How do People Judge Risk? Availability may Upstage Affect in the Construction of Risk Judgments

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When making risk judgments, people rely on availability and affect as convenient heuristics. The two heuristics share many similarities and yet there have been no or few attempts to ascertain their causal impact on risk judgments. We present an experiment ($N = 143$) where we varied availability-by-recall (thinking of less or more occurrences of someone from one's social network dying) and the affective impact of certain risks (using images). We found that availability-by-recall had a stronger impact in constructing risk judgments. Asking people to think of more occurrences led to higher judgments of mortality and higher values placed on a single life, irrespective of changes in affect, risk media coverage, and retrieval time. Affect, however, was not disregarded. Our data suggest a causal mechanism where the retrieval of occurrences leads to changes in affect, which in turn, impact risk judgments. These findings increase understanding of how risk judgments are constructed with the potential to impact risk communication through direct manipulations of availability and affect. We discuss these and other implications of our findings.

KEY WORDS: Affect heuristic; availability heuristic; mixed models; risk judgments

1. INTRODUCTION

When people make risk judgments they tend to rely on how many examples of a risky event come to mind—the *availability heuristic*, as well as affective cues evoked by (or incidental to) the events themselves—the *affect heuristic* (Finucane, Alhakami, Slovic, & Johnson, 2000; Johnson & Tversky, 1983; Lerner & Keltner, 2001; Lichtenstein, Slovic, Fischhoff, Layman, & Combs, 1978; Loewenstein, Weber, Hsee, & Welch, 2001; Slovic, 2016; Tversky & Kahneman, 1974).

Following the availability heuristic, people assess the frequency or probability of an event by the ease

with which instances or occurrences of that event can be brought to mind. Someone may, for instance, judge the prevalence of heart attacks by recalling occurrences of heart attacks among their acquaintances (Tversky & Kahneman, 1974). Presented as such, the availability heuristic is consistent with two different mechanisms: (a) amount of actually recalled instances and (b) ease of recall (Fiedler, 1983). Schwarz et al. (1991) attempted to disentangle the two and found that when people were asked to provide 12 (rather than six) examples of assertiveness, they reported being less assertive. The explanation being that difficulty associated with recalling 12 instances (even though a larger amount) led to lower estimates. Later however, Hertwig, Pachur, and Kurzenhäuser (2005) found more evidence for amount of actually recalled occurrences as the mechanism. They operationalized different cognitive mechanisms based on the availability account and found that *availability-by-recall*—which relies on knowledge about relevant occurrences in one's social network—best predicted

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people's judgments. This means that a person judges whether more people die from risk A or risk B, by recalling actual fatalities within their proximate social network. Another key component in bringing specific occurrences to mind has been the media (Meyer, 1990). For example, people estimate the frequency of those risky events that receive extensive media coverage as higher (Lichtenstein et al., 1978). In this article, to gauge the role of availability, we will rely on these two instantiations of the availability heuristic. That is, availability-by-recall, where one has to recall occurrences of a risk from their social network (e.g., family, friends, and acquaintances) and the occurrences of a risk being mentioned in the media.

The affect heuristic, on the other hand, draws on emotion. Risks generally evoke strong affective reactions. Evidence of a risk-as-feelings approach was present in early studies of risk perception where feelings of dread were observed to be major determinants of public perception and acceptance of risk (Slovic, 1987). As a result of this link, Finucane et al. (2000) proposed that people use an affect heuristic when making risk judgments suggesting that: "Using an overall, readily available affective impression can be far easier—more efficient—than weighing the pros and cons or retrieving from memory many relevant examples…" (Finucane et al., 2000, p. 3). Converging evidence has showed that affect and emotion have a strong influence on risk judgments (Lerner & Keltner, 2001; Loewenstein et al., 2001). This means that a person judges whether more people die from risk A or risk B, by noting which risk evokes more affect. In this article, to gauge the role of affect, we will ask people to tap into their "affect pool" (i.e., rely on affect), as suggested by the affect heuristic, and judge how a particular risk makes them feel.

1.1. Availability and Affect Linked

Availability and affect are often promoted alongside one another as accounts of how people judge risks (Keller, Siegrist, & Gutscher, 2006). On top of this, the two are inextricably linked. It has been suggested that the availability heuristic works through recall, but also because remembered images are connected with affect (Slovic, Finucane, Peters, & MacGregor, 2004). For instance, the visceral and affective nature of a risk such as cancer might inflate the number of examples that come to people's mind. Vice versa, multiple examples of cancer deaths can come to mind, evoking strong unpleasant affect. Furthermore, the mechanisms underlying the availability heuristic seem connected with affect. In semantic memory models, for instance (Bower, 1981; Forgas, 1995), an affective state can prime categories that guide the retrieval and use of information. Similarly, a strong predictor of the number and valence of people's spontaneous thoughts about a target is affect evoked by the target (Pham, Cohen, Pracejus, & Hughes, 2001). Recalled occurrences on the other hand, can produce mental images that have been shown to evoke affective reactions connected to the judgment target (Jaspersen & Aseervatham, 2017; Slovic et al., 2002). Moreover, in affect regulation models (Andrade, 2005; Baumeister, Vohs, Dewall, & Zhang, 2007), it has been suggested that people manage their feelings for strategic reasons. For example, risky events can evoke negative affect and people could actively try to change or avoid this state retrieving fewer examples from memory. In sum, the underlying assumptions supporting the two heuristics are linked to the point that disentangling their impact is crucial to understanding how risk judgments are constructed.

Nevertheless, attempts to experimentally manipulate the two to determine their impact on risk judgment construction are scarce. To the best of our knowledge, only one other study measured both availability and affect in risk judgments. Pachur, Hertwig, and Steinmann (2012) conducted two studies where they gathered instance knowledge about the number of occurrences people could think of pertaining to certain risky events and their affective reactions to the risks. The goal was to test the relative extent to which the availability and the affect heuristic predict people's risk judgments. They found, across a wide range of different risks, that availability-by-recall offered a better descriptive account than the affect heuristic when people judged statistical mortality rates, but that both were good predictors when people were asked to put a price tag on a single life. However, Pachur and colleagues did not manipulate availability and affect directly so we lack critical insight into their interaction or causal influence on risk judgment construction (Keller et al., 2006). Instead of relying on instance knowledge and affective responses, in the present research, we aim to experimentally manipulate both availability and affect.

1.2. Present Research

Affect and availability have an important role in the construction of risk judgments (Hogarth, Portell,

Cuxart, & Kolev, 2011; Roeser, 2012; Slovic, Monahan, & MacGregor, 2000; Xie, Wang, Zhang, Li, & Yu, 2011). We aim to expand our understanding of their role by experimentally manipulating availability and affect and investigating how this impacts risk judgment construction. To manipulate availability, we relied on an instantiation of *availability-by-recall*, operationalized as the number of deaths recalled in one's social network. We told participants to either think of two or eight occurrences of a particular risk. While it is difficult to control the fact that for some risky events, even if asked to recall only two events, participants may have thought of more, our main goal with this manipulation was to hint to participants that a lower (i.e., two) or higher (i.e., eight) number of occurrences may be *available*. To manipulate affect, we either presented an affect-augmenting image or maintained a neutral presentation (i.e., no affective image was presented). Because of their interconnectedness, we surmised that the most ecological way to probe at the influence of both affect and availability would be to manipulate them within the same individuals. It oftentimes the case that both instantiations come about naturally. For instance, when risks are communicated or discussed, people may be presented with images, thinking of occurrences of the risk in their networks. Another reason is spillover. It is difficult to ensure that one manipulation will not spillover and impact the other. For instance, solely increasing affect associated with a risk may lead people to avoid thinking of examples of a risk. By keeping both manipulations within, we attempt to minimize such occurrences. The experiment thus had two factors with two levels, that is, 2 (recall: think of two occurrences vs. eight occurrences) × 2 (affect input: none vs. affect image). For details see Section 2.2.

We predicted that availability-by-recall will have a stronger impact on risk judgment construction. We expected since availability-by-recall has been shown to be a better predictor of risk judgments (Pachur et al., 2012), those people who were asked to think of more occurrences from their social circle will judge the risks as higher, independent of the affect manipulation. However, we predicted that the more occurrences one thought of, the less accurate they would be in estimating the frequency of the risk. We expected that the higher number of occurrences thought of may lead to overestimations. We also aimed to test a possible mediatory mechanism involving both instantiations of availability and affect, but as this was an exploratory endeavor, we made no

specific hypotheses. Data, analysis code, and the materials for this experiment can be found here: https://osf.io/kajvd/

2. METHOD

2.1. Participants

We aimed to recruit 150[1] individuals. One hundred and seventy-four participants from the United States took part on MTurk. After excluding those that did not pass an initial attention check where we asked to select a specific answer from a set of given answers and those that did not complete the entire study, we were left with 143 participants (40% female, $Mdn_{Age} = 33$, $IQR_{Age} = 12$, range: 20–65). Participants were paid a fixed amount of $1.30 for their participation.

2.2. Procedure

After providing consent and answering the attention check, participants were told to make judgments about 11 risky events in two ways. For each risky event, participants had to answer what they think the frequency of the risk was and what the value of statistical life was—these served as the dependent variables (see Section 2.4). The risky events used are reported in Table I. Each participant thus went through 11 randomly presented trials as a function of the 2 (recall: think of 2 vs. 8 occurrences) × 2 (affect input: none vs. affect image) repeated measure design. To provide a sense of scale (cf., Hertwig et al., 2005) participants were told how many people died in the United States, in total, in 2016.[2]

We wanted to ensure that there would be no carryover effects of participants responding to the same risky event multiple times. Thus, for each risky event, it was randomly determined which level of a condition would be chosen. Thus, participant A could be presented with the stomach cancer first. The program would randomly determine whether to ask participant A to think of either two or eight instances and it

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[1]Given our available funds and the specifics of our design (see Section 2.2.), using G*Power, for an all within subject design of four groups and at least three measurements, with 150 participants we would have about 80% power to detect effect sizes of $> = 0.25$ (Cohen, 1988). This speaks to the sensitivity of our sample size to detect this and larger effect sizes.

[2]We used 2016 as, at the time of conducting the experiment (2018), this was the last full official CDC data: https://wonder.cdc.gov/ucd-icd10.html

Table I. List of Risky Events in Descending Order of their Official Death Tolls (in the United States) with Descriptive Statistics of the Risk Assessments: Mean, *SD*, Range (Log-Transformed Values), Median (Nontransformed Values for Easier Comparison with Real Death Toll), and Frequency of Not Being Able to Think of Any (i.e., Zero) Examples

Risky Events	Official Death Toll *N* in the United States (2016)	Risk Assessment								Zero Examples
		Perceived Freqency of Risk				Value of Statistical Life				
		M	SD	Med.	Range	*M*	SD	Med	Range	Frequency(%)
Alzheimer's disease	116.103	10.30	2.58	40.000	0.70–18.4	10.60	4.62	75.000	0–14.6	59
Myocardial infarction	111.777	9.13	2.75	10.000	0–17.7	9.66	4.57	25.000	0–22.3	81
Unintentional drug overdose	54.793	10.50	2.81	40.000	0–19.3	9.89	4.67	50.000	0–23	63
Breast cancer	41.952	9.33	2.45	12.500	0–15.4	9.66	4.32	50.000	0–20.7	87
Motor vehicle accidents	40.327	10.00	2.65	30.000	0–17.7	10.00	4.12	50.000	0–18.4	54
Parkinson's disease	29.697	9.78	2.59	20.000	0–16.8	9.61	4.48	50.000	0–20.7	82
Homicide	19.362	11.60	2.48	145.000	0.70–18.4	10.20	4.74	50.000	0–22.3	31
Stomach cancer	11.433	9.31	2.74	15.000	0.70–18.4	9.74	4.29	50.000	0–23	59
Skin cancer	8.188	10.50	2.69	40.000	0–20.6	9.07	4.60	20.000	0–20.7	52
Complications of medical and surgical care	3.203	11.10	2.45	75.000	1.1–17	9.90	4.30	40.000	0–25.3	34
Exposure to smoke, fire, or flames	2.730	9.14	2.42	10.000	0.70–16.1	9.40	4.18	27.000	0–17.7	84

would randomly determine whether to present an image or not. Then, participant A would be presented with say homicide as the risky event and the program would again make random determinations. We thus ended up with 1,573 judgments made (143×11). Certain combinations of conditions did not occur more often than others, $X^2 = 0.29$, $p = 0.59$.

One trial went as follows: (a) participants were either asked to think of two or eight occurrences and an affect enhancing image was shown or not, (b) after providing occurrences, participants answered questions about affect, (c) then in random order, they provided answers to the dependent variables. Finally, after going through all 11 of the risky events, participants provided their demographic data and responded to the measure of fluency, that is, media coverage (see Section 2.4) for each risky event.

2.3. Manipulations

2.3.1. Availability-by-Recall

To manipulate availability-by-recall, participants were asked to recall and write down two or eight (Lammers & Burgmer, 2017) occurrences from their social network (including family, friends, and acquaintances) of someone dying from the specific risky event (Hertwig et al., 2005; Pachur et al., 2012). Samples of participants answers included: "brother-in-law's stepmom," "friend of a family friend," and so on. If participants could not recall any occurrences, they were asked to write down the number zero to continue.

2.3.2. Affect

To manipulate affect, we either presented an image alongside the risky event or no image was presented. The images (which can be accessed in the Open Science Framework materials: https://osf.io/kajvd/) were representations of the risky events. For instance, for stomach cancer, there was a photo of cancerous stomach lining; for motor accident, there was a photo of a car crash, and so on. The instructions made it clear to the participants that the images were related to the risky events.

2.4. Measures

2.4.1. Risk Judgments

To probe risk judgments, we used two questions. The first was the *perceived frequency of risk*. Peo-

ple were asked: "*How many people do you think die each year in the U.S. from this risk?*". People, unlike experts, draw distinctions that do not enter tabulated mortality statistics such as that between "better" or "worse" deaths or death due to an unlucky accident (Slovic et al., 2000). To assess these distinctions, we also measured the *value of a statistical life* with: "*Imagine that one single person dies from each risk each year. What is the amount of public money that should be invested to save the person from dying*" (Tengs et al., 1995).

2.4.2. Affect

To measure affect, after each risky event, we asked participants "*How does the presented risk make you feel?*". A slider (Betella & Verschure, 2016) was used ranging from 0 (unpleasant) to 100 (pleasant). The slider was anchored in the middle, representing a neutral feeling, and participants could not see any scale numbers while moving the slider.

2.4.3. Fluency

Similar to Hertwig et al. (2005), we operationalized fluency as the frequency with which words associated with certain risks have been encountered in print media. Participants were asked, for each risk: "*How much media coverage (e.g., mentions in the news) do you think each of the risky events gets?*" (ranging from -3 *very little* to 3 *a lot*).

2.4.4. Number of Occurrences and Time

Finally, we logged how many occurrences participants actually thought of (reported) and we recorded the time it took them to write down the occurrences.

3. RESULTS

To maximize generalizability, we used linear mixed-effect models (LMEM). This means that, for all analyses, we treated both participants and the stimuli (i.e., the risky events) as random factors (Westfall, Kenny, & Judd, 2014). Each participant contributed many observations to the data set, one for each judgment that was made, so we clustered standard errors by participant to account for the nonindependence of observations within participants. Additionally, we employed by-subject and by-stimulus random slopes for the predictors that vary within subjects, that is, our manipulations of

availability and affect (Barr, Levy, Scheepers, & Tily, 2013). The use of LMEM's allowed us to take into account sources of error stemming both from participants and stimuli (risky events) thus minimizing chances of false positives (Brauer & Curtin, 2018). The lme4 (Bates, Mächler, Bolker, & Walker, 2015) and lmerTest (Kuznetsova, Brockhoff, & Christensen, 2017) packages in R were used to construct the models.

3.1. Manipulation Checks

3.1.1. Affect

We first verified whether predicted changes in affect were evoked. As expected, regressing the two factors of a 2 (recall: two occurrences vs. eight occurrences) × 2 (affect input: none vs. affect image) design on the measure of affect, we only obtained a main effect of affect input, $F(1, 139.9) = 8.07$, $p = 0.005$, $dz = 0.24$. Affect was lower (more negative) with the addition of an image ($M_{Image} = 17.40$; $SD_{Image} = 16.64$), compared to when no image was presented ($M_{NoImage} = 18.47$, $SD_{NoImage} = 16.40$). No other effects were significant (both $Fs < 2.90$) confirming that we successfully evoked a change in affect using the image manipulation.[3] Specifically, adding the images representing the risky events led to participants reporting a stronger (i.e., more negative) affective reaction than when no image was presented.

3.1.2. Number of Occurrences Recalled

Mostly, people could not think of occurrences from their social network (62.52% of the 1,569 judgments made were 0—note that four judgments were missing). This was unsurprising given the diverse risky events utilized in the experiment. There was no indication that our manipulations impacted the distribution of whether participants could or could not think of occurrences (for two occurrences 51% said 0; for eight occurrences 49% said 0; for low affect 49% said 0; for high affect 51% said 0). We then used the same analysis approach as above on the measure of number of occurrences recalled con-

trolling for the time taken[4] (centered). We included time into the model as spending more time on trying to recall occurrences could lead to higher recall rates. The results showed that there was a main effect of recall, $F(1, 108.32) = 4.87$, $p = 0.029$, $dz = 0.20$ (more occurrences were recalled when people were asked to think of eight, compared to two occurrences), a main effect of time, $F(1, 125.60) = 182.96$, $p < 0.001$, $dz = 1.16$ (the more time participants took, the more occurrences they thought of), and an interaction between these two factors, $F(1, 105.10) = 16.76$, $p < 0.001$, $dz = 0.37$. The interaction indicated that time was a strong positive predictor of number of occurrences recalled both when participants were required to think of 2 ($B = 2.64$, $p < 0.001$) and 8 ($B = 3.71$, $p < 0.001$) occurrences, although it seems to have been a stronger predictor when eight occurrences were required. Thus, participants told to recall more occurrences thought of more occurrences and the more time they took, the more occurrences they thought of.

3.2. Risk Judgments

Next, we looked at the how our manipulation of availability-by-recall and affect impacted how participants responded to the two dependent variables, that is, how they judged the risk. Table I shows the main descriptive results for all risky events.

3.2.1. Perceived Frequency of Risk

Answers on this measure were highly skewed (skew = 32.67), so we log transformed them—skew after transformation was −0.71. We regressed the two factors of a 2 (recall: two occurrences vs. eight occurrences) × 2 (affect input: none vs. affect image) design on this transformed variable and found only a significant effect of recall, $F(1, 139.3) = 5.92$, $p = 0.02$, $dz = 0.20$. People estimated higher death tolls when they were asked to think of 8 occurrences ($Mdn = 30.000$) compared to when they were asked to think of two occurrences ($Mdn = 25.000$). No other effects were significant (both $Fs < 2.85$). When we inserted people's response to the measure of fluency and the time it took them to report the occurrences into the model, the results remained the same. For more details, in Table II we report the descriptive statistics for our full design.

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[3] A reviewer request led us to verify whether there were any changes in affect simply due to filling in the questionnaire. We thus compared the affective evaluations of the first hazard shown to those of the last hazard shown and could not find any differences, hinting at low evidence for any spill-over effects, $F < 1$, $p = 0.54$. We thank the anonymous reviewer for this suggestion.

[4] Neither the affect input nor the availability by recall (or their interaction) had an impact on time taken (all $Fs < 1$).

Table II. Means and *SD*'s of Log-Transformed Values as a Function of Risky Event, Affect, and Availability Manipulations

| Risky Events	Affect	Availability	Perceived frequency of Risk		Value of Statistical Life	
			M	SD	M	SD
Alzheimer's	Image	Eight	10.42	2.43	10.50	4.72
	Image	Two	9.98	3.25	11.06	4.17
	None	Eight	10.31	2.66	10.18	4.28
	None	Two	10.72	1.73	10.47	5.41
Breast cancer	Image	Eight	9.59	2.31	9.58	4.38
	Image	Two	8.56	2.15	10.30	3.70
	None	Eight	9.54	2.27	9.63	3.74
	None	Two	9.44	2.93	9.29	5.26
Car accident	Image	Eight	10.78	1.99	10.71	3.55
	Image	Two	9.84	2.65	9.61	4.04
	None	Eight	10.41	2.95	10.82	4.73
	None	Two	9.42	2.75	9.49	4.10
Drug overdose	Image	Eight	10.51	3.04	10.11	4.93
	Image	Two	10.05	3.54	10.30	4.07
	None	Eight	10.91	2.07	11.04	4.61
	None	Two	10.62	2.00	8.28	4.88
Fire	Image	Eight	9.25	2.27	8.70	4.57
	Image	Two	8.97	2.49	9.67	4.14
	None	Eight	9.21	2.72	9.59	3.61
	None	Two	9.15	2.11	9.55	4.66
Myo. infarction	Image	Eight	9.31	2.81	8.68	4.27
	Image	Two	8.82	3.23	8.95	5.60
	None	Eight	9.46	2.62	10.87	4.01
	None	Two	9.06	1.87	10.68	3.08
Homicide	Image	Eight	11.80	2.66	10.37	4.79
	Image	Two	11.33	2.43	9.41	4.88
	None	Eight	11.28	2.58	10.26	4.70
	None	Two	12.14	2.11	10.72	4.75
Comp. med. care	Image	Eight	11.35	1.75	9.90	4.63
	Image	Two	11.03	2.47	10.11	3.70
	None	Eight	10.92	2.89	9.64	4.96
	None	Two	11.10	2.58	9.92	4.17
Parkinson's	Image	Eight	10.01	2.09	10.21	4.39
	Image	Two	9.56	2.72	9.24	4.44
	None	Eight	9.80	2.81	9.50	4.43
	None	Two	9.70	2.77	9.42	4.88
Skin cancer	Image	Eight	10.87	2.63	8.86	5.14
	Image	Two	9.98	3.38	9.17	4.90
	None	Eight	10.58	2.85	10.06	3.78
	None	Two	10.64	2.04	8.32	4.67
Stomach cancer	Image	Eight	8.82	3.18	9.40	4.48
	Image	Two	9.16	2.36	10.56	4.35
	None	Eight	9.61	3.19	9.29	3.77
	None	Two	9.64	2.30	9.57	4.54
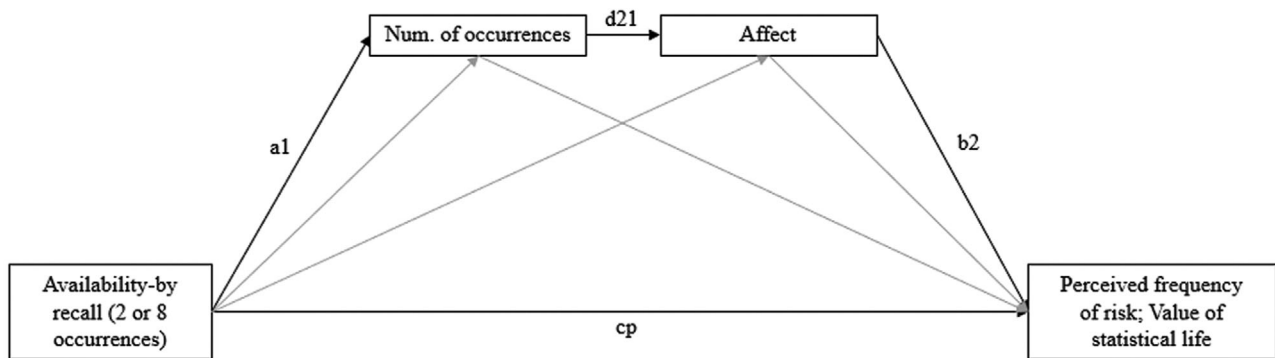
Fig 1. A representation of the serial mediation model tested for the impact of availability-by-recall on perceived frequency of risk and value of statistical life, through number of occurrences and affect. The possible grayed out paths were not tested as they were not of interest. The exact statistics (z scores and the 95% CIs) for each path (black lines) are reported in the text.

3.2.2. Value of Statistical Life

This measure was also highly skewed (skew = 30.68), so we log transformed it—skew after transformation was −0.53. The same analysis approach as above again only found an effect of recall, $F(1, 137.7) = 4.30$, $p = 0.04$, $dz = 0.17$. People thought more money should be invested when they had to think of eight (Mdn = 50.000), compared to two occurrences (Mdn = 40.000). No other effects were significant (both Fs < 1). Again, inserting fluency and time into the model, the results remained the same.

3.3. Availability, Affect, and Risk Judgment Accuracy

Using the CDC data for the number of people that actually lost their life to the risky events, we created an accuracy score. We subtracted the participants answers from the actual number of deaths. The closer this number to zero, the more accurate the perceived frequency of risk estimate. The data were skewed (skewness = −32.67) so we converted to absolute values and then we log transformed (again, the higher this number, the less accurate the estimate). Using the same analysis as above, surprisingly neither availability-by-recall nor affect input had any effect on accuracy (all Fs < 1).

3.4. Availability and Affect as Mechanisms of Risk Judgment Construction

Our results suggest that when manipulating availability-by-recall and affect directly, availability-by-recall had a stronger impact on both perceived

frequency of risk and value of statistical life. Yet, previous research demonstrated that affect *could* play a role in predicting risk judgments (Pachur et al., 2012). This led us to test a mediation model that might reconcile these findings. Specifically, we wanted to verify whether our manipulation of availability-by-recall might impact the number of occurrences thought of, which might change felt affect, which, in turn, would then impact risk judgments.

To do so, we tested a serial mediation model (Fig. 1). Specifically, we tested the model a1 → d21→ b2 (Fig. 1.). We first tested a model where perceived frequency was the dependent variable. We used the lavaan package in R (Rosseel et al., 2018) with 10.000 bootstraps to estimate the model. The overall indirect effect (a1×d21×b2), which indicates the amount of mediation through the relevant mediator variables was significant (The CIs do not cross zero although they are close) $z = 1.72$, 95% CI [0.001, 0.017]. The a1 path was significant ($z = 3.10$, 95% CI [0.06, 0.24]). The d21 path was also significant ($z = -10.85$, 95% CI [−3.31, −2.29]), as well as the b2 path ($z = -2.16$, 95% CI [−0.03, −0.002]). Note that the adjusted c path (cp) was not significant ($z = 1.59$, 95% CI [−0.05, 0.49]).

We then tested the same model but now the value of statistical life as the dependent variable. The overall indirect effect (a1×d21×b2) was again significant ($z = 1.62$, 95% CI [0.001, 0.025]). The a1 path was significant ($z = 2.79$, 95% CI [0.04, 0.22]). The d21 path was also significant ($z = -10.34$, 95% CI [−3.29, −2.24]), as well as the b2 path ($z = -2.11$, 95% CI [−0.05, −0.002]). Note also that the adjusted c path (cp) was not significant ($z = 0.91$, 95% CI

[−0.24, 0.66]) hinting at a possible full mediation. Overall, the mediation analysis indicates that a plausible mechanism of how people construct risk judgments is that thinking of more occurrences of a risk leads to a change in affect, which in turn impacts the risk judgment.

4. GENERAL DISCUSSION

Previous studies only looked at naturally occurring instances of availability and affect, to predict risk judgments (Pachur et al., 2012). We attempted to disentangle the impact of availability and affect on risk judgments by using an experimental approach.[5] The goal of this research was to experimentally manipulate availability and affect to verify their causal impact on risk judgments, specifically on judgments of perceived frequency of risk and value of statistical life. Across 11 different risky events (e.g., natural hazards, diseases, etc.), our results suggest that availability-by-recall (manipulated by asking people to think of either two or eight occurrences of someone from their social network dying from that risk) may have a stronger impact on risk judgment construction in that, when asked to think of more occurrences, people estimated that more people died from that risk and that more money should be invested to save a person dying from it. This finding was obtained independent of our manipulation of affect, controlling for an instantiation of fluency (i.e., how much people encountered the risk in the mass media), as well as controlling for the time it took participants to think of the occurrences. On top of this, for our analyses, we employed linear mixed-model effects treating both participants and stimuli (the risky events) as random factors. This approach allows us to make more generalizable conclusions beyond the subsample of participants and stimuli we selected (Brauer & Curtin, 2018; Judd, Westfall, & Kenny, 2012).

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[5]In a separate analysis reported in the Supporting Information here: https://osf.io/4qjxs/, we used the continuous measures (i.e., answers on felt affect and number of actual occurrences people thought of) as predictors of the risk judgments. Note that these variables are impacted by our manipulation, but as a robustness check and an approximate replication of Pachur, Hertwig, and Steinmann (2012), we report the findings. On the measure of perceived frequency of risk, both measures were significant predictors, but availability-by-recall offered a substantially better descriptive account. Unlike Pachur et al. (2012), who found that on the measure of statistical value of life, both availability and affect were good predictors, we found that only felt affect was a significant predictor. Detailed results are in the supplementary material.

Furthermore, we tested a mediation model where we obtained results hinting at the fact that availability-by-recall impacts the actual number of occurrences thought of, which in turn impacts felt affect, which in turn, impacts risk judgments. Our results point to the fact that this model might be an accurate description of availability's and affect's impact on risk judgments. We do not wish to speculate too much on these results as the CIs for the indirect effect were quite close to zero and the result would require further confirmation. However, we believe this finding offers an interesting reconciliation of availability and affect's role in risk judgments testable in further investigations.

Availability and affect are often used concurrently to describe how people make risks. It is understood that their underlying propositions are inherently linked (Keller et al., 2006). Affective states can impact retrieval of information and vice versa (Andrade, 2005; Bower, 1981; Jaspersen & Aseervatham, 2017; Pham et al., 2001). While availability-by-recall seems to have a stronger influence on risk judgments, it is not an infallible or even an isolated cue. Even early research suggested that it can be influenced by factors such as disproportionate exposure or imaginability (Lichtenstein et al., 1978). The results of our mediation model suggest that affect might be the second in line though. That is, while both availability and affect predict risk judgment, availability might take precedence, impacting the affective quality, which in turn, has an impact on risk judgments. Future research should dive more deeply into the sequential role of these two mechanisms to provide insights into the construction of risky judgments. In what follows, we discuss potential objections and limitations, as well as some practical implications of our results.

We made an explicit decision to focus on a repeated measures design. The benefits of this design, we believe, are in its authenticity to how risks may be judged every day. Both instantiation of availability and affect may come about together, naturally. When risks are communicated or discussed, people may be presented with images, thinking of occurrences of the risk in their networks. Nevertheless, we cannot be sure if our results may also be due to the fact that we were simply more *successful* in manipulating availability, rather than affect. While we did obtain a predicted difference in measured affect, this difference was small. This may not be surprising since risky events are already tinged with affect. Further, the way we measured affect (i.e., the question wording and the scale) could have impacted the validity of

the findings. For one, the question was framed at directly getting at the feeling ("how does the presented risk make you feel?") and we used a bipolar slider scale ranging from unpleasant to pleasant (with neutral in the middle). Participants may have not considered the right-hand side of the scale (i.e., the pleasant side) so perhaps unipolar scales may be better at getting at more precise differences. Second, other question wordings, for example, focusing on what the affective reaction to a particular risky event is, may be more appropriate.

Similarly, there may be other instantiations of availability, or other ways of manipulating affect, that are worth looking into. For example, it is difficult to control for the fact that for some risky events, even if asked to recall only two events, participants may have thought of more. Similarly, thinking of direct experiences from one's social network might artificially augment affective reactions as presumably occurrences from our social networks are more affective in nature. Our main goal was to nudge participants into a state of thinking where a lower (i.e., 2) or higher (i.e., 8) number of occurrences is *available*, but future investigations may, for example, try to prime instance knowledge. Additionally, while using images to augment affect is an established method (Kurdi, Lozano, & Banaji, 2017), future investigation could attempt to induce stronger emotions using other techniques (e.g., autobiographic recall or movies).

Our participants could not, largely, think of occurrences of someone from their social network dying from a particular risky event. However, this can be positively interpreted as the risk ecology seems to suggest that people, luckily, have a limited experience with certain risky events. This is in spite the fact that we used a selection of risks with an objectively high incidence rate (e.g., breast cancer, heart attacks). One important caveat is that our sample may have skewed more toward younger people who would have been less exposed to these risky events. One could argue that affect might have an impact when people could not discriminate based on recalled occurrences. Pachur et al. (2012) obtained indications that if retrieving direct occurrences fails, people exploit their affective responses. However, when we looked at the impact of availability-by-recall and affect solely on those judgments where people could not think of any occurrences, we failed to find any significant effects (all ps > 0.05—see the R scripts on the Open Science Framework for the detailed results). For a number of risks, we observed high

rates (>80%) of not being able to think of any occurrence. This may have hampered the effectiveness of our availability by recall manipulation for specific items, even though we did observe an *overall* significant change in number of occurrences that participants could think of. Future research could take special note to differentiate between overall manipulation success and that on the item level. Furthermore, people could think of availability in different ways. For example, there could be a difference between actually remembering more (or less) occurrences in one's social network and being led to think that there are more (or less) occurrences. These issues deserve further future unpacking.

Our risky events selection was similar to other research in this domain (e.g., Hertwig et al., 2005; Pachur et al., 2012). Nevertheless, a possible limitation could be that the risks were not sufficiently diverse. For instance, we lacked certain risky events that may have more severe consequences (e.g., natural disasters, pandemics,[6] etc.). One effect of this selection restriction could be a ceiling in terms of the affective measures or that frequencies are simply better predictors of risks that do not have such severe consequences. It may be that with more diverse risky events, the likelihood that people can find occurrences from their social networks, naturally decreases. It is imperative therefore that future research looks at more diverse risks that might provide further insights. We hope nevertheless that our use of linear mixed effect models can ease some of these generalizability concerns (Yarkoni, 2019). Another issue may have been spillover in that increasing/decreasing affect related to one hazard may have done the same to the subsequent or similar hazard (e.g., cancers). We hope though, that the random presentation of the risky events mitigated some of these issues.

Finally, similar to Pachur et al. (2012) we also failed to find that fluency, operationalized as instances about the risks being learned or seen in the media, had any impact on risk judgment construction. This goes against the idea that due to intense media coverage certain risk judgments might be distorted (Combs & Slovic, 1979; Lichtenstein et al., 1978). However, on an individual risky event basis, this idea may still hold. Even in our data, we saw large discrepancies (i.e., overestimations) in judgments relating to homicide which may be highly over-

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[6]Note: this research was conducted before the onset of the COVID-19 pandemic.

represented in the media, although there is still the possibility that participants could simply think of examples from their social network (see Table I). But, across *all* risky events, people's judgments remained relatively insulated from the skew potentially caused by media coverage (Sjöberg & Engelberg, 2010).

In terms of more general implications, our results suggest that combining both estimates of frequency (e.g., number of occurrences) and affect, perhaps in risk communication, people's judgments might not be that impacted by affect. This delicate balance should be further explored, and the exact interplay more concretely examined. This is not to say that imaginability, dread, or vividness are not important, but rather that the interplay between availability and affect might be more complicated. For example, it could be that affect may have an augmenting role in the communication of risk, but that, to adequately gauge the frequency or impact of a risk, people may need to think of, or be reminded of occurrences of this risk in their social environment. This naturally makes us question the issue of scale as we know from previous research that people are not good at internalizing or representing large-scale losses of life. For example, the phenomenon of psychophysical numbing states that people are unable to appreciate losses of life as they become larger as constant increases in the magnitude of a stimulus typically evoke smaller and smaller changes in response (Slovic & Västfjäll, 2010). Conversely, the contradiction between how confident people are in their judgment and the overwhelming evidence in the fallibility of their judgments is well-known (Meehl, 1954; Tversky & Kahneman, 1974). An interesting investigation of this discrepancy can be found in Einhorn and Hogarth (1978) where a learned model is discussed on how people's accuracy judgments are both learned and maintained, hinting at the fact that number of recalled occurrences from memory one can think of, may have a disproportionate influence on confidence in judgments. Availability of occurrences may thus be a highly biased cue to use. While we did not find any effect on the accuracy measure (comparing actual number of deaths from a risky event to what our participants judged), it may be that number of occurrences thought-of can have an impact on other aspects, like confidence, which could bias risk judgments. In that sense, as Tversky and Kahneman (1974) have suggested, people should attempt to encode events not by their substantive content, but by judged probability.

To judge the risk of a particular event is almost a daily occurrence. Understanding how people come to make such judgments is of crucial importance for policy, as well as scientific understanding of how the human mind deals with risks. In this article, we presented the results of an experiment where we experimentally manipulate availability and affect to verify their impact on risk judgment construction. The two heuristics have been discussed as important predictors in determining how people judge risks, but they also share several similarities. We found that our instantiation of availability, availability-by-recall, had a stronger impact on constructing risk judgments, over our instantiation of affect. People asked to think of more occurrences estimated that more people died from a risk and that more money should be invested to save a person dying from it. In addition, our data suggest that availability may take precedence, but that the more occurrences one thinks of can impact affective reaction, which in turn, may impact how a risky event is judged. We hope that future research continues to look at the role of these heuristics using an experimental approach and that through such efforts, we will find more about how people construct risk judgments.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Supplementary Material