Needing Everything (or Just One Thing) to Go Right:
The Psychology of Multi-Component Risk Preferences
Abstract
Multi-component risks are those whose overall success depends on the success or failure of component events. Disjunctive risks require the success of just one such component. Conjunctive risks, all of them. Across five studies, we examine people’s preferences for multi-component risks of each type. People prefer to consolidate disjunctive risks into fewer components and spread conjunctive risks across more. In this way, disjunctive risk takers—who need just a single success, one that rows increasingly unlikely as more components’ outcomes are revealed—can maximize their chances for an immediate win by pooling their chances for success into fewer components. In contrast, conjunctive risk takers—who always face the prospect that one failure will doom the broader endeavor—face a relatively low chance of immediate failure as they approach each component. In other words, disjunctive and conjunctive risk takers are myopic—disproportionately focused on maximizing the chances for an immediate reward or minimizing the chances for an immediate failure, respectively. Participants revealed these preferences in employee allocation decisions as well as valuations of different lotteries. The preference for consolidating disjunctive risks and spreading conjunctive risks emerged most strongly when the risk’s components played out or were revealed in sequence, but less so or not at all when they were realized all at once. Process evidence suggested that risk-takers did not merely stumble with difficult statistical calculations or follow their own subjective probability judgments, but were sensitive to how confident they expected to feel when multi-component risks unfolded in the preferred manner.

Keywords: multi-component risk, consolidating, spreading, confidence, myopia
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Consider an entrepreneur who seeks outside investors to support his business venture. After identifying 5 potentially interested investors, he might take one of two approaches. He could approach all 5 investors with a big ask, to pony up enough money to be the sole backer of his venture. Each large request may be relatively unlikely to be met, but the investor would need just a single success. Instead, he might approach each of the 5 with a more modest request: to fund just 1/5 of his business proposal. In this case, it may be easier to get each investor on board, though he would need the support of every investor in order for his plan to move forward.

In each case, the investor faces a multi-component risk: Meeting the funding goal depends on some number of successes among the probabilistic components. But his success in securing funding depends on one of two qualitatively different criteria. We call risks of the first type disjunctive risks—those in which the overall outcome is a success if at least one of its constituents proves successful. We label risks of the second type conjunctive risks—those in which the overall outcome is successful if and only if each constituent is a success. A fundamental goal of this paper is to consider differences in how people approach and evaluate disjunctive and conjunctive risks.

Multi-component risks differ not only in how success is achieved, but over how many components the risk is spread. The entrepreneur who needs one angel investor may spend his month trying to sell 3 or 300 possible benefactors. Focusing his efforts on just three potential backers may allow him to be better prepared to obtain each one’s endorsement, but consolidating the risk into just 3 components does limit the number of options for achieving success. In contrast, the entrepreneur who needs the support of everyone she approaches might seek out the
help of 5 medium-sized investors or 10 small-scale investors. When the conjunctive risk-taker spreads the risk across more components, this may increase her chance of success with each one, but it also means there are more investors to whom she must make a successful pitch.

Most centrally, we argue that disjunctive and conjunctive risk takers—even when they face the same objective overall probability of success—will have a preference to consolidate or spread their risks (e.g., across fewer or more components), respectively. Why would this be? One explanation likely lies in a challenge people face in calculating the probability of success for a multi-component risk. Most people are not statisticians. Translating information about the chance of each component’s success into an estimate that at least one component (disjunctive risk) or all components (conjunctive risk) are successes requires a bit of mathematical sophistication.

To understand how people might falter on such a task, it is useful to consider how the number of components (Y), the probability that each individual component is successful (X), and the overall probability of success relate (and relate differently) for disjunctive and conjunctive tasks. The probability that at least one of Y components is a success is $1 - (1 - X)^Y$. In this case (and holding the prospect of overall success constant), as Y increases X will instead decrease. Now consider a conjunctive risk. The probability that all Y components are successes (as conjunctive risks require) is $X^Y$. If we hold the overall probability of success constant, there is a positive relationship between Y and X: If a risk is spread across more components, then the probability of success at each component rises as well. Table 1 illustrates these relationships by considering disjunctive and conjunctive multi-component risks that vary in their number of components (between 2 and 6). It indicates what probability of success must be offered by each
Table 1. Component success probabilities for multi-component risks that offer a 50% chance of overall success

<table>
<thead>
<tr>
<th>Number of components</th>
<th>Disjunctive risk</th>
<th>Conjunctive risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>29.3%</td>
<td>70.7%</td>
</tr>
<tr>
<td>3</td>
<td>20.6%</td>
<td>79.4%</td>
</tr>
<tr>
<td>4</td>
<td>15.9%</td>
<td>84.1%</td>
</tr>
<tr>
<td>5</td>
<td>12.9%</td>
<td>87.1%</td>
</tr>
<tr>
<td>6</td>
<td>10.9%</td>
<td>89.1%</td>
</tr>
</tbody>
</table>

Note: Each percentage reflects the probability that an individual component will yield a successful outcome, assuming each component’s results are independent of the others’.

Of course, many people are unlikely to get these formulae and mathematical dependencies just right. Instead, they may anchor on each individual component’s probability and adjust insufficiently to arrive at an estimate of the multi-component risk’s overall probability of success (Gneezy, 1995). In other words, the subjective probability of a joint event is likely to be systematically biased in the direction of the probability of its components (Bar-Hillel, 1973; Holtgraves & Skeel, 1992; Linville, Fischhoff, & Fischer, 1993; Slovic, 1969; Slovic, Fischhoff, & Lichtenstein, 1978). This means that when considering disjunctive or conjunctive risks that have the same overall probability of success, decision-makers may be more drawn to disjunctive risks that consolidate the risk into fewer components and conjunctive risks that spread risks among more components (see again Table 1).

Although we grant that calculating probabilities of multi-component risks is difficult, we argue that laypeople’s shortcomings with statistics tell only part of the story. More specifically, we posit that a more general myopia or short-term focus that characterizes decision makers leads them to be enticed by disjunctive and conjunctive risks with different properties. That people are
myopic is reflected in a number of people’s tendencies: to be swayed by impulses and
temptations that derail them from their goals (Hock & Loewenstein, 1991), to stagnate during
periods of immediate uncertainty because they fail to look ahead and see that their next decision
does not depend on resolving it (Shafir, 1994; Tversky & Shafir, 1992), and to actually make a
decision without giving sufficient thought to its implications for future decisions one will face
(Kahneman & Lovallo, 1993; Read, Loewenstein, & Rabin, 1999). Driven by myopia, people
focus on outcomes that are imminent and thus underweight consequences that are more distal
(Walker, Risen, Gilovich, & Thaler, 2018). Applied to a multi-component risk, myopia has been
shown to change how people prefer that components be sequenced. Facing a conjunctive risk (in
which one must succeed at every component), people would rather the components offering a
high-probability of success precede those offering a low probability. This myopic preference can
be strong enough to push people toward lotteries with lower expected values (Budescu & Fischer,

Myopia reflects a short-sighted focus, but a focus on what? Note that for both disjunctive
and conjunctive risk takers, each component can prove immediately determinative (of the
outcome) and thus potentially wresting of attention. For disjunctive risk takers, each
component’s resolution brings only the possibility of an overall success. For conjunctive risk, the
reverse is true: They lose after just one component’s failure. In such contexts, myopia should
lead disjunctive risk takers to try to maximize the probability of immediate success, whereas
conjunctive risk takers will try to minimize the prospects of immediate failure.

How do disjunctive and conjunctive risk-takers try to accomplish these goals? Most
obviously, they may prefer to consolidate disjunctive risks into fewer components and spread
conjunctive risks across more components. As was displayed in Table 1, this will help to
maximize the immediate chances of disjunctive risk-takers’ succeeding and minimize the immediate chances of conjunctive risk-takers’ losing. This should help with disjunctive risk-takers’ myopic interest in sealing the deal as soon as possible. Such risk-takers may be less attuned to the non-immediate consequence of having fewer opportunities for success (itself a form of what psychologists have called extension neglect; see Kahneman & Frederick, 2002) and instead be more enticed by maximizing their probabilities that the next component will deliver a win. In contrast, conjunctive risk-takers have an interest in remaining in the game for longer (Cohen et al., 1972). For example, basketball coaches tend to try sending a game to overtime by taking a low-risk two-point shot instead of trying to win the game with an immediate three (Walker et al., 2018).

If myopia is indeed responsible for these divergent preferences, then it should matter how these individual components actually play out across time. In other words, the logic we just advanced depended not only on splitting a risk into more or fewer components, but on those components actually unfolding across time (as opposed to all at once). We have argued that disjunctive risk takers have a preference for consolidating risks into fewer components, which maximizes the likelihood of an immediate success. But temporal consolidation—i.e., having the component outcomes revealed at once instead of in a sequence—offers an alternative way to meet that goal. A scientist who needs only one assistant on her team to succeed in carrying out a complex experiment may divide her limited resources among just a few assistants, thereby insuring that each assistant has resources that maximize her chance of success. Alternatively, the lead scientist may have her team attempt the risky procedure at the same time. Both forms of consolidation—among fewer components or across less time—maximize her prospects for immediate (even when they have no effect on long-term) success. In other words, the preference
for consolidating disjunctive risks may be reduced when the outcome of each constituent is revealed all at once (as opposed to across time).

Myopia has different, but analogous, implications for how people may prefer to approach conjunctive risks. The conjunctive risk-taker who spreads that risk across more components will most effectively achieve the comfort of facing relatively certain immediate prospects when those components unfold in sequence. But if success or failure with each component is realized at the same time, such spreading across more components can no longer provide the psychological comfort that a myopic look at the immediate present would encourage. For example, the boss whose project depends on the success of all of his employees’ component projects may prefer to spread that risk across a larger number of more manageable chunks, especially if he will hear the results of each worker’s efforts separately. On the contrary, if the success or failure of each employee is revealed simultaneously, then the short-term benefits of spreading are lost. In short, we expect the preference for consolidating disjunctive risks and spreading conjunctive risks to be stronger when the outcome of each constituent is revealed in sequence across time as opposed to all at once.

Note that these hypotheses concerning how multi-component risks play out across time take a qualitatively new approach to the study of people’s preferences regarding delaying the resolution of uncertainty. For example, some research has examined how—in different domains—people differ in whether they would like to prolong uncertainty or resolve it quickly. Reflecting an interest in waiting, people would rather not know what they will get for Christmas or when they will die (Gigerenzer & Garcia-Retamero, 2017). On the other hand, the College Board charges college applicants to learn their SAT scores early by phone. In other words, it is certainly possible that multi-component risk takers might have an overall preference for
resolving uncertainty slowly (in sequence) or quickly (all at once). But we do not examine time in an effort to probe main effects. Instead, we are interested in the time course over which a risk unfolds as a key moderator that does or does not permit risks to be truly spread or consolidated.

Five studies test our hypotheses regarding people’s interest in consolidating disjunctive risks and spreading conjunctive risks. Study 1 has people role play the role of a manager who must decide whether to assign more or fewer employees to a disjunctive risk or conjunctive risk project. The remaining studies offer clean tests of our logic in the context of a dice game that includes more or fewer dice (components) whose outcome will be determined all at once or in sequence. Studies 2a and 2b test whether disjunctive and conjunctive risk-takers display a preference for lotteries consolidated into fewer or spread into more components, respectively, especially when those unfold sequentially. Studies 3 and 4 also examine disjunctive and conjunctive risks, respectively, but with slightly different goals. Study 3 provides a more precise test of our reasoning by unconfounding whether the random process itself unfolds sequentially or is revealed in sequence. Study 4 more thoroughly examines risk-takers’ feelings about and evaluations of multi-component risks that unfold across more or fewer components that occur all at once or across time.\(^1\)

\(^1\) At the conclusion of every study, we asked participants one question to make sure they encoded the key manipulation correctly. Note that this attention check is harder than one that merely verifies that participants were paying attention to the content of the question just asked. Instead, it both verifies that a participant is not merely responding randomly (as a bot or someone merely rushing through a study in order to maximize earnings might do) and that they paid attention to and internalized the key experimental instructions provided in the study’s introduction. Averaging across our five studies in the main manuscript and one supplemental study, we excluded 24% of participants for failing this check. Most of these participants essentially believed that they had been assigned to the other condition (e.g., that dice would be rolled all at once when in actuality they were rolled one-at-a-time in sequence). Given this, it is unsurprising (and reinforcing of this interpretation) that in four of our five studies the predicted effects were statistically significantly smaller for those who failed the attention check. Interested readers can find these analyses in the Supplemental Materials.
Study 1

In Study 1, participants were asked to role play a manager deciding how many employees to place on a work project. For those who considered a disjunctive risk, the managers needed only one of their employees to succeed on their respective subcomponents for the overall project to be a success. When managers instead confronted a conjunctive risk, they needed all workers to be successful. The key decision was how many employees to assign to the task: 2, 3, 4, 5, or 6. Given our arguments that people prefer to consolidate disjunctive risks and spread conjunctive risks, we predicted that fewer workers would be allocated to the disjunctive-risk project.

Method

Participants and design. A total of 100 adults recruited via Amazon Mechanical Turk (AMT) participated in exchange for monetary compensation. Each participant was randomly assigned to one of two risk conditions: disjunctive or conjunctive. Thirteen participants failed an attention check at the study’s conclusion that asked them to identify the condition to which they had been exposed (“I needed them all to succeed” or “I needed at least one of them to succeed.”) This left 87 participants in results reported below. The methods, sample size, hypotheses, and analysis plan were preregistered: http://aspredicted.org/blind.php?x=e8ir6e. Readers interested in conducting additional analyses other than those reported in the main paper can find raw data and analysis code for this and every study here: https://osf.io/hbg8/?view_only=29d9b3873d854826b21a3d80689586a6.

Procedure. Participants were asked to play the role of a work manager who had to decide how many employees—2, 3, 4, 5, or 6—to put on a task. Each employee would work on a different part of the project. How it would be determined whether the overall project was a
success differed by risk condition. Crucially, in both conditions—and regardless of the number of employees placed on the project—the actual chance of project success was constant.

**Disjunctive risk.** In the *disjunctive* risk condition, the project was divided up so that the project’s success required only one individual employee to be successful. But by adding more employees to the project, it would make it more difficult for each individual employee to succeed (as though employees had to split the same finite support). This means that each individual employee is more likely to succeed if there are fewer others working on the task. Participants received the probability information in Table 1 to help inform their decision. For example, when only 2 employees worked on the task, the probability that each one would succeed was 29.3%. But when 6 employees were put on the project, the chance of each individual’s success dropped to 10.9%. That is, with more employees assigned to the task, the chances that any one of the employees would prove successful declined.

**Conjunctive risk.** When the risk was *conjunctive*, then the project was successful if and only if each individual contributor was successful. By adding more employees to the task, the part of the task that each employee would work on would become more manageable. In this way, each individual employee became more likely to succeed if there were more fellow employees on the same project. As illustrated in Table 1, when only 2 employees worked on the task, the probability that each would succeed was 70.7%. By adding 4 additional employees, the probability of each individual’s success rose to 89.1%. But with more employees, there were more employees who had to succeed for the overall project to be considered a success.

**Results and Discussion**

Participants who confronted a disjunctive risk (one in which only one employee would need to succeed) preferred to place fewer employees on the task \((M = 3.26, SD = 1.25)\) than
those who confronted a conjunctive risk (one in which all employees would have to succeed; $M = 4.41, SD = 1.38$), $t(85) = 4.09, p < .001, d = 0.88$ (see Figure 1). In other words, people display a relative preference for consolidating disjunctive risks (reducing them to a few events) and spreading conjunctive risks. Although this pattern of results is descriptively intriguing, these preferences did not exact any cost on managers’ chances of success. After all, projects’ overall chance of success did not vary depending on managers’ employee allocation decision.

We ran a follow-up study (Supplemental Study) in which we slightly modified the percentages shown in Table 1. In this version, adding more employees to the disjunctive-risk project actually raised the project’s chance of success, whereas adding employees to the conjunctive-risk project actually lowered the project’s chance of success. Still, participants ($N = 102$, AMT; $N = 91$ after attention check exclusions) showed a (now costly) preference for consolidating disjunctive risks and spreading conjunctive risks, $t(89) = 6.76, p < .001, d = 1.42$. Details of this study appear in the Supplemental Materials.

![Figure 1](image-url)  
*Figure 1.* The frequency of Study 1 participants choosing to put each number of employees on the project when risks were *disjunctive* (left panel) and *conjunctive* (right panel).
One worry is that Study 1’s results may reflect not a preference for consolidating versus spreading risks but a difficulty with calculating disjunctive and conjunctive probabilities. Studies 2a and 2b address this limitation by considering another dimension along which risk spreading and consolidating can emerge: time. In this way, the studies hold the mathematical difficulty of probability calculations constant while probing the nature of participants’ risk preferences in a complementary way.

**Studies 2a and 2b**

Studies 2a and 2b set out to better understand whether and what it means that people prefer to consolidate disjunctive risks and spread conjunctive risks. Participants considered how much they would be willing to pay to play different die-rolling lotteries. When the game took the form of a disjunctive risk (Study 2a), a win required that only one of the dice land on a winning number. When the game reflected a conjunctive risk (Study 2b), a win would be achieved only if every die rolled an acceptable number. In order to test an interest in consolidating or spreading, we varied the number of components (i.e., dice) while holding the probability of overall success constant. This complements the test used in Study 1: Instead of asking participants how many components (in that case, workers) they would prefer to involve, we instead looked to see whether equiprobable disjunctive and conjunctive risks were priced higher as their number of components decreased and increased, respectively.

We manipulated one additional factor: how the dice game would unfold. For some participants, they learned it would unfold *sequentially*, with each die rolled one at a time. But for other participants, they were told the die rolls would occur *simultaneously*. If the desire to consolidate disjunctive risks reflects an interest in maximizing the prospect of an imminent win, then consolidating the risk into fewer components should provide this benefit less clearly if the
components’ outcomes are going to be realized spontaneously anyway. Analogously, if conjunctive risk takers would like to minimize their chance of an immediate loss, then the benefit of spreading that risk across more components should be reduced when the components’ fate is realized simultaneously. In summary, we expect that disjunctive and conjunctive risk takers will value equiprobable lotteries higher when they have fewer or more components, respectively, especially when those components unfold sequentially.

**Study 2a: Method**

**Participants and design.** We used Amazon Mechanical Turk to recruit 282 Americans, who took part in the study in exchange for nominal payment. Participants were randomly assigned to either the simultaneous or sequential process condition. Seventy-four participants failed an attention check that asked how the game would be played. Correct answerers indicated either that they “would roll up to 6 dice one at one time” (sequential condition) or that they “would roll between 2 and 6 dice all at once” (simultaneous condition). This left 208 participants in all analyses reported below.

**Procedure.** Participants learned they would play up to 25 rounds of a gambling game. For each round, participants would receive a number of dice—2, 3, 4, 5, or 6. Each die was unique, possessing a different color. At the start of each round, participants received information about which numbers were winning vs. forbidden for each die. The round would be won with a single winning die (see Figure 2). In other words, participants lost only if they threw no winners (and solely forbidden numbers). The 25 trials were presented in a random order. The versions were created by fully crossing the number of dice (2, 3, 4, 5, or 6) and the probability of winning (approximately .67, .75, .78, .83, and .89; see Appendix A).
Figure 2. Sample stimuli from Study 2a. In this version of the lottery, there are 4 dice. For the red, green, purple and pink dice, the numbers 1, 1, 1 to 2, and 1 to 3 are winners, whereas the numbers 2 to 6, 2 to 6, 3 to 6, and 4 to 6 are forbidden, respectively.

All that varied between the two conditions was how the dice would be thrown. In the *sequential* process condition, participants were told they would roll the dice one after another, looking at the outcome after each roll. In the *simultaneous* process condition, participants were told they would roll all the dice at once. Knowing that a win was worth $10, participants indicated the most they would be willing to pay (an amount that would be forfeited regardless of whether participants won or lost, what we called a “dice fee”) to play the gamble.

**Study 2a: Results and Discussion**

Given participants confronted a disjunctive risk, we predict they should show a preference for consolidating (as opposed to spreading) that risk into fewer events. To test this hypothesis, we started by constructing a simple mixed model that included two fixed effects: number of *dice* (2 dice: -2, 3 dice: -1, 4 dice: 0, 5 dice: +1, 6 dice: +2) and win *probability* (also coded from -2 to +2 in integer increments). To account for the non-independence of each participant’s 25 responses, we included a random effect of participant. Finally, to attenuate positive skew in participants’ self-reported willingness to pay for each lottery, we log-transformed our willingness-to-pay (WTP) outcome variable.
Unsurprisingly, we observed a large positive main effect of probability, \( B = 0.051, SE = 0.003, t(4990) = 15.85, p < .001, 95\% CI = [0.044, 0.057] \). Participants were sensitive to the actual win probabilities: They were willing to pay more when the chances of success were higher.

But also, participants were willing to pay more to consolidate this risk into fewer dice, \( B = -0.019, SE = 0.003, t(4990) = -6.10, p < .001, 95\% CI = [-0.026, -0.013] \). Does this reflect participants’ merely being unaware of how to calculate disjunctive risks, or instead do they show a preference for consolidating even when this calculation is held constant?

We proceeded by adding our *process* manipulation (sequential: -1, simultaneous: +1) as a third fixed effect to the model. Crucially, we also included all possible interaction terms that can be made from these three fixed effects. Of key relevance is the Process \( \times \) Dice Number interaction, \( B = 0.007, SE = 0.003, t(4986) = 2.33, p = .020, 95\% CI = [0.001, 0.014] \). The positive value of beta suggested that participants’ preference for consolidating disjunctive risk is especially strong when the events unfold sequentially: \( B = -0.027 \). But when the die rolls are already consolidated into a single throw, participants became less sensitive to how many dice they were throwing: \( B = -0.013 \). After all, when the dice are thrown simultaneously, the risk unfolds in the same consolidated manner regardless of how many dice are thrown (see Figure 3A).

**Study 2b: Method**

**Participants and design.** A total of 436 Americans recruited via Amazon Mechanical Turk took part in this study. Each participant was randomly assigned to one of two *process* conditions: sequential or simultaneous. One hundred forty-five participants were excluded from all analyses based on an attention check. They were unable to indicate either that they “would
Figure 3. Willingness-to-pay for the lottery as a function of dice number. In Study 2a, the lottery was a *disjunctive* risk, and a win was worth $10 (A). In Study 2b, the lottery was a *conjunctive* risk, and a win was worth $50 (B). All predicted log-transformed means were back-transformed so they appear on the original scale.

Procedure. Participants learned they would assess 25 rounds of a game. The game was similar to the one described in Study 2a, but in this case the numbers were labelled as *acceptable* or *forbidden* for each die. Participants would win if only acceptable (and no forbidden) numbers were rolled. And like before, participants learned that they would play the game by throwing the dice one at a time (*sequential* condition) or all at once (*simultaneous* condition). This left 291 participants in all analyses reported below.

To keep the probability of winning these conjunctive lotteries from being too low, we also modified which numbers were and were not acceptable numbers. The details for what constituted acceptable numbers for each game can be located in the Appendix B. Finally, we increased the amount that could be won on each game from $10 to $50. We took this step
because the probability of winning was lower, given one needs to roll acceptable numbers for all dice. That is, the win probabilities were approximately .11, .17, .22, .25, and .33.

**Study 2b: Results and Discussion**

We followed a similar analytic approach to that used in Study 2a. To begin, we used number of dice (coded from -2 to +2) and win probability (coded from -2 to +2) to predict (log-transformed) willingness to pay. We also included participant as a random effect. Finding participants were sensitive to the true probability of winning the game, we observed a strong positive effect of probability, $B = 0.076$, $SE = 0.004$, $t(6982) = 20.69$, $p < .001$, 95% CI = [0.069, 0.083]. But in this case, there was a positive effect for the number of dice, $B = 0.089$, $SE = 0.004$, $t(6982) = 24.29$, $p < .001$, 95% CI = [0.082, 0.096]. This is opposite of what we observed in Study 2a, thus displaying a preference for spreading (rather than consolidating) conjunctive risks across more events.

Our next model, which incorporated the process manipulation (sequential: -1, simultaneous: +1), was designed to be a more nuanced test of our theoretical account. In so doing, we can make sure that the preference for spreading does not merely reflect a difficulty in assessing the probability of conjunctive risks. Using the same model specification we did in Study 2a, we observed the critical Process X Dice Number interaction, $B = -0.014$, $SE = 0.004$, $t(6978) = -3.71$, $p < .001$, 95% CI = [-0.021, -0.007]. That this beta is negative shows that participants’ preference for spreading conjunctive risks is attenuated when spreading the events across time is no longer possible (because all die rolls occur simultaneously). When spreading events across events (dice) also allows them to be spread across time (sequential condition), participants were clearly willing to pay more to spread the risk across more dice: $B = 0.106$. But when spreading events across events would not also allow them to be spread across time
(simultaneous condition), the preference for spreading was reduced by 26%: B = 0.078 (see Figure 3B).

**Study 3**

Our final two studies were designed to probe more deeply the nature of people’s preferences for consolidating or spreading multi-component risks. Because of our interest in replicating the findings of Studies 2a and 2b, we had Studies 3 and 4 examine disjunctive and conjunctive risks, respectively. Beyond that, the studies examined different aspects of the preference for consolidating versus spreading. Study 3 examined what exactly people are aiming to consolidate or spread. Study 4 examined psychological mediators of the effects of consolidating or spreading on preferences.

To begin, Study 3 aimed to unconfound the process by which the risk unfolds (i.e., the timing of the die rolls) from the timing of when the components’ outcomes would be revealed. More specifically, we held constant the process by which the dice game would unfold; the dice would always be rolled sequentially. But what we varied was how the outcomes of the rolls would be revealed. For some participants, the die rolls would be visible immediately. For other participants, this revelation would be delayed, disclosed only after all dice were rolled.

Given Study 3 returned to Study 2a’s disjunctive risk paradigm, consider what different pattern of results would mean for our understanding of multi-component risk-takers’ preferences. If disjunctive risk takers are merely sensitive to the means by which the random events are determined, then their preference for consolidation should be equivalent in both conditions (given the dice are to be rolled sequentially in both cases). If instead disjunctive risk takers are interested in consolidating risks so that they maximize the chance of good news when they begin to receive outcome feedback, then the interest in consolidating should become stronger when the
dice outcomes are revealed immediately but be relatively high when they are revealed all at once after a delay.

**Method**

**Participants and design.** Three hundred thirty-two participants were recruited from Amazon Mechanical Turk. They were randomly assigned to one of two reveal conditions: immediate or delayed. Seventy-nine participants failed an attention check: They were unable to recognize that the gambling game would have them “roll up to 6 dice one die at a time.” This left 253 participants in all analyses reported below.

**Procedure.** Participants considered a disjunctive-risk dice game, much like that used in Study 2a. That is, participants would win only if they threw at least one winning number. (They would lose only if all of the 2, 3, 4, 5, or 6 dice they threw were forbidden numbers.) In this case, all participants knew that playing the game would entail throwing the dice one at a time. All that varied between the two reveal conditions was whether participants would learn the outcome of each die roll immediately after throwing it (immediate reveal) or only once all dice were thrown (delayed reveal). The 25 variants of the game were presented in a random order. Participants indicated the most they would be willing to pay to play each round, assuming a win would net them $10.

**Results and Discussion**

We began by testing whether people showed an overall preference for consolidating disjunctive risks. In the first model predicting (log-transformed) willingness to pay, we included only two fixed effects: the number of dice and win probability. To account for non-independence, we included a random effect of participant. Suggesting participants were sensitive to variation in their true likelihood of winning, we observed a positive main effect of probability, $B = 0.051, SE$
= 0.003, \( t(6069) = 19.13, p < .001, 95\% \text{ CI} = [0.046, 0.056] \). But in this case, we did not observe a negative main effect of dice number, \( B = -0.003, SE = 0.003, t(6069) = -1.17, p = .241, 95\% \text{ CI} = [-0.008, 0.002] \). We proceeded to our next model to see if our manipulation may have obscured evidence for what has otherwise been a robust interest in consolidating disjunctive risks.

We added the reveal manipulation as a fixed effect (-1: immediate, +1: delayed), as well as all possible interaction terms including the fixed effects. As expected, we found a Reveal X Dice Number interaction, \( B = 0.011, SE = 0.003, t(6065) = 4.10, p < .001, 95\% \text{ CI} = [0.006, 0.016] \). The positive beta of the interaction shows that participants preferred to consolidate the number of events composing a disjunctive risk only when that risk was not already consolidated (by revealing all events at once). That is, when the outcome of multiple events would be revealed one at a time, participants preferred to consolidate those into fewer events (and thus fewer reveals), \( B = -0.015, SE = 0.004, t(6065) = -3.81, p < .001, 95\% \text{ CI} = [-0.023, -0.007] \). But when the outcome was already consolidated (because there would be a single, delayed reveal), participants no longer showed a preference for consolidation, \( B = 0.0069, SE = 0.0036, t(6065) = 1.91, p = .056, 95\% \text{ CI} = [0.0002, 0.0140] \). In fact, they showed a modest, unpredicted preference for spreading (Figure 4). This reflects that the preference for consolidating disjunctive risks does not reflect an inherent preference simply for how a risky event unfolds or even how many events define it, but in how such outcomes are ultimately revealed.

Study 4

Having shown that multi-component risk takers are not simply responding to the timing of the random procedure itself, but instead to the timing of how the components’ outcomes are revealed, we proceeded to better understand the psychological mediators of people’s preferences for consolidating versus spreading. Given our interest in replicating Study 2b, Study 4 returned
Figure 4. Willingness-to-pay for the lottery as a function of dice number (Study 3). In the immediate condition, the outcome of a die roll would be revealed before the next die was thrown. In the delayed condition, the outcome of the die rolls would not be revealed until all dice were thrown. All predicted log-transformed means were back-transformed so they appear on the original scale.

to the conjunctive risk paradigm. If people approach such risks with a myopic perspective, then spreaders may take comfort in considering that they will approach each subsequent component facing relatively minimal risk. This anticipated comfort may then translate into higher valuations. For each lottery, we asked Study 4 participants how much they anticipated feeling confident and anxious as the lottery unfolded. If our reasoning is correct, then any tendency to prefer spreading conjunctive risks—i.e., preferring that they have more components that unfold over time—may be mediated by anticipated confidence and/or anxiety.

We included a third potential mediator: the subjective likelihood of winning the lottery. Our introduction of the process manipulation (sequential vs. simultaneous) was meant to help us rule out that a simple difficulty with doing the math could offer a complete explanation of why people prefer to spread conjunctive risks (or consolidate disjunctive risks). That is, knowing that the dice would be thrown all at once versus one at a time does not change the underlying math
problem. Instead, it does change whether spreading risks will permit one to face only a tiny fraction of total risk a single point in time. We included the subjective likelihood measure here to make certain that if anticipated confidence or anxiety does explain the predicted pattern of valuation, then it would be above and beyond what these subjective likelihoods would anticipate.

**Method**

**Participants and design.** A total of 484 Americans were recruited from Amazon Mechanical Turk. Each participant was randomly assigned to one of two process conditions (simultaneous or sequential). We also used an attention check to screen out participants who missed the critical manipulation. The analyses reported below were based on the 298 participants who correctly indicated how the dice would be thrown in the dice game (simultaneously or sequentially).

**Procedure.** Participants considered the same 25 conjunctive lotteries used in Study 2b. That is, to win, only acceptable and no forbidden numbers could be rolled. After indicating the most they would be willing to pay to play each gamble, participants answered three additional questions. Two were designed to probe how participants anticipated feeling as that particular game would unfold: “How [confident, anxious] would you feel as the game was unfolding?” One item was designed to probe participants’ subjective probability of winning: “How likely do you feel you would roll only acceptable numbers?” Participants responded to all three items on 101-point slider scales anchored at 0 (not at all) and 100 (very). Each slider started at the midpoint, permitting participants to move the slider toward the more relevant endpoint.

**Results and Discussion**

We started by seeing if we would replicate the findings observed in Study 2b. In the first model—including only number of dice and win probability as predictors of log-transformed
willingness to pay—we observed the two predicted main effects. That is, we observed a positive effect of probability, $B = 0.085, SE = 0.004, t(7148) = 23.28, p < .001, 95\% CI = [0.077, 0.092]$. We also observed a positive effect of number of dice, which reflects a preference for spreading: $B = 0.084, SE = 0.004, t(7148) = 23.23, p < .001, 95\% CI = [0.077, 0.091]$. As displayed in Figure 5, we replicated the Process (coded as sequential: -1, simultaneous: +1) X Dice Number interaction, $B = -0.009, SE = 0.004, t(7144) = -2.56, p = .010, 95\% CI = [-0.017, -0.002]$. This reflects that participants demonstrated a stronger preference for spreading the risk across more events when that would permit the risk to actually be spread across more time as well (sequential condition, $B = 0.095$) than when it would have no such effect (simultaneous condition, $B = 0.076$). In total, this speaks to the robustness of people’s preference for spreading conjunctive risks across events and time.

![Figure 5](image-url)  

**Figure 5.** Willingness-to-pay for the lottery as a function of dice number (Study 4). In the *sequential* condition, the dice would be thrown one after another and the outcome of each die roll would be examined before the next die roll. In the *simultaneous* condition, all the dice would be thrown at once. All predicted log-transformed means were back-transformed so they appear on the original scale.
Studies 2a, 2b, and 3’s reliance on the process or reveal manipulations reflected the first way of examining why people show a preference for consolidating or spreading depending on the nature of the risk. As a second way of examining mechanism, we looked to see which of our three new variables—anticipated confidence, anticipated anxiety, and subjective likelihood—might mediate the just-reported results (see Table 2). To begin, we examined which were predicted by the same Process X Dice Number that predicted the willingness to pay results reported above. This interaction predicted anticipated confidence, $B = -0.726, SE = 0.150, t(7146) = -4.83, p < .001, 95\% CI = [-1.020, -0.431]$, and subjective likelihood, $B = -0.956, SE = 0.156, t(7146) = -6.13, p < .001, 95\% CI = [-1.262, -0.650]$, but not anticipated anxiety, $B = 0.053, SE = 0.143, t < 1$.

To determine whether the preference for spreading conjunctive risks might be explained by anticipated confidence or subjective likelihood (or both), we added these terms to our full model predicting log-transformed willingness to pay. In this model, both predictors contributed independently to predicting willingness to pay. More specifically, participants paid more to play lotteries when the subjective likelihood of winning (above and beyond the objective likelihood) was higher, $B = 0.0080, SE = 0.0003, t(7226.52) = 23.10, p < .001, 95\% CI = [0.0073, 0.0087]$. Furthermore, such willingness to pay was higher when the anticipated confidence while playing was higher, $B = 0.0067, SE = 0.004, t(7239.71) = 18.54, p < .001, 95\% CI = [0.0060, 0.0074]$. Suggesting that these two variables—subjective likelihood and anticipated confidence (but not anticipated anxiety)—fully explained the preference for spreading conjunctive risks, the Process X Dice Number interaction dropped to non-significance, $B = 0.0031, SE = 0.0030, t(7142.58) = 1.04, p = .300, 95\% CI = [-0.0028, 0.0090]$. 
Table 2. Regressions predicting the potential mediators as well as the log-transformed WTP for each lottery from Study 4

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Mediator: Anticipated confidence</th>
<th>Mediator: Anticipated Anxiety</th>
<th>Mediator: Subjective likelihood</th>
<th>DV: Log-transformed WTP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B(SE) t 95%CI</td>
<td>B(SE) t 95%CI</td>
<td>B(SE) t 95%CI</td>
<td>B(SE) t 95%CI</td>
</tr>
<tr>
<td>Dice</td>
<td>2.5732 (0.1503) 17.12***</td>
<td>-0.1002 (0.1433) -0.70 [-0.3811, 0.1806]</td>
<td>2.5285 (0.1560) 16.21*** [2.2227, 2.8342]</td>
<td>0.0484 (0.0031) 15.73*** [0.0023, 0.0544]</td>
</tr>
<tr>
<td>Proc=Seq</td>
<td>3.2990 (0.2284) 14.45***</td>
<td>-0.1533 (0.2177) -0.70 [-0.5801, 0.2734]</td>
<td>3.4843 (0.2370) 14.70*** [3.0197, 3.9489]</td>
<td>0.0452 (0.0046) 9.73*** [0.0361, 0.0544]</td>
</tr>
<tr>
<td>Proc=Sim</td>
<td>1.8474 (0.1955) 9.45***</td>
<td>-0.0471 (0.1863) -0.25 [-0.4123, 0.3181]</td>
<td>1.5727 (0.2028) 7.75*** [1.1750, 1.9703]</td>
<td>0.0300 (0.0040) 7.53*** [0.0222, 0.0378]</td>
</tr>
<tr>
<td>Prob</td>
<td>3.4440 (0.1503) 22.91***</td>
<td>-0.3631 (0.1433) -2.53* [-0.6439, -0.0823]</td>
<td>3.7279 (0.1560) 23.90*** [3.4221, 4.0337]</td>
<td>0.0337 (0.0031) 10.75*** [0.0276, 0.0399]</td>
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<tr>
<td>Process</td>
<td>0.3156 (1.0762) 0.29 [-1.8023, 2.4334]</td>
<td>-2.2361 (1.2883) -1.74 [-4.7715, 0.2993]</td>
<td>-0.1767 (1.0584) -0.17 [-2.2597, 1.9064]</td>
<td>-0.0343 (0.0421) -0.82 [-0.1172, 0.0485]</td>
</tr>
<tr>
<td>Dice × Prob</td>
<td>-0.0995 (0.1063) -0.94 [-0.3078, 0.1089]</td>
<td>-0.1222 (0.1013) -1.21 [-0.3208, 0.0764]</td>
<td>-0.1338 (0.1103) -1.21 [-0.3500, 0.0824]</td>
<td>0.0015 (0.0021) 0.70 [-0.0027, 0.0057]</td>
</tr>
<tr>
<td>Dice × Proc</td>
<td>-0.7258 (0.1503) -4.83*** [-1.0205, -0.4312]</td>
<td>0.0531 (0.1433) 0.37 [-0.2277, 0.3340]</td>
<td>-0.9558 (0.1560) -6.13*** [-1.2616, -0.6500]</td>
<td>0.0031 (0.0030) 1.04 [-0.0028, 0.0090]</td>
</tr>
<tr>
<td>Prob × Proc</td>
<td>-0.5999 (0.1503) -3.99*** [-0.8946, -0.3053]</td>
<td>0.1201 (0.1433) 0.84 [-0.1608, 0.4009]</td>
<td>-0.7794 (0.1560) -5.00*** [-1.0852, -0.4736]</td>
<td>-0.0038 (0.0030) -1.25 [-0.0097, 0.0021]</td>
</tr>
<tr>
<td>Dice × Prob × Proc</td>
<td>0.0595 (0.1063) 0.56 [-0.1489, 0.2678]</td>
<td>0.1803 (0.1013) 1.78 [-0.0183, 0.3789]</td>
<td>0.0239 (0.1103) 0.22 [-0.1923, 0.2401]</td>
<td>0.0010 (0.0021) 0.48 [-0.0032, 0.0052]</td>
</tr>
<tr>
<td>Anticipated confidence</td>
<td></td>
<td></td>
<td></td>
<td>0.0067 (0.0004) 18.54*** [0.0060, 0.0074]</td>
</tr>
<tr>
<td>Subjective likelihood</td>
<td></td>
<td></td>
<td></td>
<td>0.0080 (0.0003) 23.10*** [0.0073, 0.0087]</td>
</tr>
</tbody>
</table>

*Note. CI = confidence interval, Proc = process (coded as: sequential = -1, simultaneous = +1), Prob = win probability (coded from -2 to +2), Dice = number of dice (coded from -2 to +2).*

a Simple effect of dice number in the sequential process condition.
b Simple effect of dice number in the simultaneous process condition.

***p < .001, **p < .01, *p < .05
General Discussion

Whether an endeavor is ultimately successful often depends on the degree of success with its components’ parts. In this paper, we considered two extremes: when overall success requires at least one component’s success (disjunctive risk) or every component’s success (conjunctive risk). Disjunctive risk takers’ prospects for victory continually decline if they remain without a single success. But as long as conjunctive risk takers “stay in the game,” their prospects for ultimate success go up. As a result, myopic decision makers will try to consolidate disjunctive risks—maximizing their chance for an immediate win, which is all that they need. In contrast, they will try to spread conjunctive risks—across events, especially when those will unfold across time—because it allows them to accomplish a short-term goal of staying in the running.

Study 1 provided an initial demonstration of this preference. Participants played the role of a manager. They chose to assign fewer employees (i.e., to have fewer components) for a disjunctive risk task (one on which only one employee needed to succeed) than for a conjunctive risk task (one on which everyone would need to be successful). The remaining studies used a more standardized paradigm (a die-rolling game) as well as a temporal manipulation to better understand these preferences for consolidation and spreading.

Studies 2a and 2b examined preferences for multi-component disjunctive and conjunctive lotteries, respectively, that played out all at once (simultaneously) or over time (sequentially). Whether dice are rolled together or one at a time may not systematically change the outcomes of those die rolls, but it does change how multi-component risks can be consolidated or spread. Disjunctive risk-takers’ preference for consolidating risks over fewer components reduced when those risks played out all at once (Study 2a). After all, consolidating components does less to maximize the chance of an immediate win if those components’ outcomes will be determined all
at once anyway. Conjunctive risk-takers’ preference for spreading risks over more components was reduced when that risk would not actually be spread across time (Study 2b). Without this temporal spreading, the myopic benefit of spreading the chance of loss across more components would not be fully realized.

Study 3 disentangled whether the preference for consolidating (vs. spreading) reflects a preference for how the risky process unfolds (i.e., how the dice are rolled) or how the outcomes are revealed (i.e., whether the outcomes are revealed one-at-a-time or all-at-once). Displaying that myopia is for maximizing the chance that news—when it is revealed—will be good news, we found that disjunctive risk takers’ preference for consolidating across events was especially strong when the outcomes would be revealed immediately upon each roll (and thus in sequence). Study 4 shed light on the phenomenological expectations of conjunctive risk-takers as they prepared to confront risks that were consolidated versus spread. Without the near prospect of a debilitating loss, these risk-takers anticipated feeling more confidence (though no less anxiety) with the conjunctive risks spread. This anticipated confidence—indeed of these risk-takers’ greater subjective likelihood of winning—predicted higher willingness to pay for spread conjunctive risks.

To be fair, integrating marginal probabilities of individual components into overall chances of disjunctive and conjunctive success is a difficult math problem. For this reason, two aspects of our results are particularly important. First, we provided evidence of decision makers’ interest in consolidating or spreading not merely by varying the number of components (thereby changing the relevant math problem), but by changing the time course over which such multi-component risks would unfold. Second, we found that an interest in consolidating versus
spreading was explained not merely by shifts in the subjective probability of overall success, but independently by decision-makers’ anticipated feelings of confidence as the risk unfolded.

We wish to highlight how our own interest in the nature of time in decision making is relatively unique. When psychologists consider the influence of time, they are typically interested in a delay between the present and when an outcome will be realized. For example, there has been considerable investigation of how future payoffs are discounted to be valued in the present (Frederick, Loewenstein, & O’Donoghue, 2002). Other work drawing on construal level theory makes the case that choices and options in the future are represented more abstractly than those that will be realized in the present (Liberman, Sagristano, & Trope, 2002; Liberman & Trope, 1998; Sagristano, Trope, & Liberman, 2002; Trope & Liberman, 2003, 2010). The present paper highlights the importance of temporal separations that relate to the time course over which information is learned—separation that allows feedback to be split into a multi-stage learning process. It seems myopia operates even under such constrained timescales: Disjunctive risk takers prefer to rip the (smaller number of) bandaids off all at once, whereas conjunctive risk takers would rather keep prodding along (by valuing risks that facilitate inching toward success).

The present examination of time is most similar in form to work by Budescu and Fischer (2001). They showed that people prefer that a multi-component risk unfold in an evenly spaced manner (e.g., a coin flip every 30 seconds) as opposed to an asymmetrically spaced one (e.g., a coin flip after 50 seconds, another after 30 seconds, another after 10 seconds; or the reverse sequencing). To Budescu and Fischer (2001), this reflected a preference for symmetric, simple processes; the asymmetrically spaced tosses reflected a needlessly complicating feature. But for the present work, our own interest in the time course of multi-component risks does not lie in the process’s aesthetic properties but instead in its ability to segregate or integrate outcomes, thereby
changing the prospects for good or bad news in the next period (see also Kovářík, Levin, & Wang, 2016). Of course, both demonstrations reflect violations of the reducibility principle, that rational decision makers should be indifferent between prospects that have identical outcomes and probabilities. Such violations have been observed before (Kahneman & Tversky, 1979; O’Donnell & Evers, 2019; Slovic, 1995), even as they take a new form in the present research. Furthermore, the present research offers a somewhat different take on myopia than do related examinations. Consider Thaler, Tversky, Kahneman, and Schwartz’s (1997) study of myopic loss aversion. Participants were more likely to take a higher-risk, higher-reward gamble if they would learn the outcome only after 40 periods as opposed to after each period. Through such aggregation, participants could avoid the unpleasant shocks of learning about every individual loss (see also Gneezy & Potters, 1997; Hardin & Looney, 2012). The researchers characterized this preference as myopic, given it involves hypersensitivity to the prospect of short-term fluctuations even though such shocks would be watered down in the aggregate. Keeping decision makers in the dark about these individual losses helps them tolerate more risk overall. But for us, myopia does not describe the frequency with which one tracks payoffs or outcomes. Instead, it reflects a disproportionate interest in the immediately looming probabilities, even though such probabilities may not characterize subcomponents that themselves offer direct payoffs (as in the gambles Thaler and colleagues’ participants preferred to aggregate over). One of the forms of myopia we demonstrated reflects an interest in continuing progress, even if doing so lengthens the road to the payoff (i.e., by spreading a conjunctive risk over more subcomponents).

Limitations and Future Directions
When multi-component risks unfold in the real world, they may differ from those in the presently used paradigms in several ways. One difference is that our participants knew the components’ probabilities of success in advance. A second is that those probabilities did not vary as a function of the risks unfolding sequentially or simultaneously. Consider again the project manager in Study 1 who faced a disjunctive risk—i.e., a need for just one employee to succeed. In reality, she might benefit from having her employees try the complex project in sequence in a way that our paradigm’s tight constraints did not permit. One employee’s failure could be a learning opportunity for the next employee’s attempt. To be clear, we raise this issue not because we see this as a threat to the study’s internal validity: If participants made this learning assumption, it would have pushed them to select more (not the hypothesis-consistent fewer) employees. Similarly, when an employer assigns more employees to a project, this entails an opportunity cost; these extra employees could have been working on something else. Of course, participants naturally attuned to this worry should presumably apply the concern to both the disjunctive and conjunctive risks alike. That said, we raise these issues to highlight the complexities of real-world multi-component risks. We also believe these considerations bring into focus the strengths of the dice game. Despite offering a stripped-down procedure that lacks certain features of real-life multicomponent risks, the die-rolling paradigm also provided full visibility into the nature of the confronted risk (e.g., the objective probabilities of individual subcomponents’ outcomes, the statistical independence of each component regardless of the time course) that permitted clean tests of our accounts.

There may also be a limit to just how far people prefer to spread conjunctive risks. In our studies, we examined preferences for spreading among two to six components. But beyond this point, the objective benefits from spreading (in terms of the myopically valued increased chance
of winning on the next component) may begin to diminish. In Table 1, it is already clear there are diminishing returns to spreading: Holding the overall probability of success constant, the effects of additional spreading on the chance of each component’s success grow smaller and smaller. This suggests that at some point additional spreading may simply not seem worth it. Future research may model determinants of conjunctive risk-takers’ optimal degree of spreading, not their unconditional preference for it.

A final consideration relates to direct experience with the risks. In most of our studies, participants indicated their preferences for a series of multi-component risks without actually playing out those risks. To be sure, our participants had a lifetime of experience with rolling dice, but perhaps not with die lotteries of this variety. How might the preference for consolidating disjunctive risks and spreading conjunctive risks change with experience? One possibility is that participants’ subjective probability estimates—informed by the cold reality of statistics—might improve (Johnson & Bruce, 2001) and be less influenced by the spreading or consolidating features. If so, this might suggest that experienced decision-makers would show less of the presently documented effects.

But we suspect that the answer to this question depends on whether participants’ forecasts—that consolidation versus spreading can affect confidence as the risk unfolds—are actually true. After all, keep in mind that Study 4 found that anticipated confidence mediated our effects above and beyond the influence of subjective likelihood judgments. Consider again conjunctive risk-takers. By spreading risks across events and time, it is the case they consistently face a relatively high-probability component risk. With a myopic perspective, they should typically be feeling pretty confident and will be rewarded with a mini (single-component) victory a relatively large percentage of the time. Furthermore, each successful component should raise
people’s hopes as they get closer and closer toward the end prize (Strickland & Grote, 1967). Such repeat confidence boosters might be even more impactful upon actual experience than they are in prospect. Of course, future research is needed to offer more definitive answers to these questions about the influence of experience on preferences for multi-component risks.

As part of examining people’s interest in consolidation or spreading, we examined multi-component risks that took one of two dichotomous forms: simultaneous or sequential. But in reality, there is something of a continuum of sequential revelation: Component outcomes may be revealed back-to-back or only after relatively longer delays in between each subpart. In terms of our own framework, this becomes a question of what it is that myopia leads people to focus on: Is it what will happen in the next few seconds or minutes, or merely what will happen next? If it is the former, then adding even greater delays between components may achieve spreading even more efficiently. But if it is the latter, then such delays should not have this effect. Study 3 gives us preliminary evidence it is the latter. This suggests that their myopia led them to value an immediate win when information would be revealed, even though such a revelation would happen only after a delay.

Conclusion

Psychologists have long been interested in how people approach risk. Typically, this means single-stage risks—prospects with uncertain outcomes that resolve in a positive or negative way. But in the real world, many if not most risks are actually multi-component risks. People end up succeeding or failing not merely because of the outcome of any one single event, but based on how multiple events play out. Our focus on multi-component risks is a recognition of their historically underappreciated importance, but also a demonstration that the form those risks take—disjunctive or conjunctive—changes people’s preferences for them. We examined
two ways that disjunctive and conjunctive risks are consolidated or spread: the number of components that define them and the time course over which the component outcomes are revealed. We suspect that these operationalizations have not fully captured the way that people *psychologically* consolidate or spread such risks. In that sense, we hope that the present findings serve as a foundation on which future research may identify a richer diversity of strategies that people use when approaching and managing multi-component risks.
References


Johnson, J. E., & Bruce, A. C. (2001). Calibration of subjective probability judgments in a
naturalistic setting. *Organizational Behavior and Human Decision Processes, 85*, 265–
290.

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in
intuitive judgment. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), *Heuristics and


Liberman, N., Sagristano, M. D., & Trope, Y. (2002). The effect of temporal distance on level of

Liberman, N., & Trope, Y. (1998). The role of feasibility and desirability considerations in near
and distant future decisions: A test of temporal construal theory. *Journal of Personality
and Social Psychology, 75*, 5–18.

biases. In J. B. Pryor & G. D. Reeder (Eds.), *The social psychology of HIV infection* (pp.


## Appendix A

### Winning Numbers for Each Die in the Disjunctive Lotteries (Studies 2a and 3)

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<th>Probability coding</th>
<th>Red die</th>
<th>Green die</th>
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*Note.* Probability coding is higher for lotteries that offer an objectively higher chance of winning.
Appendix B

Acceptable Numbers for Each Die in the Conjunctive Lotteries (Studies 2b and 4)

<table>
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<tr>
<th>Probability coding</th>
<th>Red die</th>
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</table>

*Note.* Probability coding is higher for lotteries that offer an objectively higher chance of winning.
Supplemental Materials

We begin by presenting the Supplemental Study that was described in the Results and Discussion section of Study 1. We also report additional analyses that suggest that Studies 2a-4 participants who knew how the dice would be rolled (sequentially or all at once) showed significantly stronger evidence in support of our hypotheses than participants who failed the attention check (suggesting they did not know how the dice were being rolled or were responding carelessly to the materials).

Supplemental Study

Method

Participants and design. A total of 102 adults recruited via Amazon Mechanical Turk (AMT) participated in exchange for monetary compensation. Each participant was randomly assigned to one of two risk conditions: disjunctive or conjunctive. Eleven participants were excluded from the analysis because they failed an attention check at the study’s conclusion that asked them to identify the condition to which they had been exposed. This left 91 participants in results reported below.

Procedure. Participants were asked to play the role of a work manager who had to decide how many employees—2, 3, 4, 5, or 6—to put on a project. The project was either a disjunctive risk (one in which only one employee would need to succeed) or a conjunctive risk (one in which all employees would have to succeed). The procedure was identical to that of Study 1’s except for the probability that each employee would yield a successful outcome (see Table S1). That is, adding more employees to the disjunctive-risk project would raise the project’s chance of success, whereas adding employees to the conjunctive-risk project would lower the project’s chance of success.
Table S1. Probability of Each Individual Employee’s Success at His/Her Part

<table>
<thead>
<tr>
<th>Number of employees</th>
<th>Disjunctive risk</th>
<th>Conjunctive risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>29.2%</td>
<td>70.8%</td>
</tr>
<tr>
<td>3</td>
<td>20.6%</td>
<td>79.4%</td>
</tr>
<tr>
<td>4</td>
<td>15.9%</td>
<td>84.1%</td>
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<tr>
<td>5</td>
<td>13.0%</td>
<td>87.0%</td>
</tr>
<tr>
<td>6</td>
<td>11.0%</td>
<td>89.0%</td>
</tr>
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</table>

Results and Discussion

Participants who confronted a *disjunctive* risk (\(M = 3.09, SD = 1.25\)) preferred to place fewer employees on the task than those who confronted a *conjunctive* risk (\(M = 4.79, SD = 1.14\)), \(t(89) = 6.76, p < .001, d = 1.42\). Given the chance of an overall success actually rose and dropped with more employees for the disjunctive-risk and conjunctive-risk projects, respectively, participants showed a costly preference for consolidating disjunctive risks and spreading conjunctive risks.

We conducted an additional analysis on the entire sample, even those who failed the attention check. (We do this because we will report below analogous tests for all studies reported in the main manuscript.) We defined an additional variable, *attention check*, to differentiate participants who passed (+1) or failed (-1) the attention check (failure rate: 11%). On our main test of interest, we did not find that our manipulation of risk interacted with the attention check variable to predict the number of employees, \(F(1, 98) = 1.97, p = .164, \eta_p^2 = .020\).

Study 1: Test of Moderation by Attention Check Passage

We conducted an additional analysis on the entire sample, even those who failed the attention check. We defined an additional variable, *attention check*, to differentiate participants who passed (+1) or failed (-1) the attention check (failure rate: 13%). On our main test of interest,
we did not find that our manipulation of risk interacted with the attention check variable to predict the number of employees, $F(1, 96) = 0.34, p = .563, \eta^2_p = .004$.

**Study 2a: Test of Moderation by Attention Check Passage**

We conducted an additional analysis on the entire sample, even those who failed the attention check. We defined an additional variable, *attention check*, to differentiate participants who passed (+1) or failed (-1) the attention check (failure rate: 26%).

We added *attention check* as a fourth fixed effect to the mixed model predicting the log-transformed WTP in the full sample. In other words, this new model included a random effect of participant, the fixed effects of number of *dice*, *win probability*, *process* manipulation and *attention check*, and all possible interaction terms that can be made from these four fixed effects. The analysis yielded a significant Process $\times$ Dice Number $\times$ Attention Check interaction, $B = 0.023, SE = 0.003, t(6756) = 6.76, p < .001, 95\% CI = [0.016, 0.029]$. This suggests that the critical finding in Study 2a (i.e., participants’ preference for disjunctive risk is especially strong when the events unfold sequentially as opposed to simultaneously) was stronger when participants were aware of how the risk components would unfold.

**Study 2b: Test of Moderation by Attention Check Passage**

We conducted an additional analysis on the entire sample, even those who failed the attention check. We defined an additional variable, *attention check*, to differentiate participants who passed (+1) or failed (-1) the attention check (failure rate: 33%).

We followed a similar analytic approach to that used in Study 2a to examine the importance of the attention check to our results reported in the main manuscript. That is, we added *attention check* as a fourth factor to our primary model predicting the log-transformed WTP in the full sample. We observed a significant Process $\times$ Dice Number $\times$ Attention Check
interaction, B = -0.014, SE = 0.003, t(10452) = -4.31, p < .001, 95% CI = [-0.021, -0.008]. This reflects that participants’ stronger preference for spreading conjunctive risks that unfold across time (vs. at once) was significantly reduced for participants who did not know how the risk components would unfold.

**Study 3: Test of Moderation by Attention Check Passage**

We conducted an additional analysis on the entire sample, even those who failed the attention check. We defined an additional variable, attention check, to differentiate participants who passed (+1) or failed (-1) the attention check (failure rate: 24%).

When attention check was added as a fourth factor to our primary model predicting the log-transformed WTP, we found a significant Reveal X Dice Number X Attention Check interaction, B = 0.014, SE = 0.003, t(7955) = 5.05, p < .001, 95% CI = [0.009, 0.020]. This suggests that participants who knew how the dice game would play out provided statistically significantly stronger support (compared to those unable to report this) for our prediction that the preference for consolidating disjunctive risks would be reduced when the outcome of multiple components would be revealed at a single, delayed time.

**Study 4: Test of Moderation by Attention Check Passage**

We conducted an additional analysis on the entire sample, even those who failed the attention check. We defined an additional variable, attention check, to differentiate participants who passed (+1) or failed (-1) the attention check (failure rate: 38%).

We added attention check as a fourth factor to the regressions predicting the potential mediators as well as the log-transformed WTP for each lottery. We observed significant Process X Dice Number X Attention Check interactions on anticipated confidence (B = -0.601, SE = 0.129, t(11604) = -4.64, p < .001, 95% CI = [-0.854, -0.347]), subjective likelihood (B = -0.687,
SE = 0.133, t(11604) = -5.18, p < .001, 95% CI = [-0.948, -0.427]), and WTP (B = -0.009, SE = 0.003, t(11602) = -2.74, p = .006, 95% CI = [-0.016, -0.003]), but not on anticipated anxiety (B = -0.174, SE = 0.122, t(11604) = -1.42, p = .156, 95% CI = [-0.413, 0.066]). These results reflect that participants who were clear about how the dice would be rolled showed significantly stronger evidence in support of our hypotheses regarding the psychological comfort derived from spreading conjunctive risks (or consolidating disjunctive risks) than participants who did not know this key detail.

**Summary: Test of Moderation by Attention Check Passage**

In summary, the failure rates of attention check were slightly higher in Studies 2a-4, which used the die-lottery paradigm, than they were in Study 1. But the significant interactions between attention check pass or failure and our finding of interest speak to the importance of including such stricter attention checks (see Table S2). Should participants fail to recognize how the multi-component risks will unfold (sequentially or at once) or even worse, mistake it for the other manner, then the predicted effects should be eliminated or reverse. The consistently significant interactions reinforce this story.
**Table S2.** Results for the interactions of finding of interest with attention check on log-transformed WTP in Studies 2a-4

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Study 2a</th>
<th>Study 2b</th>
<th>Study 3</th>
<th>Study 4</th>
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<tr>
<td></td>
<td>B(SE) t 95%CI</td>
<td>B(SE) t 95%CI</td>
<td>B(SE) t 95%CI</td>
<td>B(SE) t 95%CI</td>
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<tr>
<td><strong>Model 1</strong></td>
<td></td>
<td></td>
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<tr>
<td>Dice X AC</td>
<td>-0.022 -7.08*** [-0.028, -0.016]</td>
<td>0.003 1.03 [-0.003, 0.010]</td>
<td>-0.009 -3.84*** [-0.014, -0.004]</td>
<td>0.005 1.75† [-0.001, 0.011]</td>
</tr>
<tr>
<td></td>
<td>(0.003) (0.003)</td>
<td>(0.003) (0.003)</td>
<td>(0.002) (0.003)</td>
<td>(0.003) (0.003)</td>
</tr>
<tr>
<td>Prob X AC</td>
<td>0.016 5.23*** [0.010, 0.022]</td>
<td>0.006 1.74† [-0.001, 0.012]</td>
<td>0.001 0.58 [-0.003, 0.006]</td>
<td>0.007 2.31* [0.001, 0.013]</td>
</tr>
<tr>
<td></td>
<td>(0.003) (0.003)</td>
<td>(0.003) (0.003)</td>
<td>(0.002) (0.003)</td>
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<tr>
<td><strong>Model 2</strong></td>
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</tr>
<tr>
<td>Dice X Cond X AC</td>
<td>0.023 6.76*** [0.016, 0.029]</td>
<td>-0.014 -4.31*** [-0.021, -0.008]</td>
<td>0.014 5.05*** [0.009, 0.020]</td>
<td>-0.009 -2.74** [-0.016, -0.003]</td>
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<td>(0.003) (0.003)</td>
<td>(0.003) (0.003)</td>
<td>(0.003) (0.003)</td>
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</table>

**Note.** CI = confidence interval, Dice = number of dice (coded from -2 to +2), Prob = win probability (coded from -2 to +2), AC = attention check (coded as: fail = -1, pass = +1), Cond = condition (in Studies 2a, 2b and 4, coded as: sequential = -1, simultaneous = +1; in Study 3, coded as: immediate = -1, delayed = +1).

Model 1 includes dice number, win probability and attention check as fixed effects, participant as a random effect, and all possible interaction terms.

Model 2 includes dice number, win probability, process/reveal condition and attention check as fixed effects, participant as a random effect, and all possible interaction terms.

*p < .001, **p < .01, *p < .05, †p < .10.