgment. Conditional on the failure to recollect the original rating, the parameter b_C represents probability of biased responding consistent with initially imprecisely estimated knowledge or preference. This parameter captures a bias which is due to random underestimations or overestimations in the first rating which are then corrected in the second rating and reflected in the final choice behavior (cf. Chen & Risen, 2010). Introducing the possibility of reconstruction bias in the control

condition, is a departure from the original model used in the HB experiments, which assume that no reconstruction bias occurs when feedback is not provided. However, in the context of FCP we have to take into account the possibility of decreasing the second rating of rejected items and increasing the second rating of chosen items, even when these choices are made *after* the second rating. According to Chen and Risen (2010, for reviews see: Enisman et al., 2021; Izuma & Murayama, 2013), ratings are noisy measures of preferences, so initial equal ratings may in fact stem from an underestimation of the true preference for option A or an overestimation of the true preference for option B. The second rating may simply be a more precise assessment of the actual preferences for A and B (the regression to the mean effect), which is also expressed in the choice phase, performed after the second rating in the control condition. If the model fits the data well after the reconstruction bias parameter being reduced to zero, one will be able to conclude that there is no influence of the described artefact. If, however, the parameter cannot be eliminated, its comparison with the corresponding bias parameter in the experimental condition will make it possible to assess whether choice (feedback) is indeed responsible for the preference change.

Results of Experiment 2

Spreading of alternatives

As shown in Table 3, the spread index was significantly different from 0 only for the close pairs condition. In this condition, the differences were also significant when the rejected and chosen items were considered separately. In the distant pairs condition, the spread of alternatives was significant only for the chosen items. When comparing between conditions, the Mann-Whitney test indicated that spreads of alternatives were significantly larger in the close pairs condition than in the distant pairs condition, for the general spread index, $W =$

111.5, $p < .001$, rank-biserial correlation (*rrb*) = 0.705, and separately for the rejected items, $W = 524.0$, $p = 0.014$, $rrb = 0.386$, and for the chosen items, $W = 199.0$, $p = 0.003$, $rrb = 0.474$. These observations are consistent with the dissonance reduction approach, that predicts larger CIPC effect for close in desirability alternatives (Brehm, 1956).

Memory for choice and changes in ratings

The multinomial model parameter estimates are shown in Table 4.-A post-hoc power analysis was conducted for the most important hypotheses concerning the differences in context recollection across targets categorised depending on choice-consistency of their change in rating. Assuming significance level $\alpha = 0.05$ and power $1 - \beta = 0.80$, analysis revealed that the number of observations gathered in the close pairs condition, was sufficient to detect an effect of size $w = 0.04$, which corresponds to the difference of 0.32 between the RC_C parameters for targets with consistent vs. opposite change in rating and the difference of 0.23 between the RC_C parameters for targets with consistent vs. no change in rating. For context recollection of rejected targets (RC_R), the respective differences were of 0.32 and of 0.265.

In the close pairs condition, no memory parameter differed significantly across the targets categorized into three classes according to their change in rating. In pairs, there were two differences which would not remain significant after alpha correction (the target recollection parameter for rejected targets was higher for no-change targets than for consistent-change targets, $\Delta G^2(1) = 4.43$, $p = .035$, and the familiarity parameter for chosen targets was higher for no-change targets than for consistent-change targets, $\Delta G^2(1) = 4.39$, $p = .036$).

In the distant pairs condition, two significant differences were found for the context recollection parameter for chosen items and for rejected items. These parameters were significantly higher for the no-change targets than for the opposite-change targets, $\Delta G^2(1) =$

4.80, $p = .028$ (nonsignificant after alpha correction) for chosen targets, and $\Delta G^2(1) = 6.40$, $p = .011$, for rejected targets. Also the context recollection parameter was significantly higher for the no-change targets than for the consistent-change targets, $\Delta G^2(1) = 7.16$, $p = .007$, for chosen targets. Comparisons in pairs revealed one more difference which would not remain significant after alpha correction - the target recollection parameter for chosen targets was higher for no-change targets than consistent-change targets, $\Delta G^2(1) = 4.22$, $p = .04$.

When the parameters were compared according to whether the targets were chosen or rejected, in the case of the consistent-choice targets in the close pairs condition, the target recollection parameter for the rejected targets was significantly lower than for the chosen targets, $\Delta G^2(1) = 5.11$, $p = .024$ (nonsignificant after alpha correction).

Comparisons between the close pairs condition and the distant pairs condition revealed only two differences that remain significant after alpha correction. These differences concerned the context recollection parameters for no-change targets, which were significantly higher in the distant pairs condition, both for chosen targets, $\Delta G^2(1) = 17.16$, $p < .001$, and rejected targets $\Delta G^2(1) = 8.58$, $p = .003$.

Table 3

Mean spread of alternatives and the results of one-sample test of difference from 0 in Experiment 2

	Mean (SD)	95% CI	One-sample test	Effect size
RCR: Distant pairs				
R2 - R1 for chosen	**.163** (.285)	[.050, .276]	$t(26) = 2.966$, $p = .006$	$d = .571$
R2 - R1 for rejected	.081 (.356)	[–.059, .222]	$t(26) = 1.189$, $p = .245$	$d = .229$
Spread	.081 (.340)	[–.053, .216]	$t(26) = 1.246$, $p = .224$	$d = .240$
RCR: Close pairs				
R2 - R1 for chosen	**.395** (.520)	[.194, .597]	$V = 375.5$, $p < .001$	$rrb = .850$

R2 - R1 for rejected	–**.201** (.513)	[–.400, –.002]	$V = 93.5$, $p = .013$	$rrb = .539$
Spread	**.596** (.415)	[.436, .757]	$V = 386.5$, $p < .001$	$rrb = .904$

Note. In RCR: Distant pairs $n = 27$, in RCR: Close pairs $n = 28$. Means significantly different from 0 after applying the Holm sequential rejective procedure are in bold font. In RCR: Close pairs condition, the variables distributions deviated from normal distribution, therefore Wilcoxon signed-rank test was used.

Table 4

Multinomial model parameter estimates (standard errors) obtained in Experiment 2

Parameter	Choice consistent change in rating	No change in rating	Opposite to choice change in rating	Comparison
RCR: Desirability rating - close pairs				
RT_C	.51 (.045)	.53 (.046)	.57 (.067)	$\Delta G^2(2) = 0.52$, $p = .771$
RT_R	**.35 (.053)**	**.50 (.045)**	.47 (.052)	$\Delta G^2(2) = 4.69$, $p = .096$
RC_C	.18 (.064)	.28 (.059)	.15 (.102)	$\Delta G^2(2) = 1.57$, $p = .455$
RC_R	.25 (.076)	.22 (.065)	.09 (.089)	$\Delta G^2(2) = 2.04$, $p = .361$
F_C	**.36 (.138)**	**.70 (.094)**	.57 (.185)	$\Delta G^2(2) = 4.44$, $p = .109$
F_R	.44 (.122)	.50 (.122)	.27 (.163)	$\Delta G^2(2) = 1.44$, $p = .486$
b_C		.06 (.013)		
b_R		.13 (.018)		
b_{RC}		.11 (.017)		
RCR: Desirability rating - distant pairs				
RT_C	.34 (.063)	.53 (.066)	.50 (.076)	$\Delta G^2(2) = 4.91$, $p = .086$
RT_R	.41 (.074)	.45 (.062)	.36 (.054)	$\Delta G^2(2) = 1.23$, $p = .541$
RC_C	**.37 (.071)**	**.60 (.049)**	**.39 (.083)**	$\Delta G^2(2) = 8.86$, $\mathbf{p = .012}$
RC_R	.46 (.075)	**.48 (.060)**	**.24 (.079)**	$\Delta G^2(2) = 7.16$, $\mathbf{p = .028}$
F_C	.70 (.104)	.48 (.176)	.67 (.147)	$\Delta G^2(2) = 1.34$, $p = .512$
F_R	.62 (.143)	.46 (.153)	.63 (.098)	$\Delta G^2(2) = 1.10$, $p = .576$
b_C		.06 (.013)		
b_R		.11 (.017)		
b_{RC}		.07 (.014)		

Hindsight bias and free-choice paradigm

The full version of the MPT model for FCP cannot be applied for this data, since there was no control condition in this experiment. However, the model can be made identifiable by restricting the number of free parameters. First, it seems reasonable to implement an equality constraint on guessing parameters, that is, we can assume that participants' guessing strategy does not differ in close and distant pairs conditions. Moreover, we can also assume that pairing does not affect recollection, depending on the closeness of matching.

Since the parameter *b* was close to the lower boundary of the parameter space (i.e., near 0) in the distant pairs condition, we used parametric bootstrap simulations (with 500 samples) to draw inferences regarding the variability of the parameter estimates (Moshagen, 2010; Singmann & Kellen, 2013). The multinomial model parameter estimates are shown in Table 5. The model goodness of fit was satisfactory, $G^2(1) = 1.66$, $p = .20$. As predicted, reconstruction bias was significantly higher in the close pairs condition than in the distant pairs condition, $G^2(1) = 21.47$, $p < .001$ and $G^2(1) = 12.52$, $p < .001$, for chosen and rejected items, respectively.

Table 5

Parameter estimates of the multinomial model for the Free Choice Paradigm applied to data from Experiment 2

Parameter	Close pairs condition	Distant pairs condition
Recollection (*r*)		
Chosen items	.46 (.013) [.437 – .487]	
Rejected items	.42 (.012) [.394 – .440]	
Reconstruction bias (*b*)		
Chosen items	.36 (.055) [.256 – .471]	.02 (.036) [–.037 – .105]
Rejected items	.23 (.045) [.142 – .316]	.03 (.028) [–.027 – .082]
Guessing down (*g*)	.44 (.017) [.410 – .477]	

Note. Parameter estimates are presented with bootstrapped standard deviations and 95% CI.

Discussion of Experiment 2

In Experiment 2, in the distant pairs condition, we observed consistent changes in ratings only for chosen items. However, we found that context recollection was best for (chosen or rejected) targets with no change in ratings. When pairing a less-attractive country with a very attractive one, their dissimilarity probably contributed to better choice memory, or they simply inferred their choice from targets' attractiveness rather than recalling it. In the close pairs condition, which we expected to replicate the results from the RCR desirability condition from Experiment 1, we found a consistent shift in ratings corresponding to choice. Specifically, significant differences emerged in the Spread index and for both chosen and rejected items. Despite the significance of these spread changes, we did not observe significant differences in the parameters representing context recollection.

These results indicate a departure from the findings of Experiment 1, which suggested that recollecting that the target was chosen at least prevented participants from decreasing their second rating. This raises the question of the reasons for this discrepancy in results. The main difference in the procedure of the two studies was the way pairs were matched in the Choice phase. In Experiment 1, it was assumed that individual ratings would reflect those obtained in the pilot study, so the pairs were the same for all participants, but in Experiment 2, the pairs were participant-specific, based on individual ratings. We went back to the data from Experiment 1 and analysed how close the pairs in that study actually were, and found that the mean absolute value of the differences in the average ratings of the paired countries was M = 0.55 (SD = 0.47), suggesting that in general the paired countries were fairly close in terms of ratings. This analysis is based on average ratings, so presumably at the level of individual subjects and items the differences were occasionally large. We can say that the pairs were usually close in ratings (as in the close pairs condition in Experiment 2), but sometimes they were distant (as in the distant pairs condition in Experiment 2). We can speculate that this was

the reason for the observed discrepancies in results of the studies and this points to Experiment 2 as a better controlled study with more reliable results

It is unlikely that the differences in the results of Experiments 1 and 2 are due to differences in sample characteristics, as both samples were recruited mainly among students, with the majority of participants in both samples being women (Chi^2 (1) = 0.23, p = .63). It should be noted, however, that participants in the RCR desirability condition of Experiment 1 were older (M = 26.2) than those in Experiment 2 (M = 20.6), $t(80) = 4.44$, $p < .01$. Despite this difference, most of the participants in both studies fell within the same period of early adulthood, when memory can be considered optimally functioning.

The results of the MPT model for hindsight bias, applied to the free-choice paradigm, showed that in the close-pair condition, which represents more difficult choices due to the similar attractiveness of the two options, participants who were unable to recollect their initial ratings were more likely to rely on a biased reconstruction strategy compared to participants in the distant-pair condition (representing easier choices).

Experiment 3

HB and CD have been described as self-serving biases, linked to self-image protection (e.g., Bem, 1972; Roese & Vohs, 2012) and both of them share similar three-stage design involving two ratings and intervening of feedback or choice. Moreover, both may involve overlapping cognitive mechanisms: memory-based processes such as recollection and reconstruction have been implicated in hindsight bias (Erdfelder & Buchner, 1998), while the role of memory and executive control in CIPC remains debated (e.g., Chammat et al., 2017; Lieberman et al., 2001). The aim of Experiment 3 was to examine whether the latent processes underlying hindsight bias also accurately account for performance in the free-choice paradigm typically used to study cognitive dissonance. We conducted two experiments each with corresponding

control groups and aimed to measure the reduction of cognitive dissonance and hindsight bias within the free-choice paradigm with holiday destinations as material. In the dissonance condition, during second rating, participants were asked to rate again items, whereas in the hindsight bias design, they were asked to recall their first rating (as in the memory design, Pohl, 2007). We again used the multinomial model for hindsight bias developed by Erdfelder and Buchner (1998) with its modification proposed by Dehn and Erdfelder (1998). However, in this experiment we could apply data to the full version of the MPT model. We expected to observe similar result of reconstruction bias (*b*) in both conditions, along with spread of alternatives in each.

Methods

Sample

The participants were 81 (65 women, age M = 19.88, SD = 2.05) psychology students who received extra course credits for volunteering. Each participant was randomly assigned to one of four groups. The first group, the "cognitive dissonance" condition, consisted of 20 participants, aged 18 to 30 (15 women; age M = 20.05, SD = 3.12). The second group, the "cognitive dissonance" control condition, included 19 participants, aged 19 to 22 (15 women; age M = 19.89, SD = 1.07). The next group, the hindsight bias condition, consisted of 20 participants, aged 18 to 22 (18 women, age M = 18.9, SD = 1.04) and the last group, the hindsight bias control condition, included 22 participants, aged 18 to 22 (17 women, age M = 20.63, SD = 1.72). A post hoc sensitivity power analysis indicated that, with a sample of 80 participants, it was possible to detect a medium-to-large effect size of f = 0.32 with a power of $1 - \beta = 0.80$, for an ANOVA (Fixed effects, special, main effects and interactions). The critical F value for this analysis was 3.97. Additionally, for a one-sample two-tailed t-test of

difference from zero, it was possible to detect a medium-to-large effect size of $d = 0.66$ (G*Power 3; Faul et al., 2007).

Materials

The procedure of Experiment 3 followed the approach used in Chammat et al.'s (2017) study. In both the cognitive dissonance (CD) and hindsight bias (HB) conditions, travel destination were used as stimuli, consistent with materials employed in Studies 1 and 2. The additional materials (the code of the experiments, instructions and raw data) is available online: https://osf.io/g7tzs/ (file name: Experiment 3).

Procedure

The experiment was conducted in the laboratory of the Chair of Cognitive Psychology at UKSW, with participants working individually at separate computer stations. Each session involved up to five participants. The experiment was programmed and conducted in the *PsychoPy* software (Peirce, et.al., 2019).

The CD conditions were the same as in Experiment 1 (RCR: Desirability and RRC: Control) (see Figure 1). The HB condition also consisted of travel destination stimuli and a three-part procedure, but differed in Rating 2. The first part of the procedure was Rating 1 and it consisted of 60 names of countries that are potential travel destinations. Each country name was preceded by a 1000 ms fixation point and appeared on screen until participants gave their rating. They were presented in Times New Roman, 20 pt., bold, positioned in the center of the screen. At the beginning of Rating 1, there were 4 buffer items that were best and worst rated countries in the pilot study. Buffers did not appear in the later parts of the study and were not included in the analyses. The participants were given the same instructions as in Experiment 1 (RCR: Desirability), to evaluate how much they would like to visit a given country (e.g., if they won a lottery). Then, they went on to the Choice part, where they were instructed to indicate, for each pair, which of the two countries they would like to visit more. The countries

were individually paired based on participants' ratings from the first part of the experiments so that their ratings are as similar as possible. The 30 pairs were presented in random order and displayed until participant had answered. The Rating 2 phase differed across conditions. In CD conditions, participants were asked to rate again the countries and in HB conditions they were asked to recall their ratings from Rating 1.

Control conditions had the same instructions but were presented in different order with an additional filler task consisting of series of simple arithmetical operations between Rating 1 and 2. For the cognitive dissonance control condition the order of phases was: Rating 1 - Filler task - Rating 2 - Choice, and for the hindsight bias control condition it was: Rating 1 - Filler Task - Recall - Choice.

Results of Experiment 3

Spread of alternatives

Table 6 presents the mean differences between the second and the first rating, separately for the chosen and the rejected items, as well as the overall index of the spreading of alternatives. The value of the *Spread* index above zero means a change in rating that is consistent with the choice.

Table 6

Mean spread of alternatives and the results of one-sample test of difference from 0

	Mean (*SD*)	**95% CI**	**One-sample test**	**Effect size**
Ex: cognitive dissonance				
R2 - R1 for chosen	**0.346 (.507)**	[0.109, 0.584]	$t(19) = 3.056$, $p = .007$	$d = .507$
R2 - R1 for rejected	**–0.328 (.399)**	[–0.515, –0.141]	$t(19) = -3.679$, $p < .002$	$d = .399$

Spread	**0.675 (.487)**	[0.447, 0.903]	$t(19) = 6.201$, $p < .001$	$d = .486$
Control: cognitive dissonance				
R2 - R1 for chosen	**0.310 (0.246)**	[0.191, 0.429]	$t(18) = 5.486$, $p < .001$	$d = .247$
R2 - R1 for rejected	–0.004 (0.290)	[–0.143, 0.136]	$t(18) = –0.053$, $p = .958$	$d = .290$
Spread	**0.314 (0.257)**	[0.189, 0.438]	$t(18) = 5.315$, $p < .001$	$d = .257$
Ex: hindsight bias				
R2 - R1 for chosen	**0.358 (0.284)**	[0.225, 0.491]	$t(19) = 5.637$, $p < .001$	$d = .284$
R2 - R1 for rejected	**–0.278 (0.306)**	[–0.421, –0.134]	$t(19) = –4.061$, $p < .001$	$d = .306$
Spread	**0.636 (0.285)**	[0.503, 0.770]	$t(19) = 9.959$, $p < .001$	$d = .286$
Control: hindsight bias				
R2 - R1 for chosen	0.095 (0.333)	[–0.052, 0.243]	$t(21) = 1.342$, $p = .194$	$d = .333$
R2 - R1 for rejected	–0.136 (0.342)	[–0.287, 0.015]	$t(21) = –1.871$, $p = .075$	$d = .341$
Spread	**0.232 (0.406)**	[0.051, 0.412]	$t(21) = 2.677$, $p = .014$	$d = .406$

Note. Means significantly different from 0 after applying the Holm sequential rejective procedure are in bold font.

The results of the one-sample *t*-test showed that the spread index was significantly different from zero in all conditions. The change in ratings for both chosen and rejected items was also significantly different from zero in both experimental conditions, aligning with the direction of the choice.

Surprisingly, in both control conditions, the spread index was also significantly higher than zero. In the control condition for cognitive dissonance, the change in ratings for chosen items was significant and closely mirrored the change observed in the experimental condition.

These results suggest that choice-induced change plays a role in both cognitive dissonance and hindsight bias.

Table 7

2x2 Analyses of Variance for R2-R1 for chosen items, R2-R1 for rejected items and spread index

	R2-R1 for chosen				R2-R1 for rejected				Spread			
	F	*df*	*p*	*η2*	*F*	*df*	*p*	*η2*	*F*	*df*	*p*	*η2*
GROUP	3.526	1	.064	.044	**9.654**	1	.003	.111	**21.67***	1	< .001	.22
TASK TYPE	1.632	1	.205	.021	.304	1	.683	.004	0.53*	1	0.47	.001
INTERACTION	2.027	1	.159	.026	1.481	1	.227	.019	0.07*	1	0.79	.005

Note. F-values marked with an asterisk (*) are based on robust ANOVA with White's correction due to violated variance homogeneity. Significant results are in bold.

For each of the three dependent variables (R2-R1 for chosen items, R2-R1 for rejected items, Spread index) we conducted three separate 2 × 2 (Group [experimental, control] × Task type [cognitive dissonance, hindsight bias]) between-groups ANOVAs. For R2–R1 for chosen items the ANOVA showed no significant main effect or interactions.

For R2-R1 for rejected items, the ANOVA showed significant effect for the main effect of Group, which indicates that the change in ratings for rejected items was greater in experimental group (M = -0.303, SD = 0.352) than in control (M = -0.074, SD = 0.322).

For the Spread index, the assumption of homogeneity of variance was violated; therefore, a 2 × 2 ANOVA was conducted using a linear model with heteroskedasticity-consistent (White's) standard errors. This robust ANOVA revealed a significant main effect of Group, indicating that Spread was significantly greater in the experimental group (M = 0.655, SD = 0.394) than in the control groups (M = 0.269, SD = 0.343).

A Bayesian analysis of variance (ANOVA) was conducted to examine the effects of group (control vs. experimental) and task type (HB vs. CD) on the dependent variable. Model comparison revealed that the model including only group best explained the data

(posterior probability, P(M|data) = .721, Bayes Factor BF_{10} = 1585), indicating strong evidence for an effect of group. Adding task type to the model without interaction reduced model fit (P(M|data) = .212, BF_{10} = 467), and the full model including the group × task type interaction showed moderate fit but did not surpass the simpler group-only model (P(M|data) = .066, BF_{10} = 145.420).

Analysis of effects showed that group had a strong inclusion Bayes Factor ($BF_{(incl)}$ = 1121), supporting its role as a significant predictor. In contrast, task type ($BF_{(incl)}$ = 0.258) and the interaction ($BF_{(incl)}$ = 0.283) showed low inclusion probabilities, providing no evidence for their effects. These results support the hypothesis that the cognitive dissonance and hindsight bias conditions produce similar effects on the Spread index.

Multinomial processing tree model for hindsight bias in Experiment 3

To further examine cognitive mechanisms underlying hindsight bias and cognitive dissonance, a multinomial processing tree (MPT) model was applied to the data from Experiment 3. The model was tailored to the Free Choice Paradigm. Table 9 presents the estimated parameters for the CD and HB conditions.

Table 8

Parameter estimates of the MPT model for the Free Choice Paradigm for the cognitive dissonance vs hindsight conditions in Experiment 3 with vacation destinations as materials

	CD condition	**HB condition**
Control condition		
Recollection (*r*)	.50 (.015) [.469 – .527]	.49 (.014) [.459 – .513]
Reconstruction bias (*b*)	.24 (.040) [.158 – .315]	.16 (.038) [.088 – .236]
Experimental condition		
Recollection (*r*)		
Chosen items	.46 (.020) [.423 – .503]	.45 (.020) [.407 – .486]
Rejected items	.43 (.020) [.387 – .466]	.43 (.020) [.392 – .471]
Reconstruction bias (*b*)		

Chosen items	.28 (.080) [.126 – .441]	.42 (.054) [.311 – .526]
Rejected items	.16 (.038) [.088 – .236]	.27 (.063) [.145 – .395]
Guessing down (*g*)	.39 (.026) [.338 – .442]	.52 (.023) [.474 – .562]

The model goodness of fit was highly satisfactory, $G^2(2) = .53$, $p = .77$. As can be seen in Table 9, recollection parameters are nearly identical in the CD and HB conditions. In the CD condition, recollection parameter was higher in the control conditions than in the experimental conditions for rejected items, $\Delta G^2(1) = 8.10$, $p = .004$, but not for chosen items, $\Delta G^2(1) = 1.92$. The same pattern was observed in the HB condition, recollection parameter was higher in the control condition than in the experimental conditions for rejected items, $\Delta G^2(1) = 5.49$, $p = .03$ (this difference did not remain significant after the Holm's correction), but not for chosen items, $\Delta G^2(1) = 2.61$. Recollection parameters did not differ between chosen and rejected items in experimental groups, $\Delta G^2(1) = 1.63$, $\Delta G^2(1) = .27$, in the CD and HB conditions, respectively. Parameter representing tendency to guess down was significantly lower in the CD condition than in the HB condition, $\Delta G^2(1) = 13.43$, $p < .001$. Guessing was close to the neutral value of 0.50 in the HB condition, but it was significantly lower than 0.50 in the CD condition, $\Delta G^2(1) = 17.13$, $p < .001$.

Reducing the parameter *b* in control groups to zero resulted in model rejection, $G^2(3) = 33.82$, $p < .001$, $G^2(3) = 18.37$, $p < .001$, for the CD and HB conditions, respectively. Comparisons of the reconstruction bias parameter between conditions did not indicate any significant differences between respective parameters in HB and CD conditions, and between chosen and rejected items, $\Delta G^2\text{s}(1) < 2.82$. When comparing reconstruction bias in the control and experimental groups, in the CD condition, reconstruction bias was significantly higher in the control group than in the experimental group for rejected items, $\Delta G^2(1) = 6.79$, $p = .01$, but not for chosen items, $\Delta G^2(1) = .25$. In the HB condition, the pattern was reversed, reconstruction bias was lower in the control group than in the experimental group for chosen items, $\Delta G^2(1) = 12.71$, $p < .001$, but not for rejected items, $\Delta G^2(1) = 1.98$. It should be noted

that in the case of reconstruction bias parameters' standard errors are larger than for recollection parameters, so the significant difference is harder to detect. Post hoc sensitivity power analysis using *multiTree*, showed that our sample of participants (4 860 observations in total), allowed us to detect a relatively large difference of at least $\Delta = .25$ between the parameter *b* in the CD and HB conditions for chosen items, with the sufficient power of $1 - \beta = .80$. The difference of at least $\Delta = .27$ can be detected with this power between the parameter *b* for rejected vs. chosen items in the CD condition. Therefore, it seems that our experiment was underpowered to detect difference in *b* parameters.

Discussion of Experiment 3

The results of Experiment 3 suggest a similarity in the underlying cognitive processes of hindsight bias and cognitive dissonance. The spread index was above zero in both conditions, indicating that in both the cognitive dissonance and hindsight bias designs, changes in ratings were induced by the act of choosing. Notably, the magnitude of change for chosen items was highly similar across both conditions, supporting the assumption of shared mechanisms driving the preference shift.

MPT modelling analyses demonstrated satisfactory goodness of fit of the model to data both in the HB and CD condition. This confirms the suitability of the adapted model for studies using FCP. Comparisons between the CD and HB conditions revealed only one difference that was significant, that is, a greater propensity to guess a higher second rating in the CD than HB condition. Moreover, we found that the parameter *b*, representing a tendency to reconstruct the second rating consistently with the choice made *after* the second rating, cannot be eliminated in the control condition. This suggests that other factors than the choice itself, such as the regression to the mean (Chen & Risen, 2010) produce spread in ratings. What is more, the influence of choice in the experimental group was only confirmed in the

HB group, for chosen items, suggesting that choosing an item affects the recall of its first rating. Surprisingly, it seems that in the CD condition, the choice even counteracted the reconstruction bias for rejected items, since the parameter *b* was higher in the control than in the experimental group for rejected items. This result suggests a more cautious approach to explaining the spread in the FCP with a cognitive dissonance reduction mechanism. However, as indicated by post hoc sensitivity power analyses, tests of differences between *b* parameters were underpowered, so in the second experiment a larger number of observations was gathered.

Experiment 4

The aim of Experiment 4 was to replicate results of Experiment 3, but with different materials, modified task instructions and a larger sample. The travel destination material was replaced by artworks. Additionally we adjusted the hindsight bias condition by asking participants to evaluate the paintings from an external perspective, rather than their own. The purpose of the perspective manipulation was to further differentiate the HB effect from CD, in which self-relevant evaluation plays a central role in protecting self-esteem and is a key component of the distortion. Studies using memory designs to assess HB typically rely on almanac questions (e.g., “How many miles per hour can a hippo run?”, “How many feet can a kangaroo jump in one leap?”), which concern general knowledge rather than personal preferences or self-related judgements. Numerous studies (e.g. Coolin et al., 2014; Hardt & Pohl, 2003; Kaida & Kaida, 2023; Pohl & Hell, 1996;) have demonstrated that HB also occurs when the judgement is not related to the individual’s ego.

Participants were instructed to assess the paintings as if they were art experts, which we assumed would make the evaluation less self-relevant and reduce the involvement of the ego. In contrast, the cognitive dissonance condition emphasized personal involvement.

Participants were told that their choice would determine which painting would be displayed in their own home, which should increase personal responsibility and involvement.

The second rating phase remained consistent with Experiment 3. In the CD condition, participants were asked to rate the paintings again and in the HB condition, they were asked to recall their first ratings.

We expected to observe spread of alternatives in both conditions, along with reconstruction bias. However we anticipated that the contribution of reconstruction bias would differ between self-based re-rating condition and the non-self-based recall condition, as they differed in Experiment 3.

Methods

Sample

The participants were 227 (186 women, age M = 23.61, SD = 5.24) psychology students who received extra course credits for volunteering. Participants were randomly assigned to one of four groups. The first group - the experimental CD condition consisted of 60 participants aged 20 to 50 (44 women; age M = 22.80, SD = 5.02) and the CD control group consisted of 59 participants, aged 19 to 38 (50 women; age M = 22.10, SD = 2.92). The experimental HB condition involved 60 participants, aged 19 to 43 (52 women, age M = 22.63, SD = 4.58), and the control HB group consisted of 48 participants, aged 23 to 52 (40 women, one person did not specify their gender; age M = 27.71, SD = 6.46). All participants were psychology students and they received bonus points in semestral exam or received a voucher to a popular bookstore worth 50 PLN (ca. $13) for volunteering. A post hoc power analysis indicated that, with a sample of 227 participants, it was possible to detect a small to medium effect size of f = 0.19, with a power of 1 - β = 0.80, for an ANOVA (Fixed effects, special, main effects and interactions). The critical F value for this analysis was 3.88. Additionally, for a one-sample

two-tailed *t*-test of difference from zero, it was possible to detect a borderline medium effect size of $d = 0.40$ (G*Power 3; Faul et al., 2007).

Material

The material has been replaced with artwork sourced from the National Gallery of Art (National Gallery of Art). To prepare the materials, a pilot study was conducted with 105 participants using an online survey in which they rated 117 artworks based on how much they would like to have them in their household. 58 artworks were excluded due to extreme ratings. The additional materials (the code of the experiments, instructions and raw data) is available online: https://osf.io/g7tzs/ (file name: Experiment 4).

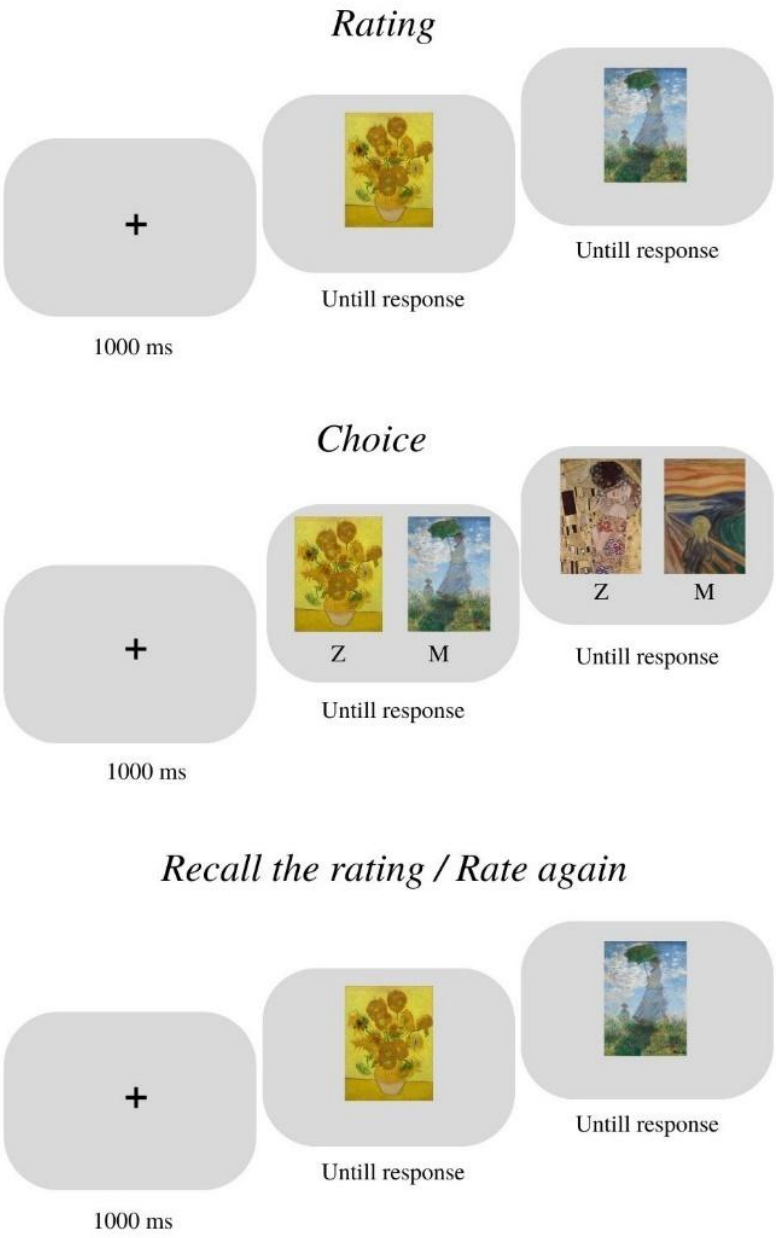
Procedure

The first part of the experiment, Rating 1, consisted of 60 artwork images. Each image was the same size, resolution (96 dpi) and appeared in the center of the screen. Below the image was a scale from 1 to 8, and above it, a question. Just like in previous experiments, at the beginning of Rating 1, there were 4 buffer items that were best and worst rated pictures in the pilot study. Buffers did not appear in the later parts of the study and were not included in the analyses. In the cognitive dissonance condition, participants rated the artworks based on how attractive they found them and how much they would want to have them in their home. In the hindsight bias condition, participants were asked to take on the role of an art expert and evaluate the paintings according to their attractiveness for an art expert. In both conditions, participants rated the artworks on a scale from 1 to 8, where "1" meant that they (or the art expert) would never want to have the artwork in their home, and "8" meant that they (or the art expert) would love to have it. Next, participants proceeded to the Choice phase, where, as in Experiment 3, artworks were individually paired for each participant based on their initial ratings. In the cognitive dissonance condition, they were asked to choose which artwork they

would prefer to have. In the hindsight bias condition, they indicated which artwork they believed the art expert would prefer. The images appeared side by side in the center of the screen. Below the left image was the letter 'Z,' and below the right image was the letter 'M.' Participants indicated their choice by pressing the corresponding key. The final phase of the procedure differed between conditions: in Rating 2 (cognitive dissonance), participants rated the artworks again, while in Recall (hindsight bias), they were asked to recall how they had previously rated the artworks as the art expert.

Figure 4

The procedure used in Experiment 4



Results of Experiment 4

Spread of alternatives

Table 9 presents the mean differences between the second and the first rating, separately for the chosen and the rejected items, as well as the overall index of the spreading of alternatives. The value of the *Spread* index above zero means a change in rating that is consistent with the choice.

Table 9

Mean spread of alternatives and the results of one-sample test of difference from 0

	Mean (SD)	95% CI	One-sample test	Effect size
Ex: dissonance				
R2 - R1 for chosen	**.485 (.534)**	[.380, .620]	$V = 1681.5$, $p < .001$	$r = .838$
R2 - R1 for rejected	**–.643 (.531)**	[-.750, -.485]	$V = 36$, $p < .001$	$r = –.961$
Spread	**1.126 (.456)**	[.980, 1.200]	$V = 1891$, $p < .001$	$r = 1.000$
Control: dissonance				
R2 - R1 for chosen	**.180 (.371)**	[.084, .278]	$t(58) = 3.739$, $p < .001$	$d = .487$
R2 - R1 for rejected	**–.425 (.451)**	[–.544, –.308]	$t(58) = –7.243$, $p < .001$	$d = –.943$
Spread	**.606 (.423)**	[.496, .717]	$t(58) = 10.989$, $p < .001$	$d = 1.431$
Ex: hindsight bias				
R2 - R1 for chosen	**.492 (0533)**	[.300, .565]	V = 1658.5 , $p < .001$	$r = .939$
R2 - R1 for rejected	**–.200 (.493)**	[–.350, –.100]	V = 404, $p < .001$	$r = –.528$
Spread	**.693 (.424)**	[.580, .770]	V = 1688, $p < .001$	$r = .973$
Control: hindsight bias				
R2 - R1 for chosen	.166 (.609)	[–.017, .342]	V = 720.5 $p = .099$	$r = .277$
R2 - R1 for rejected	**–.441 (.551)**	[–.600, –.280]	$t(47) = -5.538$, $p < .001$	$r = –.799$
Spread	**.607 (.580)**	[.438, .775]	V = 1094.5, $p < .001$	$r = .941$

Note. Means significantly different from 0 after applying the Holm sequential rejective procedure are in bold font. In the experimental condition for cognitive dissonance and experimental condition for hindsight bias, the variables distributions deviated from normal distribution, therefore Wilcoxon signed-rank test was used.

The results of the one-sample *t*-test showed that the spread index was significantly different from zero in all conditions. The change in ratings for chosen pictures was also significantly different from zero in both experimental conditions, aligning with the direction of the choice. The change in ratings for rejected items was significantly different from zero in experimental and control conditions for cognitive dissonance and hindsight bias conditions. These results may suggest that choice-induced change can be observed in chosen and rejected items in procedure of CD as well as in HB procedure.

Table 10

2x2 Analyses of Variance for R2-R1 for chosen items, R2-R1 for rejected items and spread

	R2-R1 for chosen				R2-R1 for rejected				Spread			
	F	*df*	*p*	*η2*	*F*	*df*	*p*	*η2*	*F*	*df*	*p*	*η2*
GROUP	**21.026**	1	.001	.087	.031	1	0.860	.000	**23.269**	1	<.001	.095
TASK TYPE	.003	1	.958	.000	**10.047**	1	0.002	.043	**11.873**	1	<.001	.051
INTERACTION	.026	1	.871	.000	**11.463**	1	<.001	.049	**11.888**	1	<.001	.051

Note. Significant results are in bold.

Again, for three dependent variables (R2-R1 for chosen items, R2-R1 for rejected items, and Spread index) we conducted three separate 2 × 2 (Group [experimental, control] × Task type [cognitive dissonance, hindsight bias]) between-groups ANOVAs. For R2–R1 for chosen items, the ANOVA showed a significant effect for Group. R2-R1 for chosen items was significantly greater in experimental (M = 0.488, SD = 0.047) than in control (M = 0.173, SD = 0.05) groups.

For R2-R1 for rejected items, the ANOVA showed a significant effect for Task type and for interaction between two factors. The change in ratings for rejected artworks was significantly greater for cognitive dissonance (M = –0.534, SD = 0.046) than for hindsight bias (M = –0.320, SD = 0.049). Notably, in the CD condition, the change consistent with

choice for rejected targets was significantly larger in the experimental group (M = –0.643, SD = 0.065) than in the control group (M = –0.426, SD = 0.066). In contrast, the pattern was reversed in HB condition, where the control group (M = –0.441, SD = 0.073) showed a greater change than the experimental group (M = –0.200, SD = 0.066).

For the Spread index, the effects were significant for all factors and their interaction. Spread was significantly greater in experimental groups (M = 0.909, SD = 0.043) than in control groups (M = 0.607, SD = 0.046). It was also greater in the CD condition (M = 0.866, SD = 0.043) than in the HB condition (M = 0.650, SD = 0.046). There was no significant difference between the control (M = 0.607, SD = 0.068) and experimental groups (M = 0.693, SD = 0.062) in the HB condition, but there was in the CD condition, with spread being greater in the experimental group (M = 1.126, SD = 0.060) than in the control group (M = 0.606, SD = 0.061). The last significant difference was noticed between experimental groups. Spread in the CD condition (M = 1.126, SD = 0.060) was significantly greater than in the HB condition (M = 0.693, SD = 0.062).

A Bayesian ANOVA was conducted to examine whether adding the factor task type (HB vs. CD) improves model fit over a simpler model containing only group (control vs. experimental). The full model including group, task type, and their interaction (group × task type) showed the strongest evidence for the data, with a posterior probability of P(M|data) = 0.976 and a Bayes Factor (BF_{10}) = 6.94 × 10^6, indicating decisive support over simpler models. Adding task type alone to the model with group improved fit moderately (P(M|data) increased from 0.00045 to 0.023, BF_{10} = 165 626.704), but the interaction substantially enhanced the model. Both main effects had strong inclusion Bayes Factors ($BF_{(incl)}$ = 256 528.123 for group; $BF_{(incl)}$ = 1478.150 for task type), confirming their substantial contribution. These results suggest that task type and its interaction with group substantially influence the dependent variable.

Multinomial processing tree model analyses

Again, to further examine cognitive mechanisms underlying hindsight bias and cognitive dissonance, a MPT model was applied to the data from Experiment 4**.**

Table 11

Parameter estimates of the MPT model for the Free Choice Paradigm for the cognitive dissonance vs hindsight conditions in Experiment 4 with artworks as materials

	CD condition	**HB condition**
Control condition		
Recollection (*r*)	.36 (.008) [.347 – .378]	.36 (.009) [.343 – .378]
Reconstruction bias (*b*)	.23 (.020) [.194 – .274]	.20 (.023) [.151 – .240]
Experimental condition		
Recollection (*r*)		
Chosen items	.34 (.011) [.322 – .366]	.33 (.011) [.312 – .356]
Rejected items	.35 (.011) [.324 – .368]	.33 (.011) [.308 – .352]
Reconstruction bias (*b*)		
Chosen items	.40 (.029) [.341 – .455]	.42 (.029) [.358 – .473]
Rejected items	.38 (.034) [.309 – .443]	.10 (.042) [.015 – .181]
Guessing down (*g*)	.54 (.013) [.517 – .569]	.54 (.014) [.517 – .572]

Again, the model goodness of fit was satisfactory, $G^2(2) = 2.46$, $p = .29$. Table 11 presents parameter estimates of the MPT model for HB and CD conditions. What strikes is the similarity of parameter estimates between CD and HB conditions, with the exception of the reconstruction bias for rejected items, which is significantly higher in the CD than HB condition, $G^2(1) = 26.71$, $p < .001$. Within both groups, there were no differences between the recollection parameters in the control vs. experimental conditions nor between chosen vs. rejected items.

Reducing the parameter *b* in control groups to zero resulted in model rejection, $G^2(3) = 127.90$, $p < .001$, $G^2(1) = 73.88$, $p < .001$, for the CD and HB conditions, respectively. When comparing reconstruction bias in the control and experimental groups, in the CD

condition, reconstruction bias was significantly lower in the control group than in the experimental group for rejected items, $G^2(1) = 11.33$, $p = .001$, and for chosen items $G^2(1) = 19.39$, $p < .001$ (both remained significant after the Holm's correction), but there was no difference between chosen and rejected items, $G^2(1) = .18$. In the HB condition, reconstruction bias was significantly lower in the control group than in the experimental group for chosen items, $G^2(1) = 31.67$, $p < .001$, but it was higher than for rejected items $G^2(1) = 4.32$, $p = .04$ (both remained significant after the Holm's correction). There was also a significant difference between chosen and rejected items in the HB experimental condition, with higher reconstruction bias for chosen than rejected items, $G^2(1) = 29.99$, $p < .001$. Guessing was nearly identical in the CD and HB conditions, and it was significantly higher than the neutral value of .50, $G^2(1) = 10.26$, $p = .001$, $G^2(1) = 9.86$, $p = .002$, in the CD and HB conditions, respectively.

Discussion of Experiment 4

In Experiment 4, we conducted the study with a larger sample size, introduced new stimulus material, and modified the task instructions. Unlike in Experiment 3, changes consistent with choice were significant. The spread index differed significantly between the two experimental conditions, with a greater spread observed in the CD than in HB. Although, changes in ratings for chosen items were not significant in either the CD or HB conditions, a significant difference was found for rejected items, with greater rating changes observed in the CD condition compared to the HB condition. Notably, within the CD condition, the change for rejected items was significantly greater in the experimental group than in the control group, suggesting that rejected options may evoke stronger dissonance than chosen ones. Surprisingly, in the HB condition, the opposite pattern was observed, rating's changes for rejected items were significantly greater in the control group than in the experimental group.

We confirmed the suitability of the MPT model for studies using FCP and we replicated the finding that the parameter *b* cannot be eliminated in the control condition, indicating contribution of other factors than the choice itself to spread in ratings. As in Experiment 3, we found that recollection parameters do not differ between CD and HB conditions and between chosen and rejected items. However, we found several significant differences in the reconstruction bias parameters. In contrast with Experiment 3, we confirmed the influence of choice on spread in the CD condition, since the *b* parameter was significantly lower in the control group than in the experimental group, both for rejected and chosen items, supporting dissonance reduction account. As in Experiment 3, in the HB condition, the influence of choice was confirmed for chosen items, but not for rejected items. In comparison with Experiment 3, the differences in guessing tendency between the CD and HB conditions were not replicated. In Experiment 4 a slight but significant propensity to guess down was observed in both conditions.

Experiment 5

In the final experiment, we introduced a manipulation designed to influence participants' evaluation of their choices. The aim was to examine the reduction of cognitive dissonance and hindsight bias under conditions that should heightened or decreased the experience of dissonance in the CD condition, but update knowledge in the opposite direction in the HB condition.

Festinger (1957) emphasized that the magnitude of cognitive dissonance depends on both the number and importance of conflicting cognitions. When the rejected alternative is particularly attractive, the resulting dissonance tends to be stronger. In the Experiment 5, participants were asked to choose between two similarly attractive paintings, and following their choice, they were instructed to reflect on both the positive and negative attributes of the

chosen and rejected paintings. The manipulation was inspired by Brehm's (1956) original study using the FCP. In his experiment, after participants chosen the object they wanted, they were provided with brief information about the products and then asked to reflect on what struck to them about the product being good or bad. Although Brehm hypothesized that the added new cognitive element would influence the magnitude of dissonance reduction, this effect was not supported by the results. Experiment 5 tested whether a similar manipulation, applied to different material than in Brehm's study, would influence preference change and how it would affect ratings in the context of hindsight bias.

A similar manipulation was also used in hindsight bias research by Sanna and Schwarz (2004), who asked participants to list reasons for both passing and failing an exam. This interaction between the content of thought and the experience of cognitive accessibility may function as a mechanism for knowledge updating. As previously discussed, knowledge updating can be understood as "the integration of new information into existing memory structures" (Roese & Vohs, 2012, p. 414). In Experiment 5, the task of selecting positive and negative attributes of both chosen and rejected items may have served a similar function.

Participants were asked to reflect on either: a) the positive attributes of the chosen painting and the negative attributes of the rejected painting (choice-consistent evaluation), b) the positive attributes of the rejected painting and the negative attributes of the chosen painting (choice-inconsistent evaluation), or c) respond to neutral questions about both the chosen and rejected items (control condition).

We expected that in the CD condition, the manipulation of choice-inconsistent evaluation would lead participants to rate chosen paintings higher and rejected paintings lower in Rating 2, as a way to reduce cognitive dissonance. In contrast, we hypothesized that the same manipulation in the hindsight bias condition would function as knowledge updating,

producing the opposite effect: the rejected item would be rated higher, and the chosen item lower, reflecting a retrospective adjustment based on newly considered information.

The manipulation of choice-consistent evaluation, was intended to serve as a cognitive dissonance reduction, thereby minimizing the spread of alternatives. As a result, Rating 2 (in the cognitive dissonance condition) was expected to closely match their initial Rating 1. In the hindsight bias condition, the manipulation would again function as knowledge updating, so Recall was expected to be consisted with a choice (chosen item would be rated higher, rejected item would be rated lower). The neutral questions were about dominant colours in the picture and served as a control condition.

Methods

Sample

In the Experiment 5, 107 (94 women, age M = 22.11, SD = 5.70) participants took part. Participants were psychology students who received extra course credits for volunteering and were randomly assigned to one of two groups. The cognitive dissonance condition consisted of 50 participants, aged 18 to 48 (41 women, 1 nonbinary person; age M = 21.16, SD = 4.52). The hindsight bias condition consisted of 57 participants, aged 18 to 47 (53 women, age M = 22.95, SD = 6.45). A post hoc power analysis indicated that, with a sample of 107 participants, it was possible to detect a small to medium effect size of f = 0.22 with a power of 1 - β = 0.80, for an ANOVA (Repeated measures, between factors). The critical F value for this analysis was 3.93. Additionally, for a one-sample two-tailed t-test of difference from zero, it was possible to detect a borderline medium effect size of d = 0.40 (G*Power 3; Faul et al., 2007).

Material

The same as in Experiment 4.

Procedure

In Experiment 5, we replicated the procedure from Experiment 4, but introduced a manipulation during the Choice phase. After making their choice, participants were asked two questions (one about the chosen item and another about the rejected item) from one of the following three manipulation types:

1) the positive attributes of the chosen painting and the negative attributes of the rejected painting (choice-consistent evaluation; CD-decreasing; HB-updating by distancing the options),
2) the positive attributes of the rejected painting and the negative attributes of the chosen painting (choice-inconsistent evaluation; CD-increasing; HB-updating by bringing closer the options) or
3) respond to neutral questions about both the chosen and rejected items (control condition, with a baseline spread effect).

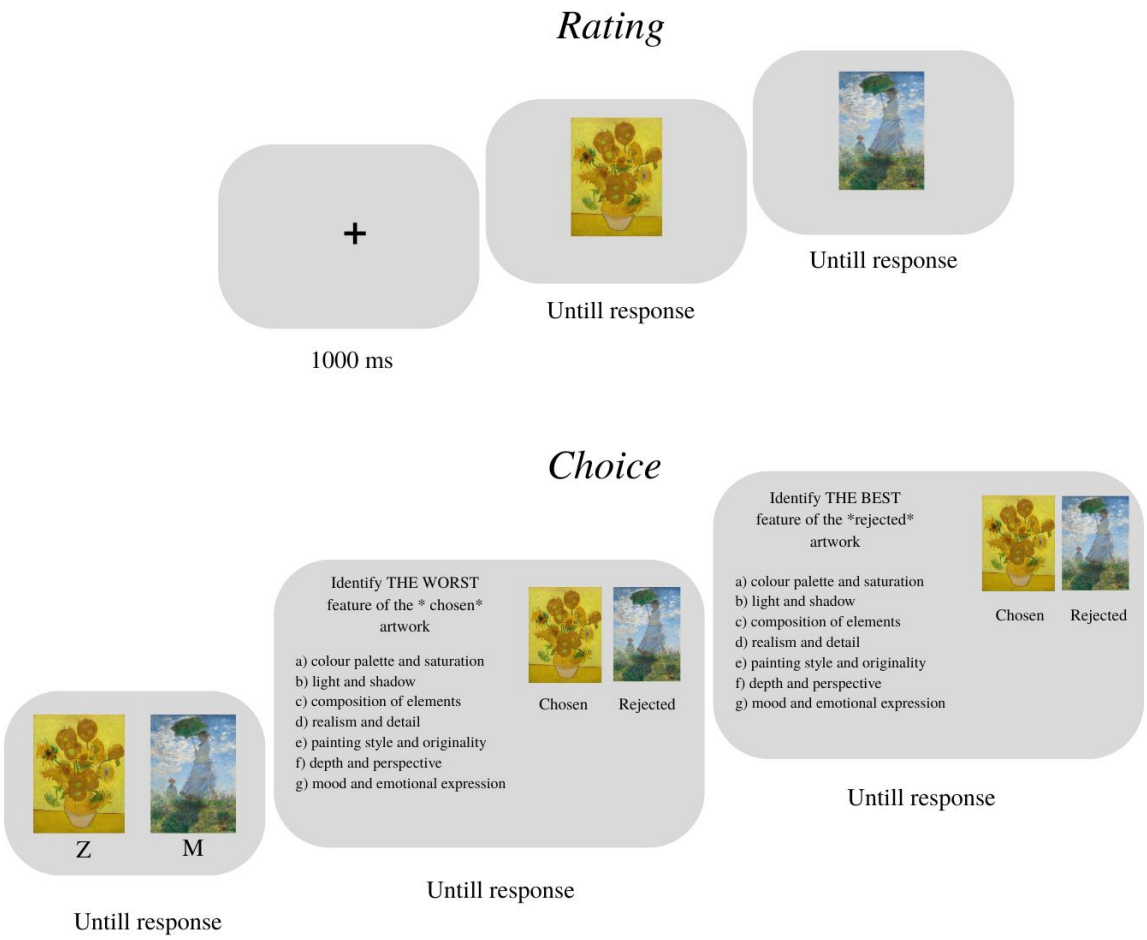
Within each condition (CD and HB), the manipulations were administered using a within-subjects design. Each manipulation (number 1, 2 and 3) was presented ten times in random order, corresponding to the thirty pairs of paintings used in the choice phase. Every manipulation consists of two questions - one for the rejected option and the other for the chosen option. Each question appeared on a separate slide with a fixed set of answer options, and participants chose their response by using the keyboard. The questions about positive and negative attributes referred to the following aspects: a) colour palette and saturation, b) light and shadow, c) composition of elements, d) realism and detail, e) painting style and originality, f) depth and perspective, and g) mood and emotional expression. The neutral question (in the control condition) asked participants to identify the dominant colour in the chosen or rejected painting. Participants also selected their response from seven available

options. Each slide with the questions included smaller versions of both the chosen and rejected paintings (see Figure 5).

The final phase of the procedure differed between conditions: in Rating 2 (cognitive dissonance), participants were asked to rate the artworks again, while in Recall (hindsight bias), they were asked to recall how they had previously rated the artworks as the art expert.

Figure 5

The procedure used in Experiment 5


Rating
+
1000 ms
Untill response
Untill response
Choice
Z
M
Untill response
Identify THE WORST feature of the * chosen* artwork
a) colour palette and saturation
b) light and shadow
c) composition of elements
d) realism and detail
e) painting style and originality
f) depth and perspective
g) mood and emotional expression
Chosen
Rejected
Untill response
Identify THE BEST feature of the *rejected* artwork
a) colour palette and saturation
b) light and shadow
c) composition of elements
d) realism and detail
e) painting style and originality
f) depth and perspective
g) mood and emotional expression
Chosen
Rejected
Untill response
Recall the rating / Rate again
+
1000 ms
Untill response
Untill response

Results of Experiment 5

Spread of alternatives

Tables 12 and 13 present the mean differences between the second and first ratings, shown separately for chosen and rejected items, as well as the overall index of the spreading of alternatives. A Spread index value above zero indicates a change in ratings consistent with the choice. Table 12 refers to the CD group, while Table 13 refers to the HB group.

Table 12

Mean spread of alternatives and the results of one-sample test of difference from 0 in Cognitive Dissonance experimental group

Dissonance	Mean (SD)	95% CI	One-sample *t*-test	Effect size
Dissonance-decreasing				
R2 - R1 for chosen	**.346 (0.687)**	[.151, .541]	t(49) = 3.558, $p < .001$	$d = .6876$
R2 - R1 for rejected	**–1.026 (.780)**	[–1.248, –.804]	t(49) = –9.300, $p < 0.001$	$d = –.780$
Spread	**1.372 (.796)**	[1.146, 1.598]	t(49) = 12.173, $p < 0.001$	$d = .796$
Dissonance-increasing				
R2 - R1 for chosen	**.270 (.804)**	[.041, .498]	$t(49) = 2.372$, $p < .001$	$d = .804$
R2 - R1 for rejected	**–.750 (.735)**	[–.950, –.541]	$t(49) = –7.211$, $p < .001$	$d = .735$
Spread	**1.020 (.680)**	[.826, 1.213]	$t(49) = 10.594$, $p < .001$	$d = .680$
Control condition				
R2 - R1 for chosen	**.252 (.563)**	[.091, .412]	$t(49) = 3.558$, $p = .001$	$d = .563$
R2 - R1 for rejected	**–.909 (.712)**	[–1.111, –.706]	$t(49) = –9.017$, $p < .001$	$d = .712$
Spread	**1.161 (.675)**	[.968, 1.353]	$t(49) = 12.147$, $p < .001$	$d = .675$

Note. Means significantly different from 0 after applying the Holm sequential rejective procedure are in bold font.

The results of the one-sample *t*-test in the CD experimental group revealed that, across all manipulation conditions, the rating changes for chosen items, rejected items, and the spread index were significantly different from zero.

Table 13

Mean spread of alternatives and the results of one-sample test of difference from 0 in Hindsight Bias group

Hindsight bias	Mean (SD)	95% CI	One-sample test	Effect size
Dissonance-decreasing				
R2 - R1 for chosen	**.600 (.648)**	[.428, .772]	$t(56) = 6.990$, $p < .001$	$d = 0.926$
R2 - R1 for rejected	**–.433 (.747)**	[–.798, –.441]	$V = 247.5$, $p < .001$	$r = –.654$
Spread	**1.033 (.667)**	[.856, 1.210]	$t(56) = 10.097$, $p < .001$	$d = .667$
Dissonance-increasing				
R2 - R1 for chosen	**.616 (.649)**	[.450, .750]	$V = 1400.5$, $p < .001$	$r = .868$
R2 - R1 for rejected	**–.407 (.629)**	[–.939, –.359]	$t(56) = –4.883$, p < .001	$d = –.647$
Spread	**1.023 (.665)**	[.846, 1.199]	$t(56) = 11.599$, p < .001	$d = .665$
Control condition				
R2 - R1 for chosen	**.621 (.763)**	[.419, .824]	$t(56) = 6.145$, $p < .001$	$d = .814$
R2 - R1 for rejected	**–.314 (.620)**	[–0.781, –.229]	$t(56) = –3.826$, $p < .001$	$d = –.507$
Spread	**.935 (.699)**	[.749, 1.121]	$t(56) = 10.097$, $p < .001$	$d = .699$

Note. Means significantly different from 0 after applying the Holm sequential rejective procedure are in bold font. For the variables distributions deviated from normal distribution, Wilcoxon signed-rank test was used.

The results of the one-sample test in the HB experimental group also showed that, across all manipulation conditions, the rating changes for chosen items, rejected items, and the spread index were significantly different from zero.

Table 14

2x3 Mixed Design Analyses of Variance for R2-R1 for chosen items, R2-R1 for rejected items and spread index

	R2-R1 for chosen				R2-R1 for rejected				Spread			
	F	*df*	*p*	*η2*	*F*	*df*	*p*	*η2*	*F*	*df*	*p*	*η2*
Within subjects												
Manipulation	0.158	2	.854	.002	2.727	2	.068	.025	**3.042**	2	.050	.028
Manipulation*Task Type	0.387	2	.679	.004	2.263	2	.107	.021	2.404	2	.093	.022
Between subjects												
Task type	**9.061**	1	.003	.079	**20.926**	1	<.001	.166	3.540	1	.063	.033

Note. Significant results are in bold. *df* = degrees of freedom. η^2 = eta squared effect size.

For three dependent variables (R2-R1 for chosen items, R2-R1 for chosen items, Spread index) we conducted three separate 2 × 3 mixed analyses of variance. The between subjects factor was Task type (cognitive dissonance, hindsight bias) and the within-subject factor was Manipulation (choice-consistent evaluation, choice-inconsistent evaluation, control).

For chosen items, a significant main effect of Task Type was found. The change in ratings for chosen items was significantly higher in HB condition (M = 0.612, SD = 0.073) than in CD condition (M = 0.289, SD = 0.289).

For rejected items, again, only a significant main effect of Task Type was significant. The change in ratings for rejected items was significantly more negative in CD condition (M = –.895, SD = .081) than in HB condition (M = –.385, SD = .076).

For spread index, a marginally significant main effect was observed for the within-subjects factor Manipulation. Planned comparison showed that choice-consistent evaluation

manipulation (M = 1.203, SD = 0.071) resulted in significantly greater spread index than both choice-inconsistent evaluation (M = 1.021, SD = 0.065) and the control manipulation (M = 1.048, SD = 0.067).

Multinomial processing tree model analyses

The application of the multinomial processing tree model in this experiment, similarly to Experiment 2, was exploratory in nature, as the design did not include all necessary conditions. In particular, it lacked a control procedure RRC (Rating-Rating/Recall-Choice), where the choice (with choice-consistent or choice-inconsistent instructions) would be made after the second rating/recall. Nevertheless, the model fit was satisfactory, $G^2(2) = 1.92$, p = .383. Parameter estimates for the MPT model across the HB and CD conditions are presented in Table 15.

It was assumed that recollection parameters would be equal for the two manipulations: the choice-consistent and choice-inconsistent evaluation, but not necessarily for the control condition. There was no theoretical basis to expect differential effects on recollection of reflecting on positive versus negative item features. However, the control condition could influence memory differently. Additionally, guessing parameters were constrained to be equal across the choice-consistent, choice-inconsistent and control conditions.

The recollection parameter was significantly lower for chosen items in the control condition compared to chosen items in the CD and HB conditions, $\Delta G^2(1) = 148.86$, $p < .001$, and also compared to rejected items in the control condition, $\Delta G^2(1) = 92.60$, $p < .001$. This result was unexpected and lacks a clear explanation. There is no obvious reason why identifying the dominant colour of a chosen painting would markedly impair memory for the choice only in CD task type. No significant differences were observed in the reconstruction

parameters (*b*) across choice-consistent, choice-inconsistent and control conditions for either chosen or rejected items in both the CD and HB tasks.

Table 15

Parameter estimates of the MPT model for the Free Choice Paradigm for the cognitive dissonance vs hindsight conditions in Experiment 5 with closing vs distancing manipulation

	Cognitive dissonance condition			**Hindsight bias condition**		
	CD-decreasing	CD-increasing	Control	CD-decreasing	CD-increasing	Control
Recollection (*r*)						
Chosen items	0.33 (0.015)		0.04 (0.011)	0.34 (0.014)		0.31 (0.020)
	[0.304 – 0.362]		[0.020 – 0.063]	[0.311 – 0.365]		[0.271 – 0.349]
Rejected items	0.26 (0.014)		0.28 (0.021)	0.32 (0.014)		0.31 (0.019)
	[0.233 – 0.288]		[0.237 – 0.320]	[0.295 – 0.350]		[0.274 – 0.350]
Reconstruction bias (*b*)						
Chosen items	0.31 (0.083)	0.27 (0.084)	0.27 (0.081)	0.48 (0.089)	0.49 (0.089)	0.43 (0.099)
	[0.162 – 0.488]	[0.126 – 0.455]	[0.134 – 0.452]	[0.218 – 0.569]	[0.225 – 0.575]	[0.128 – 0.516]
Rejected items	0.51 (0.092)	0.38 (0.108)	0.47 (0.098)	0.26 (0.085)	0.24 (0.088)	0.20 (0.086)
	[0.290 – 0.649]	[0.121 – 0.545]	[0.243 – 0.626]	[0.195 – 0.527]	[0.161 – 0.508]	[0.131 – 0.468]
Guessing down (*g*)	0.56 (0.062)			0.54 (0.062)		
	[0.464 – 0.705]			[0.345 – 0.585]		

Note. Parameter estimates are presented with bootstrapped standard deviations and 95% CI.

Discussion of Experiment 5

In Experiment 5, we introduced a manipulation in which participants, after making a choice, were asked to reflect on both the positive and negative attributes of the chosen and rejected items. The purpose of this manipulation was to create choice-consistent and choice-inconsistent conditions. We also expected dissociations in results between CD and HB conditions, since in the HB condition the same manipulation should update participants' knowledge in an opposite direction. However, similarly to Brehm's original study (1956), the manipulation did not produce the intended effect.

One possible explanation for this outcome may lie in the nature of the stimulus material. It is likely that the artworks used in the task did not evoke strong enough engagement. Participants may not have found the paintings particularly attractive or personally relevant, which would limit the effect of manipulation. Additionally, participants may have approached the task with an awareness that even if they did not appreciate certain features of a painting, it remained a piece of universally recognized art. Another potential factor is the structure of the manipulation itself. Participants were required to consider both positive and negative aspects and to select arguments from predefined list. This format may have inadvertently encouraged balanced thinking, rather than leading to deep cognitive conflict, thereby weakening the intended effect.

The results from the multinomial processing tree (MPT) analysis were also inconclusive. Although the overall model fit was satisfactory, the expected effects for the reconstruction parameter (*b*) observed in Experiments 3 and 4 were not replicated. Specifically, no significant differences were found in the reconstruction estimates across the choice-consistent, choice-inconsistent and control conditions for either chosen or rejected items in both the cognitive dissonance and hindsight bias tasks.

General Discussion

The main research objective was to explore the underlying mechanisms involved in choice-induced preferences change, with a particular focus on the role of memory processes and the potential analogies with hindsight bias. The first experiment focused on the extent to which processes from dual-recollection theory (Brainerd et al., 2014, 2015) contribute to preference changes observed after making a decision. Later, we compared CD and HB interpretation of CIPC. To do so, we used two types of material (travel destinations and artwork) and applied different manipulations in order to observe further differences or similarities between these two perspectives.

The results from Experiment 1 showed that context recollection parameter from the dual-recollection model (Brainerd et al., 2014, 2015) was close to zero for targets that changed their rating in a direction inconsistent with the prior choice, and it was significantly higher for targets that showed no change or a change consistent with the initial decision. This indicates that remembering the chosen item matters in the formation of preferences after making a decision.

Importantly, no CIPC was observed when participants rated countries based on their safety, suggesting that self-relevance context is critical, which is consistent with Aronson's view on the reduction of CD, and his self-consistency theory (Aronson, 1969; Aronson, 2019). People were rating countries according with their decisions for obtaining self-integrity. However, we also observed the involvement of familiarity, which represents an automatic process of memory. The contribution of familiarity was especially noticeable for chosen items whose ratings changed in the opposite direction of the initial choice.

In Experiment 2, items for which participants correctly recollected their prior choice were more likely to show choice-consistent changes in rating, particularly when the options

were similarly attractive (close pairs) compared to when they were more differentiated (distant pairs). This finding also supports the self-based account of CIPC, which propose that preference change is motivated by process aimed at maintaining internal consistency. An important observation is that these effects appeared specifically in the close pairs condition, which, according to Festinger's (1957) original approach, is where the experience of dissonance should be most intense, as harder decisions evoke stronger cognitive dissonance (see also Brehm, 1956; Voigt et al., 2019). However, unlike in Experiment 1, the consistent change in rating occurred for both chosen and rejected items. This discrepancy might be due to the fact that in Experiment 1, the pairs of countries were not pre-selected based on participants' individual preferences, which could explain the different pattern of results.

The next stage of our research focused on exploring the similarities between cognitive dissonance and hindsight bias in the context of CIPC. Our attempt to identify similarities between HB and CD is not the first to frame HB in more general terms. The cognitive process model SARA, proposed by Pohl et al. (2003), integrates HB with the anchoring effect described by Tversky and Kahneman (1974). Similarities between these phenomena were already noted in Fischoff's original work (1975), however the SARA model provides a detailed explanation of the cognitive processes underlying both HB and anchoring, outlining two mechanisms:1) selective activation and 2) biased reconstruction.

In Experiment 2, we re-analysed the data using the multinomial processing tree model, typically applied in HB research, to assess underlying cognitive processes. We observed a difference in the contribution of reconstruction bias between two conditions. Participants who were unable to recollect their first rating in the final phase of FCP (Rating 2), were more likely to rely on a biased reconstruction, and this effect was not seen in the distant pairs condition. This result is important, however, it should be considered exploratory, as we did

not include control groups, this finding suggests that cognitive dissonance may not be the only mechanism responsible for the changes observed in CIPC within the FCP framework.

The results from Experiment 3 showed that spread occurred in both paradigms and confirmed the suitability of the adapted MPT model for studies using FCP. Comparisons between the CD and HB conditions revealed only one difference that was significant, that is, a greater propensity to guess a higher second rating in the CD than HB condition. Moreover, we found that the parameter *b*, representing a tendency to reconstruct the second rating consistently with the choice made *after* the second rating, cannot be eliminated in the control condition. This suggests that factors other than the choice itself, such as regression to the mean (Chen & Risen, 2010), contribute to the observed spread in ratings. What is more, the influence of choice in the experimental group was only confirmed in the HB group for chosen items, suggesting that choosing an item affects the recall of its first rating. Surprisingly, it seems that in the CD condition, the choice even counteracted the reconstruction bias for rejected items, since the parameter *b* was higher in the control than in the experimental group for rejected items.

In Experiment 4, the manipulation of perspective in the instruction - asking participants to rate items as art experts (non-self-based judgment) vs. as themselves (self-based judgment) - had a measurable effect on the strength of spread and dissonance, again suggesting that ego-involvement plays a key role in whether dissonance is experienced and subsequently reduced.

Again (like in Experiment 1) we found differences between chosen and rejected items. Notably, within the CD condition, the change for rejected items was significantly greater in the experimental group than in the control group, suggesting that rejected options may evoke stronger dissonance than chosen ones. The study by Yang and Teow (2024) reported similar findings. They compared reject-framed and choose-framed decision, and they found, that

reject-framed decision between attractive options induce greater CIPC (referred to in their study as post decision modulation). Surprisingly, in the HB condition, the opposite pattern was observed, rating's changes for rejected items were significantly greater in the control group than in the experimental group. The differences in spread between chosen and rejected items add to Mills' (1965) study, which showed that participants tend to seek out information that supports their decisions (consonant information), rather than actively avoiding information that favours the rejected options. This suggests that the consequences of one's decision, as well as the importance of those consequences, should be more explicitly incorporated into theories of cognitive dissonance (see Mills, 2019).

We also, again, confirmed the suitability of the MPT model for CD and HB experiments using FCP paradigm. We replicated the results of Experiment 3 that recollection parameters in CD and HB conditions do not differ. However, unlike in Experiment 3, we found a clear influence of choice on the spread in the CD condition: the reconstruction parameter (*b*) was significantly lower in the control group than in the experimental group, both for chosen and rejected items, which supports the dissonance reduction account. As in the previous experiment, in the HB condition, the influence of choice was again confirmed only for chosen items, but not for rejected ones. However, in contrast to Experiment 3, the difference in guessing tendency between CD and HB conditions was not replicated.

Taken together, the findings from Experiments 3 and 4 suggest that similar latent cognitive processes underlie both CD and HB. These results open the possibility that choice-induced preference change may, at least in part, be understood as a form of knowledge updating, in which the choice phase serves as an anchor. The act of choosing introduces new information (i.e., the distinction between chosen and rejected options) that may modify or distort memory (Hardt et al., 2010), leading to imperfect adjustments anchored on one's current belief (Erdfelder & Buchner, 1998; Tversky & Kahneman, 1974). This might also

suggest that knowledge updating is a superordinate construct that encompasses both CD and HB.

The last experiment, however, yielded inconclusive and surprising results. We tested whether choice-consistent and choice-inconsistent manipulations could influence the magnitude of preference change. In CD research, similar manipulations were used by Brehm in his classic study, and the same conceptual approach appears in other paradigms, like the induced-compliance paradigm, where dissonance is understood to arise when a person act or speak in a manner contrary to their prior belief or attitude (Harmon-Jones & Mills, 2019, Festinger & Carlsmith, 1959). According to this view, the greater the number and importance of cognitions justifying a behaviour, the less dissonance is experienced. The greater the number and importance of the cognitions justifying the behaviour, the less the dissonance aroused. In our experiment, the behaviour in question was the choice, and the justifications were the positive and negative aspects of the chosen and rejected artworks (in the choice-consistent manipulation). In hindsight bias research, a similar strategy has been employed. A series of studies (Sanna et al., 2002; Sanna et al., 2002; Sanna & Schwarz, 2003, 2004) asked participants to generate reasons supporting or opposing a specific event's outcome.

Contrary to expectations, however, the manipulation effects were weak or inconsistent. One possible explanation is that the stimulus material (artworks) failed to generate sufficient personal involvement or emotional salience. Additionally, requiring participants to select from pre-defined lists of positive and negative attributes for both chosen and rejected items may have promoted balanced rather than polarized thinking, weakening the expected effects.

Several limitations of the experiments in this dissertation must be acknowledged. First, some experimental conditions, particularly in Experiment 1, were conducted in different modalities (in-person vs. online), which limits between-group generalizability. Second, the effectiveness of manipulations in Experiment 5 was weaker than expected, possibly due to the

nature of the stimuli or procedural demands. In future research, it would be important to use material with greater emotional salience or personal relevance for participants and to limit questions to only the chosen or rejected stimuli. It also seems important to adapt the experiment to more realistic conditions, in which participant actually select and reject items (for example small consumer goods such as stationery or snacks) and subsequently receive the chosen items while losing the rejected ones. Additionally, the manipulation designed to enhance knowledge updating could further explore the HB interpretation of CIPC.

This research contributes to a deeper understanding of the cognitive underpinnings of preference change, revealing meaningful overlap between paradigms traditionally associated with cognitive dissonance and hindsight bias. The findings provide converging evidence that choice-induced preference change is not a unitary phenomenon. Importantly, this work extends the hindsight bias paradigm beyond general knowledge or belief domains into the domain of aesthetic and preference-based judgments, showing that HB-like effects can emerge.

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Appendix 1

Cardinal Stefan Wyszyński University in Warsaw
THICAL BOARD FOR SCI ENTIFIC RESEARCH
INSTITUTE OF PSYCHOLOGY

PL, 01-938 Warsaw, ul. Wóycickiego 1/3 | tel. (48)225696801 | www.psychologia.wfch.uksw.edu.pl | e-mail: instytut_psychologii@uksw.edu.pl

Evidence #: 13/2021 Warsaw, 17 June 2021

Opinion of the Ethical Board for Scientific Research

Institute of Psychology, Cardinal Stefan Wyszynski University in Warsaw

Regarding the approval of the research project under supervision of (Principal Investigator)
Patrycja Didyk entitled " Changing preferences after making a choice and the memory of the decision made. Research from the perspective of the dual-recollection theory"

The Ethical Board for Scientific Research of the Institute of Psychology at Cardinal Stefan Wyszynski University in Warsaw issued, after ethical board meeting held on the 17th day of June 2021, according to the Ethical Board Regulations from the 2nd day of March 2021 (RDpsy-U-02/03/2021), POSITIVE OPINION
On the project lead by Patrycja Didyk entitled " Changing preferences after making a choice and the memory of the decision made. Research from the perspective of the dual-recollection theory" as meeting the ethical standards, what allows for conducting the research according to the submitted application and for dissemination of the results for scientific purposes.

Magdalena Żemojtel-Piotrowska, Ph.D., associate professor
Head of the Ethical Board for Scientific Research
Institute of Psychology
Cardinal Stefan Wyszyński University in Warsaw

Appendix 2

Involvement of the authors of publication:

Didyk, P., & Nieznański, M. (2024). Choice-induced preference change and recollection of choice in the free-choice paradigm. *Psicológica, 45*(2), 1–26. http://doi.org/10.20350/DIGITALCSIC/16496

Patrycja Didyk – Conceptualization, Methodology, Software, Data Curation, Investigation, Visualisation, Writing – Original Draft, Writing – reviewing and editing, Resources, Project administration (70%)

Marek Nieznański – Conceptualization, Methodology, Formal analysis, Writing – Original Draft, Writing–reviewing and editing, Supervision (30%)

File 1

Supplementary data: Response frequencies in the memory test phase

Table A

Response frequencies in the memory test depending on the type of test items and the change between ratings in Experiment 1

Item type and memory probe	Choice consistent change in rating		No change in rating		Opposite to choice change in rating	
	Yes	*No*	*Yes*	*No*	*Yes*	*No*
RCR: Desirability rating						
Rejected						
Rejected?	**48**	26	**63**	37	**46**	28
Chosen?	20	**46**	28	**86**	23	**50**
Rejected or Chosen?	**45**	13	**69**	16	**57**	17
Chosen						
Rejected?	30	**50**	32	**61**	30	**29**
Chosen?	**51**	24	**73**	37	**19**	23
Rejected or Chosen?	**73**	28	**97**	18	**43**	4
New						
Rejected?			65	**223**		
Chosen?			24	**264**		
Rejected or Chosen?			51	**237**		
RRC: Desirability rating						
Rejected						
Rejected?	**43**	19	**33**	26	**60**	38
Chosen?	16	**59**	12	**68**	20	**90**
Rejected or Chosen?	**51**	14	**63**	8	**65**	35
Chosen						
Rejected?	25	**56**	15	**50**	42	**73**
Chosen?	**45**	20	**45**	21	**61**	23
Rejected or Chosen?	**62**	13	**68**	14	**74**	13
New						
Rejected?			23	**265**		
Chosen?			8	**280**		
Rejected or Chosen?			10	**278**		
RCR: Safety rating						
Rejected						
Rejected?	60	34	53	**38**	36	31
Chosen?	21	46	31	**50**	25	51
Rejected or Chosen?	62	16	73	**17**	60	16
Chosen						
Rejected?	28	39	37	**48**	33	43
Chosen?	33	31	74	**39**	42	37
Rejected or Chosen?	56	11	77	**13**	67	12
New						
Rejected?			30	**258**		
Chosen?			22	**266**		
Rejected or Chosen?			30	**258**		

Note. Correct answers are in bold font.

Table B

Response frequencies in the memory test depending on the type of test items and the change between ratings in Experiment 2

Item type and memory probe	Choice consistent change in rating		No change in rating		Opposite to choice change in rating	
	Yes	*No*	*Yes*	*No*	*Yes*	*No*
RCR: Close pairs						
Rejected						
Rejected?	**49**	36	**84**	43	**46**	33
Chosen?	27	**64**	47	**67**	27	**32**
Rejected or Chosen?	**78**	25	**92**	19	**49**	22
Chosen						
Rejected?	51	**58**	52	**70**	18	**20**
Chosen?	**72**	43	**89**	42	**33**	17
Rejected or Chosen?	**85**	25	**111**	11	**37**	6
New						
Rejected?			43	**293**		
Chosen?			21	**315**		
Rejected or Chosen?			38	**298**		
RRC: Distant pairs						
Rejected						
Rejected?	**53**	21	**86**	29	**43**	33
Chosen?	17	**54**	27	**82**	26	**60**
Rejected or Chosen?	**64**	8	**96**	16	**79**	16
Chosen						
Rejected?	22	**63**	30	**98**	21	**41**
Chosen?	**48**	31	**114**	25	**40**	16
Rejected or Chosen?	**68**	9	**109**	11	**58**	6
New						
Rejected?			35	**289**		
Chosen?			18	**306**		
Rejected or Chosen?			22	**302**		

File 2

Supplementary data: One way Analyses of Variance in Experiment 1

Table C

One way Analyses of Variance for R2-R1 for chosen items, R2-R1 for rejected items and spread index from Experiment 1 (RCR: Desirability, RRC: Desirability, RCR: Safety)

	R2-R1 for chosen				R2-R1 for rejected				Spread			
	F	*df*	*p*	*η2*	*F*	*df*	*p*	*η2*	*F*	*df*	*p*	*η2*
Experiments	**4.65***	2	.015	.131	**4.41**	2	.016	.115	**6.69***	2	.003	.24

Note. F-values marked with an asterisk (*) are based on Welch's ANOVA due to violations of homogeneity of variances. Significant results are in bold. *df* = degrees of freedom. η^2 = eta squared effect size.

For three dependent variables (R2-R1 for chosen items, R2-R1 for rejected items, and Spread index) we conducted three separate one-way between-groups ANOVAs. All analyses revealed significant effects.

For R2-R1 for chosen items, the change in ratings was significantly greater in RCR: Desirability condition (M = 0.190, SD = 0.371) than in RRC: Desirability (M = -0.316, SD = 0.765).

For R2-R1 for rejected items, the change in ratings was significantly greater in RRC: Desirability (M = 0.394, SD = 0.700) compared to both RCR: Desirability condition (M = 0.012, SD = 0.418) and in RCR: Safety (M = -0.047, SD = 0.504).

And for Spread index, the significant differences were between RCR: Desirability condition (M = 0.177, SD = 0.516) and both the RRC: Desirability condition (M = -0.709, SD = 1.037) and the RCR: Safety condition (M = 0.024, SD = 0.388), with the spread being notably greater in the RCR: Desirability condition.

File 3

Supplementary data: Distributions of observations according to the type of change in rating in Experiment 1 and 2

Table D

Distribution of observations according to the type of change in rating in Experiment 1 and 2

Experimental condition	Choice consistent change in rating	No change in rating	Opposite to choice change in rating	Test of equality of distribution
Ex 1: RCR: Desirability rating	454	617	369	χ^2 (2) = 32.34, $p < 0.001$
Ex 1: RRC: Desirability rating	423	423	594	χ2 (2) = 19.30, p < 0.001
Ex 1: RCR: Safety rating	437	550	453	χ^2 (2) = 7.56, $p = 0.023$
Ex 2: RCR: Close pairs	613	727	340	χ^2 (2) = 77.84, $p < 0.001$
Ex 2: RCR: Distant pairs	458	723	439	χ^2 (2) = 43.67, $p < 0.001$