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Walencja wyobrażeń umysłowych jako predyktor skłonności do podejmowania ryzyka

The Valence of Mental Imagery as a Predictor of the Willingness to Take Risk

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Spis treści

Streszczenie

Większość teorii podejmowania decyzji zakłada, że decydenci przetwarzają informacje o przyszłych konsekwencjach wyborów za pomocą procesów werbalnych. W serii siedmiu badań, w tym czterech eksperymentów, proponujemy alternatywne ujęcie tego procesu, koncentrując się na wizualnym (epizodycznym) symulowaniu przyszłości poprzez wyobrażenia umysłowe. Pokazujemy, że tego rodzaju wyobrażenia pełnią podwójną rolę w podejmowaniu decyzji w warunkach ryzyka i niepewności: z jednej strony dostarczają informacji o ryzyku i pomagają w rozpoznaniu sytuacji decyzyjnej, z drugiej – wywołują emocje związane z przewidywanymi wydarzeniami, podobne do tych, pojawiających się w rzeczywistych sytuacjach. W pierwszej serii badań zaobserwowaliśmy, że walencja wyobrażeń (tj. ich pozytywność lub negatywność) jest dodatnio związana z deklarowaną gotowością do podjęcia ryzyka, a związek ten ma charakter przyczynowo skutkowy. W trzecim badaniu tej serii pokazaliśmy, że uczestnicy deklarują spontaniczne wykorzystywanie wizualizacji we wszystkich analizowanych domenach decyzyjnych. Druga seria badań wykazała, że emocje pozytywne i negatywne pośredniczą w relacji między walencją wyobrażeń a podejmowanymi decyzjami, zarówno w badaniu korelacyjnym, jak i eksperymentalnym. Trzecie i czwarte badanie tej serii zademonstrowały specyficzne cechy przetwarzania informacji sprzyjające nasileniu afektu integralnego. Mianowicie, przetwarzanie wizualne wywoływało silniejsze emocje negatywne i pozytywne w porównaniu z werbalnym przetwarzaniem. Ponadto, intensywność emocji wzrastała wraz z wyrazistością wyobrażeń towarzyszących rozważanym dylematom decyzyjnym. Podsumowując, wyniki przeprowadzonych badań podkreślają ważną rolę wizualnych wyobrażeń umysłowych w procesie podejmowania decyzji, ukazując je jako źródło zarówno informacji o ryzyku jak i emocji, które wspólnie wpływają na ostateczne wybory.

Słowa kluczowe: wyobrażenia umysłowe, podejmowanie decyzji, ryzyko, niepewność, emocje integralne

Abstract

Most decision-making theories assume that decision-makers process information about the future consequences of choices using verbal processes. In a series of seven studies, including four experiments, we propose an alternative approach to this process, focusing on the visual (episodic) simulation of the future through mental imagery. We show that such imagery plays a dual role in decision-making under conditions of risk and uncertainty: on the one hand, it provides information about risk and helps in recognizing the decision-making situation, and on the other hand, it evokes emotions related to anticipated events, similar to those occurring in real situations. In the first series of studies, we observed that the valence of imagery (i.e., its positivity or negativity) is positively correlated with the declared willingness to take risks, and this relationship is causal. In the third study of this series, we demonstrated that participants spontaneously report using visualization in all the decision-making domains analyzed. The second series of studies showed that positive and negative emotions mediate the relationship between the valence of imagery and decisions made in both the correlational and experimental studies. This series' third and fourth studies demonstrated specific information processing features that promote increased integral affect. Specifically, visual processing triggered stronger negative and positive emotions than verbal processing. Furthermore, the intensity of emotions increased with the vividness of the imagery accompanying the considered decision dilemmas. In conclusion, the results of the studies emphasize the vital role of visual mental imagery in the decision making process, highlighting it as a source of information about risk and emotions that jointly influence final choices.

Keywords: mental imagery, decision-making, risk, uncertainty, integral emotions

Wprowadzenie

Każdego dnia przeciętny człowiek podejmuje niezwykle dużą liczbę decyzji – szacunkowo, w samym tylko obszarze związanym z przygotowywaniem posiłków, jest ich około dwustu (Wansink & Sobal, 2007). Większość z tych codziennych wyborów odbywa się w warunkach ryzyka i niepewności (Bland & Schaefer, 2012). Nic więc dziwnego, że już od lat 40. XX wieku badacze psychologii i ekonomii starają się wyjaśnić, jakie czynniki skłaniają człowieka do podejmowania decyzji oraz jakie procesy poznawczo-behawioralne im towarzyszą (Doherty, 2003; Newell i in., 2022).

Zdecydowana większość behawioralnych teorii podejmowania decyzji wyjaśnia ten proces jako sekwencję operacji kalkulacyjnych. Odwołują się one do werbalnego myślenia o przyszłości, w którym decydent ocenia potencjalne korzyści i zagrożenia wynikające z danej decyzji oraz prawdopodobieństwa ich wystąpienia (Dror i in., 1999; Schoemaker, 1982; Tversky & Kahneman, 1992) czy też tworzy wewnętrzne narracje dotyczące możliwych zdarzeń (Beach, 1993, 2009; Johnson i in., 2023). Myślenie o przyszłości przybiera jednak także formę epizodycznych symulacji mentalnych (ang. *episodic foresight*), które pozwalają na zwizualizowanie alternatywnych wydarzeń (Suddendorf, 2017; Suddendorf & Corballis, 1997; Szpunar & Schacter, 2013). Takie dwutorowe traktowanie myślenia o przyszłości wpisuje się w tezy klasycznej teorii podwójnego kodowania Alana Paivio (1979, 1991), który podkreślał, że przetwarzanie informacji odbywa się w dwóch odrębnych, lecz współdziałających podsystemach: werbalnym i niewerbalnym. W ramach drugiego podsystemu ten autor wyróżniał między innymi doświadczenia zmysłowe oraz interesujące nas w tym projekcie wyobrażenia umysłowe (ang. *mental imagery*) dostarczające informacji w sposób całościowy i symultaniczny (Paivio, 1986). Zgodnie z jedną z najczęściej cytowanych definicji, wyobrażenia umysłowe to reprezentacje, które „(…) pojawiają się, gdy dostęp do informacji percepcyjnych uzyskuje się z pamięci, co powoduje doświadczenie ‘widzenia okiem umysłu’, ‘słyszenia uchem umysłu’ i tak dalej…” (Kosslyn i in., 2001, s.

635). Definicja ta podkreśla multimodalny charakter wyobrażeń umysłowych, które występują w obrębie każdego z podstawowych zmysłów. Spośród nich, wyobrażenia wizualne są najpowszechniejsze i cechują się największą wyrazistością (Belardinelli i in., 2004; Schifferstein, 2009).

Wyobrażenia umysłowe a podejmowanie decyzji

Wizualizacje przyszłości stanowią rutynową, niemal automatyczną aktywność umysłową (Buckner & Carroll, 2007; Mason i in., 2007; Seligman i in., 2013) i odgrywają istotną rolę w wielu aspektach codziennego funkcjonowania, takich jak motywacja do działania, kreatywność czy utrzymywanie się i rozwój zaburzeń psychicznych (Holmes i in., 2008, 2016; Holmes & Mathews, 2010; LeBoutillier & Marks, 2003; Taylor & Pham, 1996). W literaturze podkreśla się, że wizualne wyobrażenia mogą być cennym narzędziem wspierającym także proces decyzyjny, umożliwiając nie tylko „przetestowanie" potencjalnych konsekwencji wyborów bez konieczności ich rzeczywistego doświadczania (Blackwell, 2020; Markman & Dyczewski, 2013) lecz także porównanie różnych opcji przed dokonaniem wyboru (Nanay, 2016). Funkcja wyobrażeń związana z podejmowaniem decyzji nabiera szczególnego znaczenia w warunkach niepewności, gdy przetwarzanie werbalne okazuje się niewystarczające z powodu istotnych braków w dostępnych informacjach (Johnson i in., 2023). W takich sytuacjach wyobrażenia umysłowe pozwalają na uzupełnienie luk informacyjnych (Nanay, 2016), szybko ukazując pełen kontekst decyzyjny i wzbogacając go o brakujące elementy.

Modele narracyjne podejmowania decyzji podkreślają komplementarną wobec przetwarzania werbalnego rolę wyobrażeń umysłowych w dokonywaniu wyborów (Johnson i in., 2023). Zgodnie z założeniami tych modeli, decydenci tworzą złożone narracje dotyczące przyszłości, uwzględniając własne cele, przekonania, emocje oraz szerszy kontekst sytuacyjny. Następnie, opierając się na zawartych w nich informacjach, wizualizują możliwe scenariusze i ich potencjalne rezultaty (Beach, 1993, 2009; Johnson i in., 2023). Wyniki

badań empirycznych wstępnie potwierdzają również samodzielne, oderwane od przetwarzania werbalnego, znaczenie wyobrażeń w procesie decyzyjnym. Ich wpływ widoczny jest między innymi w odraczaniu gratyfikacji – osoby skłaniane do wizualizacji oddalonych w czasie konsekwencji decyzji częściej wybierają opcje prowadzące do większych, lecz odroczonych wypłat w porównaniu z uczestnikami z warunku kontrolnego (Bulley i in., 2019; Peters & Büchel, 2010). Zaleśkiewicz i współpracownicy (2020) wykazali natomiast, że przedsiębiorcy częściej generują pozytywne i bardziej wyraziste wyobrażenia dotyczące prowadzenia działalności gospodarczej niż osoby spoza środowiska biznesowego. Istnieją również dowody sugerujące, że sposób przetwarzania informacji – wizualny lub werbalny – może prowadzić do odmiennych jakościowo decyzji. Na przykład wizualizacja konsekwencji dylematów moralnych sprzyja wyborom deontologicznym, podczas gdy myślenie werbalne skłania ku rozwiązaniom utylitarnym (Amit & Greene, 2012). Podobny mechanizm może dotyczyć także oceny ryzyka. Chan i Saqib (2021) w serii czterech badań wykazali, że wizualizowanie informacji o ryzyku prowadzi do wyższej oceny związanego z nim zagrożenia niż przetwarzanie werbalne/analityczne. Zdaniem autorów, może to skutkować częstszym powstrzymywaniem się od podejmowania ryzyka przez osoby preferujące wizualny sposób myślenia.

Poza samą treścią wyobrażeń umysłowych, istotną rolę w procesie decyzyjnym mogą odgrywać także inne ich cechy, takie jak swoboda generowania symulacji mentalnych. Badania wskazują, że im łatwiej stworzyć i odtworzyć w umyśle dane wyobrażenie, tym wyższa jest subiektywna ocena prawdopodobieństwa wystąpienia przedstawionych w nim sytuacji (Carroll, 1978; Markman & Dyczewski, 2013; Sherman i in., 1985; Szpunar & Schacter, 2013). Zjawisko to znajduje również odzwierciedlenie w klasycznych badaniach nad heurystykami dostępności (Tversky & Kahneman, 1973) i symulacji (Kahneman & Tversky, 1982). Działanie tych heurystyk polega na tym, że im łatwiej wydobyć określone informacje z pamięci lub wytworzyć ich mentalną symulację, tym bardziej prawdopodobne

wydają się związane z nimi zdarzenia. Co istotne, efekt ten jest szczególnie wyraźny w przypadku przetwarzania wizualnego w porównaniu z werbalnym (Sherman i in., 1985). Możemy zatem przypuszczać, że podobny mechanizm działa przy wizualizacji przyszłych konsekwencji decyzji – gdy wygenerowanie obrazu mentalnego przychodzi z dużą swobodą, wystąpienie przedstawionych w nim zdarzeń wydaje się bardziej realne. Z kolei trudność w tworzeniu wyobrażeń prowadzi do niższych oszacowań prawdopodobieństwa. Z perspektywy naszego projektu oznacza to, że łatwość generowania wyobrażeń może wywoływać u decydenta subiektywne wrażenie, że zwizualizowane scenariusze są bardziej prawdopodobne, co będzie pośrednio oddziaływać na ostateczny wybór.

Rola wyobrażeń umysłowych w kształtowaniu emocji integralnych

Choć podejmowanie decyzji od dawna postrzegane jest jako domena psychologii poznawczej, obecny stan wiedzy jednoznacznie potwierdza rolę emocji w tym procesie (Asutay & Västfjäll, 2024; Bechara & Damasio, 2005; Lerner i in., 2015; Loewenstein i in., 2001; Loewenstein & Lerner, 2003; Slovic i in., 2007; Vastfjall & Slovic, 2013; Zaleskiewicz & Traczyk, 2020; Zeelenberg i in., 2008), koncentrując się przede wszystkim na emocjach integralnych, bezpośrednio związanych z rozważaniem konsekwencji wyborów (Loewenstein & Lerner, 2003). Choć emocje mogą mieć różne podłoże (Cunningham i in., 2013), niektóre modele teoretyczne sugerują, że wyobrażenia umysłowe w znacznym stopniu wpływają na ich powstawanie (Loewenstein i in., 2001). Zależność tę potwierdzają także badania podstawowe nad cechami i funkcjami wyobrażeń. Holmes i Matthews (2005) zwracają uwagę, że wyobrażenia umysłowe silniej wzbudzają emocje niż myślenie werbalne, co wynika z zakorzenienia tych pierwszych w doświadczeniach sensorycznych. Zdaniem autorów, aktywują one ponadto podobne struktury neuronalne co percepcja, przez co mentalne symulacje wywołują emocje porównywalne do tych towarzyszących rzeczywistym zdarzeniom (Holmes & Mathews, 2005). Ponadto, umożliwiają ponowne przeżywanie emocji związanych z wcześniejszymi doświadczeniami poprzez przywoływanie wspomnień (Holmes

& Mathews, 2005; Seligman i in., 2013). Podobną perspektywę przyjmują Cocquyt i Palombo (2023)**,** podkreślając, że za pośrednictwem wyobrażeń umysłowych ludzie mogą doświadczać emocji związanych z oczekiwaniem przyszłych wydarzeń i przewidywanych w odniesieniu do potencjalnych rezultatów. W nawiązaniu do tych koncepcji, w niniejszym projekcie zakładamy, że wyobrażanie sobie ryzykownych scenariuszy nie tylko pozwala decydentom ocenić atrakcyjność możliwych wyników, ale także umożliwia przeżywanie emocji, które mogłyby towarzyszyć podjęciu danej decyzji. Te dwa elementy współdziałają w kształtowaniu zachowania decydenta.

Nasze założenia dotyczące zależności pomiędzy wyobrażeniami a emocjami w podejmowaniu decyzji znajdują wstępne potwierdzenie w badaniach empirycznych. Przykładem występowania relacji między afektem, wyobrażeniami a percepcją ryzyka mogą być badania przeprowadzone przez Karlsson i współpracowników (2023). Autorzy manipulowali poziomem wyobrażeń związanych z postrzeganiem ryzyka klimatycznego, przydzielając badanych do trzech warunków o różnym nasileniu wyobrażeń (tj. nasilone, spontaniczne i zablokowane). Zgodnie z przewidywaniami, uczestnicy z warunku wzmocnionych wyobrażeń odczuwali wyraźniejszy spadek pozytywnego afektu oraz silniej postrzegali ryzyko związane z groźnymi zjawiskami ekologicznymi w porównaniu z osobami z pozostałych warunków. Z kolei Traczyk i współautorzy (2015) wykazali, że w związku pomiędzy walencją wyobrażeń a skłonnością do podejmowania ryzyka pośredniczyły emocje i reakcje fizjologiczne przypisywane odczuwaniu stresu. Podobnie, Sobków i in. (2016) pokazali, że negatywny afekt i stres wywołany niekorzystnymi wyobrażeniami związanymi z ryzykiem istotnie zwiększały postrzegane zagrożenie. W jeszcze innym projekcie, Dickert i współpracownicy (2016) zaobserwowali, że gotowość do przekazywania pieniędzy na rzecz zidentyfikowanych ofiar (w przeciwieństwie do anonimowych) wiązała się z większą łatwością wizualizowania osób potrzebujących, czemu towarzyszyły uczucia empatii wobec nich. Wyniki wspomnianych badań podkreślają znaczenie wyobrażeń umysłowych w

wywoływaniu emocji towarzyszących podejmowaniu decyzji także w kontekstach, które nie są bezpośrednio związane z szacowaniem ryzyka.

Należy jednak zastanowić się, czy wszystkie wyobrażenia wizualne mają taki sam potencjał wywoływania emocji. Badania nad wyrazistością wyobrażeń sugerują, że tak nie jest. Marks (1972) definiuje wyrazistość jako „połączenie klarowności i żywości. Im bardziej wyrazisty jest obraz, tym bardziej przypomina rzeczywiste spostrzeżenia" (p. 83). Zdolność do tworzenia wyrazistych wyobrażeń zależy zarówno od czynników dyspozycyjnych (Marks, 1972), jak i sytuacyjnych (Pearson i in., 2011). W pierwszym przypadku umiejętności wyobrażeniowe mieszczą się na kontinuum – od afantazji, czyli całkowitego braku zdolności do tworzenia wizualizacji, po hiperfantazję, charakteryzującą się niezwykle sugestywnymi wyobrażeniami (Zeman, 2020, 2024; Zeman i in., 2020). Z kolei w wymiarze sytuacyjnym wyrazistość może być modulowana przez czynniki takie, jak np. poziom abstrakcyjności (vs. konkretności) bodźców wywołujących (Paivio, 1965). Bez względu na przyczynę tej zmienności, wyraziste wyobrażenia sprzyjają silniejszym reakcjom emocjonalnym, zarówno pozytywnym, jak i negatywnym (Cocquyt & Palombo, 2023). Zjawisko to potwierdzają badania kliniczne dotyczące intruzywnych wyobrażeń u osób z zespołem stresu pourazowego oraz skuteczności terapii EMDR (Andrade i in., 1997; Leer i in., 2014; Rauch i in., 2004). Można więc przypuszczać, że wyrazistość wyobrażeń związanych z ryzykiem będzie moderować nasilenie emocji integralnych odczuwanych przez decydenta, co było empirycznie weryfikowane w tym projekcie.

Podsumowując, zaprezentowane podstawy teoretyczne sugerują, że wyobrażenia umysłowe odgrywają dwojaką rolę w procesie podejmowania decyzji: dostarczają informacji i intensyfikują emocje, które mogą wpływać na skłonność do ryzyka. Dokładniejsze poznanie tego procesu jest istotne z perspektywy teoretycznej, gdyż pozwala na lepszy wgląd w specyfikę podejmowania codziennych decyzji. Natomiast z perspektywy praktycznej wiedza ta może być wykorzystywana w opracowaniu interwencji zmierzających do zmniejszenia

skłonności do podejmowania nadmiernego ryzyka oraz ochrony przed jego potencjalnymi konsekwencjami.

Cel rozprawy

Niniejsza rozprawa doktorska ma na celu zaproponowanie koncepcji teoretycznej dotyczącej roli wizualnych wyobrażeń umysłowych w podejmowaniu decyzji w warunkach ryzyka i niepewności oraz jej empiryczną weryfikację. W ramach celów szczegółowych, można wyróżnić dwie kwestie. Po pierwsze, zakładamy, że wizualne wyobrażenia umysłowe pełnią funkcję źródła informacji o potencjalnych konsekwencjach decyzji, umożliwiając jednostce szybką ocenę płynących z nich korzyści i zagrożeń. Walencja wyobrażeń pozwala nie tylko przewidywać ludzkie wybory, lecz także wpływać na nie w sposób przyczynowy – wyobrażenia o charakterze pozytywnym sprzyjają podjęciu działania, podczas gdy negatywne je hamują.

Po drugie, wyobrażenia umysłowe umożliwiają doświadczanie emocji o intensywności zbliżonej do tych, które występują w reakcji na rzeczywiste zdarzenia (Blackwell, 2020; Holmes & Mathews, 2005). W kontekście procesu decyzyjnego przyjmujemy zatem, że wizualizacje kształtują emocje integralne, które z jednej strony pośredniczą pomiędzy walencją wyobrażeń a podejmowaniem decyzji, z drugiej zaś wzmacniają tendencje behawioralne wynikające ze znaku wyobrażeń. Pozytywne wizualizacje sytuacji ryzykownych wywołują afekt pozytywny, co w konsekwencji zwiększa skłonność do podjęcia działania, natomiast negatywne nasilają afekt negatywny, prowadząc do powstrzymania się od podjęcia ryzyka.

Warto podkreślić, że obydwa cele szczegółowe odzwierciedlają złożoną, poznawczo-emocjonalną rolę wyobrażeń umysłowych – zarówno w subiektywnej ocenie potencjalnych skutków decyzji, jak i w kształtowaniu reakcji emocjonalnych. Przykładowo, osoba rozważająca wyjazd na wakacje do egzotycznego, lecz potencjalnie niebezpiecznego miejsca może zwizualizować sobie zagrożenia związane z niestabilną sytuacją polityczną czy

możliwością zachorowania na chorobę tropikalną. Takie wyobrażenia zintensyfikują afekt negatywny, co – zgodnie z naszymi założeniami – skłania do rezygnacji z podróży. Z kolei wizualizacje dotyczące relaksu na plaży i malowniczych krajobrazów wywołają afekt pozytywny, zwiększając gotowość do podjęcia pozytywnej decyzji o wyjeździe. Niewykluczone, że w umyśle decydenta pojawią się zarówno pozytywne jak i negatywne wyobrażenia jednocześnie, prowadzące do ambiwalentnych odczuć. W takim przypadku prawdopodobnie najważniejsze dla podjęcia ostatecznej decyzji będą wizualizacje cechujące się największą wyrazistością, ponieważ to właśnie one wywołują najsilniejsze emocje.

Przegląd badań

W ramach niniejszej rozprawy doktorskiej przeprowadziliśmy serię siedmiu badań, z których większość została prerejestrowana w systemie Open Science Framework. Cztery spośród nich miały charakter eksperymentalny. Badania tworzą dwie tematycznie spójne serie: pierwsza została opublikowana w *Journal of Behavioral Decision Making* a druga w *Cognition.* Łącznie w badaniach wzięło udział 3960 osób (2059 kobiet, 1901 mężczyzn, brak osób o innej płci, M_{wiek} = 38,80), rekrutowanych za pośrednictwem platformy Prolific z populacji mieszkańców Stanów Zjednoczonych. Decyzja o wyborze próby amerykańskiej wynikała ze względów praktycznych – na platformie Prolific dostępnych jest znacznie więcej uczestników ze Stanów Zjednoczonych niż z Polski. Umożliwia to lepszą dywersyfikację socjodemograficzną, kluczową w badaniu ryzyka w życiu codziennym.

Pierwsza seria badań

W pierwszej serii, obejmującej trzy badania, w tym jeden eksperyment, postawiliśmy dwie główne hipotezy dotyczące związku między wyobrażeniami umysłowymi a skłonnością do podejmowania ryzyka. Pierwsza hipoteza zakładała istnienie dodatniej korelacji między walencją wyobrażeń a gotowością do działania: im bardziej pozytywne generowane przez uczestników wyobrażenia, tym większa ich skłonność do podjęcia ryzyka. Druga hipoteza, testowana w badaniu eksperymentalnym, dotyczyła związku przyczynowo-skutkowego

pomiędzy walencją wyobrażeń a podejmowaniem ryzyka. Przewidywaliśmy, że pozytywne wyobrażenia zwiększają deklarowaną gotowość do ryzykownych działań, podczas gdy wyobrażenia negatywne tę skłonność obniżają.

W celu przetestowania tych hipotez przeprowadziliśmy dwa badania, stosując w nich podobną procedurę. Przedstawiliśmy uczestnikom pięć krótkich opisów ryzykownych aktywności, zaczerpniętych z pięciu domen decyzyjnych (etycznej, finansowej, zdrowotnej, społecznej i rekreacyjnej) i inspirowanych narzędziem DOSPERT (Blais & Weber, 2006) (Np. „Wyjeżdżasz na obozowisko w dziczy"). Zadaniem badanych było zwizualizowanie sobie zaangażowania w każdą z tych aktywności, opisanie nie więcej niż trzech obrazów pojawiających się w ich umyśle oraz ocenienie walencji wyobrażeń (za pomocą suwaka ze skalą od 0 – bardzo negatywne do 100 – bardzo pozytywne) i skłonności do podjęcia działania („Czy jesteś skłonny do podjęcia takiego działania?" na skali 7-stopniowej, gdzie 1 – „zdecydowanie nie", 7 – „zdecydowanie tak"). Ponieważ badani oceniali pięć scenariuszy, uzyskane wyniki analizowaliśmy na dwa sposoby: przez uśrednienie wszystkich ocen w ramach danej osoby oraz poprzez zastosowanie modelu wielopoziomowego.

Aby upewnić się, że uczestnicy postępowali zgodnie z instrukcją i rzeczywiście generowali wizualne wyobrażenia umysłowe, poprosiliśmy o szczegółowe opisy obrazów pojawiających się w ich umysłach. Następnie przeprowadziliśmy analizę jakościową zebranych opisów, w której trzej sędziowie kompetentni oceniali czy dany opis wskazuje na wygenerowanie wyobrażenia. Większość opisów uczestników (75% w badaniu pierwszym, 82% w badaniu drugim) sugerowała generowanie wizualnych wyobrażeń umysłowych. Dane związane z opisami wskazującymi na wykorzystanie innych procesów poznawczych (np. argumentów logicznych lub norm społecznych) usunęliśmy z analizy.

Wyniki pierwszego badania, zgodnie z hipotezą, potwierdziły, że ocena walencji wyobrażeń stanowi istotny i silny predyktor deklarowanej gotowości do podejmowania ryzyka. Co więcej, dzięki manipulacji walencją wyobrażeń, w drugim badaniu wykazaliśmy

istnienie związku przyczynowo skutkowego między walencją wyobrażeń a deklarowaną gotowością do podjęcia ryzykownego działania: pozytywne wyobrażenia zwiększały skłonność do ryzyka, podczas gdy negatywne (w porównaniu z warunkiem kontrolnym) tę skłonność obniżały.

Celem trzeciego, eksploracyjnego badania było sprawdzenie czy decydenci spontanicznie wykorzystują wyobrażenia umysłowe w procesie podejmowania decyzji. Procedura różniła się od poprzednich badań na dwa sposoby. Po pierwsze, uczestnicy zostali poproszeni o „założenie", że angażują się w ryzykowne aktywności (w miejsce wcześniejszego „wyobrażania" sobie). Po drugie, mieli przyporządkować treści pojawiające się w ich umyśle po przeczytaniu opisu ryzykownej aktywności do jednej z następujących kategorii: „argumenty logiczne", „uczucia i doznania", „wspomnienia", „wyobrażenia" lub „inne". Wyniki pokazały, że badani spontanicznie korzystają z wyobrażeń we wszystkich analizowanych obszarach decyzyjnych. Częstotliwość ich występowania różniła się jednak między domenami – najwyższy odsetek pojawiania się wyobrażeń odnotowaliśmy w sferze rekreacyjnej, a najniższy – w finansowej.

Podsumowując, wyniki pierwszej serii badań sugerują, że wyobrażenia umysłowe odgrywają istotną rolę w podejmowaniu decyzji, dostarczając decydentom wglądu w możliwe konsekwencje wyborów i wpływając na ich ostateczne działania. Specyfika domeny decyzyjnej determinuje natomiast to, w jaki sposób i kiedy decydenci spontanicznie odwołują się do wyobrażeń, traktując je jako źródło informacji wspomagające ocenę potencjalnych skutków.

Druga seria badań

Druga seria badań miała na celu zbadanie roli emocji w procesie decyzyjnym wykorzystującym wizualizacje. W postawionej hipotezie zakładaliśmy, że pozytywne i negatywne emocje odczuwane podczas epizodycznych symulacji mentalnych będą pośredniczyły w zaobserwowanej wcześniej relacji pomiędzy walencją wyobrażeń a

skłonnością do ryzyka. Dwa pierwsze badania przeprowadziliśmy z wykorzystaniem procedury zaczerpniętej z serii pierwszej wprowadzając jedną istotną zmianę – do pomiarów dodaliśmy pytanie o ocenę pozytywnych i negatywnych emocji odczuwanych podczas wyobrażania sobie ryzykownych sytuacji (oceniane oddzielnie na 7-punktowej skali, gdzie 1 – „nie odczuwałem w ogóle", 7 – „odczuwałem bardzo"). Ponadto, ze względu na naruszenie założenia o niezależności obserwacji (każdy uczestnik oceniał pięć ryzykownych aktywności), dane analizowaliśmy za pomocą modelu wielopoziomowego.

W dwóch pierwszych badaniach tej serii - korelacyjnym i eksperymentalnym - udało nam się zreplikować główne efekty z pierwszej serii, co potwierdziło predykcyjny i przyczynowo skutkowy związek między walencją wyobrażeń a gotowością do podejmowania ryzyka. Kluczowym rezultatem były jednak wyniki wskazujące na to, że na poziomie wewnątrz uczestników (ang. *within-level*) pozytywne i negatywne emocje pośredniczą we wspomnianym związku (tzn. są jego mediatorem). Manipulacja walencją wyobrażeń skutkowała nasileniem emocji zgodnych z ich znakiem: pozytywne symulacje wywoływały silniejszy afekt pozytywny, podczas gdy negatywne potęgowały emocje o negatywnym zabarwieniu. Warto jednak zaznaczyć, że w obydwu badaniach mediacja przez emocje negatywne okazała się nieistotna na poziomie między uczestnikami (ang. *between-level*).

Dwa kolejne badania w tej serii testowały specyficzne właściwości wizualizacji w wywoływaniu emocji integralnych. W obu badaniach zastosowaliśmy nową operacjonalizację skłonności do podejmowania ryzyka – uczestnicy zapoznawali się z rozbudowanymi scenariuszami ryzyka w pięciu domenach, wzorowanymi na narzędziu Choice Dilemma Questionnaire (Kogan & Wallach, 1964). Ponadto, do oceny emocji integralnych wykorzystaliśmy test BERRI (Petrova i in., 2023). Wprowadzone zmiany wynikały z przesłanek metodologicznych – naszym zamiarem było wykazanie, że zaobserwowane wcześniej efekty nie są zależne od sposobu operacjonalizacji ryzyka oraz pomiaru emocji i można je uogólnić na inne metody badawcze.

Trzecie badanie drugiej serii porównywało nasilenie emocji integralnych podczas przetwarzania informacji o ryzyku w trybie wizualnym i werbalnym/analitycznym. Zgodnie z naszą główną hipotezą zakładaliśmy, że emocje będą silniejszym mediatorem w relacji między walencją wyobrażeń umysłowych a podejmowaniem ryzyka niż w przypadku zależności między walencją argumentów logicznych a decyzją. Aby przetestować tą hipotezę, oprócz manipulowania walencją, ok. połowę uczestników poprosiliśmy o wyobrażanie sobie sytuacji ryzykownych (przetwarzanie wizualne), natomiast pozostałych - o generowanie argumentów logicznych dotyczących ryzyka (przetwarzanie werbalne). Zgodnie z przewidywaniami, osoby wizualizujące ryzyko deklarowały silniejsze emocje pozytywne i negatywne niż uczestnicy formułujący argumenty logiczne, a emocje były silniejszym mediatorem relacji między walencją a skłonnością do ryzyka w warunku wyobrażeń umysłowych niż w warunku argumentów logicznych. Odkryliśmy zatem istotny efekt moderacyjny, w którym rodzaj skojarzeń z ryzykiem (wyobrażenia vs. analiza) był moderatorem relacji między walencją tych skojarzeń a skłonnością do ryzyka.

W czwartym i ostatnim badaniu postawiliśmy hipotezę, że wyrazistość wyobrażeń związanych z ryzykiem moderuje relację między walencją a emocjami integralnymi. Mówiąc dokładniej, założyliśmy, że wraz ze wzrostem wyrazistości wyobrażeń nasileniu ulegnie związek między walencją wyobrażeń a pozytywnymi i negatywnym emocjami. Oprócz manipulacji walencją, do procedury wprowadziliśmy zatem dodatkowe pytanie mierzące wyrazistość wyobrażeń generowanych przez uczestników, zaadoptowane z badania Pearsona i współpracowników (2011). Uczestnicy oceniali wyrazistość na suwaku z czterema punktami odniesienia (0 – „prawie brak wyobrażeń”, 33 – „słabe wyobrażenia”, 66 – „umiarkowane wyobrażenia” i 100 – „silne wyobrażenia, niemal jak percepcja”). Ponadto, aby uniknąć podwójnego, wizualno-werbalnego przetwarzania informacji o ryzyku, zrezygnowaliśmy z proszenia badanych o opisywanie wyobrażeń. Zgodnie z naszymi oczekiwaniami, wraz ze wzrostem wyrazistości wyobrażeń umysłowych nasilały się jednocześnie pozytywne i

negatywne emocje integralne. Co istotne, im większa była wyrazistość wyobrażeń, tym silniejszy stawał się efekt manipulacji walencją na ocenę emocji oraz tym bardziej wzrastał jej pośredni wpływ na skłonność do podejmowania ryzyka.

Wyniki drugiej serii badań jednoznacznie potwierdzają, że wyobrażenia umysłowe stanowią swoistego rodzaju katalizator emocji integralnych, które następnie wpływają na gotowość do podejmowania ryzyka. Eksperymentalne manipulacje walencją wyobrażeń oraz sposobem przetwarzania informacji miały istotny wpływ na intensywność pozytywnych i negatywnych emocji oraz stopień, w jakim pośredniczą one w relacji pomiędzy walencją a skłonnością do ryzyka. Warto podkreślić, że efekt mediacyjny emocji był silniejszy w przypadku wizualizacji niż werbalnego przetwarzania informacji o ryzyku. Dodatkowo, wyniki czwartego badania dostarczyły dowodów, że różnice w specyficznej dla sytuacji wyrazistości wyobrażeń są powiązane z intensywnością emocji i modyfikują relację między walencją a skłonnością do działania. Wskazuje to tym samym na sporą złożoność mechanizmów emocjonalnych związanych z ryzykiem.

Ograniczenia i dalsze kierunki badań

Badania przeprowadzone w ramach tej rozprawy doktorskiej dostarczyły cennych danych na temat roli wizualnych wyobrażeń umysłowych w skłonności do podejmowania ryzyka. Należy jednak zwrócić uwagę na kilka ograniczeń wpływających na interpretację wyników oraz wskazujących na obszary wymagające dalszych badań.

Jednym z ważnych ograniczeń jest sposób realizacji badań – wszystkie przeprowadziliśmy online, a uczestników rekrutowaliśmy za pośrednictwem platformy Prolific. Choć literatura wskazuje na wysoką trafność danych uzyskanych w taki sposób (Buhrmester i in., 2011; Peer i in., 2017), to badania w warunkach laboratoryjnych mogłyby zapewnić większą kontrolę nad zmiennymi zakłócającymi oraz ograniczyć wpływ czynników zewnętrznych rozpraszających uczestników. W odpowiedzi na te ograniczenia, już rozpoczęliśmy badania laboratoryjne porównujące wyobrażenia umysłowe związane z

ryzykiem u nastolatków i osób dorosłych. Wyniki wstępnie potwierdziły, że nastolatkowie – jako grupa szczególnie podatna na podejmowanie ryzyka – tworzą bardziej pozytywne wyobrażenia dotyczące codziennego ryzyka niż osoby dorosłe, a różnica ta nie występuje w przypadku wyobrażeń obejmujących neutralne aktywności.

Druga seria badań koncentrowała się na roli wyobrażeń w wywoływaniu emocji integralnych. Uczestnicy samodzielnie deklarowali, jakie uczucia towarzyszyły im podczas symulacji umysłowych. Co prawda samoocena emocji jest powszechnie stosowaną metodą pomiaru, ale jej wiarygodność może być ograniczona przez efekt społecznych oczekiwań czy zróżnicowane umiejętności w zakresie wglądu i samoobserwacji (Korpal & Jankowiak, 2018). W przyszłych badaniach warto więc rozważyć zastosowanie alternatywnych metod oceny afektu, jak na przykład pomiar reakcji skórno-galwanicznej, analiza zmian wielkości źrenic, elektromiografia (EMG) czy rejestracja mimiki twarzy (Kulke i in., 2020; Lim i in., 2020; Mauss & Robinson, 2009). Wykorzystanie takich rozwiązań mogłoby dostarczyć bardziej precyzyjnych i obiektywnych danych na temat emocji powiązanych z wizualizacją ryzyka.

Ponadto, w ramach rozprawy przyjęto, że wyobrażenia umysłowe są czynnikiem, który ma charakter pierwotny i wywołuje emocje. Nie można jednak wykluczyć, że relacja między tymi procesami jest bardziej złożona i dynamiczna, a emocje mogą pełnić także funkcję bodźca poprzedzającego pojawienie się wyobrażeń o określonej walencji. Wskazówek dotyczących tego zjawiska dostarczają badania kliniczne potwierdzające, że depresja prowadzi do redukcji pozytywnych oraz nasilenia negatywnych wyobrażeń o przyszłości (Blackwell, 2019; Holmes i in., 2016). Również badania dzienniczkowe przeprowadzone na populacji ogólnej pokazują, że myślenie perspektywiczne nacechowane emocjonalnie jest w dużej mierze zgodne z aktualnym afektem. Osoby w dobrym nastroju częściej wyobrażają sobie pozytywne scenariusze przyszłości, natomiast te w obniżonym nastroju mają skłonność do tworzenia bardziej negatywnych wyobrażeń (Barsics i in., 2016). Nie można zatem

wykluczyć, że emocje lub nastrój incydentalny, w jakim znajduje się decydent w momencie konfrontacji z ryzykiem, wpływają na walencję generowanych wyobrażeń, a tym samym pośrednio determinują wywoływane przez nie emocje integralne. Problem staje się jeszcze bardziej złożony, gdy decydent doświadcza jednocześnie pozytywnych i negatywnych wyobrażeń związanych z ryzykiem, co rodzi pytanie o charakter ostatecznie doświadczanego afektu. Prawdopodobne jest, że w sytuacji gdy istnieje kilka źródeł afektu, ich wpływ jest uśredniany, przy czym największa waga zostaje przypisana najbardziej wyrazistym wyobrażeniom (Asutay i in., 2021). Niemniej jednak, są to póki co hipotezy wymagające dalszej weryfikacji empirycznej, zwłaszcza w kontekście dynamicznej i fluktuacyjnej natury afektu, coraz częściej podkreślanej w literaturze (Asutay & Västfjäll, 2024; Cunningham i in., 2013).

Badania dotyczące różnic między przetwarzaniem wizualnym a werbalnym sugerują, że w niektórych warunkach oba tryby prowadzą do odmiennych ocen, a nawet decyzji. Chan i Saqib (2021) wykazali, że osoby preferujące wizualny styl przetwarzania lub generujące wizualne wyobrażenia dotyczące ryzyka konsumenckiego silniej dostrzegają związane z nim zagrożenia w porównaniu do osób skłaniających się ku werbalnemu przetwarzaniu informacji lub analizie językowej. Ponadto, w kontekście decyzji moralnych, wizualizacje sprzyjają podejmowaniu decyzji deontologicznych, podczas gdy przetwarzanie werbalne promuje rozwiązania utylitarne (Amit & Greene, 2012)**.** Na podstawie tych wyników oraz obserwacji o częstszym wykorzystywaniu wyobrażeń umysłowych w niektórych domenach decyzyjnych, naturalnym kierunkiem dalszych badań jest porównanie wpływu obu trybów przetwarzania na decyzje podejmowane w różnych kontekstach. Istotne byłoby na przykład sprawdzenie, czy i w jakich warunkach prowadzą one do jakościowo odmiennych lub różniących się pod względem trafności wyborów.

Ostatnim istotnym zagadnieniem nieuwzględnionym w ramach tej rozprawy jest kwestia różnic indywidualnych w zakresie wyrazistości wyobrażeń. W czwartym badaniu

drugiej serii zaobserwowaliśmy, że stopień wyrazistości generowanych obrazów moderuje reakcje emocjonalne na ryzyko. Choć w projekcie ocenialiśmy to zjawisko w odniesieniu do konkretnych bodźców, zdolność do tworzenia intensywnych wyobrażeń ma również charakter dyspozycyjny. Umiejętność ta mieści się na kontinuum – od afantazji, czyli całkowitego braku wizualizacji, po hiperfantazję, w której obrazy mentalne niemal dorównują percepcji (Zeman, 2024). Jej pomiar opiera się na narzędziach samoopisowych i behawioralnych (Andrade i in., 2014; Chang & Pearson, 2018; Marks, 1972), a wyniki badań wskazują, że skrajne wartości w tym wymiarze występują u około 5% populacji (Faw, 2009). Z perspektywy naszego projektu, prowadzi to do dwóch implikacji. Po pierwsze, osoby z hiperfantazją prawdopodobnie tworzą wyjątkowo żywe obrazy sytuacji ryzykownych, co intensyfikuje afekt, który tym samym silniej wpływa na ich decyzje. Po drugie, u osób z afantazją przetwarzanie informacji o ryzyku może częściej opierać się na analizie językowej, co ogranicza wpływ emocji na ostateczne wybory.

W tradycji psychologicznej funkcję wyobrażeń umysłowych dostrzegano przede wszystkim w obszarach takich jak twórczość, rozwiązywanie problemów oraz kreatywne myślenie (Finke, 1993; Hayes, 1973; McKim, 1993). Współczesne badania koncentrują się jednak na ich znaczeniu w codziennym funkcjonowaniu człowieka, podkreślając rolę symulacji mentalnych w przewidywaniu przyszłości, planowaniu działań, regulacji emocji czy przygotowaniu do wykonania złożonych czynności (Moulton & Kosslyn, 2009; Szpunar, 2010; Weinberg, 2008). Nasze badania rozszerzają tę perspektywę, wskazując na istotne, niemal instrumentalne znaczenie wyobrażeń umysłowych w podejmowaniu codziennych decyzji. Wyniki sugerują, że w obliczu ryzyka człowiek nie zawsze kieruje się racjonalnymi kalkulacjami, lecz często wykorzystuje szybkie procesy poznawcze takie jak wizualizacje, które angażując emocje, umożliwiają natychmiastową ocenę potencjalnych korzyści i zagrożeń związanych z podjęciem działania. Głębsze zrozumienie tej roli może mieć

implikacje zarówno dla teorii podejmowania decyzji, jak i dla budowania praktycznych interwencji nakierowanych na kształtowanie adaptacyjnych wyborów.

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Imagining risk taking: The valence of mental imagery is related to the declared willingness to take risky actions

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Abstract

The aim of the present research was to investigate the involvement of mental imagery in people's choices under risk. We tested the general idea that decision makers can use visual mental images (visual mental simulations) to pre-experience how rewarding or threatening future outcomes of risky behavior will be and try out the potential consequences of their risky activities. The paper reports the results of three preregistered studies (including one experiment) showing that the valence of mental imagery is related to the willingness to take risky actions and that people spontaneously use mental imagery as an informative decision input. In Study 1, we found that the more positive mental images people produced when faced with risk, the more willing they were to take risky actions representing different risk domains. Study 2 extended the results of Study 1, indicating that the valence of mental imagery has a causal effect on participants' risk taking willingness. Qualitative analysis based on independent judges' evaluations conducted in Studies 1 and 2 documented that, when requested, participants could easily generate visual mental images illustrating the consequences of their risky choices. Finally, with Study 3, we found that participants declared using mental imagery as a decision input (i.e., a source of information that helps them make choices) even when they were not instructed to do so. However, the frequency of reporting images as decision inputs differed across risky activities.

KEYWORDS
mental imagery, risk taking, risky actions, willingness to take risks

1 | INTRODUCTION

Decision making is inextricably associated with thinking about the future as part of a broader process of mental time travel (Boyer, 2008; Suddendorf & Corballis, 2007; Szpunar, 2010; Zaleskiewicz, Traczyk, & Sobkow, 2023). An essential aspect of decision-related information processing directly linked to episodic foresight (Suddendorf, 2017) is the consideration of potential future outcomes of current choices – their type, magnitude, and valence (Beach, 2009, 2016; Tuckett & Nikolic, 2017). For example, a decision maker may think about the possibility of a future loss but underestimates its extent. Such a misevaluation can lead to choosing an option that is inconsistent with the decision-maker's preferences and exceeds the limit of personally acceptable risk. The present research shows and discusses the findings from three preregistered studies (including one experiment) testing the general prediction that mental imagery may be a critical psychological mechanism used to simulate potential future outcomes of risky activities. In particular, we show that generating and processing more positive mental images of risky actions is associated with higher risk acceptance, while creating negative mental images makes a decision-maker more risk-averse. We also provide preliminary evidence that decision makers use mental imagery as informational input spontaneously, even if they are not encouraged to do so.

1.1 | Mental imagery and decision making

Before investigating how mental imagery might inform decision making, the concept itself should be explained. Cognitive psychology offers a broad spectrum of definitions. The most widely cited ones were introduced by Kosslyn et al. (2001) and Pearson et al. (2015). The former authors proposed that "mental imagery occurs when perceptual information is accessed from memory, giving rise to the experience of 'seeing with the mind's eye,' 'hearing with the mind's ear' and so on …" (p. 635). For the latter authors, mental imagery comprises "representations and the accompanying experience of sensory information without a direct external stimulus" (p. 590). Both definitions are useful when studying the association between mental imagery and risk taking. When making current choices, people do not experience their outcomes immediately, but they can simulate them in their imagination. In the present instance, mental imagery is interpreted as a cognitive tool that allows an individual to simulate the future (Beach, 2009; Nanay, 2016, 2023). We also refer to the concept of mental emulation as propounded by Moulton and Kosslyn (2009). They argued that the primary function of mental imagery is to generate predictions; in particular, it allows us "to predict what we would experience in a specific situation or after we perform a specific action" and "to anticipate what may occur in the near and distant future" (p. 1273). They gave an example to illustrate how mental images of a particular behavior can produce simulations of an unknown (future) experience: "To simulate a conversation via emulation, for example, you could place yourself in the 'mental shoes' of those conversing, predicting their dialogue based upon how you would respond (based on your emotions and the associations that are triggered) in their respective situations" (p. 1276). According to such an interpretation, mental imagery can be used to *pre-experience* how rewarding one's engagement in a given risky activity would be (Blackwell, 2020) and *try out* (both cognitively and emotionally) the potential consequences (Atance & O'Neill, 2001; Schacter et al., 2017). It should be noted that mental imagery can occur in different sensory modes (e.g., the auditory, haptic, gustatory, and olfactory modes), but in our present research, we focused on the specific role played by the visual mode (single images or series of images in the form of 'mental films'). Previous research has shown that people report greater vividness for vision than for other modalities, which suggests that the visual modality plays a dominant role in mental imagery (Belardinelli et al., 2004; Schifferstein, 2009; Switras, 1978). Thus, we propose that when people use mental images in their decision making, they are more likely to generate visualizations rather than images based on other modalities.

Basing one's decisions of whether to engage in risky actions on mental imagery seems highly adaptive (Zaleskiewicz, Traczyk, & Sobkow, 2023). If an individual can relatively quickly generate mental images that portray the negative consequences of risk taking, their willingness to accept risky options should diminish. This, in turn, might protect them against exceeding the limits of acceptable uncertainty. Such reasoning is supported by the fact that mental imagery is closely related to emotions (Blackwell, 2020; Holmes & Mathews, 2010; Ji et al., 2016; Nanay, 2023). For example, generating powerful negative images of a threat would evoke a strong negative affect, which will discourage the decision maker from engaging in excessive risk taking.

The idea that people can use mental simulations to recognize the shape of future actions was earlier developed in the form of a simulation heuristic (Kahneman & Tversky, 1982). MacLeod (2017) proposed that the simulation heuristic can be seen as "the process of constructing a mental model of reality in which the hypothetical model takes place" (p. 273). He also postulated that when people engage in mental simulations, they actively construe causal explanations of events rather than just retrieving past experiences. Kappes and Morewedge (2016) suggested that when people mentally simulate evidence, they tend to use it as a substitute for physical evidence, with the former having a disproportionate effect on estimations of the probability of future events. In their view, "[s]imulations affect expectations about the future because, like actual experience, they are interpreted as providing evidence about why and how events will actually occur" (p. 409). Evidence supporting such reasoning indicated that people rated the likelihood of future adverse events (e.g., developing a physical illness) as higher when they engaged more intensively in mental simulations and when they could more easily create visual images of those events (Raune et al., 2005). We would argue that mental imagery can be used as a form of mental simulation, allowing the decision maker to visualize future outcomes of their actions that (depending on their valence) can affect one's willingness to accept risk.

1.2 | Previous research linking decision making with mental imagery

Evidence pointing to the role of mental imagery in decision making emerged in areas such as intertemporal and moral decision making, and risk perception. When people are instructed to imagine future (delayed) outcomes, they become more prone to hold back from impulsively choosing immediate rewards. In Peters and Büchel's (2010) study, participants made choices between monetary rewards that differed in both amount and time. Those who were cued to engage in episodic foresight shifted their preferences towards a delayed outcome. Meanwhile, Bulley et al. (2019) instructed participants to mentally simulate either negative or positive future scenarios. They found that people in both experimental conditions more often chose larger and delayed rewards than those in the control condition. In sum, it seems that using mental imagery to simulate delayed outcomes supports self-control in intertemporal decision making.

Research on moral judgment and choice has shown that visualizing immoral behaviors with closed eyes (which provokes engagement in mental simulations and evokes more intense emotions) led to a greater condemnation of such behaviors (Caruso & Gino, 2011). Amit and Greene (2012) found that visual mental imagery supports deontological moral judgments (i.e., those favoring the rights of the individual) over utilitarian moral judgments (i.e., those favoring the greater good). In particular, the authors observed that people with a more visual cognitive style tended to make deontological rather than

utilitarian moral judgments and that introducing visual interference made moral judgments less deontological and more utilitarian. The implication here is that mental imagery can regulate moral decision making and make people more likely to follow deontological ethics.

There is some evidence of a connection between mental imagery and risk perception. For example, one of the reasons behind underestimating the risk of climate change is that people generate amorphous and unvivid mental images of threats that climate change might cause. Leiserowitz (2006) asked participants to report mental images that appeared in their minds when thinking about global warming and to rate these images on a scale from *very negative* to *very positive*. The participants generated mental images that were not personally relevant (e.g., they included distant locations or affected nonhuman species). Those images evoked moderate or weak affective reactions (see also Leiserowitz, 2006; Smith & Leiserowitz, 2012). Recent studies on people's perception of risks related to COVID-19 have shown that instructing people to generate mental images of the negative consequences of infection made subjective risk assessments more accurate (Sinclair et al., 2021).

Finally, studies that used measures based on eliciting verbal imagery (Peters & Slovic, 1996) also documented that the perception of threats can be based on processing images. It has been found, for example, that people's support for nuclear power was related to the valence of images (defined as associations or thoughts) they generated (Peters & Slovic, 1996; Slovic, Flynn, & Layman, 1991; Slovic, Layman, et al., 1991). Benthin et al. (1995) used the word association technique to investigate the role of imagery in adolescent risk taking behaviors. These authors found that health-threatening behaviors had many positive associations/images (e.g., having fun), which might explain why young people are exceptionally ready to engage in high-risk activities.

In sum, the results of previous studies suggest that mental imagery is associated with different aspects of decision making (see also Zaleskiewicz, Traczyk, & Sobkow, 2023). The main purpose of the present project was to investigate the relationship between the valence of visual mental images and people's willingness to accept risky options. The second was to examine whether people declare a spontaneous use of mental imagery in their decision making.

1.3 | Overview and contribution of the present studies

We report the results of three preregistered studies in which we focused on investigating the issue of whether producing mental images of risky activities is related to the willingness to take them. In Study 1, people were presented with risky activities and instructed to generate up to three mental images that crossed their minds when visualizing their involvement. They later rated the valence of their images and declared their willingness to engage in a given risky action. We found that the valence of mental imagery positively correlated with the readiness to take risky actions. In Study 2 (an experiment), we documented a causal link between the positivity/negativity of visual mental images and declared willingness to take risks. Participants who were instructed to generate positive mental images declared a greater readiness than the control group to engage in risky behaviors. By contrast, those who generated negative images were less willing to accept risk than the control group. Finally, Study 3 showed that envisioning the future through imagination served to assist decision making. Participants stated that they used spontaneous mental images as decision inputs.

We believe that our present research contributes to the literature on how mental imagery is associated with risk taking in several ways. First, we specifically focused on the role of visual mental imagery related to considering risky actions. Instructions that were given to participants requested them to visually imagine risky actions as if they would see them via their 'mind's eye' (i.e., in the form of single images, series of 'mental pictures', or 'mental films'). Previous research investigating risk-related imagery (Benthin et al., 1995; MacGregor et al., 2000; Peters & Slovic, 1996; Slovic, Flynn, & Layman, 1991; Slovic, Layman, et al., 1991) mainly used the methods of 'continuous associations' or 'thought-listing' procedures and, in some cases, instructed participants to think about risk instead of imagine or visualize it. In such methods, the participant's task is to provide associations that come to their minds in relation to a stimulus. The associations typically take the form of thoughts (words or phrases), meaning participants are not requested to generate visual mental images. It is possible that even though these studies employed 'thought-listing' procedures, participants might have also generated visual images. Amit et al. (2017) demonstrated that when people are prompted to think verbally and use inner speech, visual imagery is also involved to some extent. However, the authors of previous studies examining risk-related imagery did not report such data. In summary, our procedure aimed to activate and engage visual processing, with a primary focus on investigating visual mental imagery (Wyer et al., 2008).

Second, in two out of three studies we report in this paper, we run qualitative analyses in which independent judges evaluated whether participants indeed generated visual images. The aim of this procedure was to make sure that the effects we report concern visual mental imagery and not verbal associations people may also produce when faced with risk.

Third, in Study 3, we investigated the degree to which people can spontaneously generate mental imagery when considering their engagement in risky actions. To the best of our knowledge, in most studies examining mental imagery's role in decision making, participants were explicitly instructed to generate images. This suggests that prior research, unlike our Study 3, tested enforced rather than spontaneous use of mental imagery in decision-related contexts.

2 | STUDY 1

Study 1 investigated whether the valence of mental images was significantly related to participants' declared willingness to take risky actions. We expected that there would be a positive correlation between the

valence of mental images and the willingness to take action: the more positive the ratings of mental images generated by participants, the higher their declared willingness to engage in risky actions.

2.1 | Method

2.1.1 | Participants

The sample size for this study was computed with a priori analysis using G*Power (Faul et al., 2009), which revealed that given an alpha of .05 and power of .95, a sample size of 115 participants would be sufficient to observe a moderate effect size ($r = .30$). Having in mind that some participants in online studies withdraw or do not pass attention checks, we decided to increase this number and recruit 230 participants from the United States via the Internet platform Prolific (122 females, 108 males, $M_{age} = 38.93$, $SD = 13.09$). All of them received remuneration ($1.64). In line with preregistration, responses provided by nine participants who completed the study using mobile phones were excluded from the analysis. Participants provided informed consent after they had been briefly informed about the general purpose of the study and the voluntary nature of their involvement. They were also told that they could withdraw at any time. The study was designed and conducted in accordance with guidelines enforced by the University Ethical Committee and preregistered at the Open Science Framework (10.17605/OSF.IO/JDKZX).

2.1.2 | Procedure

The study was conducted online. In its respective phases, participants read brief descriptions of different real-life risky activities (e.g., "Taking strong medications without consulting your doctor" for the health domain; see Table 1 for a full list). These were displayed in random order. The participants' task was to vividly imagine themselves being actively involved, that is, seeing the scene in their mind's eye and describing up to three mental images. They then rated the valence of each image ("Was the image positive, negative, or neutral?") using a 100-point slider ranging from 0 - *very negative* to 100 - *very positive*. Finally, for each risky activity, they rated their willingness to take a risky action ("Would you be willing to take this action?") on a scale ranging from 1- *definitely no* to 7 - *definitely yes*.

2.2 | Results

2.2.1 | Qualitative analysis of the content of entries provided by participants

Before testing our main hypothesis, we conducted a non-preregistered, qualitative content analysis of the descriptions (entries) provided by participants. The purpose was to examine whether participants followed the instruction and created and described visual images related to the risky activities they were presented with. First, two independent judges fluent in English read the content of the entries and assigned each of them separately to one of two deductive codes – "visual imagery" and "non-imagery." (See Supplementary Materials for the exact wording of the codes' definitions.) Second, the third judge resolved any disagreements that arose in assigning each entry to one of the two codes by making a final, independent decision. To ensure high fidelity of analysis, each judge completed theoretical and practical training (1.5 h in total) before starting the task. The analysis was conducted using the MAXQDA software (Kuckartz & Rädiker, 2019).

First, we checked how often participants provided all three entries when reporting their mental images (96%). We collected 3,281 entries in total. Independent judges agreed in their content analysis that 2,461 (75%) of participants' entries described mental images. Among the entries assigned to the "visual imagery" code, participants provided descriptions such as: "I am picturing my husband being at work and needing to sign something for him," "I imagined being evicted from my house," or "I visualized the mountains of Arizona as I sped through them recklessly. Beautiful and tall with a sunrise." (See Supplementary Materials for additional examples of entries provided by participants in Study 1).

2.2.2 | Hypothesis testing

For the main preregistered analysis, responses were averaged across all risky activities for each participant separately. Next, we formed the

TABLE 1 Descriptive statistics for risky activities used in Study 1.

	Valence of mental imagery		Willingness to take risks	
Risky activities	***M***	***SD***	***M***	***SD***
Taking strong medications without consulting your doctor	25.294	20.492	2.462	1.790
Forging your partner's signature on a legal document	28.761	20.770	2.624	1.977
Betting a year's salary on sports	23.659	20.016	1.471	1.267
Having casual unprotected sex	41.743	27.872	3.362	2.255
Driving fast on a winding road in the mountains	41.280	29.187	3.308	2.287
Average ratings for all situations	32.147	23.667	2.645	1.915

Note: For Valence of mental imagery: min = 0; max = 100. For Willingness to take risk: min = 1; max = 7.

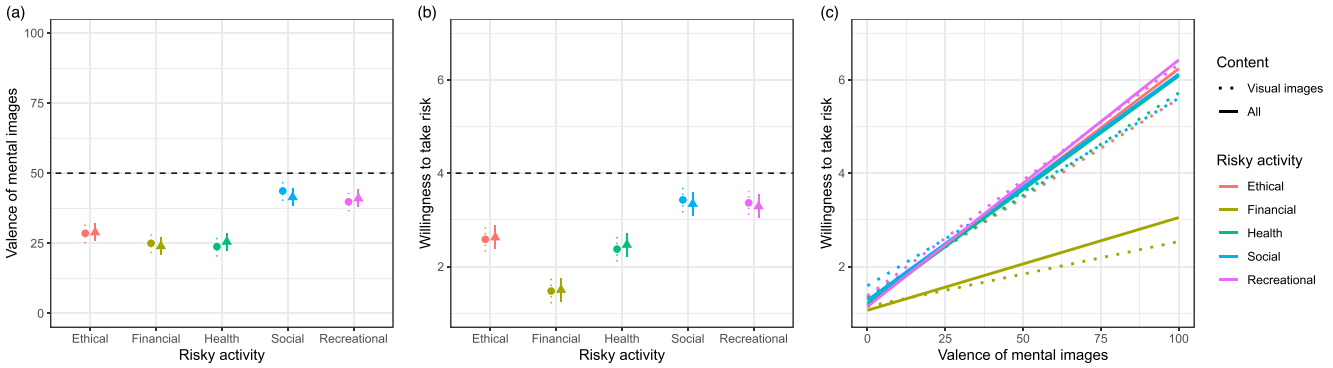

FIGURE 1 The predicted valence of mental images (panel a), willingness to take risk (panel b), and the relationship between these variables (panel c) across five risky activities (treated in the model as a random intercept effect). Solid and dotted lines represent predictions based on all data and content categorized by independent judges as visual images, respectively. Error bars represent 95% confidence interval.

general indices of the mean valence of reported mental images ($M = 32.148$, $SD = 15.029$, Cronbach's $\alpha = .756$) and the mean willingness to take a risky action ($M = 2.645$, $SD = 1.255$, Cronbach's $\alpha = .646$). Descriptive statistics for each specific activity are shown in Table 1. In the first step of the analysis (in line with our preregistration), we used responses provided by all participants without excluding entries evaluated by independent judges as belonging to the "non-imagery" category.

First, we investigated the mean valence of mental images generated by participants and found that it was significantly lower than 50: $t(220) = -17.659$, $p < .001$, Cohen's $d = -1.188$, 95% CI [−1.359, −1.015]. A parallel analysis was conducted for the mean willingness to take risks (the dependent variable): $t(220) = -10.123$, $p < .001$, Cohen's $d = -0.681$, 95% CI [−0.822, −0.534]. This suggested that participants, when confronted with risky situations, tended to produce negative rather than positive mental images and preferred to refrain from taking risky actions.

Second, we examined the relationship between the mean valence of the mental images and the mean willingness to take risky actions. In line with our preregistered hypothesis, we observed a moderate and positive correlation between the two variables: $r(219) = .543$, $p < .001$, 95% CI [.459, 1.000]. This suggested that the more participants tended to evaluate their mental images as positive, the more willing they were to take risks.

To strengthen the support for our hypothesis, we conducted an additional, non-preregistered analysis of the valence of mental images and the willingness to take risky actions using only those entries that were coded as "visual imagery" in the qualitative analysis. Before conducting the analyses, we excluded 820 participants' entries and data units related to them (i.e., ratings of the valence of mental imagery and ratings of willingness to take risks), which were rated by the independent judges as non-images. Five participants did not provide any instance of visual mental imagery, and their responses were entirely excluded from this analysis. Next, we averaged the remaining responses for each participant separately to create the general indices of the mean valence of mental images and the mean willingness to take risky actions. The quantitative analyses were conducted using the general indices. We examined the mean valence of the mental images and again found that it was lower than 50: $t(215) = -15.709$, $p < .001$, Cohen's $d = -1.069$, 95% CI [−1.235, −0.901]. The mean willingness to take risky actions also fell below the middle of the scale: $t(215) = -10.308$, $p < .001$, Cohen's $d = -0.701$, 95% CI [−0.850, −0.552]. Finally, the correlation between the mean valence of the mental images and the mean declared willingness to take risks was again moderate and positive: $r(214) = .506$, $p < .001$, 95% CI [.418, 1.000].

To address potential variability in ratings of both valence and willingness to take risks across the five risky activities, we fitted a linear multilevel regression model with participants and activities as random intercept effects. Additionally, we allowed the effect (slope) of valence on willingness to take risk to vary depending on risky activity. Models were fitted using the lme4 package (Bates et al., 2014, p. 4) run in R statistical environment (R Core Team, 2022); p-values were estimated using the lmer Test package (Kuznetsova et al., 2014), while all pairwise comparisons were performed with the emmeans (Lenth, 2023) and ggeffects (Lüdecke, 2018) packages.

We corroborated the results from preregistered analyses reported earlier in this section. In particular, the mean valence of mental images generated by participants was significantly lower than the middle of the scale (i.e., 50): $b = -17.853$, $t(5.515) = -4.955$, $p = .003$, δt[1] $= -0.707$ (Figure 1A). A similar effect was observed for the mean willingness to take risks: $b = -1.355$, $t(5.490) = -4.281$, $p = .006$, $\delta t = -0.655$ (Figure 1B). Results did not change significantly when only records categorized as visual mental images were taken into account. Additionally, we found nonnegligible variability across risky activities employed in the study (for descriptive statistics aggregated on the participants' level, see Table 1), with risky activity in the financial domain demonstrating the lowest mean willingness to engage (Figure 1B) and the weakest relationship between the valence of

[1] δt is a measure of effect size calculated by dividing the beta regression parameter by the square root of the sum of all residual variances.

mental images and the willingness to take risk (Figure 1C). Despite this, the fixed effect of the valence of mental images on risk taking was still positive and significant, $b = 0.044$, $p < .001$, 95% CI [0.030, 0.058], $\delta t = 0.028$, indicating that the type of a risky activity did not impact the overall pattern of results.

2.3 | Summary

When instructed to do so, participants could easily produce mental images related to their involvement in risky actions, but these images tended to be negative rather than positive. From the perspective of our preregistered expectations and the general assumptions underpinning our theoretical model, the mean valence of mental images was positively correlated with the mean declared willingness to take risks. These results were held after excluding data units (i.e., ratings of the valence of mental images and the willingness to take risky actions) related to those participants' entries that were classified as non-images by three independent judges and after accounting for variability across risky activities. In other words, the more positively participants could see their involvement in a risky activity through their mind's eyes, the more ready they were to take action. The results of Study 1 supported our hypothesis that mental images would increase the willingness to take risks when they were positive and vice versa.

3 | STUDY 2

In Study 1, we demonstrated that the valence of mental imagery is correlated with the readiness to take risks. The purpose of Study 2 was to show that both variables were causally related; that is, the valence of mental imagery would influence risk proneness. Based on the correlations that were found in Study 1, we assumed that imagining positive circumstances around risky actions would lead to a higher propensity to take risks, whereas generating negative mental images relating to a risky action would have the opposite effect. Additionally, we attempted to replicate the correlational findings observed in the first study, again hypothesizing that the valence of mental images rated by participants would be positively correlated with the willingness to take risky actions.

3.1 | Method

3.1.1 | Participants

While computing the sample size, we used a commonly assumed medium effect size (Cohen's $f = .25$) for the expected difference between the three experimental groups. A priori analysis using G*Power (Faul et al., 2009) revealed that, given an alpha of .05 and conventionally assumed power of .80, a sample size of 159 participants would be sufficient to observe a medium effect size ($f = .25$). We decided to increase the sample size to 180 to compensate for possible withdrawals. The participants (who were from the United States) were recruited via the Internet platform Prolific (136 females, 44 males, $M_{age} = 32.79$, $SD = 12.23$). In line with the preregistration, responses from 12 participants who completed the research using mobile phones were excluded from the analysis. Participants were remunerated ($1.65), and they took part voluntarily. Before beginning the experiment, participants gave their informed consent and were informed about the general purpose of the study. They were also told that they could withdraw at any point. The study was designed and conducted in accordance with guidelines enforced by the University Ethical Committee and preregistered at the Open Science Framework (10.17605/OSF.IO/3E65N).

3.1.2 | Procedure

The study was conducted online. Participants were randomly assigned to one of three experimental conditions: (a) negative mental imagery ($n = 63$); (b) positive mental imagery ($n = 54$); and (c) the control condition ($n = 49$). For the positive and negative mental imagery conditions, participants were asked to imagine, respectively, either positive or negative circumstances of engaging in a risky action presented to them. In the control condition, the participants' task was to freely imagine circumstances related to risk taking without specifying the valence of mental images. The control condition in Study 2, therefore, mirrored that of Study 1.

As with Study 1, Study 2 comprised five phases. Participants read randomly displayed descriptions of different real-life actions involving risk (Blais & Weber, 2006) (e.g., "Not returning a wallet you found that contains $200" for the ethical activity; Table 2 shows each of the risky activities included in the study). The participants' task was to imagine themselves being actively involved in the risky activity in their mind's eye and provide up to three descriptions of their mental images. Next, they were asked to rate the valence of each mental image they reported ("What was your image like?") on a scale ranging from 0 – *very negative* to 100 – *very positive*. Finally, participants answered questions about their willingness to take risky action ("Would you be willing to take action in this situation?") on a scale ranging from 1 – *definitely no* to 7 – *definitely yes* (with higher numbers indicating preparedness to take more risks). Before the start of each phase, participants were reminded of the type of mental imagery they should generate and the need for it to be dependent on the condition to which they were assigned.

3.2 | Results

3.2.1 | Qualitative analysis of the content of entries provided by participants

As with Study 1, before testing the preregistered hypothesis, we invited three independent judges to analyze the content of descriptions provided by participants. The purpose and procedure of this

TABLE 2 Descriptive statistics for risky activities used in Study 2.

	Positive mental imagery condition				Negative mental imagery condition				Control condition			
	Valence of Mental imagery		Willingness To take risk		Valence of Mental imagery		Willingness To take risk		Valence Of mental imagery		Willingness To take risk	
Risky activities	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Not returning a wallet you found that contains $200	59.45	23.336	2.83	2.045	21.194	21.317	2.794	2.025	36.520	26.495	2.653	1.809
Investing 10% of your annual income in a moderately growth-diversified fund	73.731	16.94	5.815	1.199	31.232	25.851	4.387	1.841	58.501	19.080	4.592	1.743
Engaging in unprotected sex	59.090	27.678	3.722	2.302	15.804	18.618	3.048	2.113	40.122	27.744	3.408	2.432
Camping in the wilderness	79.445	21.508	5.481	1.634	23.982	28.177	4.000	2.195	64.025	24.779	5.245	1.809
Dating someone you are working with	66.625	28.261	3.981	2.159	24.293	19.060	3.444	1.990	48.011	23.535	3.735	2.243
Average ratings over all situations	67.787	16.498	4.378	0.955	23.278	17.788	3.550	1.313	49.436	12.771	3.927	0.955

Note: For Valence of mental imagery: min = 0; max = 100. For Willingness to take risk: min = 1; max = 7.

qualitative analysis followed the same assumptions and methods as those used in Study 1.

We collected a total number of 2,663 participants' entries relating to risky actions. The independent judges agreed that in 2177 cases (82% of all entries), participants provided descriptions showing that they had generated visual mental images of risky situations presented to them. The descriptions evaluated as "visual imagery" included statements such as: "A nice forest scene, an assortment of tents, and a campfire. Maybe near a lake. I'm there with friends, and this is something we all decided to do together"; "Seeing myself and this person enjoying dinner and a movie"; and "Images of men screaming on the trading floor and me standing there wondering what the hell everyone is screaming for." (see Supplementary Materials for additional examples of entries provided by participants in Study 2).

3.2.2 | Manipulation check

As in Study 1, participants' responses in each group were averaged over all activities to create general indices of the mean valence of mental imagery (Cronbach's $\alpha = .859$) and the mean willingness to take risky actions (Cronbach's $\alpha = .449$) for each participant separately (see detailed descriptive statistics for each activity and condition in Table 2). In line with our preregistration, we excluded 19 entries where participants did not provide any descriptions of mental images or provided descriptions entirely unrelated to the task (as indicated in the response box). Again, in the first step of the analysis, we used responses provided by all participants without excluding entries evaluated by independent judges as "non-imagery."

First, we tested the effectiveness of our manipulation by comparing mean participants' evaluations of the valence of mental images they generated across the three conditions. The results of a one-way analysis of variance (ANOVA) indicated that the valence of mental imagery reported by participants differed significantly across conditions: $F(2, 163) = 114.237$, $p < .001$, $\eta^2 = .584$. The highest ratings were found in the positive mental imagery condition ($M = 67.787$, $SD = 16.498$), the medium ratings in the control condition ($M = 49.436$, $SD = 12.771$), and the lowest ratings in the negative mental imagery condition ($M = 23.278$, $SD = 17.788$). Further post hoc comparisons using Tukey's test showed significant differences in the valence ratings between all pairs of conditions: positive vs. negative mental imagery: $t(115) = -14.974$, $p < .001$, Cohen's $d = -2.587$; negative mental imagery vs. controls: $t(110) = 8.568$; $p < .001$, Cohen's $d = 1.656$; and positive mental imagery vs. controls: $t(101) = -5.803$, $p < .001$, Cohen's $d = -1.236$. In both experimental conditions, the valence ratings deviated significantly from 50 (the middle of the scale) and in the direction presumed by the manipulation: positive mental images: $t(53) = 7.923$, $p < .001$, Cohen's $d = 1.078$, 95% CI [0.739, 1.411]; and negative mental images: $t(62) = -11.923$, $p < .001$, Cohen's $d = -1.502$, 95% CI [−1.861, −1.138]. The valence of mental imagery in the control condition did not deviate significantly from 50: $t(48) = -.309$, $p = .758$, Cohen's $d = -0.044$, 95% CI [−0.324, 0.236]. The analysis, therefore, confirmed that the manipulation of the valence of mental imagery used in Study 2 was successful.

3.2.3 | Hypothesis testing

To test the main hypothesis, we conducted two preregistered analyses. First, we compared participants' willingness to engage in risky actions between the three conditions. As expected, the results of a one-way ANOVA showed a main effect of our manipulation ($F[2, 163] = 7.979$, $p < .001$, $\eta^2 = .089$), with the greatest willingness to take risky actions in the positive mental imagery condition ($M = 4.378$; $SD = 0.954$); the lowest willingness to take risky actions

in the negative mental imagery condition ($M = 3.550$; $SD = 1.313$); and a medium willingness to take risky actions in the control condition ($M = 3.927$; $SD = 1.001$). A post hoc Tukey test indicated that the difference in the willingness to take risks between positive and negative imagery conditions was significant: $t(115) = -3.995$, $p < .001$, Cohen's $d = -0.712$. The comparisons between the experimental and control conditions were not significant. Negative mental imagery vs. controls: $t(110) = 1.768$, $p = .184$, Cohen's $d = 0.317$; and positive mental imagery vs. controls: $t(101) = -2.047$, $p = .104$, Cohen's $d = -0.462$.

We then examined correlations between the valence of mental imagery and the willingness to take risks. We observed significant and positive correlations between the valence of mental imagery and the willingness to engage in risky actions in each condition but with varying strengths. In the conditions where participants generated either positive or negative mental images, the relationships were moderate, respectively: $r(52) = .515$, $p < .001$, 95% CI [.327, 1.000] and $r(61) = .299$, $p = .009$, 95% CI [.096, 1.000]. The correlation in the control condition was also significant: $r(47) = .704$, $p < .001$, 95% CI [.560, 1.000]. We compared all possible pairs of correlation coefficients and found that the comparison between the negative imagery condition and the control condition was the only significant one (Fisher's $z = -2.9021$, $p = .001$). The significance of the remaining correlations was beyond the commonly assumed threshold (positive imagery vs. control condition: $p = 0.06$, positive imagery vs. negative imagery: $p = 0.08$).

As was the case in Study 1, we conducted an additional, non-preregistered analysis of the valence of mental images and the willingness to take risks using only those entries that were coded as "visual imagery" in the qualitative analysis. After excluding 486 separate entries and data units related to them (i.e., ratings of the valence of mental images and the willingness to take risky actions) rated by independent judges as "non-images," we carried out a quantitative analysis using only the data assigned by the judges to the category of "visual mental images." First, we repeated the manipulation check by comparing the mean valence of mental images reported by participants in each condition. The ANOVA results revealed a significant difference in the mean valence of mental images: $F(2, 163) = 98.339$, $p < .001$, $\eta^2 = .547$. The highest ratings were in the positive mental imagery condition ($M = 67.696$, $SD = 17.884$); the medium ratings in the control condition ($M = 50.248$, $SD = 12.875$); and the lowest ratings in the negative mental imagery condition ($M = 24.036$, $SD = 18.871$). This provided further evidence that the manipulation was successful. Post hoc Tukey test comparisons between all pairs showed significant differences in the mean valence of mental images across all conditions (Table 3). Next, we compared the declared mean willingness to take risks across the three conditions. The ANOVA results again showed a significant effect of our manipulation ($F[2, 163] = 6.773$, $p < .001$, $\eta^2 = .077$), with the greatest willingness to take risky actions in the positive mental imagery condition ($M = 4.313$, $SD = 1.016$); a medium willingness to take risks in the control condition ($M = 3.979$, $SD = 0.974$); and the lowest willingness to take risks in the negative mental imagery condition ($M = 3.557$, $SD = 1.282$). Post hoc Tukey test comparisons between all pairs of conditions replicated the results from the quantitative analysis, revealing a significant difference in the mean willingness to take risky actions between positive and negative mental imagery conditions (Table 3). Moreover, the mean valence of mental images in each experimental condition was significantly different from the middle of the scale (50), in the direction assumed by the manipulation. Positive mental images: $t(53) = 7.271$, $p < .001$, Cohen's $d = 0.989$, 95% CI [0.660, 1.313]; negative mental images: $t(62) = -10.921$, $p < .001$, Cohen's $d = -1.376$, 95% CI [−1.718, −1.027]. In the control condition, the mean valence did not differ from the middle of the scale: $t(48) = -0.135$, $p = .893$, Cohen's $d = -0.019$, 95% CI [−0.257, 0.294]. These results supported the hypothesis that there would be a causal link between the valence of mental images and the propensity to take risky actions.

We calculated correlation coefficients for the relationship between the valence of mental images and declared readiness to take risky actions. In the conditions with positive and negative images, the correlation was moderate and significant, respectively: $r(52) = .579$, $p < .001$, 95% CI [.406, 1.000] and $r(61) = .353$, $p = .002$, 95% CI [.155, 1.000]. The correlation observed in the control condition was also significant: $r(47) = .613$, $p < .001$, 95% CI [.439, 1.000]. Finally, we compared all possible pairs of correlation coefficients; only the difference between the negative imagery condition and the control condition was significant (Fisher's $z = -1.759$, $p = .03$). In the remaining comparisons, the significance level did not reach the commonly assumed threshold: positive imagery vs. control condition: $p = .30$, positive imagery vs. negative imagery: $p = .06$. The analysis, therefore, mirrored the results from the entire data set.

TABLE 3 Detailed results for post hoc comparisons between pairs of conditions after qualitative analysis.

Conditions compared	*t*	*p*	Cohen's *d*
	Valence of mental images		
Positive imagery vs. negative imagery	$t(115) = -13.866$	< .001	−2.370
Positive imagery vs. control condition	$t(101) = -5.208$	< .001	−1.111
Negative imagery vs. control condition	$t(110) = 8.105$	< .001	1.586
	Declared willingness to take risks		
Positive imagery vs. negative imagery	$t(115) = -3.660$	< .001	−0.648
Positive imagery vs. control condition	$t(101) = -1.521$	.284	−0.335
Negative imagery vs. control condition	$t(110) = 1.988$	.118	0.364

Similarly to Study 1, to address potential variability between risky activities, we fitted a multilevel linear regression model predicting participants' willingness to engage in risky activities with the condition, ratings of valence (mean-centered in each condition), and their interaction as fixed effects, and participants and risky activities as random intercept effects. The results showed a main effect of our manipulation $R^2 = .479$, with the greatest willingness to take risky actions in the positive mental imagery condition ($M = 4.371$; 95% CI [3.859, 4.882]); the lowest willingness to take risky actions in the negative mental imagery condition ($M = 3.519$; 95% CI [3.017, 4.021]); and a medium willingness to take risky actions in the control condition ($M = 3.928$; 95% CI [3.410, 4.447]). A post hoc Tukey test indicated that the difference in the willingness to take risks between positive and negative imagery conditions was significant: $t(167.56) = 4.636$, $p < .001$. The comparisons between the experimental and control conditions were not significant: negative mental imagery vs. control condition, $t(167.56) = 2.168$, $p = .079$, and positive mental imagery vs. control condition, $t(167.56) = -2.265$, $p = .064$ (Figure 2).

Next, we examined relationships between the valence of mental imagery and the willingness to take risks. We observed significant and positive associations between these variables in each condition: positive imagery condition, $b = 0.050$, $p < .001$, 95% CI [0.042, 0.058], negative imagery condition, $b = 0.036$, $p < .001$, 95% CI [0.027, 0.044], and control condition, $b = 0.054$, $p < .001$, 95% CI [0.046, 0.062]. The slopes did not differ significantly between conditions. The pattern of findings based on multilevel modeling remained the same when entries rated by independent judges as "non-images" were excluded.

3.3 | Summary

The results from Study 2 supported our prediction that the valence of mental imagery would be positively related to the willingness to take risks. Moreover, the relationship between the positivity or negativity of mental images and the proneness to engage in risky actions was causal. Preparedness to take risks was greater in the positive imagery group than in the negative imagery group. Nevertheless, contrary to the results of Study 1, we found that in the control condition, the mean valence of mental images did not differ significantly from 50. We assume that this discrepancy in results could be driven by the characteristics of risky activities (see Tables 1 & 2) or samples. In particular, in Study 2, most participants were women. It means that the effect we found here should be replicated in a sample with an even gender balance and on a larger set of risky activities.

4 | STUDY 3

The results of Studies 1 and 2 supported our expectation that visual mental imagery depicting circumstances of risky actions would be associated with participants' declared willingness to take risks. The potential limitation of these two studies was that participants were explicitly instructed to generate mental images when faced with risky situations. The aim of Study 3 was to investigate whether decision makers, when faced with a dilemma of whether to take a risky action or not, would spontaneously produce mental images without being directly asked to do so. This would indicate that people engage in a spontaneous generation of mental images, thus supporting our general thesis that visual mental imagery is used as a guide for making decisions that entail risk.

For Study 3, we assumed that participants might access different types of information arising from different sources and originating in diverse psychological processes, such as logical arguments concerning threats and benefits, feelings and sensations, memories, and mental images (Weber et al., 1995; Weber & Lindemann, 2007; Zaleskiewicz, Traczyk, & Sobkow, 2023). We aimed to investigate whether participants would state that they based their decisions on mental images besides other types of information. To simplify the presentation of our methods and results, we hereafter use the term *decision inputs* when referring to said information.

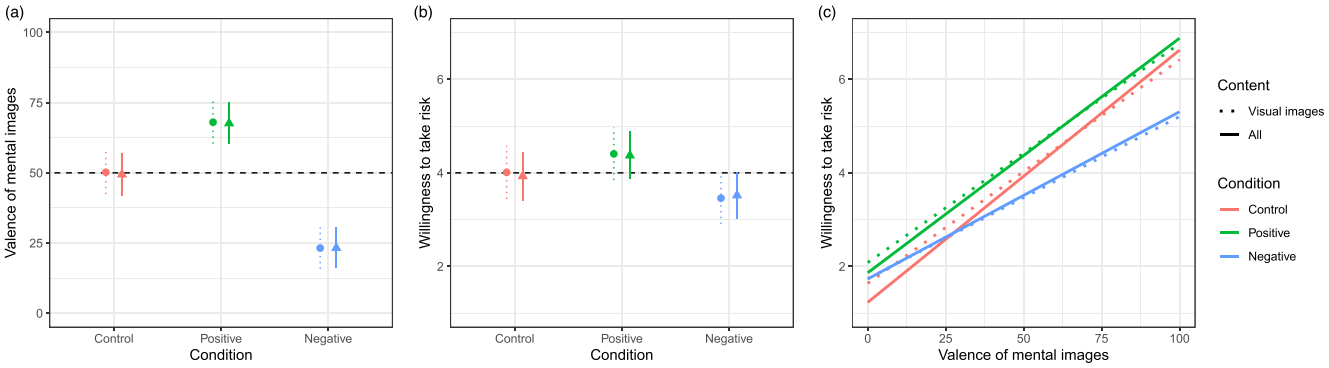

FIGURE 2 The predicted valence of mental images (panel a), willingness to take risk (panel b), and the relationship between these variables (panel c) across three experimental conditions. Participants and risky activities were treated in the model as random intercept effects. Solid and dotted lines represent predictions based on all data and content categorized by independent judges as visual images, respectively. Error bars represent 95% confidence interval.

Study 3 was exploratory, that is, we did not test a specific hypothesis. We did, however, predict that participants would use mental images in addressing risky dilemmas and that there would be a positive correlation between the valence of decision inputs (including mental images) and a declared willingness to take risks.

4.1 | Method

4.1.1 | Participants

One-hundred-and-fifty participants from the United States were recruited via the Internet platform Prolific (75 females, 75 males, $M_{age} = 37.70$, $SD = 13.52$). Since this was an exploratory study, we determined the sample size using a heuristic sample selection, considering our budgetary restrictions (Lakens, 2022). In line with the preregistration, data from six participants who used mobile phones were excluded from the analysis. Participants, all of whom were volunteers, were remunerated ($0.82). Before the study began, participants signed an informed consent form that briefly described the general purpose of the study; they were also told that they could withdraw at any point. The study was designed and conducted following ethical guidelines enforced by the University Ethical Committee and preregistered at the Open Science Framework (10.17605/OSF.IO/KWCBJ).

4.1.2 | Procedure

The study was conducted online. As with Studies 1 and 2, Study 3 comprised five steps. In each one, participants read descriptions of risky activities (presented in random order) taken from Study 2. Participants' task was to assume that they were engaged in risky activities presented to them and write down the first thing that crossed their minds. They then rated the valence of their descriptions ("What was the thing you just described like?") on a scale ranging from 0 (*very negative*) to 100 (*very positive*) and declared their willingness to take action (e.g., "Would you be willing to take this action [i.e., not returning a wallet][2]?") on a 7-point scale with responses ranging from 1 (*definitely no*) to 7 (*definitely yes*). In the final phase, participants were presented with each of the descriptions they provided in the previous phases of the research. Their task was to classify each description into only one of the following categories: "Logical argument," "Feeling and sensation," "Memory," "Visual imagery," and "Other." The categories were defined for the participants and selected based on studies of the different types of decision strategies people adopt when dealing with real-life dilemmas (Weber et al., 1995; Weber & Lindemann, 2007; Zaleskiewicz, Traczyk, & Sobkow, 2023).

[2]For each situation, the question measuring the dependent variable included the description of the specific risky situation to remind participants.

4.2 | Results

First, we calculated the overall frequency (i.e., aggregated over all risky activities) with which participants used different decision inputs. The multinomial test revealed significant differences between the frequency of reported decision inputs, $\chi^2(4) = 355.653$, $p < .001$. Taken together, participants' choices were most often guided by logical arguments, followed by feelings and sensations, visual images, and memories, in descending order (Table 4). Overall, mental images were indicated as decision inputs in 16% of cases. Post-hoc pairwise comparisons with Bonferroni correction showed that there were no statistical differences between the frequency of reporting logical arguments and feelings and sensations ($p = .479$) as well as visual images and memory ($p = .146$). All other comparisons were statistically significant ($p < .001$).

Next, we analyzed the relative frequency of decision inputs across five risky activities (financial, ethical, social, health, and recreational), as shown in Figure 3.

As can be seen in Figure 3, the frequency of using decision inputs differed among risky activities, with logical arguments predominant in the financial and health activity, feelings and sensations in the ethical activity, and visual images in the recreational activity. In the social activity, participants declared using logical arguments and feelings or sensations with almost equal relative frequency.

Since we intended to focus on the declared frequency of using mental images, we compared responses concerning this specific decision input among different risky activities. In other words, we made comparisons among activities of how frequently mental images were used as decision inputs within these activities. Table 5 shows that mental images occurred most frequently in recreational activity—56% of all mental images reported as a decision input were generated in response to recreational action. In other activities, mental images were used relatively less frequently. The multinomial test indicated significant differences between activities, $\chi^2(4) = 97.130$, $p < .001$. Post-hoc pairwise comparisons with Bonferroni correction clearly showed that visual images were reported more frequently in recreational activity compared to activities in other domains (all $ps < .001$). We found no statistically significant differences in using visual mental images as decision inputs between financial, ethical, social, and health activities.

To test our hypothesis that there would be a positive relationship between the valence of decision inputs and a declared willingness to take risky actions, we conducted a series of correlation analyses. We found strong and positive correlations between the valence of all decision inputs and the declared willingness to take risks (Table 6; see also Table S1 in Supplementary Materials for correlations within five separate risky activities). No significant differences were found in the strength of compared pairs of correlation coefficients.

To account for variability between risky activities (Cronbach's α for the ratings of valence and willingness to take risks were 0.211 and 0.411, respectively), we ran a multilevel regression model with participants as random intercept effect and the valence of mental images as random slope varying across risky activities. In this model, we

TABLE 4 Overall frequencies of decision inputs declared in Study 3.

Decision input	Frequency of Occurrence	Percentage of Occurrence	95% CI	
			LL	UL
Logical arguments	282	39.2%	35.6%	42.8%
Feelings and sensations	236	32.8%	29.4%	36.3%
Visual imagery	115	16.0%	13.4%	18.9%
Memories	80	11.1%	8.9%	13.6%
Other	7	1.0%	0.4%	2.0%

Note: Confidence intervals are based on independent binomial distributions.

FIGURE 3 Proportions of five categories of decision inputs among risky activities in Study 3. Error bars represent 95% confidence interval.

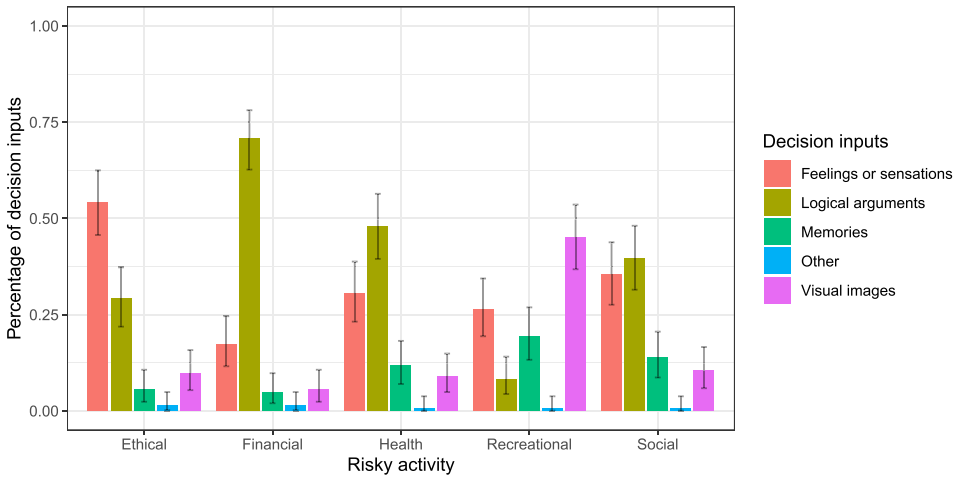

TABLE 5 Percentage of reported mental images as decision inputs across risky activities in Study 3.

Risky activity	Frequency of Occurrence	Percentage of Mental images	95% CI	
			LL	UL
Ethical	14	12.2%	6.8%	19.6%
Financial	8	7.0%	3.1%	13.2%
Health	13	11.3%	6.2%	18.6%
Social	15	13.0%	7.5%	20.6%
Recreational	65	56.5%	47.0%	65.7%

Note: Confidence intervals are based on independent binomial distributions.

TABLE 6 Pearson's correlations between the participants' evaluations of the valence of decision inputs and their willingness to take risky activities.

Decision strategy	Person's *r*	*p* value	95% CI
Logical arguments	$r(280) = .774$	< .001	[.723, .816]
Feelings and sensations	$r(234) = .824$	< .001	[.780, .860]
Visual images	$r(113) = .801$	< .001	[.726, .858]
Memories	$r(78) = .818$	< .001	[.731, .879]
Other	$r(5) = .386$	.450	[−.620, .912]

introduced the interaction between the valence of mental images and reported decision input (i.e., visual images vs. other inputs) as fixed factors. The relationship between the valence of mental images and willingness to take risks was significant, $b = 0.047$, $t(5.713) = 10.177$, $p < .001$, 95% CI [0.036, 0.058], $\delta t = 0.037$ (Figure 4). The effects of decision input and the interaction of this factor with the valence of mental imagery were not significant ($ps > .100$).

4.3 | Summary

In conclusion, we observed that participants used a range of decision inputs, the perceived valence of which was significantly associated with a declared willingness to take risky actions. From our theoretical perspective, mental images served as a spontaneous decision input in 16% of all cases, with the highest prevalence in recreational activity (56%) compared to other activities. This suggests that envisioning the

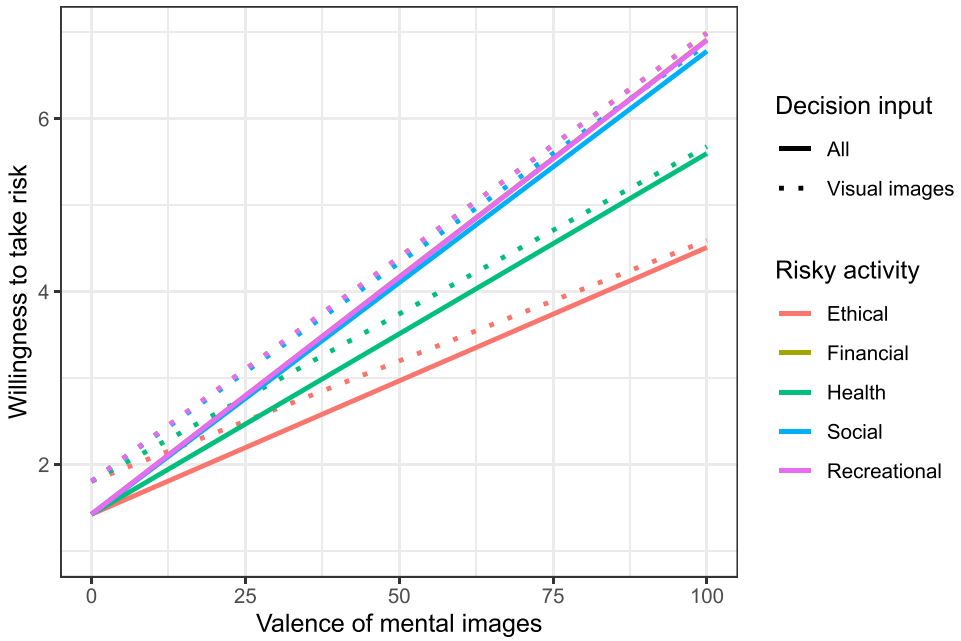

FIGURE 4 Predicted effect of the valence of mental images on willingness to take risk as a function of decision input: visual images (dotted lines) vs. other decision inputs (solid lines) across five risky activities.

future using visual imagery may be considered a "mental tool" in the decision-making process in real-life situations.

To investigate whether the effects found in Study 3 and in two previous studies could have been driven by some basic characteristics of the activities that were presented to participants, we conducted an auxiliary study with an independent sample (the detailed results of the auxiliary study are presented in Supplementary Materials). We asked participants to judge the five risky activities on two scales measuring imaginability and concreteness because these two characteristics can impact the easiness with which people generate mental imagery (Paivio, 1969). Suppose the activities we used in this project differed remarkably in how imaginable and concrete they were in the eyes of the participants. In that case, such differences might explain why mental imagery was more or less frequently indicated as a decision input in Study 3. The results of the auxiliary study showed that (1) the mean ratings of the risky activities on both scales were above the midpoint of the scales (i.e., 4) and (2) the activity in the recreational domain, for which mental imagery was most often indicated as a decision input in Study 3, had the highest rating in imaginability and relatively high rating in concreteness. The former effect suggests that all activities had a fair potential to be visualized. The latter effect indicates that risky activities in some domains (e.g., recreational domain) may have more significant imaginative potential than activities in other domains (e.g., financial domain). Undoubtedly, this result needs further examination.

5 | GENERAL DISCUSSION

The present research provided initial evidence for the role of visual mental imagery in people's willingness to engage in risk taking. First, we showed that when instructed, participants were able to produce mental images of risky actions. The mean valence of mental images generated by participants in Study 1 was negative rather than positive, but this effect was not replicated in Study 2, which suggests that it requires further investigation. Second, we found that the valence of mental images was positively correlated ($r = .29$ to $r = .70$) with the willingness to engage in risky activities. It means that generating more positive mental images was associated with people's higher propensity to take risks. Third, in Study 2, we provided evidence that the valence of visual mental images could be successfully manipulated, and our instructions affected not only the valence of mental images but also the willingness to engage in risky actions. Finally, we found that participants declared using mental imagery as a decision input (i.e., a source of information that helped them make choices) even when they were not instructed to do so. This suggests that participants were able to use mental imagery spontaneously in their choices.

The results from all three studies show that episodic simulations of the future based on activating mental imagery were involved in participants' simulations of their potential engagement in risky activities they were presented with. Previous studies have suggested that mental images are associated with risk perception (Leiserowitz, 2006; Sinclair et al., 2021; Smith & Leiserowitz, 2012; Sobkow et al., 2016; Zaleskiewicz, Traczyk, & Sobkow, 2023). The outcomes of our current research indicate that imaginative visualizations can also correlate with or causally influence the willingness to engage in risky activities. This suggests that mental imagery that is involved in the decision making process not only regulates the way people evaluate threats but also may be linked to people's motivation to either approach risk or avoid it. Indeed, as previous studies have documented, mental imagery can operate as a "motivational amplifier" (Renner et al., 2019), that is, when people generate positive images of reward activities, their motivation to engage in such activities increases (Ji et al., 2021). Our results support such a conclusion and additionally

indicate that when imagery-based episodic simulations are negative in valence, they encourage restraint. In the present instance, mental imagery both amplified and inhibited certain behaviors. Future research might investigate whether the primary role of mental imagery generated in decision making is to strengthen the motivation to engage in risky activities to achieve some benefits or the motivation to restrain from risky actions to avoid potential losses.

One issue that might be discussed further is whether the link between the valence of mental imagery and a propensity for risk taking might be mediated by other factors. Given that mental imagery is closely related to affect (Blackwell, 2020; Holmes & Mathews, 2005; Ji et al., 2016; Nanay, 2023), we would suggest that emotions could be considered as a candidate, particularly because feelings play an essential role in both risk perception and risk taking (Damasio, 2005; Loewenstein et al., 2001; Slovic et al., 2004, 2007). However, bearing in mind that affect might be automatically evoked when people are faced with risk (Damasio, 2005; Slovic et al., 2007), it is also possible that emotions direct the search for imagery in memory (see also Blackwell, 2019; Holmes et al., 2016; Nanay, 2023). In such a case, mental images could either strengthen or disrupt the impact of affect on risk perception or risk taking propensity. Undoubtedly, future research on imagery-based decision making should carefully investigate the nature of reciprocal relationships between mental imagery, emotions, and decision-making.

Another finding in Study 1 was that mental images evoked in response to risky situations were largely negative. This is perhaps not surprising because risky situations, by definition, can have negative repercussions, and negative outcomes are weighted more heavily than positive outcomes (Baumeister et al., 2001; Kahneman & Tversky, 1979). Being alert to potentially harmful events is an evolutionary adaptation. Moreover, previous studies have found a negative valence of mental images spontaneously generated by participants in response to risky situations to be prevalent (e.g., Sobkow et al., 2016; Traczyk et al., 2015). It is possible that one highly adaptive function of decision-related episodic simulations may be designed to protect the decision maker against exceeding the limits of acceptable risk (just as somatic markers do; Damasio, 2005). However, this is a speculative idea based only on the results of our Study 1. Therefore, it requires further investigation.

The results of the present research (Study 2) also point to a possible causal relationship between the valence of mental images and the tendency to engage in risky actions. In particular, participants who were instructed to imagine positive situations in which they engaged in risky behaviors not only declared more positive mental images (which indicated that our manipulation was successful) but were also more willing to accept risk. We would argue that the possibility of inducing the specific valence of mental images that people process further in their decision making might have practical implications. For example, instructing people to imagine the positive consequences of an extremely stressful and uncertain event (e.g., the COVID-19 pandemic) may increase positive feelings (Petrova et al., 2022; Sobkow et al., 2020) and well-being. Relatedly, encouraging people to imagine the negative aspects of a risky action may encourage them to be more risk-averse and more prepared to take protective measures (Zaleskiewicz et al., 2020). Rakow et al. (2015) stressed the proper design of emotional information as one of the main challenges in risk communication. Bearing in mind that mental imagery has strong connections with emotions (Blackwell, 2020; Holmes & Mathews, 2005; Ji et al., 2016), it may be expected that mentally vivid and affect-laden risk communication would be particularly important in the context of threats that are underestimated and difficult to imagine spontaneously (e.g., those relating to climate change; Sundblad et al., 2007).

Studies have shown that future cognitions can appear involuntarily without external cues (Berntsen, 2019) and that people can use mental images spontaneously in planning and decision making (Barsics et al., 2016; D'Argembeau et al., 2011). We would suggest that mental imagery might be driven not only by various external factors (e.g., instructions) but might also emerge spontaneously in the decision-making process. As was noted above, we tested this hypothesis in Study 3 and found that in approximately 16% of cases, participants declared that visual images appeared spontaneously in their minds and that they used them as decision inputs. Moreover, the valence of these visual mental images was highly correlated ($r > .80$) with the willingness to take risky actions. It should be noted, however, that, in this study, participants could classify their descriptions (decision inputs) into only one category ("Logical argument," "Feeling and sensation," "Memory," "Visual imagery," and "Other"). It is, therefore, possible that some participants who chose one of the non-imagery categories had also generated a visual mental image that evoked a specific emotion or was linked to memory. If feeling or memory was more salient, it was reported instead of a mental image. It is also plausible that some experiences in the form of mental images were rapidly recoded in another format (e.g., a logical argument) that was easier to report. Taken together, there are reasons to presume that the actual frequency of mental images used by participants in the form of decision inputs was higher than 16%. Moreover, as already mentioned earlier in this paper, even when people are prompted to use verbal processing, visual mental imagery is also likely to be spontaneously activated (Amit et al., 2017).

We also found substantial differences in how often participants declared that mental images served as an input in their decision making across the risky activities. For example, in recreational activity, the category of mental images was most often referred to as a source of information. By contrast, mental imagery was trumped by other decision inputs in the financial activity (with logical arguments being the most prominent). It should be noted, however, that investigating differences across domains was not the aim of the present study, so we used only one activity per risk domain. Nevertheless, the results were sufficiently interesting to merit further examination. Previous studies have demonstrated substantial differences among risk domains in the degree to which diverse psychological processes are involved in risk perception and risk taking (Hanoch et al., 2006; Weber et al., 2002), and the results from Study 3 bore this out. One of the sources of such heterogeneity may be the use of different decision inputs (e.g., a stronger or weaker tendency to use mental images).

5.1 | Limitations and future research directions

The present study has several limitations. One major methodological challenge faced by researchers studying mental imagery is the accurate identification and reliable measurement of the content processed by participants. In other words, even if participants are instructed to generate mental images, researchers should find ways to document that what is generated can be reliably identified as visualization. In the present study, we asked participants to report their mental images, and independent judges subsequently coded them. We found that the vast majority of participants' entries were coded as visual imagery, suggesting that (even though the experiments were conducted online), participants followed our instructions and did generate mental images. Nevertheless, future studies should employ indirect measures of assessing mental imagery (e.g., neuroimaging techniques) to provide stronger support for the conclusion that mental images of risk appear spontaneously in people's minds.

Another limitation that may be a promising line of future research concerns the fine-grained recording of affective/emotional responses to risk evoked by mental imagery. In the present study, the valence of mental images was rated sequentially for each scenario. Even though such an approach is straightforward (and has been employed successfully in studies on affect and decision making; Asutay et al., 2019; Asutay & Västfjäll, 2022), it misses essential aspects regarding the temporal dynamics of mental imagery. For instance, it is unclear whether participants based their risk preference on a global evaluation of the mental image valence, used the emotional peak of the most vivid mental image, or used the valence of the last image. This problem might be tackled by adopting classic methods of studying subjective emotional experience (Fredrickson & Kahneman, 1993), which would allow for a more detailed investigation of the dynamics of mental image generation and possibly reveal a link between subjectively experienced emotions elicited by mental imagery and risk taking.

The third limitation refers to the design of our Studies 1 and 2. In both studies, we explicitly asked participants to generate mental imagery. In other words, we did not have a non-imagery condition in which some participants would be requested to think about a decision situation differently (e.g., to consider analytical arguments). Alternatively, in a non-imagery condition, participants could be engaged in a mental activity unrelated to the decision-making process, which could block or disrupt visual mental imagery before making a decision. Future studies should use the non-imagery condition to more accurately detect those effects that are specific to visual mental imagery.

The fourth limitation refers to the fact that, in our present research, we asked participants to visualize their engagement in different risky actions. Our prediction was that the valence of such visualizations could be helpful in deciding whether to take a risky action or not. However, in many real-life situations, people are faced with a choice between two distinct alternatives, of which one is safe and another risky. In such cases, decision makers can generate independent mental images illustrating both alternatives and, afterward, make a choice based on comparing the valence and vividness of both images. Future research might use a design in which participants produce not only images of a risky action but images of all alternatives at hand.

Finally, our research has shown that mental imagery plays an important causal role in risky decision making. However, besides the abovementioned limitations and possible heterogeneity among risky activities, we argue that some dispositional characteristics may moderate these effects. In particular, people may differ in how often they spontaneously use mental imagery in real life (e.g., Zaleskiewicz, Sobkow, & Traczyk, 2023) and how vivid their mental images are (Campos & Perez-Fabello, 2009). For example, in the extreme case of people with aphantasia (Keogh & Pearson, 2018) who do not generate visual mental images, it could be hypothesized that they base their risky decisions on logical inputs and calculations more often than people from the general population. Future research should investigate this issue and include individual differences measures as potential moderators.

DATA AVAILABILITY STATEMENT

Data available on request from the authors.

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SUPPORTING INFORMATION

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Mental imagery shapes emotions in people's decisions related to risk taking

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ABSTRACT

This research investigates the specific effects of mental imagery on people's emotional responses and risk-taking decisions. We present findings across four studies, including three experiments, that highlight emotions as a mediator between the valence of mental images related to risk and subsequent risk-taking propensity. Our research identifies two key factors that moderate this relationship: the category of cognitive process (analytical thinking vs. visual mental imagery) and the vividness of mental imagery. In Study 1, we found an effect of the valence of mental images on the intensity of emotional reactions, which in turn were linked to risk-taking willingness. Positive imagery corresponded with stronger positive emotions and increased declared risk taking. The experimental Study 2 provided causal evidence for these associations, showing that participants positively imagining risk-related behaviors reported more intense positive feelings and a greater inclination to take risks than those imagining risk taking in a negative manner. Subsequent preregistered experiments (Studies 3 and 4) corroborated our central hypothesis that mental imagery is a distinct driver of emotional responses in risk-related decision making and showed potential boundary conditions for this effect. Study 3 emphasized that decisions influenced by mental imagery had greater emotional strength than those based on analytical reasoning. The final Study 4 demonstrated that vividness of mental imagery further moderates this effect: more vivid images led to stronger emotions, thus affecting risk-taking propensity. These results underscore the significance of emotions in decision making, particularly when decisions are based on mental imagery rather than analysis, and point to the amplifying effect of image vividness on emotional and decision-making processes.

1. Introduction

Leading a fulfilling and secure life requires consistent thinking about the future. The engagement in episodic foresight is a routine mental activity (Barsics et al., 2016; D'Argembeau et al., 2011; Seligman et al., 2013; Szpunar et al., 2014), which serves multiple purposes, such as making plans, setting objectives, and evaluating potential risks, rewards, or anticipated emotions (Barsics et al., 2016; Blackwell, 2020a; D'Argembeau et al., 2011). Prospection is also an integral part of decision making under uncertainty, given that the long-term outcomes, both tangible and emotional, of real-life choices are not immediately evident (Beach, 1993; Johnson et al., 2023; Nanay, 2016; Zaleskiewicz et al., 2023). An illustrative example could be the decision related to career change. In such a situation, one must weigh potential future benefits and threats (e.g., an increase in salary but also a highly uncertain future of the new company) as well as expected emotional consequences (e.g., expected pride or regret), all of which are inherently ambiguous. The primary objective of our current research was to explore the dynamics of decisions related to risk taking within the framework of episodic foresight and mental imagery, with a particular emphasis on the mediating role of emotions. Specifically, using mainly an experimental approach, we examined the relationship between visually imagining personal engagement in real-life risky activities and the propensity to undertake such risks.

While numerous decision-making researchers have underscored the importance of future thinking and affective forecasting (Kappes & Morewedge, 2016; Lerner et al., 2015; Loewenstein et al., 2001; Loewenstein & Lerner, 2003; Weber & Lindemann, 2007), prevailing models of choice emphasize verbal reasoning concerning utility assessment and probability evaluation (Schoemaker, 1982; Tversky & Kahneman, 1992) or the influence of narrative self-talk (Beach, 1993, 2009; Johnson et al., 2023). Nevertheless, thinking about the future can manifest through various mental processes with different phenomenological dimensions (Szpunar, 2010). According to Paivio's (1971, 1991, 2014) dual coding theory, information processing involves two cognitive subsystems: one dedicated to verbal and the other to non-verbal

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components (Baddeley, 1993; Kraemer et al., 2009; Wyer et al., 2008). The non-verbal system involves mental images, sensory experiences, and other non-linguistic elements. It encodes and stores information in a visual or sensory format, allowing individuals to create images associated with concepts or experiences. In the present project, we show how representing decision situations in the form of visual mental images may regulate the risk-taking propensity and also document that vivid mental imagery can be considered as an underlying source of emotions that are involved in the decision-making process.

On the theoretical level, we propose that mental imagery makes a dual contribution to decision making in situations involving risk or uncertainty. Firstly, mental imagery supports forecasting the future. As a growing amount of evidence suggests, people can rapidly simulate potential events associated with the choice dilemma through episodic foresight and then use those simulations as inputs for decision making (Smieja et al., 2023; Suddendorf et al., 2022; Townsend & Kahn, 2014; Zaleskiewicz et al., 2023). Secondly, mental images evoke affective reactions. Visual mental imagery has the capacity to evoke emotions, closely resembling feelings and bodily sensations experienced in response to real experience (Blackwell, 2020; Cocquyt & Palombo, 2023; Heise et al., 2022; Holmes & Mathews, 2010; Marks, 1999). The present project focuses mainly on investigating the second assumption. In a series of four studies, including three experiments, we show that (1) mental imagery's valence (i.e., its positiveness or negativeness) predicts or impacts the willingness to take risky actions, (2) the positive and negative emotions experienced while envisioning risk-related activities mediate the relationship between the valence of mental imagery and risk-taking proneness, (3) this mediation effect is more pronounced in the case of visual mental simulations compared to verbal reasoning, and (4) the vividness of mental imagery moderates the link between mental imagery's valence and emotions.

1.1. Mental imagery and decision making

In recent decades, research on mental imagery has shifted from examining its phenomenology to understanding its functions in human cognition, psychological disorders, and guiding individuals through everyday activities (Cumming & Williams, 2012; Holmes et al., 2016; Logie & Denis, 1991; Taylor & Pham, 1996). Some authors have proposed that mental imagery can also serve as a valuable and adaptive tool in decision making. Namely, mental simulations allow individuals to "pre-experience" or "preview" plausible courses of action and recognize threats and benefits tied to them, thereby aiding people in making choices that align with their values and promote safety (Beach, 1993; Blackwell, 2020; Nanay, 2016; Zaleskiewicz et al., 2023). As Blackwell (2020) suggested, "This 'preview' can then inform our decision-making and also contribute to our motivation to work toward ensuring the event occurs" (p. 243). Recent evidence indeed suggests that individuals report spontaneously using visual mental imagery as one of the decision-making modes (Smieja et al., 2023). Interestingly, this tendency appears to be domain-specific. In one study, participants more frequently relied on mental imagery for decisions in recreational contexts, while using it less often for financial decisions (Zaleskiewicz et al., 2024).

In the face of risk and uncertainty, mental imagery emerges as a valuable asset, allowing individuals to skillfully bridge informational gaps by mentally filling in the missing pieces (Nanay, 2016). Narrative theories of decision making that highlight the role of verbal processing also posit that it is insufficient to explain real-life decisions due to the substantial absence of clues (Johnson et al., 2023). In line with the narrative approach, decision makers initially weave intricate stories incorporating their distinct goals, beliefs, emotions, experiences, and the overarching environmental context. Subsequently, they employ mental imagery to visualize potential futures, drawing from the information intricately woven into their narratives (Beach, 1993, 2009; Johnson et al., 2023). The informative power of imagery in decision making may stem from its richer sensory component compared to verbal (e.g., analytical) associations (Paivio, 1991). While the verbal system is sequentially constrained, the visual system operates synchronously, allowing multiple informational components to be processed simultaneously (Paivio, 1986). As Paivio noted in one of his papers, "A visual scene, for example, is perceptually available all at once" (Paivio, 1991, p. 268). The structure of mental images reflects the intricacy of the objects they depict. Images retain detail and are built up piece by piece, similar to how real scenes are formed in our perception (Finke, 1989). Thus, vivid mental images can serve as a source of information in decision making, similar to feelings, as suggested by the feelings-as-information theory (Schwarz, 2012). For instance, 'visual thinking' (Grandin, 2022) can help decision makers identify threats that might be overlooked with purely analytical reasoning. Visual imagery, as an information provider, processes data through pictures and patterns, simulating real-world scenarios. The information obtained through visualization is often more concrete than abstract probability assessments, enabling individuals to perceive more details in a given situation. This underscores the adaptive value of the nonverbal visual system in decision making under risk or uncertainty (Paivio, 2007).

It seems, however, that the role of mental imagery in decision making under risk could also be discussed from a more traditional theoretical perspective, which posits that individuals engage in cognitive operations to assess values and probabilities (see also Zaleskiewicz et al., 2023). First, the generation of visual mental images may influence how individuals process and evaluate probabilities. Consistent with the availability heuristic (Tversky & Kahneman, 1973) and the simulation heuristic (Kahneman & Tversky, 1982), vivid mental images that easily come to mind can bias probabilistic judgments, potentially leading to inflated subjective likelihoods. For example, vivid and highly negative visualizations of investing in the stock market (e.g., a mental image of an individual anxiously watching charts of falling stock prices) may amplify the perceived probability of loss, while diminishing the perceived likelihood of gain. Conversely, when it is difficult for a decision maker to generate a mental image of a particular option, they may improperly underestimate its probability. This latter example would be analogous to the phenomenon observed in decisions made from experience, where individuals tend to underrate the likelihood of rare events, as compared to decisions made from description (Hertwig et al., 2004). Second, engaging in mental imagery during the decision-making process can also influence how different outcomes are valued. Given the strong connection between mental imagery and emotions, when decision makers can more easily imagine and visualize certain outcomes, they may be more inclined to rely on affect-based valuation rather than rational analysis (Hsee & Rottenstreich, 2004). A potential consequence of this process might be reduced sensitivity to scope when evaluating outcomes that can be vividly imagined.

Previous studies have lent preliminary support to some of the arguments advanced thus far in this paper. For example, Smieja et al. (2023) found that the valence of risk-related mental imagery significantly predicted individuals' declared willingness to take risky actions across various decision domains (ethical, financial, health, social, and recreational). Moreover, manipulating the valence of such imagery was found to causally influence participants' inclination to take risk. In a similar vein, Zaleskiewicz et al. (2020) observed that entrepreneurs' proclivity for business risk taking was linked to their higher tendency to generate positive mental imagery, compared to non-entrepreneurs. Significantly, when assessing risk-related information, differences emerge between verbal and visual processing styles. For example, Chan and Saqib (2021) demonstrated in their research that individuals who visually simulated the consequences of risk perceived more harm in these situations compared to those who evaluated them verbally.

1.2. Mental imagery as a source of emotions in decision making

In the past decades, researchers have increasingly recognized the influence of affect on people's decisions, mainly investigating integral

emotions that are directly related to the consequences of choice and have a significant influence on the decision-making process (Bechara & Damasio, 2005; Lerner et al., 2015; Loewenstein et al., 2001; Loewenstein & Lerner, 2003; Slovic et al., 2007; Vastfjall & Slovic, 2013; Zaleskiewicz & Traczyk, 2020; Zeelenberg et al., 2008). While the origins of integral emotions in decision making are multifaceted, certain theoretical models suggest that mental imagery can be recognized as one of these contributing sources (Loewenstein et al., 2001; Loewenstein & Lerner, 2003). Indeed, the distinctive ability of mental imagery to evoke emotions appears to substantiate this proposition (Holmes et al., 2006; Holmes & Mathews, 2005; Holmes, Mathews, et al., 2008). As suggested by Holmes and Mathews (2010), mental imagery becomes more predisposed to trigger emotional responses than verbal thought because the former relies mostly on sensory inputs. These authors also postulated that there is an overlap in neural systems involved in mental imagery and perception, allowing the mental simulation of scenarios to evoke emotions akin to those in real-life events. Finally, they proposed that mental images possess the ability "to make contact with memories for emotional episodes in the past and reactivate related feeling states" (Holmes & Mathews, 2010, p. 352). In a similar vein, Cocquyt and Palombo (2023) posited that through mental imagery, we can experience both anticipatory and anticipated emotions. Expanding on these premises, in our present work, we suggest that envisioning potential paths of risky action empowers decision makers not only to evaluate outcome desirability but also to undergo their emotional reactions. Producing positive mental images is likely to elicit positive emotions, whereas generating negative mental imagery could result in more negative emotional reactions. These emotions are anticipated to have a connection with the final decision. In more technical terms, we expect that emotions will mediate the link between the valence of risk-related mental imagery and the willingness to take risks.

Existing evidence appears to establish a robust theoretical foundation for formulating such predictions. For example, Traczyk et al. (2015) documented that the relationship between the valence of mental imagery and participants' inclination towards risk taking was mediated by both feelings and physiological stress responses. Aligning with these outcomes, Sobkow et al. (2016) demonstrated that negative affect and stress arising from adverse risk-related mental imagery significantly heightened individuals' perceptions of risk. Lastly, Dickert et al. (2016) demonstrated that the willingness to donate money to identified victims (in contrast to unidentified ones) was linked to an increased ability to generate coherent mental images of those in need, accompanied by victim-focused feelings of sympathy. In a recent attempt to discern a causal relationship between mental imagery, affect, and the perception of risk related to climate change, Karlsson et al. (2023) manipulated the level of mental imagery related to climate change (enhanced, spontaneous, and prevented). As the authors expected, participants in the enhanced mental imagery condition exhibited a more pronounced decrease in positive affect and a significant increase in climate risk perception after contemplating risky ecological events in contrast to those in the spontaneous and prevented imagery conditions. These findings emphasize the compelling role of mental imagery in generating emotions related to risk, particularly when individuals are explicitly directed to envision environmental threats.

In our theoretical framework, we not only posit the involvement of emotions in connecting mental imagery and decision making but also suggest that the role of affective processing depends on the vividness with which individuals can generate their visual mental images. According to Marks (1972), vividness is defined as a "combination of clarity and liveliness. The more vivid an image, therefore, the closer it approximates an actual percept" (p. 83). The variability in vividness can be ascribed to individual differences (Marks, 1972) or viewed as an inherent trait of specific mental imagery within a given context (Pearson et al., 2011). Regardless of its origins, the increased vividness of mental imagery is associated with intensified emotional responses, encompassing both positive and negative affect (Cocquyt & Palombo, 2023). This association has been documented in clinical investigations exploring mental imagery in patients with post-traumatic stress disorder (Rauch et al., 2004). In the present work, we propose that the vividness of mental imagery may serve as a factor that moderates the connection between the valence of mental imagery and emotions that, in turn, have an effect on risk-taking willingness. In other words, we propose that vividness indirectly regulates the strength with which affect regulates the decision-making process.

1.3. Overview of present studies and the hypotheses

In a series of four studies—one correlational study and three experiments (total $N = 3261$)—we aimed to investigate the interplay between mental imagery and emotions in guiding the declared willingness to take real-life risky actions. Based on the results of previous studies and our theoretical model, we hypothesized for all four studies that the valence of risk-related mental imagery will be positively connected with participants' willingness to take risky actions. In Study 1, we expected a correlational effect, whereas in the remaining three studies, we predicted a causal effect of mental imagery valence on emotional intensity and declared risk taking. Other hypotheses pertained to the specific effects of emotions, the role of the processing modality (verbal vs. visual), and the vividness of mental imagery. In Study 1, we hypothesized that the relationship between the valence of risk-related mental imagery and risk-taking willingness will be mediated by positive and negative emotions experienced while generating mental imagery. In experimental Study 2, we manipulated the valence of risk-related mental imagery (positive vs. negative mental images) and again hypothesized that the link between the valence of mental images and participants' willingness to take risks will be mediated by emotions. Unlike Study 1, this study tested the causal effect of mental imagery on risk propensity. The aim of experimental Study 3 (preregistered) was to show that mental imagery representing visual processing has a greater capacity to evoke emotions than logical arguments[1] that represent verbal processing. This study manipulated not only valence of risk-related associations, as Study 2, but also processing type (mental imagery vs. analytical thinking). We hypothesized that the mediating effect of emotions will be stronger when participants were asked to generate risk-related visual mental imagery than when their task was to produce rational/analytical arguments in favor or against risk taking. In other words, we predicted that the type of risk-related associations generated by participants (mental images vs. rational arguments) will moderate the link between the valence of the risk-related association and the strength of positive and negative emotions. Finally, in experimental Study 4 (preregistered), our aim was to demonstrate that the relationship between the valence of risk-related mental imagery and emotions will be moderated by the imagery vividness. Here, our specific hypothesis was that the relationship between the valence of mental imagery and emotions would strengthen in tandem with the vividness of visual images generated by participants.

1.4. Analytical strategy

In the correlational Study 1 and experimental Studies 2–4, we tested a general model of parallel mediation, in which positive emotions (M1) and negative emotions (M2) mediated in parallel the relationship between the valence of mental imagery (X) and participants' willingness to engage in risky actions (Y). In Study 1, the valence of imagery was

[1] In our OSF preregistration we use the term 'logical arguments' as a description of this experimental condition. Nevertheless, in this paper, we employ it interchangeably with other closely related expressions, such as 'analytical arguments' and 'logical reasoning.' These terms collectively refer to a cognitive process in which individuals verbally assess potential gains and losses associated with risk, in contrast to the mental visualization of situations involving risk.

measured with a scale, while in the remaining experimental studies it was manipulated in the between-participants design. In Study 3, we additionally included a moderator (the type of risk-related associations: mental imagery vs. logical arguments) that we manipulated on the between-participants level. In Study 4, we included another moderator (vividness of mental imagery) that was measured as a variable existing on both levels.

As our data were nested within participants and risk domains, we applied the multilevel structural equation modeling (MSEM) with Bayesian estimation (mediation on both levels in Study 1 and 2–1-1 mediation model in all remaining studies, see McNeish, 2017; Preacher et al., 2010) and calculated our models using Mplus 8.8. In all studies conducted within this project, we considered the two mediators correlated on both levels. In Studies 1–3, we included random intercepts for both participants and risk domains. In Study 4, we used a multilevel version of latent moderated structural (LMS) equations to create latent product terms (Klein & Moosbrugger, 2000) and investigated cross-level interaction between vividness and valence manipulations on level 1 and level 2 interaction between these variables. As the LMS procedure is not supported in cross-classified models in Mplus, in Study 4, we included random intercepts for participants only.

Importantly, regression-based techniques, including MSEM, offer great flexibility and power in accounting for variance in both experimental and correlational research (Cohen, 1968). Moreover, MSEM outperforms traditional multilevel regression modeling (MLM) in terms of bias and confidence interval coverage, providing more accurate mediation analysis in clustered data (Preacher et al., 2010). However, in response to a reviewer's request, we also conducted complementary analyses for Studies 2–4, using mixed-subject ANOVA, to enhance the transparency and clarity of our findings. Across these analyses, we treated domains as a within-subject factor and the experimental condition (valence manipulation) as a between-subject factor. In Study 3, we incorporated the type of risk-related associations (mental imagery vs. logical arguments) as a between-subject factor. For Study 4, vividness of mental imagery was included as a within-level moderator. The outcomes of these analyses were consistent with those obtained using MSEM (see Supplementary Materials for detailed results of these complementary analyses). These complementary analyses do not capture mediation effects but illustrate, in simplified terms, how the dependent variables (emotions and willingness to take risks) vary across levels of the independent variable (e.g., the manipulated valence of mental imagery).

In our experimental studies 2, 3, and 4, employing multilevel structural equation modeling allows for causal interpretations between the independent and dependent variables, as well as between the independent variable and the mediator. However, it does not enable testing causal relationships between the mediator and the dependent variable. Nevertheless, this limitation did not impact our project, since our hypotheses did not suggest a causal link between emotions and willingness to take risks. Our research specifically focused on the mediating role of integral emotions—those that arise directly from processing risky situations either positively or negatively—rather than incidental emotions, which are unrelated to the mental processing of risk and can be manipulated independently.

2. Study 1

The main aim of this study was to investigate the mediating role of emotions in the link between mental imagery and risk-taking willingness. The additional purpose was to replicate earlier findings (Smieja et al., 2023) indicating that the valence of risk-related mental imagery predicts declared risk taking. In the present research, we proposed that the generation of positive imagery associated with risk leads to heightened positive emotions and decreased negative emotions, thereby increasing an individual's propensity to engage in risky activities. Conversely, the prevalence of negative imagery was expected to correlate with increased negative emotions and reduced positive emotions, diminishing the inclination towards risk taking. Empirical validation of these relationships would underscore the significance of risk-related mental imagery as an emotional driver in the decision-making process, highlighting how envisioned personal risk behaviors emotionally steer choices involving risk.

2.1. Method

2.1.1. Participants

The sample size for this study was calculated using a simulation method performed with Monte Carlo Power Analysis for Indirect Effect (Schoemann et al., 2017) based on 1000 replicates. Based on our previous results, we assumed that we would observe a large effect size ($r = 0.50$) for the total effect of the predictor on the outcome variable. Because we did not have specific predictions for the indirect effect sizes, we conservatively assumed that the correlations between our predictor and the mediators, as well as the correlations between the mediators and the dependent variable, were weak ($r = 0.20$) and that the two mediators were moderately intercorrelated ($r = -0.30$). The results of an a priori analysis calculated for the model with two parallel mediators (i.e., positive and negative emotions) indicated that with an alpha of 0.05 and a power of 0.90, a sample size of $N = 350$ participants would be sufficient for such effects. Recognizing that some participants' responses might be excluded based on the results of a qualitative analysis conducted by independent judges, we recruited 450 U.S. participants from Prolific Academic to participate in an online study for remuneration of £1.07 (244 women, 206 men, no others, $M_{age} = 39.87$, $SD = 13.01$). We then excluded data based on two premises. First, we excluded responses from 25 participants who completed the study on devices with small screens (i.e., mobile phones).[2] Second, we excluded responses from 10 participants who did not provide descriptions of visual mental imagery throughout the study, as confirmed by three independent judges in the qualitative analysis. The final sample consisted of 415 participants (226 women, 189 men, no others, $M_{age} = 40.3$, $SD = 13.1$). The study was approved by the University Ethical Committee (approval # 08/P/05/2020).

2.1.2. Procedure

After participants gave their consent, they completed five blocks representing risky actions from different domains, displayed in random order. Each block began with a brief description of a risky activity (e.g., "Not returning a wallet you found that contains $200" for the ethical domain or "Going camping in the wilderness" for the recreational domain; see Supplementary Materials for the full list of activities that were adapted for the present research from the DOSPERT method; Blais & Weber, 2006; Weber et al., 2002). After reading a description, participants were asked to vividly imagine (visualize) that they were involved in the action in the form of mental pictures/movie clips as if they saw the scene in their "mind's eye." Next, they were required to provide brief descriptions (i.e., entries) of up to three mental images they generated and to rate the valence of these images using a 100-point slider ranging from 0 % – "very negative" to 100 % – "very positive." Afterward, participants rated the extent to which they experienced positive (good, pleasant) and negative (bad, unpleasant) integral emotions while processing mental images, using a 7-point scale ranging from 1 – "not at all" to 7 – "very much." They also assessed their willingness to take risky actions on a scale ranging from 1 – "definitely no" to 7 – "definitely yes" (see Supplementary Materials for exact wording of instructions and questions). The questions about integral emotions and willingness to take risks were displayed in counterbalanced order.

[2] In the Prolific instructions, we required participants to complete the study only with the use of computers or tablets (not mobile phones). This requirement was present in all studies conducted in this project.

2.2. Results

2.2.1. Qualitative analysis of the entries provided by participants

Before testing the hypotheses, we conducted a qualitative content analysis of the descriptions provided by participants. We had two goals in conducting this analysis: (1) to determine whether participants followed the instructions and indeed produced visual mental images related to risk taking, and (2) to exclude from the main quantitative analysis the data of those participants whose contributions did not describe visual imagery (as decided by independent judges).

The analysis was performed using the MAXQDA software (Kuckartz & Radiker, 2020). In the first step, two independent judges fluent in English read the 6723 participants' entries collected in the study and assigned each of them separately to one of the two deductive codes—either "visual imagery" or "non-imagery" (see Supplementary Materials for the exact wording of the codes' definitions). Next, the third judge resolved inconsistencies in the assignment of entries in the first step of the analysis by making a final and independent decision. To ensure high accuracy and integrity of the analysis, each judge participated in online theoretical and practical training before starting the task.

Based on the judges' agreement, we excluded 2302 data units (i.e., mental imagery valence ratings, integral emotion ratings, and risk-taking ratings) that referred to entries assigned to the code "non-imagery." Specifically, for some participants, we removed only certain entries and data units that referred to "non-imagery" items and left the entries and data units assigned to the code "visual imagery." Ten participants failed to provide descriptions of mental imagery on any occasion. Consequently, their data were entirely excluded from subsequent analyses. The three independent judges agreed that the remaining 4422 data entries described instances of visual mental imagery. Among the entries assigned to the "visual imagery" code, participants provided descriptions such as "I wake up in the morning and make my way to the cabin's restrooms, which are down the hill from the cabin. I feel sleepy and cold in the crisp morning air, but it is a little refreshing," "We can keep each other company and communicate easily during breaks at work. Work is much more bearable knowing what we are both going through in real time," or "I read about different types of investments (futures, options, etc.)" (see Supplementary Materials for more examples of "visual imagery" and "non-imagery" entries).

2.2.2. Descriptive statistics

Descriptive statistics for all variables used in the analysis, along with correlation coefficients, are shown in Table 1. In Supplementary Materials, we additionally present descriptive statistics and plot figures for all variables per all risk domains. The examination of the 95 % confidence intervals for the mean valence of mental images produced by participants revealed that it was significantly greater than 50, i.e., the middle of the scale. This suggests that when confronted with risky actions, participants were more likely to generate positive rather than negative images. Further examination of the 95 % confidence intervals for the variables' mean ratings indicated that the mean willingness to engage in risky actions was slightly lower than the scale's midpoint (i.e., 4). Participants reported experiencing positive emotions with greater intensity as compared to negative emotions, with average positive emotion ratings slightly above the midpoint of the scale (i.e., 4) and average negative emotion ratings slightly below this value. Taken together, such results suggest that, on average, participants perceived risky activities presented to them in a relatively positive manner, but their mean readiness to take risks was almost neutral.

The correlation analysis showed that the declared willingness to take risks and the ratings of emotions were correlated with the valence of risk-related mental imagery. Positive (negative) mental imagery was associated with positive (negative) feelings and a higher (lower) propensity to engage in risky actions.

2.2.3. Mediation analysis

To test our main hypothesis that the intensity of emotions mediates the link between mental imagery and declared risk taking, we tested our hypothesized model both on the within-participants level and between-participants level (see Fig. 1).

On the within-participants level (level 1 in Fig. 1), we found a significant total effect of the valence of mental imagery on the declared readiness to take risks ($b = 2.60$, post SD = 0.08, $p < .001$, 95 % CI [2.44, 2.76]). Further, the valence of mental imagery was positively associated with the intensity of positive emotions ($b = 3.07$, post SD = 0.07, $p < .001$, 95 % CI [2.93, 3.21]) and negatively associated with the intensity of negative emotions ($b = -2.67$, post SD = 0.08, $p < .001$, 95 % CI [−2.82, −2.52]). The two dimensions of emotions were significantly and negatively interrelated, $cov_w = -1.627$, post SD = 0.04, $p < .001$, 95 % CI [−1.34, −1.20]. Moreover, they were both linked to the willingness to take risks, respectively $b = 0.50$, post SD = 0.02, $p < .001$, 95 % CI [0.46, 0.54] for positive emotions and $b = -0.15$, post SD = 0.02, $p < .001$, 95 % CI [−0.19, −0.11] for negative emotions. After controlling for the two mediators, the direct effect of the valence of mental imagery on the willingness to take risks remained significant, $b = 0.67$, post SD = 0.09, $p < .001$, 95 % CI [0.50, 0.84].

The total indirect effect via two mediators was significant: ab = 1.93, post SD = 0.08, $p < .001$, 95 % CI [1.80, 2.06]. Further analysis of relative indirect effects revealed that the 95 % credibility interval for the effect through positive emotions did not include zero, ab1 = 1.54, post SD = 0.07, $p < .001$, 95 % CI [1.39, 1.68], same as for the effect through negative emotions, ab2 = 0.39, post SD = 0.05, $p < .001$, 95 % CI [0.29, 0.50]. This indicates that on the within-participants level, both relative indirect effects were significant, with the effect via positive emotions being stronger than the one via negative emotions.

On the between-participants level (level 2 in Fig. 1), we also found a significant total effect of the valence of mental imagery on the declared willingness to take risks ($b = 4.58$, post SD = 0.55, $p < .001$, 95 % CI [3.51, 5.67]). The valence of mental imagery was positively associated with the intensity of positive emotions ($b = 6.49$, post SD = 0.43, $p < .001$, 95 % CI [5.67, 7.39]) and negatively associated with the intensity of negative emotions ($b = -6.40$, post SD = 0.53, $p < .001$, 95 % CI [−7.48, −5.40]). The two dimensions of emotions were not related to each other, $cov_b = 0.001$, post SD = 0.03, $p = .964$, 95 % CI [−0.06, 0.06]. Moreover, the strength of positive emotions was associated with the willingness to take risks, $b = 0.44$, post SD = 0.14, $p = .004$, 95 % CI [0.15, 0.72], while the strength of negative emotions was not, $b = -0.11$, post SD = 0.09, $p = .230$, 95 % CI [−0.27, 0.07]. After controlling for the two mediators, the direct effect of the valence of mental imagery on the willingness to take risks was not significant, $b = 1.02$,

Table 1
Descriptive statistics and correlations for variables in Study 1.

Variable	*M*	*SD*	95 % CI for *M*	Skewness	Kurtosis	Correlations			
						(1)	(2)	(3)	(4)
(1) Valence of mental imagery	57.51	34.22	[56.33, 58.53]	−0.37	−1.22	–			
(2) Positive emotions	4.36	2.10	[4.29, 4.42]	−0.32	−1.24	0.66	–		
(3) Negative emotions	3.47	2.15	[3.43, 3.54]	0.34	−1.31	−0.57	−0.77	–	
(4) Willingness to take risk	3.94	2.33	[3.87, 3.99]	0.01	−1.55	0.55	0.71	−0.63	–

Note: all correlation coefficients were significant at level $p < .001$.

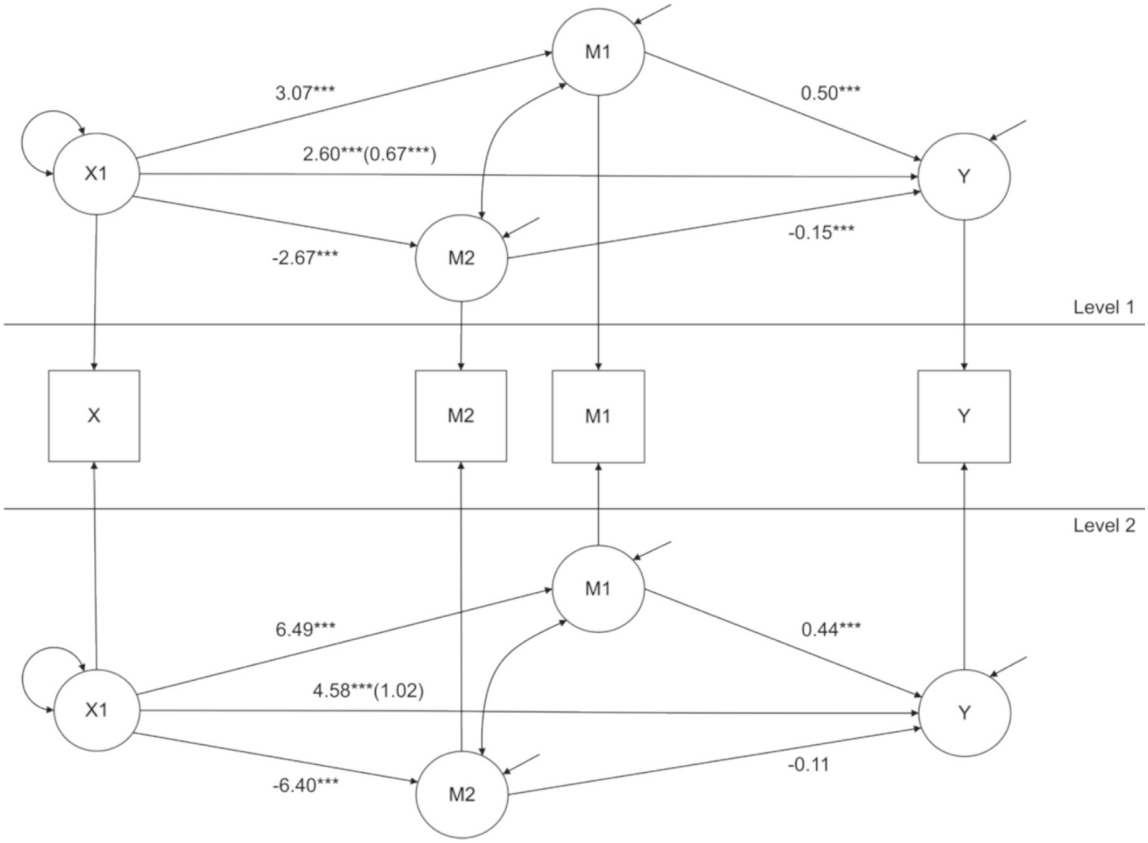

Fig. 1. Positive emotions (M1) and negative emotions (M2) as mediators of the relationship between the valence of mental imagery (X) and the willingness to take risks (Y) both on the within-participants level (level 1) and between-participants level (level 2).

post SD = 1.54, $p = .494$, 95 % CI [−1.94, 4.13].

The total indirect effect via two mediators was significant: ab = 3.52, post SD = 1.32, $p < .001$, 95 % CI [0.98, 6.19]. Further analysis of relative indirect effects showed that the 95 % credibility interval for the effect through positive emotions did not include zero, suggesting that this effect was significant: ab1 = 2.86, post SD = 0.97, $p = .004$, 95 % CI [1.00, 4.85]. However, the credibility interval for the indirect effect via negative emotions included zero and was insignificant: ab2 = 0.67, post SD = 0.57, $p = .230$, 95 % CI [−0.46, 1.79]. This indicates that on the between-participants level only the relative indirect effect via positive emotions was significant.

Recognizing that participants' written descriptions ('entries') may have varied due to individual differences in writing ability, we acknowledged the possibility that some participants engaged in visual mental imagery even if the descriptions they provided did not explicitly reflect this. To account for this, we conducted an additional analysis including all responses collected in Study 1 (see Supplementary Materials for a summary of the results). This analysis indicated that the overall pattern of findings remained unchanged.

Overall, our findings align with the hypothesis, indicating a relation between positive mental imagery generated by participants and their increased inclination to engage in risk-taking activities. Furthermore, we identified a mediating role of integral emotions; specifically, a rise in positive mental imagery was associated with heightened positive emotional responses and diminished negative emotional experiences. This emotional modulation, in turn, appeared to facilitate a greater willingness to engage in risky activities. The opposite effects were observed for a rise in negative mental imagery.

3. Study 2

Study 1 offered initial insights into the mediating role of positive and negative emotions in connecting the valence of mental imagery with the declared inclination for risk taking. However, certain limitations warrant consideration. Firstly, the use of correlational design in Study 1 restricts our ability to establish a causal relationship between the valence of mental imagery and declared risk taking. To address this, Study 2 employs an experimental design, manipulating the valence of risk-related mental imagery (positive, negative, unspecified). Secondly, the task of generating three risk-related mental images and evaluating their overall emotional impact may have posed challenges for participants. Notably, most participants in Study 1 provided only one or two descriptions of mental imagery. In response, in Study 2, we refined the procedure by instructing participants to generate and describe only the first mental image that came to mind in relation to risky activity. Furthermore, we decided not to analyze participants' mental imagery descriptions. This decision was based on findings from Study 1, which showed that the majority of participants adhered to instructions and actively engaged in visual simulations of risky activities.[3]

In Study 2, we again aimed to replicate the findings from prior research (Smieja et al., 2023), affirming the causal link between the valence of mental imagery and the inclination towards risk taking. Specifically, we anticipated that instructing participants to envision positive or negative circumstances related to risk taking would respectively increase or decrease their declared willingness to engage in risky actions compared to the control condition. Furthermore, we hypothesized that the connection between the valence of mental imagery and declared risk taking would be mediated by the positive and negative emotions participants experience during the mental imagery processing.

[3] For the same reason, we did not exclude any observations based on the qualitative analysis of imagery descriptions in Study 3. In Study 4, these descriptions were not collected.

We anticipated observing a positive indirect effect for positive emotions and a negative indirect effect for negative emotions. This experimental verification of the causal relationship, alongside the mediation through emotions, would highlight the unique role of visualization in the decision-making process.

3.1. Method

3.1.1. Participants

The sample size for this study was again calculated using a simulation method performed with Monte Carlo Power Analysis for Indirect Effect (Schoemann et al., 2017) based on 1000 replicates. However, this time, we relied on the effect sizes observed in Study 1. The results of an a priori analysis calculated for the model with two parallel mediators (i.e., positive and negative emotions) indicated that with an alpha of 0.05 and a power of 0.95, a sample size of $N = 330$ participants would be sufficient to detect the weaker of the two effects. Therefore, we recruited 330 US participants from Prolific to participate in an online study for £1.35 (165 women, 165 men, no others, $M_{age} = 39.08$, $SD = 14.06$). We removed data from 10 participants who completed the study via mobile phones. The final sample consisted of 320 participants (160 women, 160 men, no others, $M_{age} = 39.4$, $SD = 14.2$). The study was conducted in accordance with ethical guidelines enforced by the University Ethical Committee (approval # 08/P/05/2020).

3.1.2. Procedure

The procedure mirrored the one used in Study 1, with two differences: (1) participants were randomly assigned to one of the three experimental conditions—positive imagery, negative imagery, and control condition (the valence of mental imagery not specified), and (2) participants were asked to generate and process one mental image per risk domain. Hence, after providing informed consent, participants were presented with five brief descriptions of risky actions referring to real-life situations, the same as in Study 1. After reading each description, participants' task was to visually imagine that they were engaged in the described action, seeing the scene through their "mind's eye". In the positive imagery condition ($n = 101$), participants were asked to imagine only positive circumstances of their risky behavior, whereas, in the negative imagery condition ($n = 119$), their task was to imagine only negative circumstances. Finally, in the control condition ($n = 110$), we did not specify the valence of mental images but instead asked participants to imagine different circumstances of presented actions (see Supplementary Materials for the exact wording of instructions). Each time, participants provided a short description of their first mental image and rated its valence on a 100-point slider scale ranging from 0 – "very negative" to 100 – "very positive." Next, for each domain, on the two screens presented in counterbalanced order, participants rated the intensity of integral emotions (positive and negative, separately) experienced while processing visual images of their engagement in risk and their willingness to take risky action, using the same scales as in Study 1.

3.2. Results

3.2.1. Descriptive statistics

Table 2 displays the descriptive statistics and correlation coefficients for the variables under examination, and Fig. 2 presents their mean levels across the three experimental conditions. In Supplementary Materials, we additionally present descriptive statistics and plot figures for all variables per conditions and all risk domains. The 95 % confidence intervals for the mean valence of mental images, when compared to the scale midpoint (i.e., 50), revealed a significant inclination towards generating negative risk-related mental imagery. Further exploration of the 95 % confidence intervals for mean ratings showed that participants' willingness to engage in risky actions fell below the mid-point of the scale (i.e., 4). Additionally, participants reported experiencing negative emotions more intensely than positive emotions, with both means for these variables residing below the scale midpoint (i.e., 4). However, the average rating of negative emotions did not significantly differ from 4. Taken together, the findings suggest a trend wherein participants, when faced with risky actions, generated negative rather than positive mental imagery and a reduced willingness to take risks.

Correlation analysis revealed a significant link between the declared risk-taking willingness and the valence of risk-related mental imagery. Positive mental imagery correlated with positive feelings and a greater propensity for risky actions, while negative mental imagery correlated with negative feelings and a reduced inclination for risk taking.

3.2.2. Manipulation check

As our data were nested within participants, we conducted a mixed ANOVA with an experimental condition as a between-participants factor and the risk domain as a within-participants factor. We found a significant effect of experimental manipulation, $F(2, 328) = 391.19$, $p < .001$, $\eta_p^2 = 0.705$, accompanied by a significant effect of risk domain, $F(4, 1312) = 99.21$, $p < .001$, $\eta_p^2 = 0.233$, and a significant interaction between these two factors, $F(8, 1312) = 21.45$, $p < .001$, $\eta_p^2 = 0.116$. Further analysis of post hoc comparisons with Tukey's correction confirmed the effectiveness of our experimental manipulation, with the imagery valence ratings in the positive imagery condition significantly higher ($M = 72.70$, $SE = 1.49$, 95 % CI [69.77, 75.63]) than those in the control condition ($M = 51.15$, $SE = 1.43$, 95 % CI [48.33, 53.97]), $t(328) = 10.43$, $p < .001$), and the ratings in the negative imagery condition ($M = 16.84$, $SE = 1.38$, 95 % CI [14.13, 19.55]) significantly lower than those in the control condition, $t(328) = -17.26$, $p < .001$ (see Fig. 2). Taken together, the results of the presented analyses confirmed that the manipulation of the valence of mental imagery in Study 2 was successful.

3.2.3. Hypothesis testing

We tested our hypothesized model where negative (M1) and positive (M2) emotions parallelly mediated the relationship between the valence of mental imagery (X) and the willingness to take risky actions (Y) (see Fig. 3). Because our manipulation was a multi-categorical variable, we used indicator coding with the control condition as a reference category (Hayes & Preacher, 2014) with one dummy variable representing the positive vs. control condition comparison (X1) and a second dummy variable representing the negative vs. control condition comparison (X2).

On the within-participants level (level 1 in Fig. 3), we found that the two dimensions of emotions were significantly and negatively interrelated, $cov_w = -2.05$, post SD = 0.09, $p < .001$, 95 % CI [−2.23, −1.87].

Table 2
Descriptive statistics and correlations for variables in Study 2.

Variable	*M*	*SD*	95 % CI for *M*	Skewness	Kurtosis	Correlations			
						(1)	(2)	(3)	(4)
(1) Valence of mental imagery	45.50	37.21	[43.76, 47.46]	0.18	−1.51	–			
(2) Positive emotions	3.74	2.22	[3.62, 3.83]	−0.13	−1.45	0.74	–		
(3) Negative emotions	3.99	2.25	[3.87, 4.09]	−0.03	−1.49	−0.67	−0.86	–	
(4) Willingness to take risk	3.57	2.28	[3.34, 3.69]	0.25	−1.46	0.44	0.66	−0.61	–

Note: all correlation coefficients were significant at level $p < .001$.

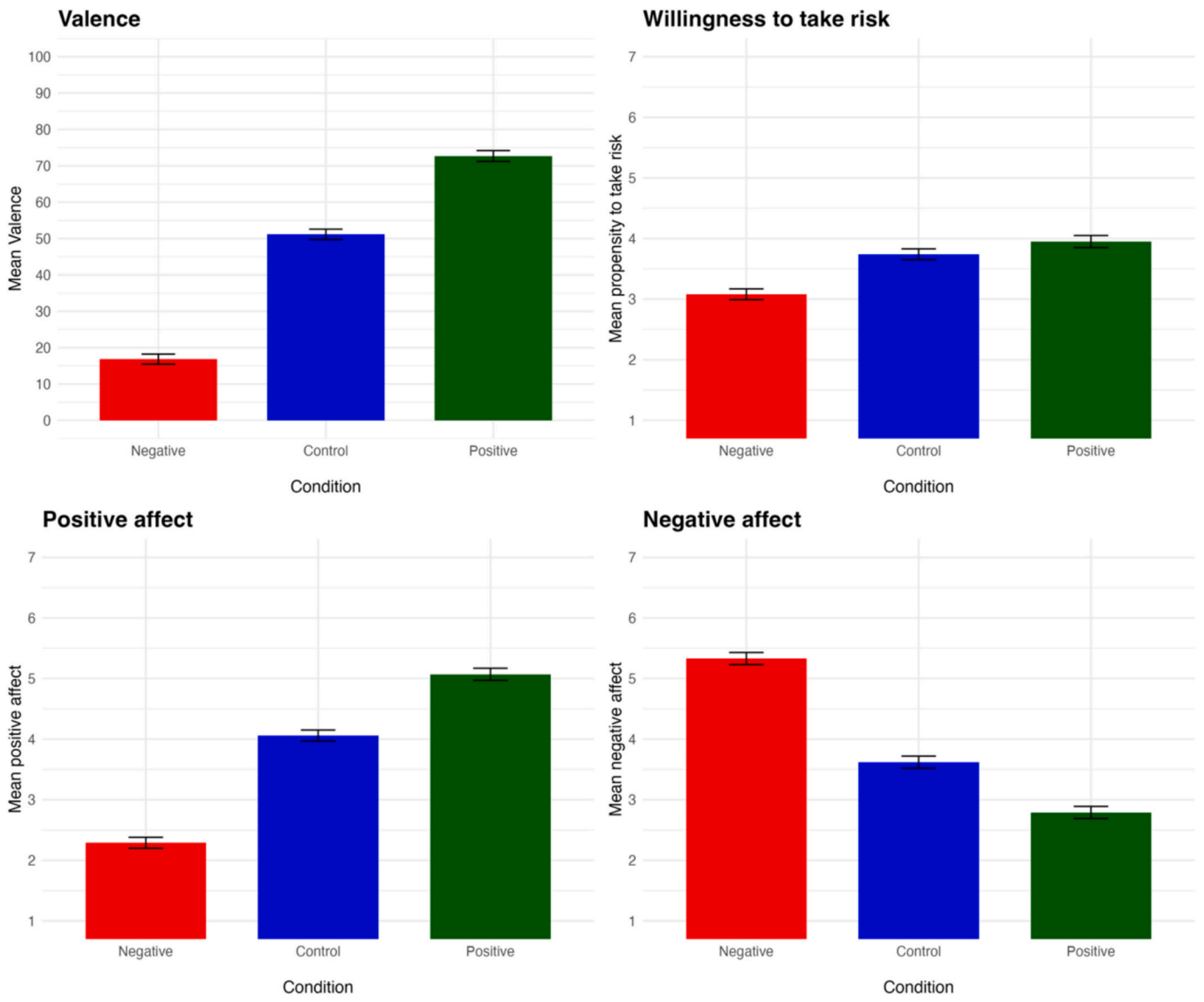

Fig. 2. The mean values for valence of mental imagery, positive emotions, negative emotions, and declared willingness to take risks across three experimental conditions (Study 2).

Moreover, they were both linked to the willingness to take risks, respectively $b = 0.54$, post SD = 0.04, $p < .001$, 95 % CI [0.46, 0.61] for positive emotions and $b = -0.19$, post SD = 0.04, $p < .001$, 95 % CI [−0.27, −0.12] for negative emotions. After controlling for the two mediators, the direct effect of the positive imagery manipulation on the willingness to take risks was not significant, $b = -0.21$, post SD = 0.15, $p = .172$, 95 % CI [−0.50, 0.11], same as the direct effect of the negative imagery manipulation on the willingness to take risks, $b = 0.06$, post SD = 0.23, $p = .804$, 95 % CI [−0.39, 0.49].

The total indirect effect of positive mental imagery manipulation via two mediators was significant: ab = 0.42, post SD = 0.12, $p < .001$, 95 % CI [0.19, 0.67], same as the total indirect effect of negative mental imagery manipulation, ab = –0.72, post SD = 0.20, $p < .001$, 95 % CI [−1.12, −0.32]. Further analysis of relative indirect effects showed that the 95 % credibility interval for the effects from both negative and positive imagery manipulations through positive emotions did not include zero, suggesting that these effects were significant, respectively ab = −0.74, post SD = 0.26, $p = .008$, 95 % CI [−1.22, −0.20] for the effect of negative valence manipulation and ab = 0.42, post SD = 0.16, $p = .008$, 95 % CI [0.12, 0.75] for the effect of positive valence manipulation. However, the credibility intervals for the indirect effects via negative emotions included zero and were not significant, respectively ab = 0.01, post SD = 0.22, $p = .932$, 95 % CI [-0.40, 0.47] for the effect of negative valence manipulation and ab = −0.01, post SD = 0.11, $p = .932$, 95 % CI [−0.23, 0.20] for the effect of positive valence manipulation. This indicates that on the between-participants level, as in Study 1, only the relative indirect effect via positive emotions was significant.

To summarize, this study reveals that individuals prompted to generate positive risk-associated mental imagery reported a heightened experience of positive emotions over negative ones. Conversely, participants tasked with producing negative visualizations of their risk taking noted the reverse effect. Importantly, those in the positive mental imagery condition also expressed an elevated readiness to take risky actions compared to individuals in the negative mental imagery group. This finding is pivotal, showing support for our hypothesis: the nature of mental imagery—positive or negative—significantly influences one's risk-taking propensity through the mediation of integral emotions. More precisely, positive mental imagery was found to amplify positive emotional responses, which, in turn, were related to a greater likelihood of engaging in risky actions. An inverse relationship was observed for participants who generated negative mental imagery.

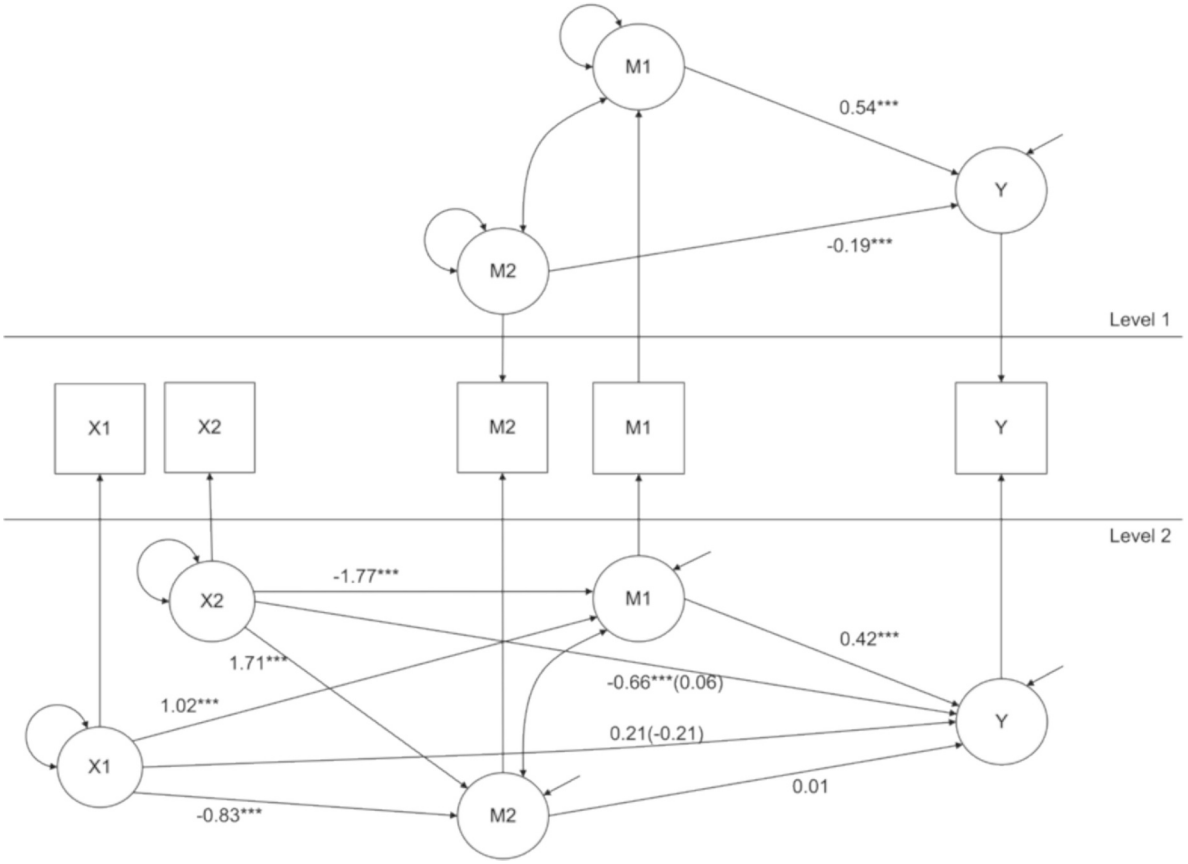

Fig. 3. Positive emotions (M1) and negative emotions (M2) as mediators of the relationship between the positive (X1) and negative (X2) mental imagery manipulations and the declared willingness to take risks (Y).

4. Study 3

Studies 1 and 2 provided both correlational and causal evidence that emotions are integral to the relationship between mental imagery and the inclination towards risk taking. In Study 3, we aimed to investigate further the unique nature of decision-making processes afforded by mental imagery. Specifically, we posited that mental imagery has a superior ability to elicit emotions when compared with more analytical (verbal) decision-making strategies (Weber & Lindemann, 2007). In experimental Study 3, participants were presented with examples of risky situations inspired by the Choice Dilemma Questionnaire (Kogan & Wallach, 1964). Next, depending on the experimental condition participants were randomly assigned to, they were prompted to generate either visual mental images that illustrated their personal involvement or analytical (logical) arguments weighing the pros and cons of engaging in the risk. Our hypothesis focused on the strength of emotions as a mediating factor being more pronounced when linking the valence of mental imagery to the propensity for risk taking than when linking the valence of analytical arguments to the willingness to take risks. It was acknowledged that analytical reasoning is not devoid of emotional impact—individuals may still experience excitement or regret while weighing potential gains and losses (Lerner et al., 2015). However, our primary prediction was that visual mental imagery induces decision making that is stronger connected with emotional processing than verbal reasoning grounded in rational argumentation does.

4.1. Method

4.1.1. Participants

Similarly to two prior studies, the sample size for Study 3 was calculated using a simulation method performed with Monte Carlo Power Analysis for Indirect Effect (Schoemann et al., 2017) based on 1000 replications using the effect sizes observed in Study 1. The results of an a priori analysis calculated for the model with two parallel mediators (i.e., positive and negative emotions) indicated that with an alpha of 0.05 and a power of 0.95, a sample size of $N = 330$ participants would be sufficient to detect the weaker of the two effects. However, since this study was planned in 2 (valence of risk-related associations: positive vs. negative) x 2 (the category of risk-related associations: mental imagery vs. logical arguments) between-participants design, and since we assumed that the effects in the logical arguments condition would be weaker than those in the mental imagery condition, we aimed to quadruple this sample size and recruit 1320 participants.

Therefore, we recruited 1320 US participants from Prolific to participate in an online study for £1.20. We removed data from 53 participants who completed the study via mobile phones. The final sample consisted of 1267 participants (639 women, 628 men, no others, $M_{age} = 43.0$, $SD = 14.7$). The study was conducted online, per the ethical standards enforced by the University Ethical Committee (approval # 08/P/05/2020) and preregistered at the Open Science Framework (https://osf.io/ybk4r?view_only=7e63999c03cf4371893c3c8251e9d929).

4.1.2. Procedure

After providing informed consent, participants underwent a training trial to acquaint themselves with the procedure for gauging their willingness to take risks. The inclusion of this training trial was deemed necessary due to the complexity of the rating scale used by the Choice Dilemmas Questionnaire (Kogan & Wallach, 1964), which assesses an individual's risk inclination based on the accepted probability of positive outcomes occurring. Next, participants were randomly assigned to one of the four experimental conditions in 2 (positive valence vs.

negative valence) x 2 (mental imagery vs. logical arguments) between-participants design. In each condition, participants were presented with five brief descriptions of risk referring to real-life situations based on the choice dilemmas paradigm (Kogan & Wallach, 1964). After reading each description, participants were asked to generate either visual mental imagery ($n = 644$) or logical arguments related to risky decision dilemmas ($n = 623$), based on the experimental condition they were assigned to. Depending on the valence condition, the participants' task was to generate either positive ($n = 613$) or negative ($n = 654$) mental images or logical arguments (see Supplementary Materials for the exact wording of instructions). Again, participants provided short descriptions of their imagery/logical arguments and rated their valence on a 100-point slider scale ranging from 0 – "very negative" to 100 – "very positive." Next, for each domain, on the two screens presented in counterbalanced order, participants rated their integral emotions and indicated their willingness to take risks. To measure integral emotions (positive and negative, separately), we used The Berlin Emotional Responses to Risk Instrument (Petrova et al., 2023). To measure willingness to take risks in five real-life situations, in line with the Choice Dilemma Questionnaire (Kogan & Wallach, 1964), we asked our participants to indicate the chance of beneficial consequences occurrence (from 1 in 10 to 10 in 10) sufficient for them to take risk. The lower the acceptable chance, the higher their propensity to take risk. To be consistent with how the propensity to take risk was measured in the previous studies, we recoded this variable so that the higher score indicated a higher risk-taking propensity (see Supplementary Materials for the exact wording of instructions and risk scenarios used in the Study).

4.2. Results

4.2.1. Descriptive statistics

Table 3 provides an overview of descriptive statistics and correlation coefficients for all variables measured in the study, and Fig. 4 presents their mean levels across the four experimental conditions. In Supplementary Materials, we also present descriptive statistics and plot figures for all variables per conditions and all risk domains. The exploration of the 95 % confidence intervals for the mean valence of risk-related associations generated by participants revealed a significant inclination towards negativity. This was evident as the mean valence was significantly lower than the scale midpoint (i.e., 50). Delving into the 95 % confidence intervals for the mean scores of other variables, the mean willingness to engage in risky actions slightly exceeded the midpoint of the scale (i.e., 4). Participants also reported a greater intensity of negative emotions compared to positive emotions, with the former falling above and the latter below the scale's midpoint (i.e., 4). In sum, these outcomes suggest that when confronted with risky activities, participants predominantly generated negative risk associations and declared a nearly neutral mean willingness to take risks.

Correlation analysis demonstrated that the relationships between declared readiness to take risks, ratings of emotions, and the valence of risk-related associations were significant and supported our predictions. Positive (negative) associations were connected with positive (negative) feelings and a higher (lower) propensity for engaging in risky actions.

4.2.2. Manipulation checks

First, to validate whether the manipulation of the valence of risk-related associations (positive vs. negative) was effective, we conducted a multilevel regression with the valence of risk-related associations (positive vs. negative), the category of risk-related associations (logical arguments vs. mental imagery) and their interaction as predictors, and the rating of the valence of risk-related associations as DV. We expected that the main effect of valence would be significant, but we did not have any specific expectations concerning other effects. We found a significant and strong main effect of the valence manipulation, $b = 25.24$, post SD = 0.43, $p < .001$, 95 % CI [24.38, 26.05], accompanied by a weak main effect of the category of risk-related association manipulation, $b = -0.83$, post SD = 0.50, $p = .040$, 95 % CI [−1.92, −0.002], and a significant interaction, $b = 1.94$, post SD = 0.55, $p < .001$, 95 %CI [0.76, 2.94]. The effect of the valence manipulation in the logical arguments condition was weaker, $b = 23.20$, post SD = 0.68, $p < .001$, 95 % CI [21.96, 24.95], than it was in the mental imagery condition, $b = 27.14$, post SD = 0.68, $p < .001$, 95 % CI [25.74, 28.57]. Taken together, the results of the presented analyses confirmed that the manipulation of the valence of mental imagery in Study 3 was successful.

Second, to confirm that the manipulation of risk-related associations was successful, we conducted a two-step qualitative content analysis of risk-association descriptions ("entries") provided by participants in this study. In the first step, two proficient English-speaking judges assigned participants' descriptions of risk-related associations to codes such as "visual imagery," "logical argument," or "other" (see Supplementary Materials for all codes' definitions). We calculated the inter-rater reliability using Krippendorff's alpha, yielding a value of $\alpha = 0.121$, 95 % CI [0.097, 0.145], suggesting poor reliability (Marzi et al., 2024). To address this, we conducted a second step of the analysis, in which a third judge resolved disagreements between the initial two judges to reach a final decision. Next, after achieving agreement in the qualitative analysis, we conducted a multilevel regression analysis using Mplus 8.8 to investigate the odds ratio of "visual imagery" and "logical argument" codes occurrence in each condition. Given the nominal nature of the judges' coding nested within participants, we applied a two-level analysis with maximum likelihood with robust standard errors estimator. The analysis included predictors such as the valence of risk-related associations (negative vs. positive, coded as −1 vs. 1), the category of risk-related associations (logical arguments vs. mental imagery, coded as −1 and 1 respectively), and their interaction. The dependent variable was defined as the ratings of entries falling into the codes "visual imagery," "logical argument," or "other." Furthermore, we created an additional code, „no agreement," for the descriptions where consensus was not reached among the three judges after the second step of qualitative analysis. We expected that in the mental imagery (logical arguments) condition, the odds ratio of code "visual imagery" ("logical arguments") will be significantly higher than the code "logical arguments" ("visual imagery"), and entries assigned to "other" or "no agreement" taken together. We did not have any specific expectations concerning other effects. For each of the following analyses, we created a dummy variable where 1 denoted a risk-related association of interest (e.g., "visual imagery"), and 0 indicated all remaining categories of risk-related association codes (e.g., "logical arguments," "other," and "no agreement").

For the code "visual imagery," we found a significant effect of the

Table 3
Descriptive statistics and correlations for variables in Study 3.

Variable	*M*	*SD*	95 % CI for *M*	Skewness	Kurtosis	Correlations			
						(1)	(2)	(3)	(4)
(1) Valence of risk-related association	46.92	34.52	[46.07, 47.77]	0.08	−1.43	–			
(2) Positive emotions	3.15	1.71	[3.11, 3.20]	0.34	−0.95	0.63	–		
(3) Negative emotions	4.05	1.83	[4.01, 4.10]	−0.10	−1.08	−0.45	−0.36	–	
(4) Willingness to take risk	4.50	2.52	[4.43, 4.55]	0.33	−0.66	0.20	0.27	−0.12	–

Note: all correlation coefficients were significant at level $p < .001$.

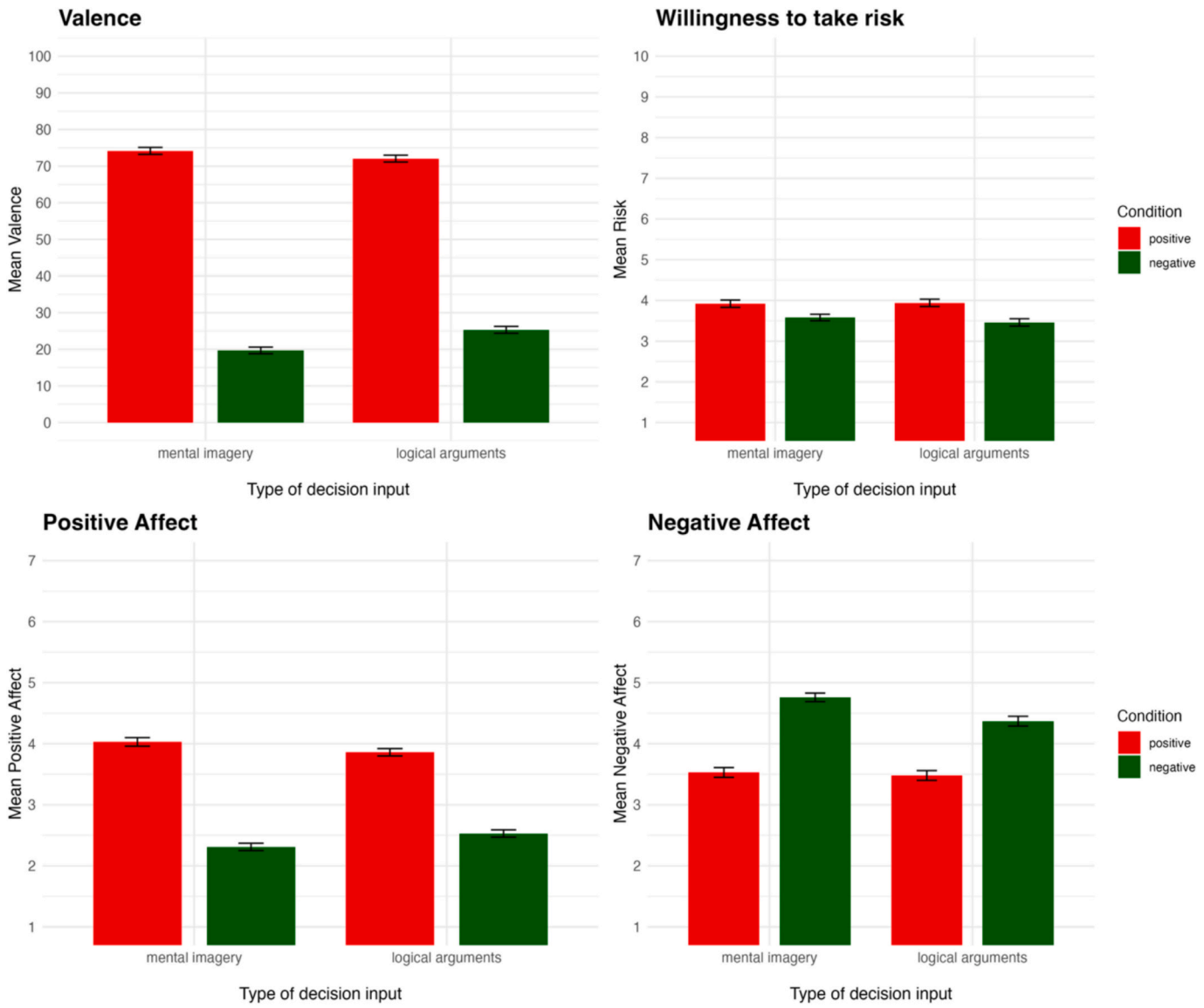

Fig. 4. The mean values for valence of mental imagery, positive emotions, negative emotions, and declared willingness to take risks across four experimental conditions (Study 3).

risk-related associations category, $B = 1.10$, SE = 0.04, Z = 26.46, $p <$ .001, such that this code occurred almost three times more often in the mental imagery condition than in the logical arguments condition, odds ratio exp.(B) = 2.99. The effect of the valence manipulation was not significant, $B = 0.06$, SE = 0.04, Z = 1.46 $p = .146$, same as the interaction between the two factors, $B = -0.03$, SE = 0.04, Z = − 0.80, $p =$ .424.

For the code "logical arguments," we again found a significant effect of the risk-related association manipulation, $B = -0.94$, SE = 0.04, Z = − 24.31, $p < .001$, such that this code occurred 2.5 times more often in the logical arguments condition than in the mental imagery condition, odds ratio exp.(B) = 2.55. We did not find significant effects for either the valence manipulation, $B = -0.02$, SE = 0.04, Z = − 0.62, $p = .532$, or the interaction of the two factors, $B = 0.01$, SE = 0.04, Z = 0.29, $p =$ .768.

For the code "other," we did not find a significant effect of the manipulation of risk-related associations, $B = 0.13$, SE = 0.09, Z = 1.45, p = .146, nor the effect of the valence manipulation, $B = 0.10$, SE = 0.09, Z = 1.13, $p = .258$. However, we found a significant but weak effect of the interaction of these two factors, $B = -0.18$, SE = 0.09, Z = − 1.98, p = .048.

Finally, for the code "no agreement," there was a significant effect of the manipulation of risk-related associations, $B = -0.28$, SE = 0.05, Z = − 5.31, $p < .001$, such that this code occurred 1.3 more often in the logical arguments condition than in the mental imagery condition, odds ratio exp.(B) = 1.32. No other effects were significant, $B = -0.073$, SE = 0.05, Z = − 1.39, $p = .164$ for the valence manipulation and $B = 0.05$, SE = 0.05, Z = 1.02, $p = .305$ for the interaction of the two factors.

To test our main expectation, we conducted two analyses to compare the frequency of "visual imagery" ("logical arguments") code occurrence with the frequency of all remaining categories within the mental imagery (logical arguments) condition. In the mental imagery condition, the proportion of "visual imagery" code (64.2 % of all entries) was significantly higher than the proportion of all other risk-related associations (35.8 %), $B = 0.58$, $SE = 0.06$, $Z = 10.35$, $p < .001$, odds ratio exp.(B) = 1.79. In the logical arguments condition, the proportion of "logical arguments" code (69.0 % of all entries) was significantly higher than the proportion of all other risk-related associations (31.0 %), $B = 0.80$, $SE =$ 0.05, $Z = 15.94$, $p < .001$, odds ratio exp.(B) = 2.20. Taken together, the results of the qualitative and quantitative analyses suggested that there was a higher odds ratio of the "visual imagery" ("logical arguments") code in the mental imagery (logical arguments) condition than all three

remaining codes. Moreover, the code "visual imagery" ("logical arguments") occurred more often in the mental imagery (logical arguments) condition than in the logical arguments (mental imagery) condition. Thus, the manipulation of risk-related associations was successful.

4.2.3. Hypothesis testing

We tested our hypothesized moderated model where (1) negative (M1) and positive (M2) emotions parallelly mediated the relationship between the experimental manipulation of the valence (X1; coded as −1 = negative associations vs. 1 = positive associations) and the willingness to take risky actions (Y) and (2) these effects were moderated by the category of risk-related associations (X2; coded as −1 = logical arguments vs. 1 = mental imagery) (see Fig. 5, for the illustration of a conceptual model).

On the within-participants level, we found that the two dimensions of emotions were significantly and negatively related to each other, $cov_w = -0.71$, post SD = 0.02, $p < .001$, 95 % CI [−0.76, −0.67]. Moreover, they were both linked to the willingness to take risks, respectively $b = 0.18$, post SD = 0.03, $p < .001$, 95 % CI [0.13, 0.34] for positive emotions and $b = -0.11$, post SD = 0.03, $p < .001$, 95 % CI [−0.16, −0.06] for negative emotions.

On the between-participants level (level 2 in Fig. 5), we found a significant total effect of the positive vs. negative valence of risk-related associations on the declared willingness to take risks, $b = 0.20$, post SD = 0.04, $p < .001$, 95 % CI [0.12, 0.29]. The total effect of the category of risk associations (logical arguments vs. mental imagery) was not significant, $b = 0.03$, post SD = 0.05, $p = .560$, 95 % CI [−0.06, 0.11], same as the interaction between the two factors, $b = -0.03$, post SD = 0.04, $p = .428$, 95 % CI [−0.12, 0.05].

The strength of positive emotions was affected by the valence manipulation, $b = 0.76$, post SD = 0.03, $p < .001$, 95 % CI [0.70, 0.82], but not by the category of risk-related associations manipulation $b = -0.01$, post SD = 0.03, $p = .654$, 95 % CI [−0.08, 0.05]. The effect of the interaction between these two factors on the strength of positive emotions was significant, $b = 0.10$, post SD = 0.03, $p = .002$, 95 % CI [0.03, 0.16]. In turn, the strength of negative emotions was associated with the valence of risk-related associations, $b = -0.53$, post SD = 0.03, $p < .001$, 95 % CI [−0.60, −0.46], the category of risk-related associations, $b = 0.11$, post SD = 0.04, $p = .004$, 95 % CI [0.03, 0.18], and their interaction, $b = -0.09$, post SD = 0.04, $p = .022$, 95 % CI [−0.16, −0.01]. As in the previous studies within this project, the strength of positive emotions was associated with the willingness to take risks, $b = 0.42$, post SD = 0.03, $p < .001$, 95 % CI [0.33, 0.51], while the strength of negative emotions was not, $b = 0.01$, post SD = 0.04, $p = .748$, 95 % CI [−0.06, 0.08]. The two mediators were not related to each other, $cov_w = 0.02$, post SD = 0.04, $p = .480$, 95 % CI [−0.06, 0.11]. After controlling for the two mediators, the direct effect of the risk-related associations' valence on the willingness to take risks was not significant, $b = -0.11$, post SD = 0.06, $p = .064$, 95 % CI [−0.23, 0.01], same as the direct effect of the category of risk-related associations, $b = 0.03$, post SD = 0.04, $p = .474$, 95 % CI [−0.05, 0.11], and their interaction, $b = -0.08$, post SD = 0.04, $p = .076$, 95 % CI [−0.16, 0.01].

The index of moderated mediation for negative emotions was not significant, $b = -0.001$, post SD = 0.004, $p = .754$, 95 % CI [−0.01, 0.01], suggesting that the indirect effect of the valence of risk-related associations via negative emotions on the risk-taking willingness was similar for the logical arguments and mental imagery conditions. However, the index of moderated mediation for positive emotions was significant, $b = 0.04$, post SD = 0.02, $p = .002$, 95 % CI [0.01, 0.07], what suggests that the indirect effect of the valence of risk-related associations on the risk-taking willingness via positive emotions varied significantly across different categories of risk associations (logical

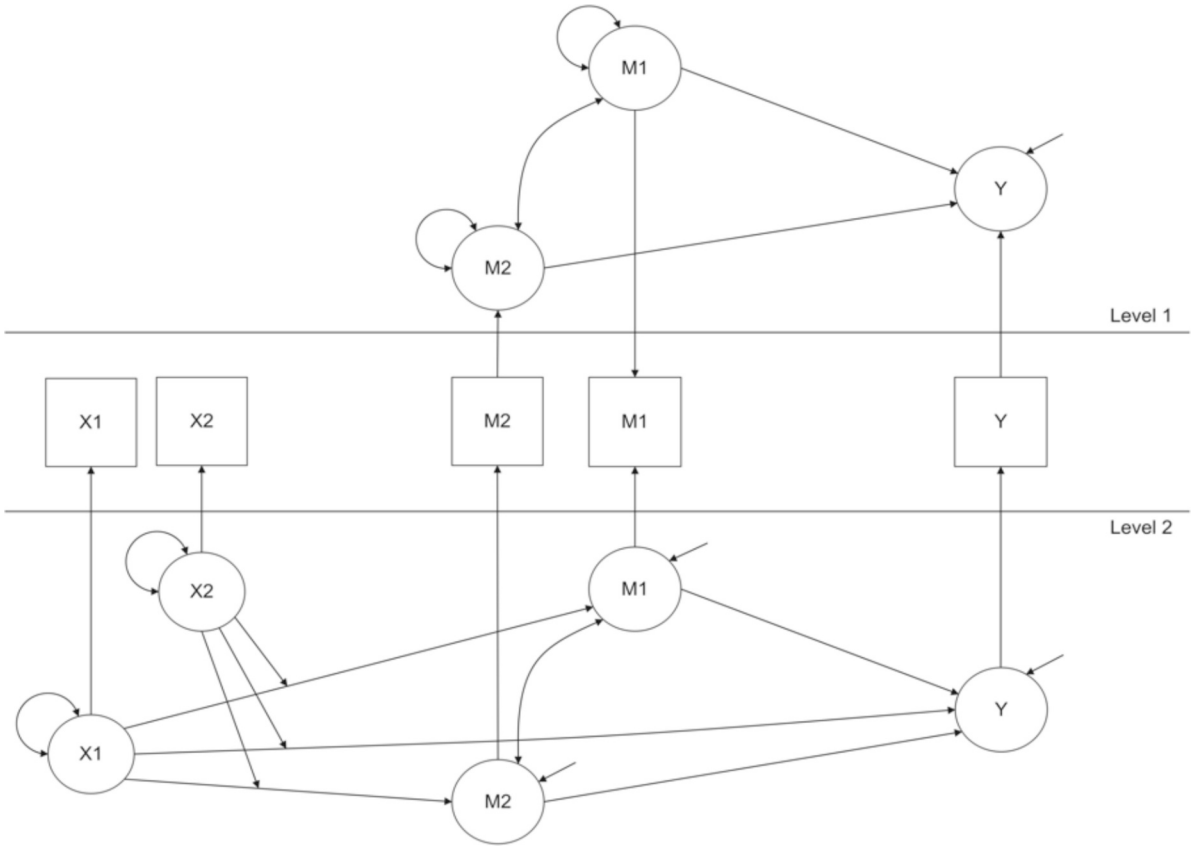

Fig. 5. Positive emotions (M1) and negative emotions (M2) as mediators of the relationship between the valence (X1) and the category (X2) of risk-related associations and the willingness to take risks (Y) depending on the category of risk-related associations (logical arguments vs. mental imagery). Conceptual model.

arguments vs. mental imagery). Therefore, we decomposed the moderated mediation on level 2, testing the links between the valence of risk-related associations, the two dimensions of integral emotions, and the willingness to take risks, separately in the logical arguments and mental imagery conditions.

In the logical arguments condition, the total effect of positive vs. negative associations on the willingness to take risks was significant, $b = 0.24$, post SD = 0.06, $p < .001$, 95 % CI [0.12, 0.35]. We also found significant effects of the valence manipulation on the level of both positive emotions, $b = 0.66$, post SD = 0.05, $p < .001$, 95 % CI [0.57, 0.75], and negative emotions, $b = -0.44$, post SD = 0.05, $p < .001$, 95 % CI [−0.55, 0.34]. Furthermore, the willingness to take risks was associated with the level of positive emotions, $b = 0.41$, post SD = 0.06, $p < .001$, 95 % CI [0.27, 0.53], but not with the level of negative emotions, $b = 0.02$, post SD = 0.05, $p = .688$, 95 % CI [−0.08, 0.12]. After controlling for the two mediators, the effect of the risk-related associations' valence on the willingness to take risks was not significant, $b = -0.02$, post SD = 0.07, $p = .760$, 95 % CI [−0.17, 0.13]. The indirect effect via positive emotions was significant, $b = 0.27$, post SD = 0.04, $p < .001$, 95 % CI [0.19, 0.36], while the indirect effect via negative emotions was not, $b = -0.01$, post SD = 0.02, $p = .688$, 95 % CI [−0.06, 0.03] (see Panel A in Fig. 6).

In the mental imagery condition, the total effect of positive vs. negative associations on the willingness to take risks was significant, $b = 0.17$, post SD = 0.06, $p = .006$, 95 % CI [0.05, 0.29]. We again found significant effects of the valence manipulation on the level of positive emotions, $b = 0.86$, post SD = 0.04, $p < .001$, 95 % CI [0.77, 0.95], and negative emotions, $b = -0.61$, post SD = 0.05, $p < .001$, 95 % CI [−0.72, −0.51]. Again, the willingness to take risks was associated with the level of positive emotions, $b = 0.44$, post SD = 0.07, $p < .001$, 95 % CI [0.30, 0.58], but not with the level of negative emotions, $b = 0.01$, post SD = 0.05, $p = .908$, 95 % CI [−0.10, 0.11]. After controlling for the two mediators, the effect of the risk-related associations' valence on the willingness to take risks was significant and negative, $b = -0.20$, post SD = 0.09, $p = .036$, 95 % CI [−0.38, −0.02]. The indirect effect via positive emotions was significant and stronger than it was in the logical argument condition, $b = 0.38$, post SD = 0.06, $p < .001$, 95 % CI [0.25, 0.50]. The indirect effect via negative emotions was not significant, $b = -0.003$, post SD = 0.03, $p = .908$, 95 % CI [−0.07, 0.06] (see Panel B in Fig. 6).

In summary, the findings from Study 3 lend further empirical support for the hypothesis that the generation of positive mental imagery can significantly increase an individual's propensity to engage in risky activities, as opposed to when negative mental imagery is elicited. Additionally, this study has demonstrated that the relationship between the valence of mental imagery and the propensity for risk-taking is mediated by emotional states. Interestingly, this pattern was also observed when participants were instructed to formulate analytical arguments rather than engage in the visual simulation of their actions. Crucially, however, and in alignment with our pre-registered hypothesis, the mediating effect of emotions was moderated by the type of cognitive processing (logical arguments vs. mental imagery). The role of emotions was markedly stronger when decision making was based on visual mental imagery as compared to when it was founded on verbal analytical reasoning.

5. Study 4

The preceding series of three studies have highlighted the unique ability of risk-related mental imagery to evoke both positive and negative integral emotions. Recognizing that additional phenomenological aspects of mental imagery, such as vividness and liveliness, are correlated with variations in the intensity of emotional experiences (Cocquyt & Palombo, 2023), our attention shifted to these features in experimental Study 4. Here, in addition to other measures, participants were asked to assess the state vividness of mental imagery in the context of their potential engagement in risk taking. We hypothesized that changes in vividness would serve as a moderating factor in the relationship between the valence of imagery and integral emotions. More precisely, we expected that the heightened state vividness of mental imagery generated by participants would amplify the connection between the valence of mental imagery and both positive and negative emotions. Moreover, to ensure that the effects observed in this study are linked specifically to the visual processing of risky situations (and not verbal processing), we opted not to ask participants to describe their mental images. In other words, the employed methodology was designed to prevent participants from transitioning from visual to verbal processing modalities. We believe that this change in the procedure was highly valuable from the perspective of interpreting the results. If the expected effects are indeed observed, they cannot be attributed to a shift from visual to verbal processing, which could potentially occur when participants are required to report the content of their imagery in written form.

5.1. Method

5.1.1. Participants

We based our sample size estimation on the total indirect effect of positive vs. negative mental imagery manipulation via positive and negative emotions on the willingness to take risks that we found on the between-participants level in the mental imagery condition in Study 3 in the present project. We performed Monte Carlo simulations using Mplus 8.8 with 1000 repetitions and found that with an alpha of 0.05 and a power of 0.95, a sample size of $N = 650$ participants would be sufficient to detect such an effect. However, as in this study, we planned to test whether the vividness of mental imagery moderates the effect of the valence of mental imagery, and since we assumed that the effects of our manipulation would be weaker for low levels of vividness, we aimed to double this sample size and invite 1300 participants.

Therefore, we recruited 1300 US participants from Prolific to participate in an online study for £1.20 (650 women, 650 men, no others, $M_{age} = 40.25$, $SD = 13.52$). We removed data from 41 participants who completed the study via mobile phones. The final sample consisted of $N = 1259$ participants (627 women, 632 men, no others, $M_{age} = 40.27$, $SD = 13.62$). The study was conducted in line with ethical guidelines enforced by the University Ethical Committee (approval # 08/P/05/2020) and preregistered at the Open Science Framework (https://osf.io/4sur9/?view_only=533f5b7a9c2740deb3937db5f64ce71a).

5.1.2. Procedure

After providing informed consent, participants engaged in two training trials to familiarize themselves with the measurement procedures employed in the main study. As in Study 3, the first training trial focused on the measurement of participants' inclination to take risks. The second training trial was incorporated to elucidate the concept of mental imagery vividness and provide practice in its measurement, given its pivotal role in this study. Next, participants were randomly assigned to one of the two experimental conditions in a 2 (positive imagery vs. negative imagery) between-subjects design. In each condition, they were presented with five brief descriptions of risky actions referring to real-life situations based on the Choice Dilemmas Questionnaire paradigm (Kogan & Wallach, 1964), the same as in Study 3. After reading each description, participants were asked to generate either positive mental images ($n = 624$) or negative mental images ($n = 635$) related to risky decision dilemmas (see Supplementary Materials for the exact wording of instructions). This time, participants were not required to provide descriptions of their imagery. Instead, they only rated the valence of their imagery on a 100-point slider scale ranging from 0 – "very negative" to 100 – "very positive" and its vividness. Participants rated the vividness of their visual mental images using a method adapted from the study by Pearson et al. (2011). They were asked to indicate their responses on a slider scale ranging from 0 to 100, with four anchors (0 = "almost no imagery;" 33 = "some weak imagery;" 66 = "moderate

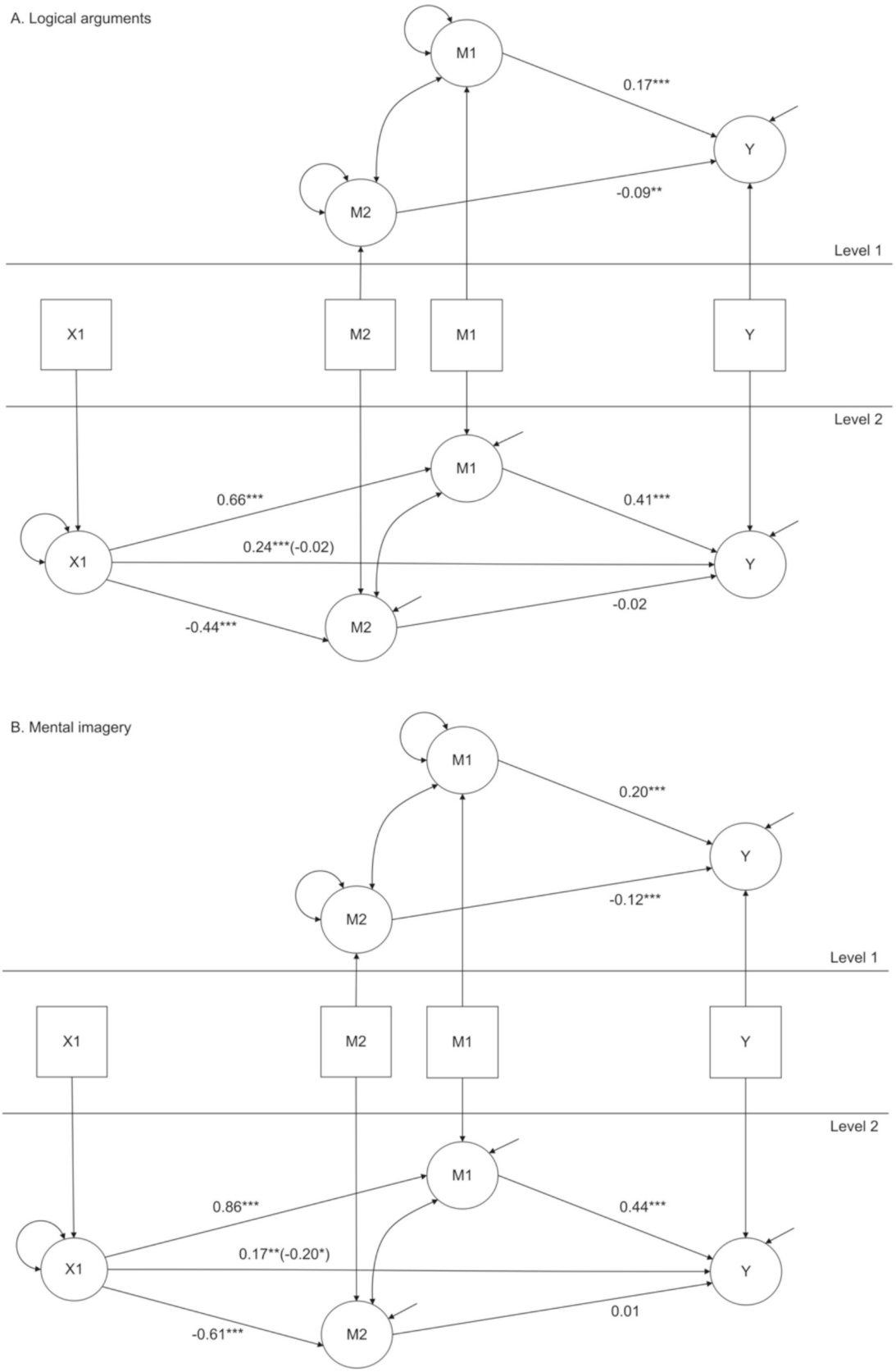

Fig. 6. Positive emotions (M1) and negative emotions (M2) as mediators of the relationship between the valence (X1) and the category (X2) of risk-related associations and the willingness to take risks (Y).

imagery;" and 100 = "strong imagery almost like perception"). Next, for each domain, on the two screens presented in counterbalanced order, participants rated their integral emotions and indicated their willingness to take risk. As in Study 3, we used The Berlin Emotional Responses to Risk Instrument (Petrova et al., 2023) to measure integral emotions (positive and negative, separately). To measure the risk-taking willingness in five real-life situations, as in Study 3, we asked participants to indicate the chance of beneficial consequences (from 1 in 10 to 10 in 10) sufficient for them to take risks and then recorded this variable so that the higher score indicated higher risk-taking propensity.

5.2. Results

5.2.1. Descriptive statistics

Descriptive statistics and correlation coefficients for all variables measured in this study are presented in Table 4, and Fig. 7 presents their average levels across the two experimental conditions moderated by the vividness of mental imagery. Similarly to previous studies, in Supplementary Materials, we present descriptive statistics and plot figures for all variables per conditions and all risk domains. The investigation of the 95 % confidence intervals for the mean valence of mental imagery revealed that it was significantly lower than the middle of the scale (i.e., 50). Further, the examination of the 95 % confidence intervals for the other variables' mean ratings indicated that the mean willingness to engage in risky actions was above the middle of the scale (i.e., 4). As in Study 3, participants rated their negative emotions as stronger than positive emotions, with the mean score of the former falling above and the latter below the scale's midpoint (i.e., 4). Moreover, participants rated their mental imagery as relatively vivid, with the mean rating significantly above the middle of the scale (i.e., 50). Taken together, these results suggested that when confronted with risky activities, participants again generated rather negative risk-related mental imagery, but their mean willingness to take risks was higher compared to three previous studies.

The analysis of correlations showed that the declared readiness to take risks and the ratings of emotions were correlated with the valence of risk-related images. Positive (negative) images were related to positive (negative) emotions and a higher (lower) propensity to engage in risky actions.

5.2.2. Manipulation check

To validate whether the manipulation of the valence of risk-related images (positive vs. negative) was effective, we conducted a multilevel regression with the valence of risk-related images (positive vs. negative) as a predictor, and the rating of the valence of risk-related images as DV. We considered our data nested within participants and domains and used Bayesian estimation in Mplus 8.8. We found a significant and strong main effect of the valence manipulation, $b = 15.21$, post SD = 0.47, $p < .001$, 95 % CI [14.29, 16.13], which confirmed that the manipulation of the valence of mental imagery in Study 4 was successful.

5.2.3. Hypothesis testing

We tested our hypothesized moderated mediation model where (1) negative (M1) and positive (M2) emotions parallelly mediated the relationship between the experimental manipulation of the imagery valence (X1; coded as −1 = negative images vs. 1 = positive images) and the willingness to take risky actions (Y), and (2) vividness moderates the effects of valence manipulation on both levels (see Fig. 8 for the graphical illustration of the conceptual model). The main test of the preregistered hypothesis is the analysis on the between-participants level. However, we first present the results on the within-participants level.

5.2.4. Results on the within-participants level (level 1)

On the within-participants level, we found that vividness was significantly and positively associated with positive emotions, $b = 0.68$, post SD = 0.06, $p < .001$, 95 % CI [0.57, 0.79], and with negative emotions, $b = 0.16$, post SD = 0.08, $p = .028$, 95 % CI [0.01, 0.30]. We also found significant interactions between vividness and valence of mental imagery on both positive emotions, $b = 0.04$, post SD = 0.01, $p = .004$, 95 % CI [0.14, 0.07], and negative emotions, $b = -0.05$, post SD = 0.02, $p = .009$, 95 % CI [−0.09, −0.01], meaning that the associations between the vividness of mental imagery and two dimensions of emotions differed across the two experimental conditions. The two dimensions of emotions were significantly and negatively related, $cov_w = -0.78$, post SD = 0.05, $p < .001$, 95 % CI [−0.86, −0.67]. Moreover, negative emotions were linked to the willingness to take risks, $b = -0.30$, post SD = 0.21, $p = .018$, 95 % CI [−0.90, −0.05], but positive emotions were not, $b = 0.02$, post SD = 0.37, $p = .960$, 95 % CI [−0.86, 0.67].

The total effect of vividness on the willingness to take risks was significant, $b = 0.57$, post SD = 0.15, $p < .001$, 95 % CI [0.32, 0.87]. The indirect effect of vividness on the willingness to take risks via negative emotions was significant, $b = -0.04$, post SD = 0.05, $p = .046$, 95 % CI [−0.20, −0.001], while the indirect effect via positive emotions was not, $b = 0.01$, post SD = 0.27, $p = .960$, 95 % CI [−0.78, 0.32]. After controlling for the two mediators, the direct effect of vividness on the willingness to take risks was significant, $b = 0.62$, post SD = 0.44, $p = .040$, 95 % CI [0.03, 1.73], while the interaction between the valence and vividness of mental imagery on the willingness to take risks was not significant, $b = -0.05$, post SD = 0.03, $p = .120$, 95 % CI [−0.11, 0.01]. Most importantly from the perspective of our hypotheses, the indices of moderated mediation were significant for both positive emotions, $b = 0.09$, post SD = 0.02, $p < .001$, 95 % CI [0.05, 0.13], and negative emotions, $b = 0.04$, post SD = 0.01, $p = .034$, 95 % CI [0.001, 0.05], suggesting that the indirect effects of the vividness on the willingness to take risks via two dimensions of emotions differed between the two experimental conditions. Therefore, we decomposed the cross-level interaction, examining the effect on level 1 separately for participants who were asked to generate positive and negative mental images.

In participants asked to generate positive risk-related mental images (Panel A in Fig. 9), the vividness of such images was positively associated with positive emotions, $b = 1.14$, post SD = 0.31, $p = .032$, 95 % CI [0.40, 0.20], and negatively with negative emotions, $b = -0.45$, post SD = 0.16, $p = .032$, 95 % CI [−0.61, −0.12]. The level of negative emotions was significantly associated with the willingness to take risks, $b = -0.71$, post SD = 0.49, $p = .028$, 95 % CI [−1.82, −0.06], while the

Table 4
Descriptive statistics and correlations for variables in Study 4.

Variable	*M*	*SD*	95 % CI for M	Skewness	Kurtosis	Correlations				
						(1)	(2)	(3)	(4)	(5)
(1) Valence of mental imagery	44.88	29.06	[44.16, 44.88]	0.17	−1.09	–				
(2) Vividness of mental imagery	71.14	22.67	[70.58, 71.70]	−0.92	0.51	0.09	–			
(3) Positive emotions	3.16	1.56	[3.12, 3.20]	0.36	−0.73	0.63	0.14	–		
(4) Negative emotions	4.26	1.75	[4.21, 4.30]	−0.27	−0.95	−0.48	0.48	−0.33	–	
(5) Willingness to take risk	4.64	2.50	[4.58, 4.70]	0.28	−0.70	0.23	0.04	0.27	−0.13	–

Note: all correlation coefficients were significant at level $p < .001$.

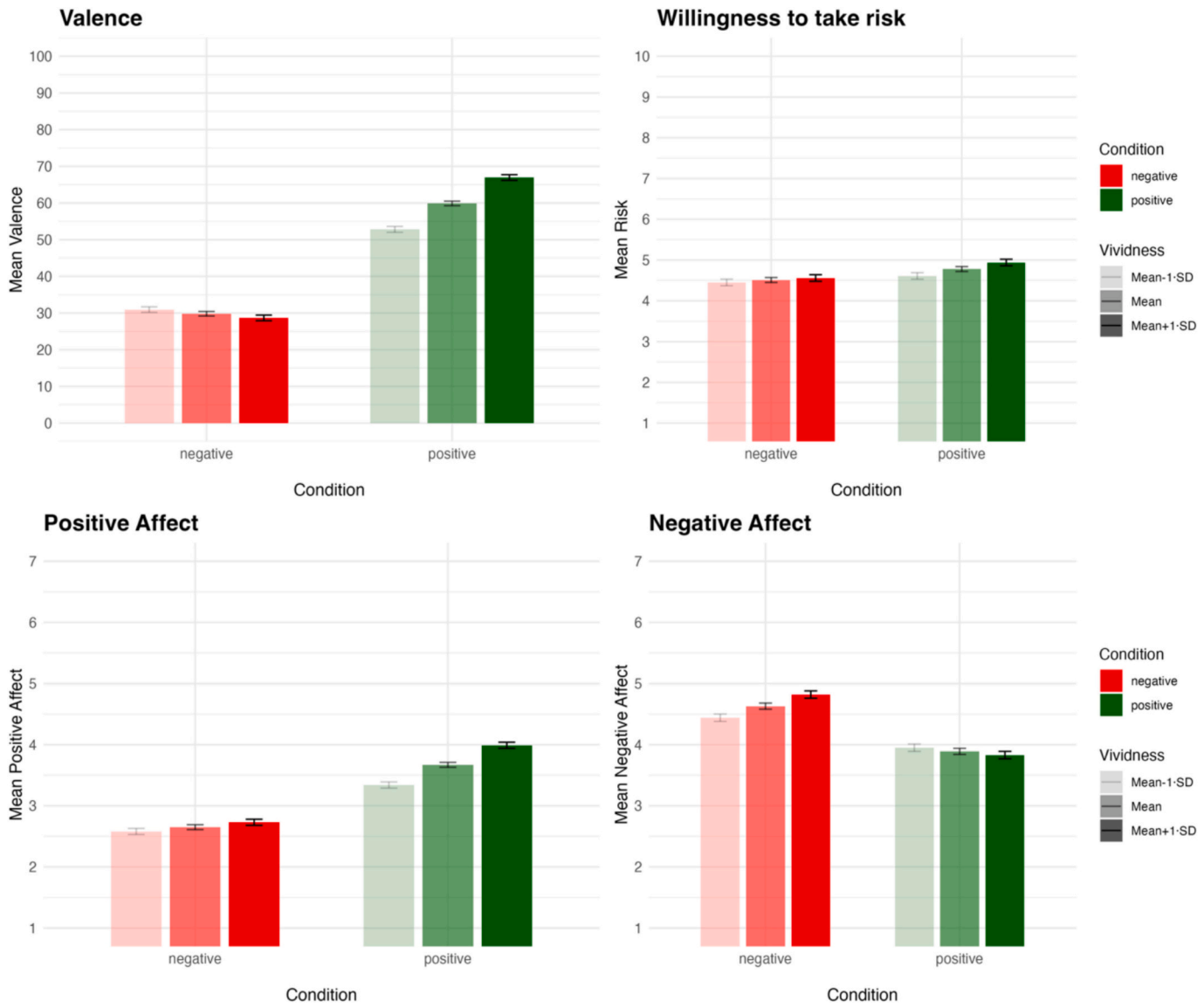

Fig. 7. The mean values of valence of mental imagery, positive emotions, negative emotions, and declared willingness to take risks across two experimental conditions, moderated by the vividness of the imagery (Study 4).

effect of positive emotions was not, $b = -2.30$, post SD = 2.57, $p = .198$, 95 % CI [−8.43, 0.62]. The total effect of mental imagery vividness was significant and positive, $b = 0.30$, post SD = 0.22, $p = .014$, 95 % CI [0.02, 0.80]. The indirect effect of vividness on the willingness to take risks via negative emotions was significant, $b = 0.30$, post SD = 0.22, $p = .014$, 95 % CI [0.02, 0.80], while the indirect effect via positive emotions was not, $b = -3.31$, post SD = 2.90, $p = .163$, 95 % CI [−9.80, 0.32]. After controlling for the two mediators, the direct effect of vividness on the willingness to take risks was not significant, $b = 0.20$, post SD = 1.42, $p = .666$, 95 % CI [−0.84, 4.75]. In other words, for participants prompted to generate positive risk-related mental images, enhanced vividness of these visualizations was related to an increase in positive emotions and a decrease in negative emotions. This emotional shift correspondingly increased their readiness to engage in risk-taking behaviors but mainly due to a reduced impact of negative emotions as the effect of positive emotions on risk-taking propensity was not significant.

In turn, in participants who were asked to generate negative risk-related mental images (Panel B in Fig. 9), the imagery vividness was positively associated with both negative emotions, $b = 0.59$, post SD = 0.15, $p < .001$, 95 % CI [0.31, 0.88], and positive emotions, $b = 0.41$, post SD = 0.13, $p < .001$, 95 % CI [0.17, 0.66]. The level of positive emotions was significantly associated with the willingness to take risks, $b = 0.53$, post SD = 0.04, $p < .001$, 95 % CI [0.44, 0.61], while the effect of negative emotions was not, $b = 0.01$, post SD = 0.04, $p = .768$, 95 % CI [−0.07, 0.09]. The total effect of mental imagery vividness on the willingness to take risks was not significant, $b = 0.43$, post SD = 0.27, $p = .112$, 95 % CI [−0.10, 0.96]. The indirect effect of vividness on the willingness to take risks via positive emotions was significant, $b = 0.22$, post SD = 0.07, $p < .001$, 95 % CI [0.09, 0.36], while the indirect effect via negative emotions was not, $b = 0.01$, post SD = 0.02, $p = .768$, 95 % CI [−0.04, 0.06]. After controlling for the two mediators, the direct effect of imagery vividness on the willingness to take risks was not significant, $b = 0.21$, post SD = 0.26, $p = .426$, 95 % CI [−0.33, 0.71]. In other words, when participants were asked to generate negative mental images, highly vivid images resulted in more positive and more negative emotions than images of low vividness. Heightened positive emotions correspondingly amplified participants' propensity to engage in risk-taking actions.

5.2.5. *Results on between-participants level (level 2)*

In this section, we present the outcomes that are crucial for our

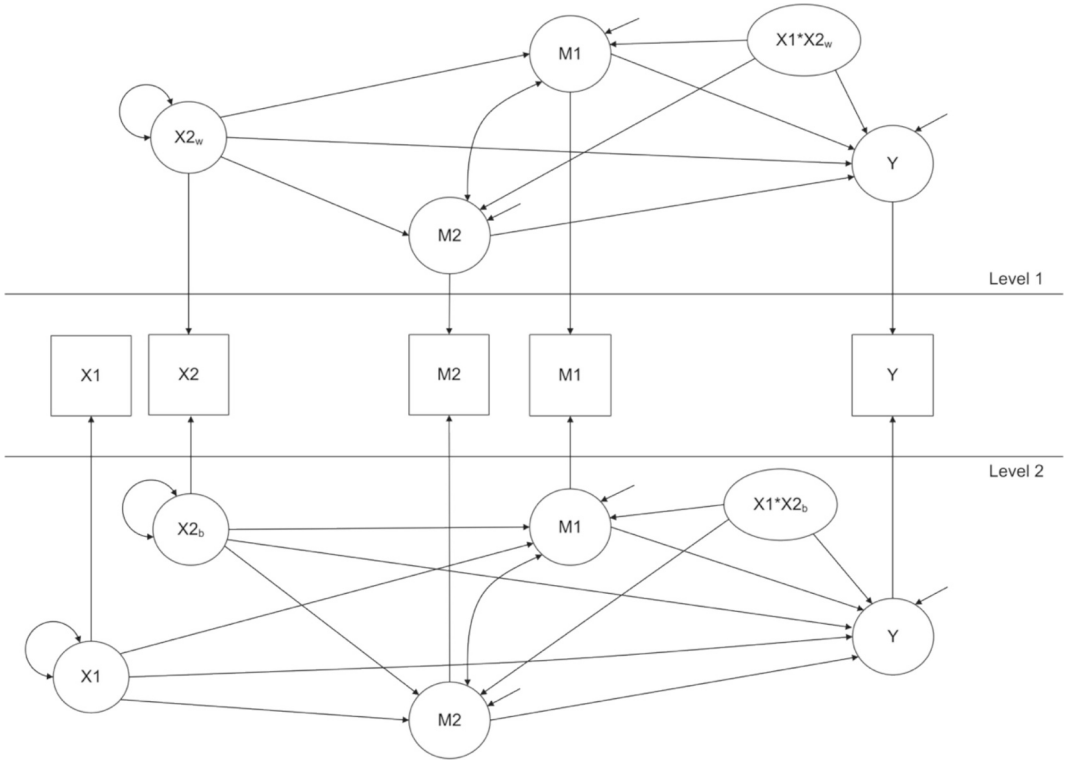

Fig. 8. Positive emotions (M1) and negative emotions (M2) as mediators of the relationship between the valence (X1) and the vividness (X2) of risk-related images and the willingness to take risks (Y). Conceptual model.

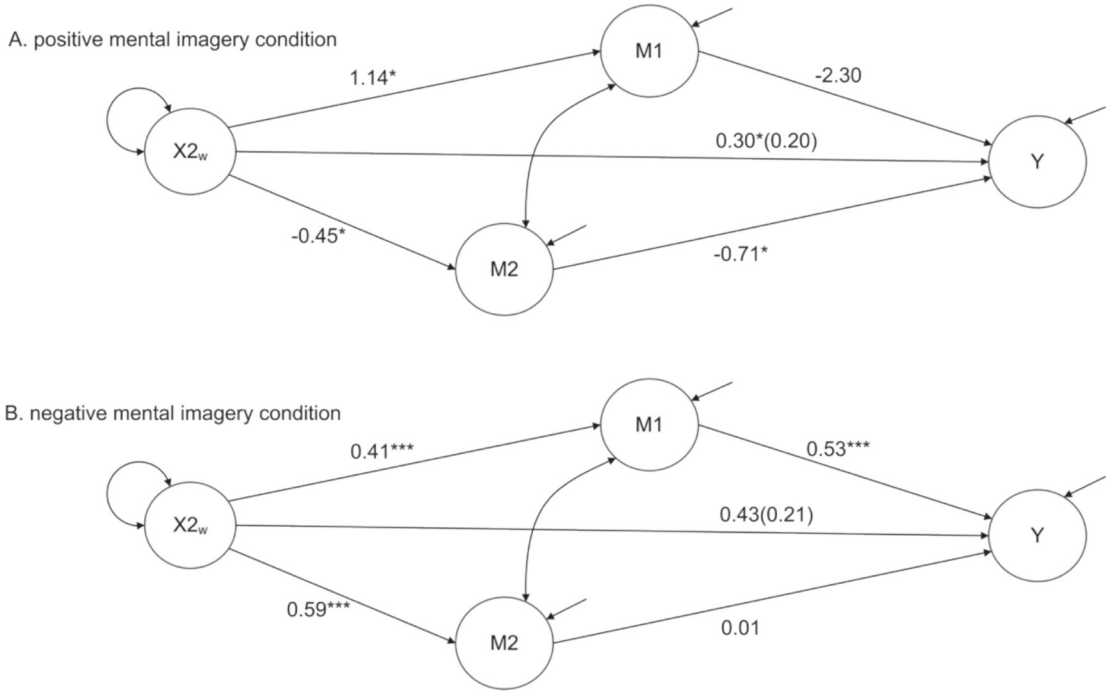

Fig. 9. Positive emotions (M1) and negative emotions (M2) as mediators of the relationship between the vividness of mental imagery (X2) and the willingness to take risks (Y) depending on the valence of mental imagery (positive mental imagery condition and negative mental imagery condition). Decomposition of the interaction on level 1.

preregistered hypothesis that the vividness of visual mental imagery moderates the relationship between the valence of images generated by the participants and the emotions they experienced. As in previous studies, on the between-participants level (level 2 in Fig. 8), we found a significant effect of the valence manipulation on the strength of positive emotions, $b = 0.51$, post SD $= 0.03$, $p < .001$, 95 % CI [0.45, 0.57], and negative emotions, $b = -0.38$, post SD $= 0.04$, $p < .001$, 95 % CI [−0.45, −0.31]. We also found significant effects of vividness on the strength of

positive emotions, $b = 0.19$, post SD = 0.05, $p < .001$, 95 % CI [0.11, 0.30], and negative emotions, $b = 0.29$, post SD = 0.053, $p < .001$, 95 % CI [0.19, 0.41]. What is more, the interactions between vividness and the valence manipulation were significant, respectively $b = 0.20$, post SD = 0.04, $p < .001$, 95 % CI [0.12, 0.29] for positive emotions and $b = -0.24$, post SD = 0.05, $p < .001$, 95 % CI [−0.36, −0.14] for negative emotions. As in the previous studies, the strength of positive emotions was associated with the willingness to take risks, $b = 0.42$, post SD = 0.05, $p < .001$, 95 % CI [0.32, 0.53], while the strength of negative emotions was not, $b = -0.07$, post SD = 0.05, $p = .170$, 95 % CI [−0.16, 0.03]. The two mediators were not related to each other, $cov_w = -0.07$, post SD = 0.04, $p = .078$, 95 % CI [−0.15, 0.01].

The total effect of the valence of risk-related imagery on the willingness to take risks was significant, $b = 0.57$ post SD = 0.15, $p < .001$, 95 % CI [0.32, 0.87]. The indirect effect via positive emotions was significant, $b = 0.22$, post SD = 0.03, $p < .001$, 95 % CI [0.16, 0.28], while the indirect effect via negative emotions was not, $b = 0.02$, post SD = 0.02, $p = .170$, 95 % CI [−0.01, 0.06]. After controlling for the two mediators, the direct effect of the risk-related imagery valence on the willingness to take risks was significant, $b = -0.11$, post SD = 0.05, $p = .048$, 95 % CI [−0.21, −0.001]. The direct effect of vividness was not significant, $b = -0.005$, post SD = 0.07, $p = .942$, 95 % CI [−0.14, 0.12], same as the interaction between valence and vividness, $b = 0.003$, post SD = 0.07, $p = .972$, 95 % CI [−0.13, 0.14].

The index of moderation mediation for positive emotions was significant, $b = 0.09$, post SD = 0.02, $p < .001$, 95 % CI [0.05, 0.13], while the index of moderated mediation for negative emotions was not, $b = 0.01$, post SD = 0.01, $p = .170$, 95 % CI [−0.01, 0.04]. Crucially, from the perspective of our theoretical predictions, these results indicated that the indirect effects of the valence of the risk-related imagery on the willingness to take risks via positive emotions significantly varied depending on the level of the vividness of mental imagery. Therefore, we decomposed the moderated mediation on level 2, testing the associations between the valence of the risk-related imagery, the two dimensions of emotions, and the willingness to take risks at low (*M*-1*SD*), medium (*M*), and high (*M*+1*SD*) levels of the moderator.

Table 5
Positive emotions (M1) and negative emotions (M2) as mediators of the relationship between the valence of the risk-related mental imagery (X1) and the willingness to take risks (Y) depending on the vividness of the risk-related mental imagery. Decomposition of interaction on level 2.

Effect	*b*	Post. *SD*	*p*	95 % CI	
M1 ➔ Y	0.42	0.05	***	0.32	0.53
M2 ➔ Y	−0.07	0.05		−0.16	0.03
Low vividness (*M* – 1*SD* = 48.48)					
X1 ➔ M1	0.31	0.05	***	0.20	0.41
X1 ➔ M2	−0.14	0.07	*	−0.26	−0.003
Indirect effect via M1	0.13	0.03	***	0.08	0.19
Indirect effect via M2	0.01	0.01		0.00	0.03
Total effect	0.03	0.08		−0.13	0.18
Direct effect	−0.11	0.07		−0.25	0.03
Medium vividness (*M* = 71.14)					
X1 ➔ M1	0.51	0.03	***	0.45	0.57
X1 ➔ M2	−0.38	0.04	***	−0.45	−0.31
Indirect effect via M1	0.22	0.03	***	0.16	0.28
Indirect effect via M2	0.03	0.02		−0.01	0.06
Total effect	0.13	0.04	**	0.05	0.22
Direct effect	−0.11	0.05	*	−0.21	0.00
High vividness (*M* + 1*SD* = 93.81)					
X1 ➔ M1	0.72	0.05	***	0.62	0.82
X1 ➔ M2	−0.63	0.07	***	−0.76	−0.50
Indirect effect via M1	0.30	0.05	***	0.22	0.40
Indirect effect via M2	0.04	0.03		−0.02	0.10
Total effect	0.24	0.08	**	0.09	0.40
Direct effect	−0.11	0.10		−0.29	0.09

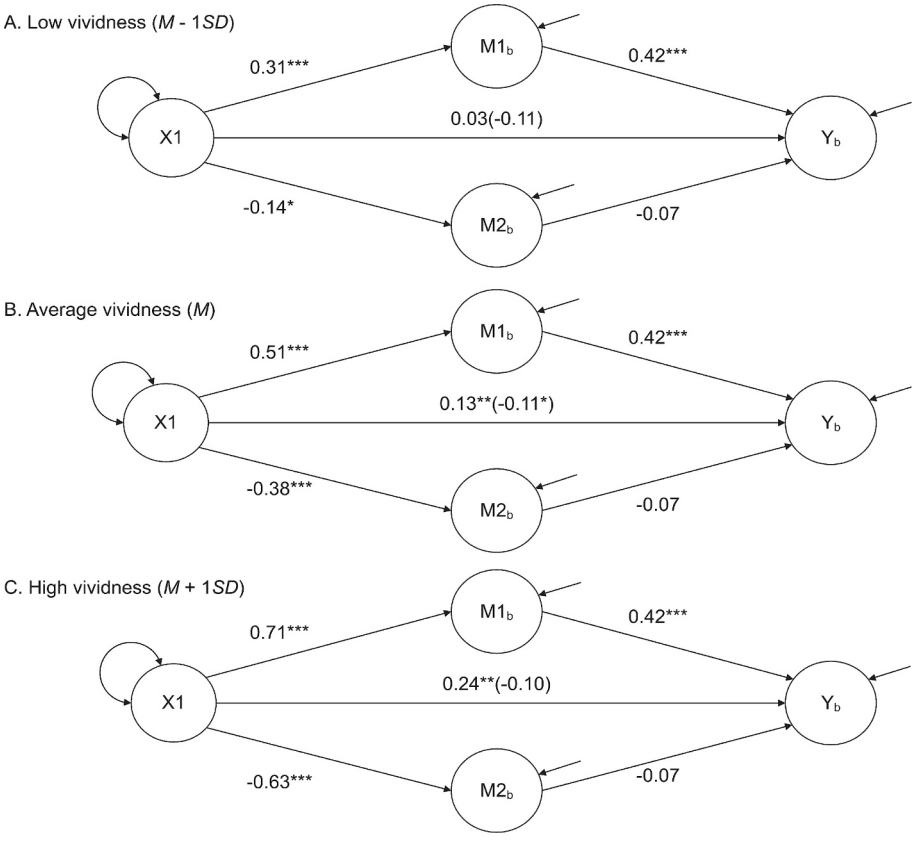

Fig. 10. Positive emotions (M1) and negative emotions (M2) as mediators of the relationship between the valence of mental imagery (X1), the willingness to take risks (Y) depending on the vividness of risk-related mental imagery. Decomposition of interaction on level 2.

Overall, as demonstrated in Fig. 10 and in Table 5, the higher the levels of mental imagery vividness, the stronger the effect of the valence manipulation on the levels of positive and negative emotions, and the stronger the indirect effect of the valence manipulation on the willingness to take risks via the strength of positive emotions. This stronger indirect effect also resulted in a stronger total effect of the valence of mental imagery on the willingness to take risks in participants who generated more vivid images compared to those who generated less vivid images. These findings provided strong support for our hypothesis, demonstrating that the link between the valence of mental imagery and the depth of corresponding emotions is moderated by the vividness of the imagery. Specifically, increased vividness almost linearly intensifies the impact of mental imagery on the emotions experienced.

6. General discussion

6.1. Summary of the results

Our present research comprised four studies, including three experiments, aimed at exploring the role of emotions in people's propensity for risk taking when stimulated by mental imagery. We endeavored to demonstrate that emotions serve as a mediator between the valence of risk-related visual mental images and subsequent declared risky decision making and that two factors—the type of associations people process when faced with risk and the vividness of mental imagery—moderate this mediating effect. In Study 1, we found evidence for a correlation between the valence of participants' mental imageries and the strength of emotional responses, which were, in turn, related to a declared likelihood of taking risks. Specifically, the more positive valence of mental images was associated with heightened positive affect and reduced negative affect, as well as an increased willingness to engage in risk-taking activities. Experimental Study 2 sought to causally replicate these findings, revealing that participants prompted to positively imagine their engagement in risky activities reported more intense positive emotions (and less intense negative emotions) and a higher tendency to take these risks compared to those generating negative mental images. Subsequent preregistered experiments, Studies 3 and 4, provided further support for the general hypothesis that mental imagery is a specific source of emotions in decision making under risk. Study 3 highlighted that the mediation of emotions between the valence of risk-related associations and declared risk taking was moderated by the nature of the cognitive process: visual mental imagery vs. verbal analytical thinking. Here, the emotional impact was more pronounced in decisions derived from mental imagery. Finally, Study 4 revealed the vividness of mental imagery as another moderating factor. We discovered that participants who more vividly imagined engaging in risky activities experienced more intense emotions (both positive and negative), which were then related to their risk-taking willingness. These findings suggest that the role of emotions is not only more significant when decisions are imagery-based rather than analytical but also more potent when these images are particularly vivid. Importantly, in Study 4, participants were not asked to report the content of their images. The reason behind this change in the procedure was to assure that the results cannot be attributed to a shift from visual to verbal processing, which could potentially occur when participants describe their imagery in written form.

Our primary data analysis employed multilevel structural equation modeling (MSEM) with Bayesian estimation. To enhance the clarity of our findings, we also performed supplementary analyses using mixed-subject ANOVA, detailed in the Supplementary Materials. Notably, the results of these additional analyses aligned with those obtained through MSEM.

6.2. Interplay of emotions and mental imagery in risk-related decision making

Advances in behavioral decision research have demonstrated that emotions play a multifaceted role in people's choices under risk (Lerner et al., 2015; Loewenstein & Lerner, 2003; Peters et al., 2006; Zaleskiewicz & Traczyk, 2020). For instance, a comprehensive meta-analysis revealed a relationship between heightened fear and a reduction in risk taking, alongside an increase in perceived risk (Wake et al., 2020). Conversely, the experience of positive emotions, such as excitement, has been shown to augment tendencies towards behaviors characterized by increased risk and potential recklessness (Taubman - Ben-Ari, 2012; Zuckerman, 2007). Our current research goes beyond confirming the pivotal regulative role of emotions in decision making, by providing evidence that mental imagery serves as both an origin and a catalyst for these emotions. Loewenstein et al. (2001) posited in their risk-as-feelings model that the ability to vividly envisage outcomes can be one of the key factors in generating emotions that shape people's risky decisions. This perspective aligns with a more recent Zaleskiewicz et al.'s (2023) theoretical framework, which contends that mental imagery is not only a cognitive process that enables 'pre-living' and 'trying-out' possible consequences but also an emotional intensifier that modulates the drive towards or away from risk-taking behaviors. The idea is based on earlier findings that suggest mental imagery wields the power to elicit emotions; wherein imagery with positive connotations tends to engender positive emotional responses, and conversely, imagery with negative connotations is associated with negative emotional reactions (Blackwell, 2020; Holmes, Geddes, et al., 2008; Holmes & Mathews, 2005; Ji et al., 2016). In addition to this, it has also been found that the disruption of mental imagery reduces the intensity of emotional responding (Andrade et al., 1997; Kavanagh et al., 2001). Within this framework and based on the outcomes of our present project, a multitude of inquiries emerge regarding the nuanced dynamics between mental imagery and emotional processes within the realm of risk-taking proneness. We discuss all of them in the next sections.

6.2.1. Vividness of mental imagery

First, it seems pertinent to inquire into the determinants that amplify or mitigate the linkage between mental imagery and emotional responses in decision making. The findings of our Study 4 revealed that the emotional impact of visualizing one's involvement in risk is augmented when mental images are processed with greater vividness. In this particular investigation, participants were requested to evaluate the (state) vividness of their mental imagery. It appears feasible, however, that certain strategies (or interventions) could be systematically employed to modulate the level of vividness, thereby influencing the emotional intensity associated with the imagery and, as a consequence, enhancing or reducing risk-taking propensity. For example, one strategy might involve the generation of mental images that are either concrete or abstract in nature. It could be hypothesized that concrete images (e.g., those more proximal in time) will possess a higher degree of vividness in comparison to abstract images (e.g., those more temporally distal). This supposition draws upon extant theoretical frameworks which are substantiated by empirical research elucidating the disparities in processing concrete versus abstract stimuli (Hemati & Hossein-Zadeh, 2018). Such differences have also been observed across a spectrum of mental imagery tasks (Jessen et al., 2000). Another strategy may draw upon the dichotomy between self-immersive vs. other-referential mental imagery in the context of risky behaviors. It seems reasonable to expect that individuals may generate more vivid mental representations when they imagine themselves as risk takers compared to imagining others. Research testing the self-reference effect in memory indicated that self-referent encoding strategies yield superior memory relative to other-referent encoding strategies (Symons & Johnson, 1997). The two aforementioned strategies are not mutually exclusive: it can be predicted that self-directed imagery is more concrete and, consequently, more

vivid than the one directed towards others.

Discussion regarding the moderating role of vividness within the nexus of mental imagery valence and emotional intensity in decision making should also encompass an examination of the underlying structure of the vividness construct. It has been proposed in the literature that vividness can be interpreted as a combination of two elements—clarity and liveliness (Marks, 1973, 1999). "The clarity of a visual image refers to the brightness of its colors and the sharpness of the outline and details. The liveliness of a visual image refers to how dynamic, vigorous and alive the image is" (Marks, 1999, p. 570). One may inquire which of these two dimensions—clarity (detailness) or liveliness—exerts a greater influence on the emotional responses of a decision maker, given that they may operate in a relatively independent fashion. Specifically, a mental image might lack clarity and details yet still be imbued with a sense of immersion. This parallels the instances where individuals struggle to recall details of very vivid and lively dreams (Beaulieu-Prévost & Zadra, 2015). To address this research problem, it would be essential to evaluate not only the overall vividness of mental imagery but also its distinct components, including the level of detail and liveliness.

6.2.2. Mental imagery vs. analytical thinking

Second, in our Study 3, we found that emotions played a more crucial role in decision making when mental representations of risk were formed through visual mental imagery rather than analytical or logical thinking. This implies that affective influence on decision making may vary based on the cognitive approach employed, with emotional impact intensifying during visualization over verbal deliberation. Significantly, Smieja et al. (2023) have shown in their recent work that preference for particular decision inputs (such as analytical arguments, emotions, memories, or mental images) is contingent on the context (risk domain). They observed that individuals most often resorted to mental imagery when faced with risks associated with recreational activities (e.g., extreme sports or ventures into hazardous environments). Conversely, in the financial domain, people least often reported the use of mental imagery when considering their involvement in risky activities. Here, the participants declared that they were much more prone to refer to analytical thinking. Synthesizing these findings, it can be inferred that decision making across different domains (Blais & Weber, 2012; Weber et al., 2002) varies with regard to the reliance on mental imagery and this, in turn, influences the degree to which emotions govern the decision-making process. A potential outcome might be a variation in individuals' vulnerability to affect-driven biases, such as the affect heuristic (Peters et al., 2006; Slovic et al., 2007), contingent upon the decision-making domain and, in relation to this, the extent of mental imagery's role in shaping the processing of risk. Although mental imagery is deemed an adaptive strategy in problem solving and decision making (Marks, 1999; Paivio, 2007; Zaleskiewicz et al., 2023), it could also predispose individuals to specific errors linked to heightened emotional engagement. This effect may be particularly likely to manifest in instances where decision makers employ mental imagery within their risk perception processes yet remain unaware of this (unconscious mental imagery; Nanay, 2021, 2023). This hypothesis warrants additional empirical investigation.

6.2.3. Positive vs. negative emotions

Third, in all studies encompassed by this project, there emerged a recurring pattern with regard to the mediating function of positive and negative emotions. Negative emotions served as a mediating factor between the valence of mental imagery and the inclination towards risk taking, but this was exclusively evident at the within-participant level. Such a mediating effect of negative emotions was not observable at the between-participants level. Conversely, positive emotions were found to significantly mediate this relationship at both levels. Delving into the within-participant level, the aim of the analysis is to decode and understand the diversity in individuals' readiness to take risks depending on situational context (decision domain). It appears that an individual's propensity to engage in risk is heightened when their imagery-induced emotions skew towards the positive spectrum and diminish in negativity. In other words, there seems to be a pronounced people's sensitivity to the emotional consequences, both uplifting and detrimental, stemming from visual mental images. Meanwhile, at the between-participants level, the willingness to partake in risky activities is predominantly influenced by positive emotions elicited by mental imagery. This suggests that individuals who can generate positive mental scenarios and consequently experience heightened positive affect are more likely to engage in risk-laden activities compared to those whose positive feelings are less intense. Negative emotions appear to play a less distinctive role. A plausible interpretation of this phenomenon could be rooted in the concept that risk aversion is an intrinsic or fundamental characteristic of human conduct (Zhang et al., 2014), indicating a default behavioral tendency. It is, therefore, individuals who perceive risk taking as more emotionally gratifying who are more inclined towards accepting risk in their choices. Nonetheless, this intriguing effect requires further empirical examination.

6.2.4. Dynamic interplay between mental imagery and emotions

Finally, in the present project, we specifically concentrated on a unidirectional relationship between mental imagery and emotional responses, postulating that mental imagery serves as a source for the latter. However, it is conceivable that mental imagery and emotions remain in a dynamic and reciprocal relationship. This implies that emotions may serve as both a consequence and a foundation for visual mental imagery. Clinical psychology offers insights supporting this assumption, particularly with regard to research investigating depression. Evidence indicates that depression is correlated with a reduction in positive mental imagery and an amplification of negative mental imagery (Blackwell, 2019; Holmes et al., 2016). Such findings suggest a broader hypothesis: individuals outside of clinical populations may similarly exhibit a tendency to conjure vivid and adverse mental images following negative emotional experiences, such as anxiety or sadness, or conversely, generate positive mental images in response to strong positive emotions, like excitement or joy. The concept of somatic markers further enriches this discussion (Bechara & Damasio, 2005; Poppa & Bechara, 2018). Somatic markers idea posits that emotions, as reflected in bodily changes, are informed by past experiences and serve to direct decision making in new situations—for instance, influencing a decision maker to either embrace or eschew a risky proposition. It is possible that somatic markers may also act as a catalyst in the generation of mental imagery during decision-related deliberations. For instance, if an individual previously experienced an accident while participating in extreme sports, the somatic markers may not only evoke a specific physiological response that reduces their motivation to engage but also amplify vivid mental images of the possible negative outcomes of risk taking. This assertion aligns with existing research that documents a tight link between mental imagery and episodic memory (Kosslyn et al., 2001; Schacter et al., 2008).

6.3. Limitations and future research directions

In this section, we review limitations inherent to our current work and, on this basis, suggest directions for future empirical investigations.

6.3.1. Online vs. laboratory studies

First, it should be noted that all four studies were conducted online, using the Prolific platform. Although the quality of data obtained from online labor markets has been questioned, different analyses have suggested that data collected on MTurk and Prolific Academic are valid and comparable to data collected via traditional methods (Buhrmester et al., 2011; Mason & Suri, 2012; Peer et al., 2017). Nevertheless, future research examining the interplay between mental imagery and emotions in the context of decision making under risk should be conducted in the

laboratory setting to replicate the online effects.

6.3.2. Measures of emotions

Second, our data collection on emotional intensity relied solely on self-report measures. Although this approach is generally recognized as efficient, existing literature highlights that alternative emotional measurement methodologies are marked by inherent variances unique to each (Mauss & Robinson, 2009). In light of this, future research should corroborate and broaden the scope of our current study's findings through the incorporation of neurophysiological methodologies in future research. These would include electroencephalograms (EEG), galvanic skin response (GSR), eye tracking systems, and electromyography (EMG). In addition, implementing behavioral assessments to gauge the propensity for risk taking could also offer a more nuanced understanding of this phenomenon, as self-reports may not fully capture the multidimensional nature of risky behaviors (Aklin et al., 2005).

6.3.3. The object of mental imagery

Third, our inquiry delved into participants' propensity to take risky actions across various domains. Participants were prompted to visualize themselves in different scenarios, subsequently reporting their emotional responses and inclination towards risk taking. We anticipated a correlation wherein more positive mental visualizations would correspond with heightened positive emotions and an increased propensity for risk taking. This conjecture led to a binary choice model: participants balanced between embracing a risky venture or maintaining the status quo. Nonetheless, real-world decisions are seldom so binary; individuals often weigh multiple options, each carrying its own set of potential gains and losses. Literature suggests (Zaleskiewicz et al., 2023) that in such multifaceted decision-making processes, people are inclined to conjure mental imageries of varying outcomes for all available choices. Their final decision then hinges on the perceived balance of these imagined scenarios' positive and negative attributes. For future studies, it would be prudent to adopt a more complex decision-making framework that mirrors real-life complexity. Instead of a simplistic accept-or-reject paradigm, participants could be presented with a spectrum of choices and asked to envision and evaluate the potential consequences of each.

6.3.4. The potential role of individual differences

Fourth, in the current project, we did not control for the potential moderating role of individual dispositions. However, given the domain of our investigation—the dynamic interrelationship among mental imagery, affective responses, and risk-taking tendencies—it is pertinent to consider two primary dimensions of individual differences: the ability to produce vivid mental imagery (Marks, 1973, 1999) and emotional intensity (Larsen et al., 1986). The data derived from our Study 4 suggest that the vividness of mental imagery exerts a moderating effect on the association between the valence of mental images and the intensity of emotional responses. The influence of mental images on affective states was amplified by the greater vividness of mental visualization. Recent studies highlight significant individual variability in 'phantasia'–the capacity to generate vivid visual mental imagery–with aphantasia and hyperphantasia representing the two opposite extremes of this spectrum (Milton et al., 2021; Zeman, 2024; Zeman et al., 2020). Consequently, it is reasonable to hypothesize that individuals with an enhanced ability to generate vivid mental images (i.e., those with hyperphantasia) would similarly exhibit heightened emotional responses to such images. At the opposite extreme would be aphantasic individuals, who are unable to visualize and report little to no use of vivid mental imagery in daily life (Keogh & Pearson, 2018; MacKisack et al., 2016; Zeman, 2020). These individuals may be more inclined to rely on calculus-based evaluations and exhibit weaker emotional responses when asked to employ mental imagery in the decision-making processes.

Individual differences in the vividness of mental imagery may also arise from dispositional traits that are not directly related to the ease of generating visualizations. For example, Blackwell et al. (2013) found that individuals with high self-reported optimism were more likely to produce vivid mental images of the future, characterized by highly positive valence. In contrast, research by Du et al. (2022) indicated that anxious individuals tended to generate vivid imagery, but it was filled with negatively valenced elements.

Pertaining to the second domain of individual differences—affect intensity—our prediction, informed by earlier findings of Chan and Saqib (2021), would be that mental imagery exerts a more pronounced impact on the emotional experiences of individuals characterized by lower scores on affect intensity measure. Typically, such individuals do not prominently engage with their affective states, a pattern that may shift when they are induced to conjure and engage with vivid mental imageries of their own risk-laden behaviors.

6.3.5. Different modalities of mental imagery

In this project, we focused exclusively on visual mental imagery. While mental images can encompass various sensory modalities (e.g., auditory, haptic, gustatory, and olfactory), previous research has demonstrated that individuals tend to report greater vividness for visual imagery compared to other senses (Belardinelli et al., 2004; Schifferstein, 2009; Switras, 1978). This suggests that the visual modality plays a dominant role in mental imagery. Nevertheless, future studies exploring the relationship between mental imagery and decision making could examine the specificity of different modalities, particularly in the context of individuals' risk-taking behaviors.

6.4. Concluding remarks

In the scope of this research, we have demonstrated that visual mental imagery constitutes a significant emotional catalyst in people's willingness to engage in risky activities. Our empirical evidence indicates that more positive visualization concerning one's participation in risky situations amplifies positive affect while simultaneously diminishing negative affect. This dual emotional effect ostensibly escalates an individual's propensity to take risks. In contrast, negative mental imagery yields opposite outcomes. Furthermore, the intensity of the emotions implicated in decision making under risk is proportional to the vividness of the mental imagery. Additionally, our findings delineate a differentiation between mental imagery and analytical thinking as strategies or informative inputs used in decision making. Notably, visual representations are shown to possess a superior influence in engendering emotions related to risk, as opposed to the employment of analytical deliberation, which engages in a systematic evaluation of potential outcomes associated with decisions.

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CRediT authorship contribution statement

Joanna M. Smieja: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tomasz Zaleskiewicz:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Agata Gasiorowska:** Writing

– original draft, Visualization, Formal analysis, Data curation.

Declaration of competing interest

The authors declare no competing financial or personal interests that could have influence their work reported in the article.

Supplementary data

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Data availability

Data available on request from the authors.

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Odnośniki do materiałów dodatkowych:

Artykuł 1. *Imagining risk taking: The valence of mental imagery is related to the declared willingness to take risky action* - https://doi.org/10.1002/bdm.2340

Artykuł 2. *Mental imagery shapes emotions in people's decisions related to risk taking* - https://doi. org/10.1016/j.cognition.2025.106082