IS RELIANCE ON THE AFFECT HEURISTIC ASSOCIATED WITH AGE?

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ABSTRACT

With age, decision makers rely more on heuristic and affect-based processing. However, age differences in reliance on the 'affect heuristic' have not yet been quantified. This heuristic derives judgments by drawing on one's positive and negative feelings towards stimuli. To test whether affect heuristic usage is associated with age, an adult lifespan sample ($N = 195$, 21 – 90 years, $M_{age} = 52.95$, 50% female, 71% non-Hispanic White) completed three affect heuristic tasks. Reliance on affect was indexed through a positive relationship between feelings of dread and statistical inferences about mortality risks, a positive relationship between affective responses and impact judgments when evaluating catastrophes, and a negative perceived relationship between food risks and benefits. Contrary to our hypothesis, older age did not predict stronger use of the affect heuristic. Indices did not correlate across tasks, suggesting that use of the affect heuristic is context- or stimulus-dependent rather than a stable trait.

by

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BIOGRAPHICAL SKETCH

In 2014, Julia Nolte gained a B.Sc. in Psychology from Heidelberg University, Germany, followed by an M.Sc. in Psychology in 2017. During her time in Heidelberg, Julia also completed research visits at Cornell University (2015 – 2016), Harvard University (2016), Oxford University (2016), and Cambridge University (2017). Since 2017, Julia has been an M.A./ Ph.D. student at Cornell University's Human Development Department, where she is a member of Dr. Corinna Löckenhoff's Healthy Aging Laboratory. Concentrating on 'Health and Well-Being', Julia's research interests lie at the intersection of decision making, lifespan development, and health.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS AND SYMBOLS

al.	alia (Latin: “others”)
α	significance level in hypothesis testing
ANOVA	analysis of variance
b	regression coefficient
CDC	Centers for Disease Control and Prevention
Cronbach’s α	internal consistency
F	F-test statistic
M	mean
N	size of sample
n	size of sub-sample
p	probability of observing test result
p./ pp.	page number / page numbers
$pseudo\text{-}R^2$	amount of variance explained
r_s	Spearman’s rank correlation coefficient
SD	standard deviation
t	t-test test statistic
V	V-statistic (in the context of Wilcoxon signed rank tests)
X^2	chi-square test statistic
*	$p < .05$ (probability of observing test result is less than 5%)
**	$p < .01$ (probability of observing test result is less than 1%)
***	$p < .001$ (probability of observing test result is less than 0.1%)

1 INTRODUCTION

The US is undergoing a major demographic shift, with important implications for the field of decision science. By 2030, one in five US residents will be 65 years or older (United States Census Bureau, 2017). In this, the US is not alone: Across the world, populations are aging (United Nations, 2015). As a result, gerontologists and decision scientists see the need for improving our understanding of how aging impacts judgment and decision making (Carstensen & Hartel, 2006; Hanoch, Wood, & Rice, 2007; Peters, Finucane, MacGregor, & Slovic, 2000).

The current study addresses two processes relevant to age differences in the judgment of risks that have only been studied separately so far: age-related increases in the reliance on heuristics and age-related increases in the reliance on affect. In brief, the present study aims to quantify adult age differences in people's use of the affect heuristic; a strategy that simplifies judgments and decisions by drawing on one's positive and negative affective responses. To this end, we first review age-related decrements in deliberative judgment and decision making as well as age-related increments in heuristic and affect-reliance. We then outline how the affect heuristic is defined and will be tested in the presented study. Finally, we present a series of hypotheses, including the assumption that older adults rely more strongly on the affect heuristic than younger adults do.

1.1 Age-Related Decrements in Analytical-Deliberative Judgment and Decision Making

The extant literature suggests that many decision-relevant abilities deteriorate with age. For instance, aging is linked to declines in aspects of attention, executive functioning, working memory, processing speed, and reasoning skills (Salthouse, 1996; Salthouse & Ferrer-Caja, 2003; Singh-Manoux et al., 2012; Verhaeghen, & Cerella, 2002; Verhaeghen & Salthouse, 1997; Wasylyshyn, Verhaeghen, & Sliwinski, 2011). These losses correspond to age-related changes in brain connectivity and in the activation of brain areas that are implicated in the recruitment of decision-relevant abilities (Fjell, Sneve, Grydeland, Storsve, & Walhovd, 2017; Madden, Bennet, & Song, 2009; Turner & Spreng, 2012). As a consequence, decision making that requires a deliberative analysis of the available choice options or information becomes more difficult with age (for reviews, see Hanoch et al., 2007; Peters, Diefenbach, Hess, & Västfjäll, 2008; also see Breton, Seeland, & Redish, 2015).

To illustrate, older adults prefer having fewer choice options (Reed, Mikels, & Löckenhoff, 2012), use less complex choice strategies (Mata, Schooler, & Rieskamp, 2007), and consider fewer pieces of information before making decisions (Mata & Nunes, 2010). Such age differences in information acquisition can be remedied by instructing older adults to focus on the facts and details at hand (Löckenhoff & Carstensen, 2007). However, nudging older adults to focus more on concrete information may come at a price: In a study that combined information seeking with a subsequent choice task, the quality of older adults' decisions waned when asked to focus on decision-relevant information (Mikels et al., 2010). Conversely, younger adults benefited from an information-focus. This mirrors other findings suggesting that age differences in choice quality become more apparent in contexts that require a stronger reliance on deliberation (Hess, Queen, & Patterson, 2012). Taken together, it appears that relying on the deliberation of decision-relevant information may be a more optimal decision strategy for younger adults than it is for older adults.

1.2 Bounded Rationality and the Use of Heuristics to Make Judgment and Decisions

Hanoch and colleagues (2007) contextualize age-related losses in analytical-deliberative decision making by proposing that older adults experience "intensified bounded rationality" (p. 344). According to the concept of bounded rationality (Simon, 1957, 1991), our ability to reason rationally is constrained by the limited means at our disposal. When decision makers lack the necessary time, information, or cognitive capacity to weigh their options, they are thought to fall back on heuristics. Heuristics are rules-of-thumb or strategies aimed at facilitating judgment and decision making. While analytical-deliberative information processing describes one mode of judgment and decision making, heuristic processing represents a second mode (e.g., Reyna, 2004; Sloman, 1996) that relies on intuitive rather than reasoned responses.

Typically described as fast and resource-efficient, heuristics operate by neglecting some of the available information or by substituting one type of judgment with another, more readily made judgment (Gigerenzer & Gaissmaier, 2011; Tversky & Kahneman, 1974). Although the use of heuristics will often lead to correct judgments or beneficial decisions (Gigerenzer, Todd, & ABC Research Group, 1999; Mata & Nunes, 2010), heuristics can also induce bias (Tvsersky & Kahneman, 1974).

For instance, heuristics sometimes lead decision makers to ignore decision-relevant concepts like statistical chance or base-rate probabilities (e.g., Denes-Raj & Epstein, 1994). As a result, using heuristics can result in incorrect judgments such as estimating the joint probability of two events as higher than the probability of one of the two events occurring alone (Tversky & Kahneman, 1983). Yet other heuristics can skew the perception of whether information is trustworthy (Lord, Ross, & Lepper, 1979; Plous, 1993), what possessions are worth (Kahneman, Knetsch, & Thaler, 1990, 1991; Knetsch, 1989), or how easy it is to foresee future events (Fischhoff, 2007; Fischhoff & Beyth, 1975). Considering their possible pitfalls, relying on heuristics to make judgments or decisions is an approach that can be risky even though it is often adaptive.

1.3 Age-Related Increments in Intuitive or Heuristic Judgment and Decision Making

Because older decision makers experience more cognitive limitations, it is plausible that they rely more strongly on heuristics and intuition than younger adults do. However, whereas age-related decrements in deliberation are well-studied, research on age-related increments in heuristic or intuitive processing is still scarce (Hanoch et al., 2007; Pachur, Mata, & Schooler, 2009; Peters et al., 2008).

What has been established is that older adults are more likely to use simpler, non-compensatory heuristics such as “satisficing”. That is, older adults are more likely to look for “good enough” rather than the “best” choice options (Bruine de Bruin, Parker, & Strough, 2016; Chen & Sun, 2003; Hanoch, Wood, Barnes, Liu, & Rice, 2001; Johnson, 1990; Mata & Nunes, 2010; Riggle & Johnson, 1996; Streufert, Pogash, Piasecki, & Post, 1990). For example, Besedeš, Deck, Sarangi, and Shor (2012) report that older adults are less likely to make optimal or near-optimal decisions than younger adults are. This difference in decision quality can be explained by older adults relying more strongly on a simpler decision heuristic, whereas younger adults use more elaborate heuristics or are more focused on maximizing decision payoffs (Besedeš et al., 2012). Mata et al. (2007) report similar results and show that older adults' increased reliance on simpler, less effortful decision strategies by can be explained by age-related decreases in fluid intelligence.

Aside from older adults relying on *simpler* heuristics than younger adults do, older adults are generally more likely to rely on heuristic or intuitive processing than their younger peers are (Korniotis & Kumar, 2011; Mutter & Pliske, 1994; Pachur et al., 2009; Worthy & Maddox, 2012). The reason for this may be two-fold. First, Queen and Hess (2010) find that whereas deliberative decision-making becomes less efficient, the ability to make intuitive choices remains stable with age. Second, older adults may benefit from experience and expertise they have accumulated over time: To illustrate, more knowledgeable physicians make more accurate triaging decisions than less knowledgeable physicians do, and achieve this by relying on fewer rather than more dimensions of information (Reyna & Lloyd, 2006). In a similer vein, stronger self-reported preferences for affect-based and intuitive rather than deliberative decision making correlate with participants' perceived expertise regarding different choice domains (Pachur & Spaar, 2015).

Further support for the assumption that older adults rely more strongly on their intuition or on heuristics stems from the fact that older adults are sometimes more biased in their judgments and decisions. For instance, some studies report that older adults exhibit stronger framing effects when choosing between sure and risky choice options (Kim, Goldstein, Hasher, & Zacks, 2006; Pu, Peng, & Xia, 2017; Reyna, Chick, Corbin, & Hsia, 2014; Rönnlund, Del Missier, Mäntylä, & Carelli, 2019; cf. Mata, Josef, Samanez-Larkin, & Hertwig, 2011; Mikels & Reed, 2009; Rönnlund, Karlsson, Laggnäs, Larsson, & Lindström, 2005; Watabene & Shibutani, 2010). Framing effects refer to the inclination to avoid risks when a choice option is presented as a possible gain and to seek risks when a choice is presented as a possible loss, although the differently framed options are objectively identical. Comparable to the use of heuristics, framing effects are more likely to occur under time pressure (Guo, Trueblood, & Diederich, 2017), when cognitive resources are low (Rönnlund et al., 2019; also see Bruine de Bruin, Parker, & Fischhoff, 2007), and among individuals with stronger tendencies towards intuitive and spontaneous decision making or a lower need for cognition (Bruine de Bruin et al., 2007; Carnevale, Inbar, & Lerner, 2011). Hence, age-related increases in the susceptibility to framing effects may reflect older adults' heightened reliance on heuristic processing.

In a similar vein, a recent meta-analysis finds that older adults experience stronger reconstruction bias, that is, a stronger influence of outcome information on the reconstruction of their original memory (Groß & Pachur, 2019). As such, reconstruction bias feeds into hindsight bias (Groß & Pachur, 2019), which is the tendency to overestimate the predictability of an event *after* it has happened. Similar to framing effects, hindsight bias might be connected to heuristic processing (Agans &

Shaffer, 2020; Hertwig, Fanselow, & Hoffrage, 2003), again suggesting a link between reliance on heuristics and older age.

Finally, older adults perform more poorly on the Cognitive Reflection Test. Better performance on this test requires individuals to overcome intuitive but incorrect responses in favor of correct, deliberate responses (Hertzog, Smith, & Ariel, 2018; Sinayev & Peters, 2015). Hence, older adults may experience more difficulties overcoming their reliance on intuition.

In sum, evidence suggests that whereas deliberation becomes more costly and less efficient across the lifespan, the use of intuition and heuristics becomes more common with age, as might decision makers' susceptibility to certain reasoning biases. Nevertheless, it is important to stress that an increased reliance on heuristic or intuitive processing does not necessarily have to have negative consequences for older adults. For instance, a recent study involving older patients found that patients' treatment choices were equally good or improved when instructed to make fast, intuitive decisions under high cognitive load rather than slow, deliberative decisions under no cognitive load (Rubin, Buehler, & Cooney, 2019). Therefore, some authors have argued that whether increased reliance on heuristics helps or hurts older adults' judgment and decision making will depend on the specific task context at hand (e.g., Queen & Hess, 2010; Worthy & Maddox, 2011).

1.4 Age-Related Increments in Affect-Reliance during Judgments and Decisions

Several scholars have argued that with age, decision makers also rely more strongly on affect to make judgments or decisions (Hanoch et al., 2007; Mikels, Cheung, Cone, & Gilovich, 2013; Peters & Bruine de Bruin, 2012; Peters, Hess, Vjästfjäll, & Auman, 2017; Peters et al., 2008). In fact, decision science often regards fast and intuitive processing – such as the use of heuristics – as an affective-experiential mode of decision making (Huang, Wood, Berger, & Hanoch, 2015; Löckenhoff, 2018; Peters & Bruine de Bruin, 2012; Peters et al., 2007; Strough, Karns, & Schlosnagle, 2011; Strough, Parker, & Bruine de Bruin, 2015). As a result, reliance on affect can be understood to be a special type of intuitive or heuristic processing.

Age-related changes in affect-reliance are well-documented in the contexts of memory (Fung & Carstensen, 2003; Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005; Zhang, Fung, & Ching, 2009), information seeking (English & Carstensen, 2015; Löckenhoff & Carstensen, 2007, 2008), judgment (Shamaskin, Mikels, & Reed, 2010; Zhou, Lu, Chen, Dong, & Yao, 2017) and decision making (Chen & Ma, 2009; Chou, Lee, & Ho, 2007; Huang et al., 2015; Mikels et al., 2010; Notthoff & Carstensen, 2014; Zhang et al., 2009). In general, this research has found that older adults attend more strongly to affective information and the valence associated with affective information (i.e., positive, neutral, or negative affect) than younger adults do. Specifically, older adults are more likely to focus on or select positively valenced faces, descriptive terms, facts, or persuasive messages than younger adults do, and less likely to attend to, select, or be persuaded by negatively valenced information (Löckenhoff & Carstensen, 2007, 2008; Mather & Carstensen, 2003; Notthoff & Carstensen, 2014; Zhou et al., 2017). Unlike younger adults, older adults also remember affective information better than visual information, positive stimuli better than negative stimuli, and information stressing affective goals better than information stressing future-oriented or neutral goals (Mather & Carstensen, 2003; Mikels et al., 2005; Shamaskin et al., 2010; Zhang et al., 2009). This corresponds to findings suggesting that unlike other cognitive abilities, memory for affective information is relatively well-preserved with age (Denburg, Buchanan, Tranel, & Adolphs, 2003; Mikels et al., 2005).

This increased focus on affect or affective information also has implications for older adults' judgment and decision making. In judgment tasks, older adults were found to rely more frequently on affect-based than deliberative strategies (Horhota, Mienaltowski, & Blanchard-Fields, 2012; McNair, Okan, Hadjichristidis, & Bruine de Bruin, 2018). Sometimes, this tendency can benefit older adults' choice quality: For example, older adults but not younger adults make higher-quality choices when focusing on how they feel about each choice option (Mikels et al., 2010). In healthcare contexts, focusing on affect can thus promote older adults' exercise intentions (Notthoff & Carstensen, 2014; Steltenpohl, Shuster, Peist, Pham, & Mikels, 2018) and their willingness to eat healthily (Zhang et al., 2009).

However, depending on the task context, reliance on affect can also prove disadvantageous for older adults. For instance, when choosing between an intuitively more attractive and an objectively more beneficial choice, older adults are more likely to make affect-based, nonoptimal choices than younger adults are (Mikels et al., 2013). As stated before, older adults also make poorer decisions than young adults do when they are instructed to focus on the information at hand rather than their feelings about the information (Mikels et al., 2010). This suggests that different age groups recruit different strategies to make judgment or decisions, a notion backed by an analysis of younger and older adults' decision strategies (Wood, Busemeyer, Koling, Cox, & Davis, 2005) as well as self-reports generated by different age groups (Huang et al., 2015) after completing the Iowa Gambling Task, an experience-based decision task. Whereas younger adults recruit deliberative decision strategies or both affect-based and deliberative strategies to complete this task, older adults favor affect-based strategies (Huang et al., 2015; Wood et al., 2005). Despite this difference in how each group approaches the task, they perform equally well (Huang et al., 2015; Wood et al., 2005). This is compelling considering that in the Huang et al. (2015) study, older adults performed worse than younger adults on the Columbia Card Task. Unlike the Iowa Gambling Task, the Columbia Card Task is a description-based task in which decision makers have to rely on probabilistic information. Older adults' poorer performance on this task can be explained by declines in deliberative abilities such as decreased numeracy and executive functioning (Huang et al., 2015). Together, these findings suggest that a stronger reliance on affect-based strategies and a weaker reliance on deliberative strategies might allow older adults to compensate for cognitive losses in deliberative abilities, provided the decision environment allows for the recruitment of affect-based strategies.

1.5 The Affect Heuristic

One heuristic that specifically incorporates affect into one's judgments and decisions is the affect heuristic (Slovic, Finucane, Peters, & MacGregor, 2002). In the broadest sense, affective reactions capture whether stimuli "feel" inherently good or bad (Finucane, Alhakami, Slovic, & Johnson, 2000). As such, affective reactions form the basis of evaluative judgments (Schwarz & Clore, 1988) that distinguish between stimuli that are perceived as likable or desirable and stimuli that are not (see Zajonc, 1980). It has been suggested that these judgments are derived from decision makers' "affective pool[s]" (Finucane et al., 2000, p. 14): sets of symbolic representations that are consciously or unconsciously associated with either favorable or unfavorable feelings (Slovic, Peters, Finucane, & MacGregor, 2005). These associations are formed through learning processes that tag experiences as evoking either positive or negative affect (Slovic et al., 2002). The affect heuristic operates by relying on positive and negative feelings when judging stimuli or deciding between different choice options. For instance, the affect heuristic has been implicated in instances where decision makers choose more subjectively attractive over more objectively beneficial options (Shiv & Fedorikhin, 1999; Slovic et al., 2007; also see Denes-Raj & Epstein, 1994). As such, drawing on the affect heuristic to evaluate stimuli has been likened to drawing on one's implicit attitudes towards these stimuli (Dohle, Keller, & Siegrist, 2010; Spence & Townsend, 2008).

Since the affect heuristic draws on internal representations or one's "gut feeling" (Visschers & Siegrist, 2008, p. 158), it is a prime example of the intuitive-experiential (or affective-experiential) mode of decision making that underlies heuristic processing (Slovic et al., 2002, 2007; Spence & Townsend, 2008). Like other heuristics, falling back on affect can precede deliberative thought (Slovic et al., 2002), allows for fast and automatic judgments (Slovic et al., 2007), and "can be easier and more efficient than weighing the pros and cons of various reasons or retrieving relevant examples from memory“ (Slovic et al., 2005, p. S36; Sokolowska & Sleboda, 2015). To accomplish this, the affect heuristic substitutes relevant attributes that are difficult to process for sometimes “irrelevant attributes that can be easily processed“ (Sokolowska & Sleboda, 2015, p. 1253).

The definition of the affect heuristic as a strategy that relies on good and bad feelings is broad enough to apply to many contexts. However, the study of the affect heuristic often centers on the judgment of risks (e.g., Alhakami & Slovic, 1994; Bruine de Bruin, Lefevre, Taylor, Dessai, & Fischhoff, 2016; Finucane et al., 2000; Greenberg et al., 2012; Pachur, Hertwig, & Steinmann, 2012; Siegrist, Cousin, Kastenholz, & Wiek 2007; Siegrist & Keller, 2011; Skagerlund, Forsblad, Slovic, & Västfjäll, 2019; Slovic et al., 2002, 2005, 2007; Sokolowska & Sleboda, 2015). In fact, Pachur and colleagues (2012) offer their own definition of the affect heuristic, specifically focusing on risk-related judgments (see Slovic, 1987): “Gauge your feeling of dread that Risk A and Risk B, respectively, evoke and infer that risk to be more prevalent in the population for which the level of dread is higher” (Pachur et al., 2012, p. 316). In general, research linking affect and judgments of risk has found that negative feelings are associated with stronger perceptions of riskiness, higher perceived risk frequency, and lower perceived acceptability of risk (e.g., Alhakami & Slovic, 1994; Evans et al., 2015; Pachur et a., 2012; Poortinga & Pidgeon, 2005; Slovic et al., 2004; Slovic, 1987; Sokolowska & Sleboda, 2015). In addition, one study comparing decision makers’ risk perception across two different tasks suggests that the degree to which individuals rely on this heuristic to judge risks may be a stable inter-individual preference (Slovic, MacGregor, Malmfors, & Purchase, 1999, as referenced by Finucane, Peters, & Slovic, 2003; Slovic et al., 2002).

1.6 The Present Study

Given that the extent to which individuals rely on the affect heuristic might reflect a personal preference for affect-based heuristic processing, the present study evaluates whether this preference differs between age groups. Specifically, past literature has speculated about age-related increases in people's use of the affect heuristic when seeking information and making judgments or decisions (Mikels et al., 2010; Mikels, Shuster, & Thai, 2015; Peters et al., 2008). However, we know of no study that has directly sought to quantify these age differences. In the present study, we presented an adult lifespan sample (21 to 90 years) with three tasks that have all been argued to assess reliance on the affect heuristic. The selection of these tasks was guided by following four criteria.

First, we chose tasks that assess evaluative judgments (Schwarz & Clore, 1988) over tasks that assess decision making. Although each task captured a different kind of judgment, all tasks centered on the judgment of risks, as the affect heuristic is most often studied in the context of risk perception. As such, the tasks were conceptually similar enough for us to assess whether the degree to which each participant relies on the affect heuristic is indeed similar across tasks. Second, each task allowed for judgments to be made on the basis of good or bad feelings towards the stimuli we presented, thus enabling use of the affect heuristic as it is commonly defined. Third, to verify that participants indeed relied on affect to make their judgments, each task entailed an assessment of participants' affective reactions or attitudes concerning the presented stimuli. This permitted us to link participants' affect or attitudes to the judgments they made about a given stimulus. Each task included a manipulation check to confirm that use of affect heuristic was in fact evident. Finally, each task allowed us to identify whether participants' reasoning was to some degree biased, as would be expected when relying on heuristic processing. Given these four criteria, we identified three tasks that fit our requirements: an affect-impact task, a dread-inference task, and a risk-benefit task.

Affect-Impact Task. One way of assessing the affect heuristic focuses on the relationship between participants' affective responses to risks and their judgments of the risks' impact (Siegrist & Sütterlin, 2014), acceptability (McComas, Lu, Keranen, Furtney, & Song, 2016), or their efficiency (Siegrist & Sütterlin, 2016). Previous research suggests that even when information about objective outcomes is provided (Siegrist & Sütterlin, 2014), subjective judgments of the outcomes of risks are influenced by individuals' affective responses to these risks. Specifically, negative affective reactions to a risk lead to more negative evaluations of its outcome (Siegrist & Sütterlin, 2014). For the purposes of the present study, we relied on a version of this task that confronts participants with catastrophic events or trends that are either caused by human activity or that occurred naturally (Siegrist & Sütterlin, 2014). Prior research suggests that man-made catastrophes elicit more negative affective reactions than naturally occuring catastrophes do (also see McComas et al., 2016). As a result, catastrophes caused by human activity are subjectively perceived to have worse impact than naturally caused catastrophes, even when the objective impact is identical regardless of cause (Siegrist & Sütterlin, 2014). This task suited the criterion set because it linked participants' affective responses to risk scenarios to their subjective judgment of the risks' impact. In addition, it allowed us to assess bias by comparing impact ratings between naturally caused and man-made catastrophes (which have the same objective impact and should receive identical impact ratings).

Dread-Inference Task. In an alternative test of the affect heuristic, Pachur and colleagues (2012) tasked participants with judging the frequency with which different causes of death claim lives every year. In addition, participants indicated how negatively they felt about each cause of death. This enabled Pachur et al. (2012) to correlate feelings of dread with the magnitude of participants' frequency judgments about each cause of death. This dread-inference task is based on the authors' risk-centric definition of the affect heuristic suggesting that decision makers draw on feelings of dread to identify more and less common risks (Pachur et al., 2012; see Slovic, 1987). Indeed, Pachur and colleagues (2012) find that those causes of death that evoke stronger feelings of dread are judged to be more common in the population. In a related vein, feelings of dread are linked to perceptions of riskiness (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978) as well as perceptions of risk acceptability (Slovic, 1987). In line with our criteria, the dread-inference task included in the present study entailed an assessment of affect – that is, feelings of dread. The task also entailed a direct test of the way affect was associated with participants' judgments of the frequency of risks. This was accomplished by correlating participants' feelings of dread with the magnitude of their frequency judgments. In addition, comparing participants' judgments to real-life mortality statistics allowed us to verify whether reliance on the affect heuristic is linked to biased reasoning.

In the dread-inference task, we also tested an alternative explanation for age differences in how people evaluate risks: the availability heuristic (Mutter & Pliske, 1994; see Peters et al., 2008). The availability heuristic operates by judging the frequency of events based on how easy it is to extract examples of these events from memory (Tversky & Kahneman, 1973). Therefore, we accounted for the possibility that due to their richer life experience, older adults might be able to recall more relevant examples of the events from their memory, and that this influences how they feel about or perceive them. Previous research suggests that similar to relying on affect, recalling relevant examples from memory colors people's judgments of risks (Bruine de Bruine, Lefevre et al., 2016; Keller, Siegrist, & Gutscher, 2006; Pachur et al., 2012). Therefore, we assessed participants' direct and indirect exposure to the events presented.

Risk-Benefit Task. Finally, and most commonly, reliance on the affect heuristic is studied by asking participants to evaluate different stimuli's risks and benefits. Specifically, use of the affect heuristic is thought to manifest itself as the (incorrect) perception that risks and benefits are inversely related (e.g., Alhakami & Slovic, 1994; Poortinga & Pidgeon, 2005; Siegrist, Cousin, et al., 2007; Siegrist & Keller, 2011; Slovic et al., 2005; Sokolowska & Sleboda, 2015). This perception reflects bias because real-life risks and benefits often share a positive rather than a negative relationship (Slovic & Peters, 2006): The higher the risks, the higher the benefits (and vice versa). However, decision makers typically view the benefits associated with high risks as low and the benefits associated with low risks as high.

Building on the affect heuristic, prior research suggests that stimuli associated with positive affect receive more favorable risk-benefit evaluations than stimuli associated with negative affect (Finucane et al., 2000). Whereas negative affect results in perceptions of *high* risk and *low* benefit, positive affect results in perceptions of *low* risk and *high* benefit (e.g., Evans et al., 2015; Sokolowska & Sleboda, 2015). In fact, once affective reactions (as proxied by decision makers' attitudes) are taken into consideration, risks and benefits no longer share a significant negative correlation (Sokolowska & Sleboda, 2015). To verify participants' reliance on the affect heuristic, the present risk-benefit task thus included an assessment of participants' attitude towards each stimulus.

1.7 Hypotheses

The analyses in the present paper were guided by a series of hypotheses. Extrapolating from previous findings, we hypothesized that older age would predict a stronger reliance on the affect heuristic across all three task types (Hypothesis 1). Additionally, we hypothesized that stronger reliance on the affect heuristic would predict a stronger extent of bias or incorrect inferences in participants' judgments (Hypothesis 2). Because in the risk-benefit task, reliance on the affect heuristic was indistinguishable from the extent of bias participants demonstrated, this hypothesis was only tested in the dread-inference and affect-impact tasks. Furthermore, we evaluated the hypothesis that reliance on the affect heuristic is associated across the three different task types (Hypothesis 3).

In addition, we collected data on covariates that have been previously implicated as predictors of people's judgments of risks or their use of the affect heuristic: current affect at the time of the study (Finucane et al., 2000; Johnson & Tversky, 1983; Västfjäll, Peters, & Slovic, 2014; Slovic et al., 2002), personality (Beyer, Fasolo, de Graeff, & Hillege, 2015; Chauvin, Hermand, & Mullet, 2007; Hampson, Andrews, Barckley, Lichtenstein, & Lee, 2006; Oehler, & Wedlich, 2018; Zambrano-Cruz, Cuartas-Montoya, Meda-Lara, Palomera-Chávez, & Tamayo-Agudelo, 2018), cognitive reflection ability (Skagerlund et al., 2019), and numeracy (Pachur & Galesic, 2013; Skagerlund et al., 2019).

Finally, we accounted for several additional factors that are known to vary across the lifespan: physical and mental health (e.g., Jeste et al., 2013; Swift et al., 2014), perceived position within the life span (Hancock, 2010; Rutt & Löckenhoff, 2016), a preference for verbatim or gist-based information processing (Reyna et al., 2014; Reyna & Casillas, 2009; Reyna & Lloyd, 2006), crystallized intelligence (Ackerman, 2000; Hartshorne & Germine, 2015; Horn & Cattell, 1967), and the motivation to pursue growth (versus maintenance) goals (Ebner, Freund, & Baltes, 2006; Mustafić & Freund, 2012).

Although we evaluated the predictive power of each individual difference measure, we specifically hypothesized that increased reliance on the affect heuristic would be predicted by indicators of intuitive reasoning: a stronger self-reported preference for pursuing goals based on feelings as opposed to information, a stronger behavioral preference for intuitive, gist-based information processing as opposed to fact-based, verbatim processing, and poorer cognitive reflection ability (Hypothesis 4).

2 METHODS

Hypotheses, design, and analytical approach were pre-registered with AsPredicted.com (Project #29144) prior to data collection (see Appendix).

2.1 Sample

We aimed to recruit 75 young adults (age range 18 – 35 years), 75 middle-aged adults (age range 36 – 65 years), and 75 older adults (66 years and older), resulting in an adult lifespan sample of $N = 225$. In an effort to account for participants we might have to exclude, Qualtrics.com recruited $N = 232$ participants. Of this sample, we excluded 37 participants due to admitting to cheating ($n = 34$), extreme completion times[1] ($n = 2$), or an unresolved mismatch between alleged age and birth year ($n = 1$). The final sample ($N = 195$, $M_{age} = 52.95$, $SD_{age} = 18.10$) consisted of 55 younger adults ($M_{age} = 29.22$, $SD_{age} = 3.79$), 73 middle-aged adults ($M_{age} = 53.33$, $SD_{age} = 8.79$), and 67 older adults ($M_{age} = 72.03$, $SD_{age} = 5.27$). Fifty percent of participants were women (49%, 49%, and 52%, respectively). Across the entire sample, 151 participants (77%) identified as White/Caucasian, 25 participants (13%) identified as Black/African American, and 16 participants (8%) identified as Asian. The remainder of the sample identified as Hispanic, Mexican, or Spanish (one participant each (1%)).

[1] We relied on Qualtrics.com's internal selection criteria for excluding participants due to short completion times. We excluded two additional participants due to completion times over 100 minutes because the affect they reported at the beginning of the survey likely had changed by the time the survey was completed.

Table 1

Overview of affect heuristic tasks

Name	Sources	Task Structure and Items	Group-Level Index	Individual-Level Index
Affect-Impact Task	McComas et al. (2016); **Siegrist & Sütterlin (2014)**; Siegrist & Sütterlin (2016)	Affective response and impact ratings concerning three catastrophic events or trends (each presented twice)	Positive group-level correlation between affective response and impact ratings	Positive individual-level correlation between affective response and impact ratings
Risk-Benefit Task	e.g., Alhakami & Slovic (1994); Poortinga & Pidgeon (2005); Siegrist, Cousin, et al. (2007); Siegrist & Keller (2011); Slovic et al. (2005); **Sokolowska & Sleboda (2015)**	Perceived risks, perceived benefits, and affective response (attitudes) concerning five food characteristics	Negative group-level correlation between perceived risks and perceived benefits	Pre-registered index: Negative individual-level correlation between perceived risks and perceived benefits Actual index: Average distance between perceived risks and benefits (e.g., Average(|Risks – Benefits|)
Dread-Inference Task	Fischhoff et al. (1978); Hertwig et al. (2005); **Pachur et al. (2012)**, Slovic (1987)	Frequency judgments, affective response (feelings of dread), direct and indirect exposure concerning five causes of accidental deaths	Positive group-level correlation between affective response (feelings of dread) and frequency judgments	Positive individual-level correlation between affective response (feelings of dread) and frequency judgments

Note. Main sources are bolded.

2.2 Affect Heuristic Tasks

An overview of all affect heuristic tasks is provided in Table 1. Because we aimed to explore the role of age in reliance on the affect heuristic and to compare whether affect heuristic use was stable across different task types, test materials were restricted to a single domain (i.e., the health domain). Limiting stimuli to one as opposed to several domains was advantageous because domains often differ in perceived riskiness (Kruger, Wang, & Wilke, 2007; Västfjäll et al., 2014), especially across age groups (Bonem, Ellsworth, & Gonzalez, 2015). By adopting a health-related focus, we could thus rule out that task and domain effects in the judgments of risks were being confounded.

To select stimuli, we piloted a range of health-related materials (including stimuli related to food characteristics, cancer deaths, accidental deaths, and catastrophes endangering human lives) that were thought to evoke strong affective responses among adults of different age groups. A final lab-based pilot involving 37 younger adults (age range 21 – 35 years, M = 28.78, SD = 4.09 years) and 29 older adults (age range 65 – 88 years, M = 71.97, SD = 6.24 years) confirmed that the materials used in the present study showed patterns consistent with the use of the affect heuristic.

Affect-Impact Task. An affect-impact task served as the first affect heuristic measure. This task assessed the strength of the positive relationship between participants' affective responses to catastrophes and the catastrophes' perceived impact. To this end, we adapted and devised scenarios following the example of

Siegrist and Sütterlin (2014). Specifically, we chose three scenarios in which human deaths either occured due to human activity or environmental influences (i.e., naturally occuring minerals, hazardous weather). Following presentation of each scenario, participants were asked, “What feelings did you experience due to this information?” (Cronbach’s $\alpha = .93$ across all six items) and “How big do you consider the impact on the population?” (Cronbach’s $\alpha = .94$ across all six items). Responses were assessed using a slider anchored at “Very positive feelings” [“Very small impact”] on the left side and “Very negative feelings” [“Very high impact”] on the right side. In both cases, responses were coded from 0 to 100, with the slider initially resting at the midpoint of the scale (= 50). Participants did not see these numerical scores.

Unlike previous studies (McComas et al., 2016; Siegrist & Sütterlin, 2014, 2016), which utilized a between-subjects design, we presented all participants with both variations of each scenario, resulting in six items overall. Asking participants to evaluate each catastrophe twice – once when it arose due to natural causes and once when it arose due to human action – allowed us to assess bias in participants’ judgments. To this end, participants first responded to either all three man-made or all three naturally caused scenarios before then evaluating the same scenarios again but paired with a different cause. As the impact remained the same regardless of cause, participants should assign the same impact rating to both versions of each scenario.

Dread-Inference Task. A dread-inference task served as the second affect-heuristic measure. To reiterate, this task was based on a risk-centric definition of the affect heuristic stating that feelings of dread can help differentiate between more and less common risks (Pachur et al., 2012). Therefore, this task measured the strength of the positive relationship between participants' affective responses and their judgment concerning the frequency of different causes of death. Causes of death were adapted from item lists previously used by Hertwig, Pachur, and Kurzenhäuser (2005) and Lichtenstein, Slovic, Fischhoff, Layman, and Combs (1978): flood, fire and flames, excess cold, poisoning by solid or liquid, and animal sting, bite, or attack. Participants provided numerical estimates for the number of US deaths associated with each mortality cause ("What do you think: how many people in the US die from the following causes of death every year? Please provide a number."). In addition, we assessed participants' affective response (Cronbach's α = .85 across all five items) as well as their direct and indirect exposure to each cause of death. Affect was measured by asking, "Please indicate the level of dread (fear and anxiety) you feel when considering the following causes of death". Responses were recorded on a 7-point Likert scale ranging from (1) "No dread" to (7) "Very strong dread". Direct [indirect] exposure was measured by asking "How many people do you know in your personal environment (family, friends, acquaintances) [through the media (news, books, movies)] that have died from the following causes of death? Please provide a number."

Risk-Benefit Task. A risk-benefit task served as the third affect heuristic measure. This task, modeled after previous work (e.g., Alhakami & Slovic, 1994; Poortinga & Pidgeon, 2005; Siegrist, Cousin, et al., 2007; Siegrist & Keller, 2011;

Slovic et al., 2005; Sokolowska & Sleboda, 2015), assessed the degree to which participants perceived the relationship between risks and benefits as negative. Food-related stimuli were chosen as the basis for this task, as food-based stimuli have been successfully utilized in previous affect heuristic research and can induce strong affective responses (Finucane et al., 2000; Poortinga & Pidgeon, 2005; Siegrist & Sütterlin, 2016). In the present study, participants rated perceived risks, benefits, and their affective response concerning five food characteristics : added electrolytes, added vitamins, added minerals, added flavoring, and genetically modified food. Responses were recorded on 10-point Likert scales ranging from (1) "Not at all risky" to (10) "Very risky", (1) "Not at all beneficial" to (10) "Very beneficial", and (1) "Highly negative attitude" to (10) "Highly positive attitude", respectively. After removing added flavoring and genetically modified food due to low reliability (inter-item correlation with the other items was $r = .32$ and $r = .21$, respectively, compared to *rs*. $\geq .79$ for all other items), three items remained in the risk-benefit task: Added electrolytes, added vitamins, and added minerals. Across these three items, internal consistency was high (Cronbach's $\alpha = .93$ for risks, $\alpha = .92$ for benefits, and $\alpha = .93$ for affective responses).

2.3 Measures

Demographic items. We collected standard information on participants' age, sex, gender, race, and ethnicity. Educational attainment was assessed with the question "How far did you go (or have you currently gone) in school so far?", with five possible answer options: (1) Did not finish high school, (2) Graduated from high school, (3) Attended some college but did not finish a 4-year degree, (4), Graduated from a 4-year college or more, and (5) Obtained a graduate/ professional degree. Income was assessed with the question "In what range is your yearly household income?", with seven possible answer options: (1) Less than $10,000, (2) $10,000 - $30,000, (3) $30,000 - $50,000, (4), $50,000 - $70,000, (5) $70, 000 - $90,000, (6) $90,000 - $110,000, and (7) More than $110,000.

Affect. At the beginning of the study, participants responded to two separate items assessing their current affect (adapted from Nielsen, Knutson, & Carstensen, 2008). Specifically, participants rated how negative versus positive and how quiet/ still versus activated/ aroused they felt in the moment. Responses were recorded on 7-point Likert scales ranging from (1) "Very negative" to (7) "Very positive" and (1) "Very quiet/ still" to (7) "Very activated/ aroused", respectively.

Subjective health and memory. Participants responded to four health-related items adapted from Bowling (2005) and Sorokowski, Sorokowska, Frąckowiak, and Löckenhoff (2017). They rated their physical health, emotional health, learning ability, and memory as either (1) "Poor", (2) "Fair", (3) "Good", (4) "Very good", or (5) "Excellent". Each item was treated as a separate variable.

Personality. To assess Big Five personality traits, participants were provided with the ten items from the Big Five Inventory-10 (Rammstedt & John, 2007) and asked, "How well do the following statements describe your personality?" Openness, conscientiousness, extraversion, agreeableness and neuroticism were measured using two items each, with scores averaged across the two items. For instance, to assess neuroticism, participants rated how well they coped with stress and how commonly they experienced feelings of nervousness. Responses were measured on a 5-point Likert scale ranging from (1) “Disagree strongly” to (5) “Agree strongly”.

Numeracy. Participants’ ability to understand and work with numbers was assessed using the Lipkus, Samsa, and Rimer (2001) 3-item numeracy scale (i.e., 0 to 3 correct responses). Each item presented participants with a mathematical problem for which they provided a numerical response. For example, participants had to indicate how often they would expect to roll an even number when rolling a regular, six-sided die 1,000 times.

Crystallized intelligence. Vocabulary, assessed via 12 items taken from a short version of the Nelson-Denny Reading Test (Brown, 1960), served as a proxy of participants’ crystallized intelligence. Each item required participants to identify synonyms among a list of five possible answer options. The number of correct responses was summed up into a total score of 0 to 12 points.

Life position. Participants’ subjective perception of their position in life was tested using a variant of the single-item Lines Test (Hancock, 2010). Participants used a slider anchored at “Birth” (equaling a value of 0) on the left side and “Death” (equaling a value of 100) on the right side. The slider initially rested at the midpoint of the scale (= 50). All numbers were masked.

Life goals. We assessed two types of life goals: growth (versus maintenance) goals and information (versus affect) goals (adapted from Ebner et al., 2006). The first was tested with the question, “In planning your life and pursuing your goals, are you more focused on maintaining something/ preventing a loss OR more focused on improving something/ achieving something new?”. The latter was tested with the question, “In planning your life and pursuing your goals, do you rely more on your feelings and intuition OR more on analyzing the specific facts and details?” In both cases, participants used a slider that initially rested at the midpoint stating “A mix between the two” (equaling a value of 50). The growth (versus maintenance) goals slider was anchored by “Maintaining something or preventing a loss” (= 0) on the left and by “Improving something or achieving something new” (= 100) on the right. Conversely, the information (versus affect) goals slider was anchored by “Feelings and intuition” (= 0), and “Facts and details” (= 100), respectively. Numbers were not visible to participants.

Preference for verbatim (versus gist-based) processing. Participants’ preference for information-based as opposed to intuition-based processing was tested using the Fuzzy-processing preference index (Wolfe & Fisher, 2013), a measure derived from fuzzy-trace theory (Reyna, 2008, 2012). According to this theory, verbatim representations of information focus on objective details such as precise numbers and wording. In contrast, gist representations of information focus on the overall subjective meaning of information, which is informed by intuitive responses to information. To which degree individuals rely on either verbatim information or the subjective gist can be expressed on a scale from 0 to 1, with higher scores indicating a stronger preference for verbatim-based processing.

To assess this preference, participants responded to five probability judgment items taken from the Fuzzy-processing preference index (Cronbach's α = .79). Every item provided an either low (10 – 20%) or high (80 – 90%) base rate as well as contradictory qualitative evidence. For instance, one item states that 20% of female students at a certain university spend, on average, $100 on clothes every month. Participants are then asked to rate the probability that Heather, a female student at the same university who is fashionable and has an extensive wardrobe, spends at least $100 on clothes per months. Whereas estimates closer to the base rate of 20% indicate a preference for verbatim, information-based processing, estimates far from the base rate (e.g., 80%) indicate a preference for intuitive gist-based processing. To identify pattern-matchers (i.e., participants whose responses are identical to the provided base rates, irrespective of additional information that renders the base rate meaningless) participants responded to a sixth item taken from the Fuzzy-processing preference index. Pattern-matchers were not assigned an information processing preference score.

Cognitive reflection ability. To index whether participants preferred using deliberative or intuitive reasoning, participants also completed the Cognitive Reflection Test (Frederick, 2005). For each of the three items, there is one deliberate, correct response and at least one intuitive but incorrect response. For example, the first item states that two objects together cost $1.10, with one of the objects costing $1.00 more than the other. The participants' task is to indicate the cost of the less expensive object, with 10 cents being the intuitive but incorrect response, and 5 cents being the deliberate, correct response. Each item is scored for correctness, with a higher number of correctly answered items reflecting a stronger tendency toward deliberative reasoning, whereas a lower score reflects a stronger tendency toward intuitive reasoning. Participants also indicated whether they were familiar with any of the items.

2.4 Procedure

Participants completed the study in the form of a 30 – 60-minute online survey (see Table 9 in the Appendix) and were compensated by Qualtrics.com. After providing informed consent, participants responded to assessments of their demographic background, current affect, life goals, subjective life position, subjective health status, and personality traits. Participants then completed the affect-impact, dread-inference, and risk-benefit tasks (always in this order). Finally, participants' cognitive abilities and processing or reasoning preferences were assessed by evaluating their preference for verbatim (versus gist-based) processing, crystallized intelligence, cognitive reflection ability, and numeracy skills.

Only participants who provided informed consent and passed attention checks at the beginning and end of the survey were included in the present sample. The first attention check was hidden among the subjective health items ("Please select 'Fair' to show that you're paying attention"). The second attention check was incorporated into the numeracy assessment ("At the FUN IN THE SUN music festival, everybody gets a door prize. Out of 1,000 visitors, how many are expected to get a door prize?"). Finally, participants provided their birth year at the end of the survey and were excluded if self-reported age and birth year did not correspond (a 1 year-margin was given to account for birthdays later in the year). At the end of the study, participants were also asked to disclose if they had cheated. Specifically, participants reported whether they had researched mortality statistics, looked up information about people they know in person or through the media, and whether they had used a calculator or asked other people for help answering questions. Participants who disclosed cheating were excluded from the sample. As a last step, participants were debriefed that none of the scenarios presented in the affect-impact task represented real events or trends.

3 RESULTS

3.1 Data Screening and Analyses

Analyses were conducted using RStudio version 1.1.423. Prior to data analyses, variables were screened for non-normal distribution patterns and the existence of univariate or multivariate outliers. Non-normal distributions were identified using a combination of Q-Q plots, histograms, and Shapiro-Wilk tests. Univariate outliers were defined as values equaling *z*-scores ≥ |3.29| (Tabachnick & Fidell, 2007). To retain ordinal rankings, these outliers were winsorized to values equaling *z*-scores = |3.30|, |3.31|, etc. Multivariate outliers were defined as cases where Mahalanobis Distance assumed $X^2 < .001$ (with degrees of freedom depending on the number of variables tested together). Multivariate outliers were excluded and default pairwise exclusion chosen as basis for all analyses with the exception of partial correlations, in which case listwise exclusion was chosen. Because all variables were non-normally distributed, we calculated Spearman's rank correlations (r_s) and adopted Generalized Linear Models paired with Nagelkerke's *pseudo*-R^2 (from the R package 'rcompanion') to run regression models.

For each affect heuristic task type, we conducted two types of analyses (see Table 1): First, we conducted group-level analyses to demonstrate the presence of the affect heuristic and replicate the basic effects described in the prior literature. Second, we conducted individual-level analyses for which we derived indices of affect heuristic use for each participant. This approach allowed us to examine the consistency of affect heuristic usage across tasks and to regress use of the affect heuristic on participants' age as well as other individual difference measures. Additionally, we used individual-level data to evaluate whether stronger reliance on the affect heuristic leads to stronger bias in judgment, that is, seemingly irrational judgments or incorrect inferences.

3.2 Preliminary Analyses

All demographic information is summarized in Table 2. To assess age trends, we examined correlations between all measures and participants' chronological age ($\alpha = .05$). Partial correlations were conducted for gender and ethnicity because ethnic and racial groups were unevenly distributed across genders ($X^2(1, N = 195) = 19.84$, $p < .001$), Specifically, there were more non-Hispanic White individuals among the female participants (86%) than the male participants (56%).

Emotional health ($p < .01$), perceived life position ($p < .001$), agreeableness ($p < .001$), and crystallized intelligence ($p < .001$), were positively associated with age. Conversely, neuroticism ($p < .001$), the preference for growth over maintenance goals ($p < .001$), and the preference for verbatim over gist-based information processing ($p < .05$) were negatively associated with age. In addition, older age was associated with marginally lower levels of openness to new experiences ($p = .054$) and marginally higher scores on the Cognitive Reflection Test ($p = .066$). Because previous exposure to the Cognitive Reflection test can improve participants' performance (Stieger & Reips, 2006) we only analyzed Cognitive Reflection Test scores from participants who reported being unfamiliar with the test's items or reported knowing the test items but answered them incorrectly in the present study. Closer inspection of the relationship between age and Cognitive Reflection Test score revealed that there were no age differences in cognitive reflection ability when we analyzed all responses irrespective of familiarity with the test ($r_s = .07$, $p = .318$).

Table 2

Demographic variables, individual difference measures, and their correlation with age

Variable	*M* (*SD*)	Correlation with Age	
		r_s	*p*
Demographic variables			
Age	52.95 (18.10)		
Gender[a] (0 = Male, 1 = Female)		.05	.478
Ethnicity[b] (0 = Non-Hispanic White, 1 = All Other)		-.04	.639
Income	3.51 (1.69)	-.02	.765
Education	3.28 (1.07)	.07	.299
Socioemotional and health variables			
Self-rated physical health	3.14 (0.94)	-.02	.819
Self-rated emotional health	3.30 (1.08)	.22	< .01**
Current affect: valence	5.16 (1.31)	.07	.353
Current affect: activation	3.29 (1.53)	-.10	.154
Life position	60.55 (22.30)	.63	< .001***
Growth (versus maintenance) goals	61.97 (22.70)	-.24	< .001***
Information (versus affect) goals	61.02 (22.43)	-.08	.241
Personality			
Extraversion	2.85 (0.93)	-.02	.735
Openness	3.26 (0.93)	-.14	.054
Conscientiousness	3.94 (0.83)	.09	.225
Neuroticism	2.65 (1.07)	-.27	< .001***
Agreeableness	3.67 (0.88)	.26	< .001***
Cognitive measures			
Self-rated learning ability	3.80 (0.91)	-.12	.100
Self-rated memory	3.34 (0.96)	-.05	.488
Crystallized intelligence (Nelson-Denny Vocabulary)	6.47 (2.32)	.39	< .001***
Cognitive reflection ability – naïve	0.25 (0.60)	.14	.066
Numeracy	1.30 (0.99)	.00	.956
Preference for verbatim (versus gist-based) processing	0.42 (0.31)	-.19	< .05*

Note. Correlations were calculated using Spearman's *rho* (r_s). Partial correlations were run between [a]gender and age (accounting for ethnicity) and [b]ethnicity and age (accounting for gender). * $p < .05$, ** $p < .01$, *** $p < .001$.

3.3 Affect-Impact Task

Mean ratings for the feelings associated with each catastrophe and the catastrophes' perceived impact are summarized in Table 3.

Group-level analyses. To begin, we first assessed whether use of affect heuristic was present at a group level. Importantly, we deviated from past approaches (Siegrist & Sütterlin, 2014, 2016) as these were based on between-participant designs. We instead report correlations between participants' affective reactions and impact judgments both at an item level (Siegrist & Sütterlin, 2014; see Table 3) as well as an aggregate level. Across all six items, we observed a moderate positive relationship between affect and impact judgments ($r_{Fisher\ Z}$ =.42, z = 6.11, p < .001), demonstrating that reliance on the affect heuristic was evident at the aggregate level.

Individual-level analyses. At the individual level, reliance on the affect heuristic was assessed as the strength of the positive linear relationship between affective responses to the different hazard scenarios and judgments of their impact. This correlation was calculated separately for each participant across all six items. The average correlation between feelings and perceived impact across all six items was significantly greater than 0 (V = 14,502, p < .001) and moderately positive (r_s = .40). Comparable to the group-level analyses, this indicates that stronger negative feelings were associated with higher perceived impact. Thus, reliance on the affect heuristic was evident at the individual level as well.

Table 3

Means, standard deviations, and group-level correlation results for affective reaction and perceived impact in the affect-impact task

				Affect-Impact Correlation	
Cause	**Item**	**Affective Reaction**	**Impact**	r_s	p
Human	Traffic accidents	67.40 (19.84)	48.15 (28.20)	.38	< .001***
	Groundwater pollution	76.46 (21.27)	59.19 (29.82	.45	< .001***
	Medication shortage	78.14 (19.99)	60.32 (30.35)	.44	< .001***
Nature	Traffic accidents	67.08 (18.82)	47.77 (27.39)	.31	< .001***
	Groundwater pollution	72.59 (20.15)	58.13 (29.76)	.47	< .001***
	Medication shortage	73.38 (20.08)	59.29 (29.00)	.46	< .011***

Note. Correlations were calculated using Spearman's *rho* (r_s). Affective reaction and impact were both scored on sliders ranging from 0 to 100. *** $p < .001$

In a next step, we used individual-level data to evaluate whether age predicted stronger reliance on the affect heuristic (Hypothesis 1). To this end, we regressed affect heuristic use on participants' chronological age. Contrary to Hypothesis 1, age did not predict use of the affect heuristic in this task ($b = .00$, $p = .785$, *pseudo*-$R^2 = .00$).

In a last step, we assessed whether stronger reliance on the affect heuristic predicted greater levels of bias (Hypothesis 2). To measure bias, we first conducted two one-sided Wilcoxon signed-rank tests to test whether affective responses and impact ratings differed between naturally caused and man-made catastrophes. This was accomplished by calculating Average(|Human Cause – Natural Cause|) across the three scenarios (traffic accidents, groundwater pollution, medication shortage). Although we assumed that man-made catastrophes would lead to greater ratings of negative affect and impact, we chose to ignore the direction of these differences and instead averaged across absolute differences. This step was taken because any differences in ratings suggest bias, irrespective of the direction of this bias. This difference (i.e., Average(|Human Cause – Natural Cause|)) was then tested against an expected value of 0 using Wilcoxon signed-rank tests, which produce a V statistic to reflect the sum of all positive ranks. Results confirmed that naturally caused and man-made catastrophes resulted in both different affective responses ($V = 16{,}653$, $p < .001$) and different impact ratings ($V = 17{,}578$, $p < .001$). Participants varied in the extent to which their affective responses and impact ratings varied between the different causes:

Averaged across all three scenarios, participants' affective responses differed between 0 and 35.55 points between the naturally caused and man-made catastrophes (M = 10.33, SD = 7.28). Similarly, perception of impact differed between 0 and 38.99 points between the two types of causes (M = 11.57, SD = 8.30). Differences in impact ratings between naturally caused and man-made catastrophes served as a measure of bias because the objective impact remained the same across the two different causes, even when different causes evoked different affective responses. Contrary to Hypothesis 2, regression results did not indicate that a stronger reliance on the affect heuristic predicted a greater extent of bias in this task (b = .00, p = .508, $pseudo\text{-}R^2$ = .00). Similarly, age was not predictive of bias (b = -.01, p = .716, $pseudo\text{-}R^2$ = .00).

3.4 Dread-Inference Task

Mean frequency judgments concerning annual death rates, dread ratings, direct exposure, and indirect exposure to each of the five causes of death are summarized in Table 4. For comparison purposes, annual US death rates were drawn from 2017 data compiled by the CDC (n. d.).

Table 4

Means and standard deviations for frequency judgments, dread, direct, and indirect exposure to each cause of death in the dread-inference task

Cause	Actual Annual Death Rate	Frequency Judgment of Annual Death Rate	Dread	Direct exposure	Indirect exposure
Flood	27	152,665.60 (322,639.50)	3.76 (2.11)	0.01 (0.03)	130.89 (315.68)
Animal	251	72,132.64 (159,887.50)	3.58 (1.82)	0.08 (0.27)	22.12 (51.65)
Poisoning	126,264	102,277.50 (218,424.00)	3.72 (1.92)	0.05 (0.20)	25.88 (61.11)
Fire	3,304	150,693.30 (311,443.40)	5.24 (1.74)	0.21 (0.60)	114.67 (272.08)
Cold	804	88,374.12 (195,616.50)	4.10 (1.94)	0.06 (0.20)	43.74 (108.75)

Note. Standard deviations are presented in parentheses.

Table 5

Group-level correlations between frequency judgments and dread, direct, and indirect exposure in the dread-inference task

	Frequency x Dread									
	Zero-order		Partial (accounting for Direct Exposure)		Partial (accounting for Indirect Exposure)		Frequency x Direct Exposure		Frequency x Indirect Exposure	
Cause	r_s	*p*	r_s	*p*	r_s	*p*	r_s	*p*	r_s	*p*
Flood	.09	.243	.09	.220	.09	.234	.19	< .01**	-.01	.886
Animal	.17	< .05*	.15	.053	.14	.067	.04	.589	.05	.459
Poisoning	.14	.051	.09	,234	.10	.121	.11	.122	.08	.308
Fire	.16	< .05*	.11	.156	.12	.111	.09	.204	-.01	.942
Cold	.10	.172	.10	.186	.09	.231	-.07	.332	.10	.172

Note. Correlations were calculated using Spearman's *rho* (r_s). * $p < .05$, ** $p < .01$

Group-level analyses. In a first step, we again verified whether use of the affect heuristic was evident at a group level (following Pachur et al., 2012). Because Pachur and colleagues (2012) report dread-inference correlations only at an aggregate level, we averaged the five correlation coefficients and tested this value against a correlation coefficient of 0. Results confirmed that there was a significant, albeit weak, positive correlation between feelings of dread and participants' frequency judgments ($r_{Fisher\ Z}$ = .13; z = 1.79, p < .05). Hence, reliance on the affect heuristic was supported at the group level. As can be seen in Table 5 (see "zero-order" column), only some of the five items demonstrated a significant correlation between dread and frequency estimates when each item was tested separately.

To account for another strategy participants might have used to make frequency judgments, we also evaluated participants' reliance on an availability heuristic (Pachur et al., 2012). This was accomplished by correlating frequency judgments with the degree to which participants had been directly and indirectly exposed to each of the five causes of death (see Table 5). At an aggregate level (Pachur et al., 2012), there was no evidence that participants relied on an availability heuristic informed by direct ($r_{Fisher\ Z}$ =.07, z = .95, p = .170) or indirect ($r_{Fisher\ Z}$ = .02, z = .27, p = .394) exposure to the different causes of death. However, the relationship between dread and frequency judgments was no longer statistically significant after partialing out either direct or indirect exposure (both $r_{Fisher\ Z}$ =.11, z = 1.45, p = .074; see Table 5). This suggests that availability may have played an indirect role in informing participants' frequency judgments.

Individual-level analyses. On an individual level, reliance on the affect heuristic was assessed by the strength of the positive linear relationship between feelings of dread and judgments concerning the frequency with which different causes of death kill people in the US every year. This correlation was calculated separately for each participant across the five items. The average correlation between participants' frequency judgments and the dread they experienced was weakly positive (r_s = .28). The size of this correlation was significantly larger than 0 (V = 9,939.50, p < .001), confirming that participants relied on affect at an individual level as well.

We also evaluated participants' use of the availability heuristic (Pachur et al., 2012) at the individual level. To this end, we partialed out direct and indirect exposure to causes of death from the correlation between participants' feelings of dread and the frequency judgments participants provided[2]. A one-sided Wilcoxon signed-rank test for paired samples suggested that the correlation between dread and frequency judgments did not significantly decrease when partialing out participants' direct exposure to each of the five causes of death (r_s = .23, V = 355, p = .264). However, accounting for indirect exposure to the causes of death through the media did decrease the relationship between dread and frequency judgments (r_s = .20, V = 1,923, p < .05), indicating that availability also played some role at the individual level. (Additional analyses regressing frequency judgments for each of the five items on participants' age, dread, direct, and indirect exposure can be found under Supplementary Analyses in the Appendix. Few predictors reached statistical significance (p < .05), irrespective

[2] Zero-order correlations between either direct or indirect exposure frequency judgments will not be reported because these analyses resulted in a lot of missing data. Missing data points were the result of invariance, with many participants reporting no direct or indirect exposure to any of the causes of death.

of whether predictors were entered separately (Table 9) or jointly (Table 10), and irrespective of model fit (assessed via *pseudo-*R^2). Age and direct exposure did not achieve a meaningful model fit for any of the five items (*pseudo-*R^2*s* = .00 to .01), with one exception: Direct exposure achieved good model fit in the context of flood victims (*pseudo-*R^2 = .65). Model fit was low in the context of all dread ratings (*pseudo-*R^2*s* = .24 to .27) and excellent in the context of all indirect exposure estimates (*pseudo-*R^2*s* = .79 to .82). Similarly, joint regression models including all four predictors achieved excellent fit for all five items (*pseudo-*R^2*s* = .86 to .95).)

In a next step, we evaluated Hypotheses 1 and 2 using regression analyses on individual-level data. Contrary to Hypothesis 1, age did not predict affect heuristic reliance in this task (b = .00, p = .271, *pseudo-*R^2 = .01).

To test Hypothesis 2 (that stronger reliance on the affect heuristic predicts stronger bias), we averaged across the absolute differences between participants' frequency judgment for each cause of death and the associated real annual death rates (Average(|Death Rate Estimate – Actual Death Rate|), V = 19,110, p < .001). There was considerable variation in participants' bias, ranging from mean differences as low as 911 and as high as 723,691.50 (M = 125,783.10, SD = 180,429.60). Contrary to Hypothesis 2, stronger reliance on the affect heuristic did not predict greater levels of bias (b = -12,427, p = .636, *pseudo-*R^2 = .99). Similarly, greater bias was not predicted by either younger or older age (b = -288.60, p = .688, *pseudo-*R^2 = .00)

3.5 Risk-Benefit Task

Mean ratings for each items' perceived benefits, perceived risks, and participants' affective response toward each item are summarized in Table 6.

Group-level analyses. First, we report group-level analyses to replicate prior work demonstrating use of the affect heuristic in risk-benefit tasks (see Table 7). To this end, we report results for each separate item (an approach used by Alhakami & Slovic, 1994; Finucane et al., 2000; Siegrist & Keller, 2011; Slovic et al., 1991; Sokolowska & Sleboda, 2015) as well as aggregate results averaged across items (an approach used by Finucane et al., 2000; Siegrist, Keller, Kastenholz, Frey, & Wiek, 2007; Skagerlund et al., 2019; Slovic et al., 1991). In addition, we evaluate whether affect was relevant to participants' risk-benefit judgments (Sokolowska & Sleboda, 2015). Across all three items, risks and affect showed a moderate negative correlation ($r_{Fisher\ Z}$ = -.45, z = -6.56, $p < .001$), whereas benefits and affect showed a strong positive correlation ($r_{Fisher\ Z}$ = .73, z = 12.56, $p < .001$). Participants perceived the relationship between the items' risks and benefits as moderately negative ($r_{Fisher\ Z}$ = -.39, z = -5.57, $p < .001$), suggesting use of the affect heuristic. Indeed, once affect was accounted for (Sokolowska & Sleboda, 2015), the negative relationship between perceived risks and benefits was no longer significant at the aggregate level ($r_{Fisher\ Z}$ = -.10, z = -1.36, p = .087).

Table 6

Means and standard deviations for affect, benefits, and risks in the risk-benefit task

Item	Affect	Benefits	Risks
Added electrolytes	6.36 (2.41)	6.30 (2.38)	3.31 (2.61)
Added vitamins	6.96 (2.30)	7.19 (2.11)	2.75 (2.59)
Added minerals	6.69 (2.35)	6.99 (2.18)	2.91 (2.51)

Note. Responses were scored on 10-point Likert scales ranging from 1 to 10.

Table 7

Group-level correlations between affect, benefits, and risks in the risk-benefit task

					Risks x Benefits			
	Affect x Benefits		**Affect x Risks**		**Zero-Order**		**Partial (Accounting for Affect)**	
Item	r_s	***p***	r_s	***p***	r_s	***p***	r_s	***p***
Added electrolytes	.72	< .001***	-.44	< .001***	-.25	< .001***	.11	.121
Added vitamins	.74	< .001***	-.50	< .001***	-.48	< .001***	-.20	< .01**
Added minerals	.73	< .001***	-.42	< .001***	-.44	< .001***	-.21	< .01**

Note. Correlations were calculated using Spearman's *rho* (r_s). ** $p < .10$, *** $p < .001$

Individual-level analyses. The pre-registered assessment of individual-level use of the affect heuristic concerned the strength of the individual-level correlations (across all items) between participants' judgments of risks and of benefits. Affect was thought to be relevant to participants' judgments if the negative relationship between risks and benefits was no longer significant after partialing out participants' affective response to each item (Sokolowska & Sleboda, 2015). However, we were unable to utilize individual-level correlations between perceived benefits and risks, as this approach resulted in 60.51% missing data. Most missing data points were the result of invariance, with participants assigning identical risk or benefit ratings to the three items that remained in the present analysis. Thus, we were not able to follow the pre-registered analytical plan.

Instead, we averaged the absolute difference between risks and benefits (i.e., Average(|Risks – Benefits|)) across items (Alhakami & Slovic, 1994). For this measure, higher scores indicate more disparate perceptions of risks and benefits, that is, stronger reliance on affect. Perceptions of items' risks and benefits were significantly disparate from one another (Average(|Risks – Benefits|): $M = 4.31$, $SD = 3.13$, $V = 14{,}365$, $p < .001$), confirming use of the affect heuristic at the individual level.

To test whether affect was central to participants' ratings of risks and benefits at the individual level as well, we calculated Average(|Affect – Risks|) and Average(|Affect – Benefits|) and compared the difference between these two measures. We expected ratings of positive affect to be more similar to participants' ratings of benefits than to their ratings of risks, resulting in smaller values for

Average(|Affect – Benefits|) than for Average(|Affect – Risks|). As expected, a one-sided Wilcoxon signed-rank test for paired samples suggested that Average(|Affect – Risks|) was significantly greater than Average(|Affect – Benefits|) (M_{risks} = 4.41, SD_{risks} = 3.20, $M_{benefits}$ = 1.08, $SD_{benefits}$ = 1.07, V = 12,778, p < .001). Hence, affect factored into participants' risk-benefit judgments.

Next, we evaluated the assumption that older age would predict stronger reliance on the affect heuristic (Hypothesis 1). For this purpose, we regressed the individual-level index of affect heuristic use (Average(|Risks – Benefits|)) on participants' age. Contrary to expectations, age did not predict use of the affect heuristic (b = .01, p = .490, $pseudo\text{-}R^2$ = .00).

3.6 Convergence Between the Three Different Affect Heuristic Indices

In a next step, we calculated correlations to assess Hypothesis 3 that individual differences in the tendency to reason in line with the affect heuristic are consistent across tasks. Because we tested this hypothesis by means of three separate correlations (i.e., correlations between the (1) affect-impact and the dread-inference task, the (2) affect-impact and the risk-benefit task, and the (3) dread-inference and risk-benefit task), α was Bonferroni-corrected to .017. In deviation from the pre-registration, we did not include separate affect heuristic indices for man-made (r_s = .39) and naturally caused catastrophes (r_s = .44) in the context of the affect-impact task: A one-sided Wilcoxon signed-rank test for paired samples indicated that these two sub-indices did not significantly differ from one another (V = 4,040.50, p = .564, with V indicating the sum of all positive ranks). Instead, we only entered the overall affect-impact task index into correlations analyses.

Results revealed that the affect-impact task index was not significantly correlated with the dread-inference task index (r_s = .05, p = .494) or the risk-benefit task index (r_s = .12, p = .111). The dread-inference task index and the risk-benefit task index were also not significantly associated (r_s = -.09, p = .263). Hence, we find no evidence to support Hypothesis 3. Because age did not meaningfully predict reliance on the affect heuristic in any of the tasks, we forewent the pre-registered plan to re-run the three correlation analyses as partial correlations accounting for age.

3.7 Regressions

Finally, we regressed reliance on each of the three affect heuristic indices on four blocks of predictors (Table 8): Demographic variables (block 1), socioemotional and health variables (block 2), personality (block 3), and cognitive measures (block 4). Due to the high number of predictors considered across all models, we set α = .001 (Bonferroni correction). None of the individual predictors reached this level of significance, although several marginal findings ($p < .05$ or $p < .01$) emerged.

In the affect-impact task, two variables predicted stronger reliance on the affect heuristic, but only at a marginal level: stronger positive affect (b = 1.42, $p < .05$) and higher levels of openness to new experiences (b = .30, $p < .01$).

In the dread-inference task, only one variable predicted reliance on the affect heuristic, and again only at the marginal level: in this task, more conscientious participants were less likely to rely on the affect heuristic (b = -.12, p < .05).

In the risk-benefit task, the opposite trend was observed: here, stronger reliance on the affect heuristic was marginally predicted by higher rather than lower levels of conscientiousness (b = .93, p < .01). In addition, stronger use of the affect heuristic was marginally predicted by stronger positive affect (b = .50, p < .05), more advanced life position (b = .03, p < .05), higher openness to new experiences (b = .67, p < .01), , and better subjective learning ability (b = .83, p < .01). Also, women were marginally less likely to use the affect heuristic than men were (b = -1.10, p < .05).[3]

Across tasks, we were especially interested in the role of predictors that differentiated between individuals who prefer to make decisions based on intuition and individuals who prefer to make deliberate, information-based decisions. Specifically, we had hypothesized (Hypothesis 4) that stronger reliance on the affect heuristic would be predicted by weaker cognitive reflection ability, a stronger motivation to rely on affect (as opposed to information) to pursue goals, and a stronger behavioral

[3] Note that our affect heuristic index in the risk-benefit task (i.e., Average(|Risks – Benefits|)) does not reflect differences between participants who experienced more or less intense affective reactions to the stimuli in this task (see Alhakami & Slovic, 1994). For example, participants received the same Average(|Risks – Benefits|) score of 2 when scoring risks as 9 and benefits as 7, or when scoring risks as 3 and benefits as 1. To account for the intensity of participants' affective responses we re-ran each block of predictors with Average(Risk, Benefit) as a an additional predictor, with higher values on this variable suggesting a stronger affective response to the stimuli presented (Table 11 in the Appendix). Once intensity of responses was accounted for, the only relevant difference we observed was that higher levels of conscientiousness now significantly predicted a stronger reliance on the affect heuristic (b = 1.01, p < .001).

preference for gist-based (as opposed to verbatim-based) processing. Contrary to expectations, none of these variables predicted reliance on the affect heuristic in any of the three tasks (*ps* = .263 to .765 when tested as part of their respective blocks, *ps* = .270 to .892 when tested individually).

Table 8

Regression of affect heuristic task indices on demographic variables, socioemotional and health variables, personality, and cognitive measures

Variable	Affect Heuristic Task					
	Affect-Impact		Dread-Inference		Risk-Benefit	
	b	*p*	*b*	*p*	*b*	*p*
Demographic variables	*pseudo-*R^2 = .02		*pseudo-*R^2 = .03		*pseudo-*R^2 = .03	
Age	-.01	.689	.00	.321	.01	.387
Gender (0 = Male, 1 = Female)	.89	.489	-.02	.843	-1.10	< .05
Ethnicity (0 = Non-Hispanic White, 1 = All Other)	2.03	.158	.11	.251	-.40	.464
Income	.27	.468	-.02	.359	-.01	.920
Education	.46	.449	.04	.299	.04	.867
Socioemotional and health variables	*pseudo-*R^2 = .04		*pseudo-*R^2 = .02		*pseudo-*R^2 = .04	
Physical health	-.73	.336	-.05	.332	-.25	.374
Emotional health	-.55	.462	.04	.460	.19	.513
Affect: valence	1.42	< .05	-.04	.362	.50	< .05
Affect: activation	-.07	.864	.01	.613	-.29	.054
Life position	.01	.660	.00	.997	.03	< .05
Growth (versus maintenance) goals	-.02	.522	.00	.984	.01	.568
Information (versus affect) goals	.02	.554	.00	.765	.00	.710
Personality	*pseudo-*R^2 = .06		*pseudo-*R^2 = .11		*pseudo-*R^2 = .13	
Extraversion	1.33	.061	.06	.151	-.03	.902
Openness	.30	< .01	-.07	.128	.67	< .01
Conscientiousness	.68	.382	-.12	< .05	.93	< .01
Neuroticism	.13	.836	-.06	.119	.02	.921
Agreeableness	-.51	.493	-.07	.175	.20	.464
Cognitive measures	*pseudo-*R^2 = .46		*pseudo-*R^2 = .17		*pseudo-*R^2 = .42	
Learning ability	.32	.695	-.09	.108	.83	< .01
Memory	-.71	.361	.08	.116	-.18	.536
Crystallized intelligence (Nelson-Denny Vocabulary)	-.33	.268	-.03	.161	.05	.660
Cognitive reflection ability – naïve	1.18	.300	.06	.433	-.30	.471
Numeracy	-.17	.815	.03	.602	.15	.582
Preference for verbatim (versus gist-based) processing	-1.48	.502	-.08	.591	-.93	.263

4. DISCUSSION

The present study evaluated the hypothesis that stronger reliance on the affect heuristic to make judgments is associated with higher age (Hypothesis 1). To this end, an adult lifespan sample completed three different assessments of the affect heuristic. In each task, use of the affect heuristic was evident at both the group level as well as the individual level, suggesting that the design was adequate to assess differences in affect heuristic reliance. However, contrary to expectations, age did not predict usage of the affect heuristic in any of the tasks. In addition, stronger reliance on the affect heuristic did not predict greater levels of reasoning bias (Hypothesis 2).

In an additional line of inquiry, we evaluated whether individual participants' reliance on the affect heuristic was stable across tasks (Hypothesis 3). This was not the case, as the extent to which participants relied on the affect heuristic in one of the tasks was not significantly related to the extent to which they relied on the heuristic in the other tasks. Finally, we tested whether individual difference measures, particularly measures of affective or intuitive processing (Hypothesis 4), predicted stronger use of the heuristic. Although we identified several marginal predictors of affect heuristic use (which were not predictive at the Bonferroni-corrected significance level), stronger reliance on the affect heuristic was not associated with a stronger self-reported motivation to rely on feelings (as opposed to information) to pursue goals, a stronger behavioral preference for intuitive, gist-based processing (as opposed to verbatim-based processing), or weaker cognitive reflection ability.

In sum, we consistently replicated prior findings by documenting use of the affect heuristic at the group level and extended prior work by showing it at the individual level. Because none of the pre-registered hypotheses were supported by our data, we concede that our assumptions about the affect heuristic and its association with age might have been incorrect. Alternatively, it is possible that our choice of task design and stimulus material was not suited to assess the hypothesized results. In the following sections, we discuss this possibility as one potential explanation for our findings.

4.1 Invariance Across the Lifespan

Across the three tasks, we find that reliance on the affect heuristic is not associated with age. One possible reason underlying this finding is that all three task types focused on negative judgments and relied on materials that are likely to induce negative affect. This is characteristic of the affect heuristic literature as a whole, with less attention given to positive than negative affect, and positive affect rarely studied on its own (cf. Bruine de Bruin, Lefevre, et al., 2016; Lefevre et al. 2015; Sjöberg, 2007). In the context of lifespan research, such a focus on negatively valenced stimuli has the potential to confound our findings: Unlike younger adults, older adults are more likely to attend to positively valenced than negatively valenced information (Carstensen & DeLiema, 2018; Löckenhoff & Carstensen, 2007, 2008; Mather & Carstensen, 2003; Notthoff & Carstensen, 2014). What's more, older adults are better equipped at shielding their thoughts and emotions from negative information or situations (Mather, 2013). Hence, older adults might not have engaged as strongly with our test materials as they might have if the materials had evoked positive affect (e.g., affect heuristic research focused on the perception of hot temperatures in the summer, Bruine de Bruin, Lefevre, et al. 2016; Lefevre et al., 2015).

In discussing the affect heuristic, Mikels and colleagues (2015) make a similar assessment, stating that "[a]s a result of the age-related positivity effect, it is likely that older adults would place greater weight on benefits and less weight on risks" (p. 176). Providing some support for this notion, Mikels and colleagues (2013) compared younger and older adults' risk taking in a ratio bias task. In this task, participants choose to draw tokens from a subjectively more attractive option (a dish with a higher absolute number but a smaller ratio of winning tokens) and an objectively more beneficial option (a dish with a smaller absolute number but a higher ratio of winning tokens). Mikels et al. (2013) find that older adults made more biased, nonoptimal choices, suggesting that they were more enticed by the choice option that was subjectively more attractive – but less likely to win – than their younger peers were. Because some authors argue that choosing the attractive (but inferior) option in the ratio bias task may reflect use of the affect heuristic (Slovic et al., 2007), the Mikels et al. (2013) finding suggests that positive stimuli or choice options may evoke stronger reliance on the affect heuristic among older than younger adults, with negative implication for older adults' choice quality. Consequently, our study may underestimate the existence of age differences in the reliance on the affect heuristic, and the null finding for age might not generalize to positively valenced materials.

4.2 Convergence Across Task Types

The lack of cross-task convergence in affect heuristic use could have been influenced by methodological factors as well: Although all tasks were completed within a single test session by the same participants, indices derived from different affect heuristic tasks did not converge. Conceivably, reliance on the affect heuristic may be context- or stimulus-dependent rather than a stable inter-individual trait: As is the case for other heuristics, use of the affect heuristic increases under time pressure, when cognitive resources run low, or in the absence of explicit information (Fleming, Townsend, van Hilten, Spence, & Ferguson, 2012; Finucane et al., 2000; King & Slovic, 2014; Shiv & Fedorikhin, 1999; Trendel & Werle, 2016; Trujillo, 2018). For example, decision makers are more likely to choose emotionally favorable options over less favorable options when their cognitive load is high and the choice environment is complex (Shiv & Fedorikin, 1999; Trujillo, 2018). As a result, use of the affect heuristic may be sensitive to the specifics of the task design.

We know of only one previous attempt to compare different affect heuristic indices with one another. In a not formally published study, Slovic et al. (1999) report that toxicologists who perceive stronger inverse relationships between different hazards' risks and benefits also show stronger relationships between experienced affect and judgment of different chemicals' risks (as referenced by Finucane et al., 2003; Slovic et al., 2002). Hence, Slovic and colleagues conclude that different assessments of the affect heuristic can indeed lead to the observation of "reliable individual differences" (Finucane et al., 2003, p. 345; Slovic et al. 2002, p. 412) in affect heuristic uptake.

The sample in question consisted of toxicologists and both tasks seem to have centered on participants' specific area of expertise (i.e., chemical risks, Finucane et al., 2003; Slovic et al., 2002). Therefore, we cannot rule out that task context or materials influence whether stable differences emergence across tasks (see Fleming et al., 2012). Despite the fact that all three tasks drew on the same higher-domain domain (i.e., health), we chose different subdomains (i.e., food characteristics, accidental deaths, catastrophes) for each task type to avoid spillover effects. This approach carries the disadvantage that different stimuli will inevitably vary in the valence and intensity of affect each participant associates them with (Slovic et al., 2004; also see Fleming et al., 2012; Siegrist, Keller, et al., 2007; Slovic, 1987; Sokolowska & Sleboda, 2015). This issue is exacerbated by the fact that the stimulus sets we chose ranged from low-risk, everyday stimuli in the risk-benefit task (i.e., added vitamins) to high-risk, rare events in the other two tasks (i.e., encountering groundwater pollution, dying as a flood victim). Hence, each participant might have reacted differently to the three stimulus sets we presented, and each set in itself might have evoked different types or levels of reactions, preventing task indices from converging.[4]

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[4] It is also worth nothing that the tasks included in our study are less conceptually similar than the two tasks compared by Slovic and colleagues (1999): One of Slovic et al.'s (1999) tasks assessed risk-benefit correlations (which were found to be mediated by the toxicologists' affective reactions to each hazard item), and one assessed affect-risk correlations. Results from our supplementary analyses (see Appendix) support the notion that affect heuristic indices are more likely to converge when tasks are conceptually similar and stimuli are identical across tasks. Specifically, our supplementary analyses included a forced-choice task in which participants had to infer which of two causes of death leads to more deaths in the US every year (Pachur et al., 2012). As suggested by Pachur and colleagues (2012, see Slovic, 1987), this task type rests on the assumption that decision makers will infer the likelihood of dying from a specific cause of death by the degree to which they dread that particular

4.3 Predicting Reliance on the Affect Heuristic

To better understand the pattern of results, we accounted for a range of likely predictors of affect heuristic usage. However, across tasks, only few variables predicted affect heuristic reliance, with none of the predictors reaching significance once we accounted for multiple comparisons. Because they were associated with more than one task type each, however, three of these predictors warrant further discussion: baseline affect ($ps < .05$), openness to new experiences ($ps < .01$), and conscientiousness ($ps < .05$ to $<.01$).

Both in the context of the affect-impact and the risk-benefit task, stronger positive affect predicted a marginally stronger reliance on the affect heuristic. This is plausible considering that incidental affect has been shown to influence judgments (for a review, see Vjästfjäll et al., 2016), including judgments of risks and benefits (Johnson & Tversky, 1983; Västfjäll et al., 2014). The direction of association between affect and affect heuristic use also make sense: Whereas negative mood has been linked to more analytical and more effortful processing, positive mood is linked to more heuristic and less effortful processing (Clark & Isen, 1982; Bless & Fiedler, 2006; Forgas, 1995, 2013; Park & Banaji, 2007).

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cause of death. Thus, causes of death that trigger more intense feelings of dread should be judged to be more common. To test this assumption, participants judged item pairs involving the same mortality items they later encountered in the dread-inference task. In our sample, we observed that those participants who relied more strongly on the affect heuristic when estimating the number of annual deaths in the dread-inference task were also more likely to rely on dread when making forced-choice comparisons. Therefore, we assume that cross-task convergence is more likely to be observed among related tasks and stimuli sets than among dissimilar task types or unrelated stimuli sets.

Across the same two tasks, stronger affect heuristic use was also weakly predicted by higher levels of openness. Comparable to baseline affect, openness to new experiences influences risk perception, with more open individuals perceiving fewer risks (Chauvin et al., 2007; Man & Chan, 2018; Zambrano-Cruz et al., 2018). Furthermore, higher levels of openness are tied to the experience of positive affect (Steel, Schmidt, & Shultz, 2008), engagement in intuitive processing (Belhekar, 2017; Jalajas & Pullaro, 2018; Kaufman, 2013; Sobków, Traczyk, Kaufman, & Nosal, 2018), and increased processing of irrelevant information (Agnoli, Franchin, Rubaltelli, & Corazza, 2015; Peterson & Carson, 2000; Peterson, Smith, & Carson, 2002; also see Kaufman, 2009). Therefore, both the affect-impact and the risk-benefit task were associated with inter-individual differences in affective experience and the aptitude for heuristic processing. Notably, of all three tasks, these two task types also demonstrated the strongest degree of convergence, although the correlation between the affect-impact and risk-benefit task was not significant (r_s = .12, p = .111)

By contrast, inconsistent associations were observed between reliance on the affect heuristic and different levels of conscientiousness. In the context of the risk-benefit task, stronger affect heuristic usage was tied to higher levels of conscientiousness. In the context of the dread-inference task, the opposite was true. Why we observed this pattern is not entirely clear. One possibility is that the relationship between conscientiousness and risk or benefit judgments depends on the decision domain or stimuli judged. For example, more conscientious decision makers perceive financial investments, construction-related risks, as well as sex, deviance, and addiction risks as more risky than less conscientious decision makers do (Chauvin et al., 2007; Oehler & Wedlich, 2018; Wang, Xu, Zhang, & Chen, 2016). At the same time, higher levels of conscientiousness are linked to lower risk perceptions in the context of pollutants and weapons (Chauvin et al., 2007) as well as higher benefit perceptions in the context of medical drugs (Beyer et al., 2015). Therefore, differences between the risk-benefit and dread-inference task may simply reflect differences in the stimuli participants were judging. Yet again, this would suggest that affect heuristic reliance is sensitive to the choice of stimulus material used.

4.4 Limitations

Given the critical role study material, context, and design seem to play in understanding use of the affect heuristic, we discuss two additional limitations of our study that have not yet been addressed.

A first shortcoming of our study is that we restricted all test materials to health-related stimuli. As stated before, limiting our materials to a single higher-order domain was advantageous because it allowed us to better compare reliance on the affect heuristic across different task types. In addition, focusing on a single domain accounted for the fact that some decision domains are perceived to be more risky than others (Kruger et al, 2007; Västfjäll et al., 2014), with age groups differing in their perception of riskiness (Bonem et al., 2015). On the downside, choosing only health-related stimuli has the disadvantage that our findings might not generalize to other decision domains or contexts. That being said, Vjästfäll and colleagues (2014) document inverse risk-benefit correlations for a variety of separate domains within the same sample (i.e., the social, recreational, gambling, ethical, investment, and health domains). Similarly, Skagerlund and colleagues (2019) report strong evidence of inverse risk-benefit correlations when studying reliance on the affect heuristic across several domains at once (i.e., the social, health, economic, and sensation-seeking domains). In general, affect heuristic reliance is often studied in the context of mixed-domain stimulus sets (e.g., Alhakami & Slovic, 1994; Finucane et al., 2000; Hertwig et al., 2005; Lichtenstein et al., 1978; Slovic, 1987; Slovic et al., 1991; Townsend, Spence, & Knowles, 2013), many of which pair health-related stimuli with other types of stimuli. As a result, it is possible that affect heuristic findings obtained from a single domain will still have implications for other types of decision domains.

A second drawback of this study is that it was conducted in an online environment rather than a lab-based setting. Past literature has voiced concerns about the generalizability of lifespan or older adult samples recruited online (Remillard, Mazor, Cutrona, Gurwitz, & Tjia, 2014). Since older adults lag behind their younger peers in internet usage (Smith, 2014), older adults participating in online studies may be younger (Latimer Hill, Cumming, Lewis, Carrington, & Le Couteur, 2007) or of higher socioeconomic background (Remillard et al., 2014; Russell, Campbell, & Hughes, 2008) than older adults participating in lab-based research.

Despite these differences in sample characteristics, data generated in lab-based and web-based studies involving older adults have been found to be comparable (Latimer Hill et al., 2007; Sekeres et al., 2011). Specifically, Löckenhoff and Samanez-Larkin (2020) did not find differences between intertemporal choice data collected from a lifespan sample when comparing lab-based results to results obtained through Qualtrics.com. Having recruited participants through Qualtrics.com for the present study, the characteristics of the present participants matched the expectations we would hold for a lifespan sample. In line with the aging literature, older adults demonstrated better subjective well-being (Jeste et al., 2013; Swift et al., 2014), perceived their position in life as more advanced (Hancock, 2010; Rutt & Löckenhoff, 2016), and were more motivated to pursue maintenance than growth goals (Ebner et al., 2006; Mustafić & Freund, 2012). From a personality standpoint, older adults reported typical age patterns of higher agreeableness and lower neuroticism and openness to new experiences compared to younger adults (Donellan & Lucas, 2008; Lucas & Donellan, 2011; Terracciano, McCrae, Brant, & Costa, 2005; Wortman, Lucas, & Donellan, 2012). Cognitively, older adults demonstrated significantly higher scores in crystallized intelligence (Ackerman, 2000; Hartshorne & Germine, 2015; Horn & Cattell, 1967), and were more likely to process information in an intuitive, gist-based fashion than an information-focused, verbatim fashion (Reyna et al., 2014; Reyna & Casillas, 2009; Reyna & Lloyd, 2006). Hence, we consider the present online sample representative of a typical lifespan sample.

4.5 Conclusion

Increasing rates of older adults in the population challenge us to determine how aging affects judgment and decision making. Despite age-related increments in affective as well as heuristic processing, we find that use of the affect heuristic is not positively associated with age. As stated above, our sample covered the entire adult lifespan and demonstrated expected age differences in personality and other background variables. Consequently, we believe that our findings do not represent sampling bias. In a similar vein, we demonstrated that our findings do not reflect a general inability to evoke use of the affect heuristic among different age groups.

Instead, we argue that how strongly decision makers rely on the affect heuristic is susceptible to variations in study context, design, or material. As a result, more research is needed to verify whether use on the affect heuristic indeed reflects a reliable personal preference for affect-based heuristic processing. Similarly, additional research is needed to evaluate the possibility that this preference is associated with age. Specifically, future studies ought to assess age-related differences in affect heuristic usage by presenting participants with positively valenced rather than negatively valenced stimuli.

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APPENDIX

Table Of Contents

1 ASPREDICTED.COM PRE-REGISTRATION

Author(s)

- Julia Nolte (Cornell University) - jn472@cornell.edu
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1) Have any data been collected for this study already?

- No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?

- This study evaluates whether reliance on the affect heuristic (AH) increases with age. Because the affect heuristic has been tested in different ways, we utilize three existing affect heuristic measures.
- *Task 1* = Negative correlation between perceived risks and perceived benefits of food additives; reversed so that higher values = stronger reliance on AH.
- *Task 2* = Positive correlation between feelings of dread and statistical estimates regarding causes of death; higher values = stronger reliance on AH.
- *Task 3* = Positive correlation between affective response to a catastrophic scenario (higher scores = stronger negative affect) and rating of impact (higher scores = stronger perceived impact). Sub-indices differentiate between man-made and natural causes.
- *Hypothesis 1:* Older age predicts a stronger reliance on the AH across all three tasks.
- *Hypothesis 2:* Stronger reliance on the AH predicts a stronger extent of bias/ incorrect inferences in Tasks 2 and 3.
- *Hypothesis 3:* Reliance on the AH correlated across tasks.
- *Hypothesis 4:* The following covariates predict decreased reliance on AH:
    - Self-reported preference for facts and details over feelings and intuition [higher values = stronger preference for facts]
    - Behavioral information processing preference [higher values = stronger preference for facts/numbers]
    - Cognitive reflection ability
- *Question 1:* To what extent do other demographic, cognitive, and socioemotional covariates predict reliance on AH?

3) Describe the key dependent variable(s) specifying how they will be measured.

- *Age* (continuous)
- *Task 1 AH index* (correlation between perceived risks and perceived benefits across five food characteristics; correlation ranges from -1.00 to +1.00; reversed so higher values = stronger reliance on AH)
- *Task 2 AH index* (correlation between dread and death rate estimate across five causes of death; correlation ranges from -1.00 to +1.00)
- *Task 2 bias/lack of correctness* (mean absolute difference between actual US annual death rates and death rate estimates)

- *Task 3 AH index* (correlation between negative affective response and perceived impact of catastrophic scenarios; 3 "man-made" and 3 "naturally caused" items,
  -1.00 to +1.00)
- *Task 3 bias* (mean absolute difference in impact ratings between man-made and naturally caused catastrophic scenarios, 0 to 100)
- Please see here for further details (this document was also deposited on OSF on 10/13/2019): https://docs.google.com/document/d/1eXm1ZRpxqftXJNSjxmUBrwvfkpoZoXagyX_vWOStGqE/edit?usp=sharing

<u>4) How many and which conditions will participants be assigned to?</u>

- *Age* = treated as a continuous variable.

<u>5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.</u>

- *H1:* For each AH index, we regress use of the AH on age.
- *H2:* In Tasks 2 and 3, bias/ incorrect inferences will be regressed on use of AH.
- *H3:* Correlations between the three AH indices.
- *H4:* We regress reliance on each AH index on self-reported preference for facts, behavioral information processing preference, and cognitive reflection ability.
- *Q1:* We regress AH indices on other demographic, cognitive, and socioemotional covariates (please see 8).

<u>6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.</u>

- We winsorize all univariate outliers to values equaling z-scores of +/- 3.30, 3.31, etc. Multivariate outliers are cases where Mahalanobis Distance = X2 < .001.
- We rely on Qualtrics XM's default criteria for handling method-based outliers (e.g., time to complete the survey).
- Participants are excluded if age is missing, below 18, over 120, or does not match birth year (1 year error margin). Participants must pass attention and cheating checks.

<u>7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.</u>

- 225 participants recruited through the Qualtrics Recruitment Services (75n 18-35, 75n 36-65, 75n 66+ years). Selective recruitment to yield comparable gender and race/ethnicity composition across groups.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

- Variable details (this document was also deposited on OSF on 10/13/2019): https://docs.google.com/document/d/1eXm1ZRpxqftXJNSjxmUBrwvfkpoZoXagyX_vWOStGqE/edit?usp=sharing
- We conduct the following supplementary analyses:

- Task Type 1
  - To confirm the role that affect (here assessed as self-reported attitude) plays in the context of Task Type 1, we will run correlations between perceived risks and attitude, perceived benefits and attitude, and a partial correlation between perceived risks and perceived benefits that controls for attitude. In order to do so, we will run separate correlations for each participant across the five items, and summarize all participants' scores in one variable per risk-attitude, benefit-attitude, and partial risk-benefit correlation (-1.00 to +1.00). We expect a negative correlation between perceived risks and attitude, a positive correlation between perceived benefits and attitude, and a weak negative or positive correlation for the partial risk-benefit correlation (as opposed to a moderate to strong negative correlation between risks and benefits without accounting for attitude). If we do not find the expected associations, we will discuss implications for the validity of Task Type 1 in our discussion section.

- Task Type 2
  - To evaluate alternative factors that may influence the death estimates that participants generate, we regress death estimates on age, affect, direct, and indirect exposure.
  - In an alternative test of AH, participants complete a forced-choice task involving all five mortality items. In a random order, participants will have to choose which of two of the causes of death kills more people in the US per year. These decisions will be coded for their reliance on affect ratings and for their correctness on the basis of actual US mortality statistics. We will report on the overall percentage of cases in which affect ratings correctly differentiate between more and less common causes of death and regress each participant's percentage of correct choices on the Task Type 2 affect heuristic and age.

- Task Type 3
  - To confirm the hypothesized role of affect in Task Type 3, and to examine the existence of bias, we conduct two 2 (cause) x 3 (scenario) factorial analyses to see whether a) affect ratings and b) impact ratings for a given catastrophic scenario differ between man-made and natural causes.

2 SUPPLEMENTARY ANALYSES

Unplanned supplementary analyses were conducted in the context of the risk-benefit task. Pre-registered supplementary analyses were conducted in the context of the dread-inference task and the affect-impact task.

2.1 Affect-Impact Task

A 2 (cause) x 3 (catastrophe) ANOVA was conducted on log-transformed data to establish whether affective reactions differed between man-made and naturally caused catastrophes. There was no main affect of cause ($F(1, 188) = 0.63$, $p = .429$), however, there was a significant main affect of catastrophe type ($F(2, 376) = 40.59$, $p < .001$ with Huynh-Feldt correction). Post-hoc tests revealed that the traffic accident scenario resulted in less negative affect than both the medication shortage scenario ($t(2, 188) = 8.04$, $p < .001$) and the groundwater pollution scenario ($t(2, 188) = 6.31$, $p < .001$). This main effect was qualified by an interaction effect between causes and catastrophes ($F(2, 376) = 5.60$, $p < .01$ with Huynh-Feldt correction). First, naturally caused traffic accidents resulted in less negative affect than both the naturally-caused medication shortage ($t(2,188) = 5.16$, $p < .001$) and the naturally-caused groundwater pollution ($t(2, 188) = 5.04$, $p < .001$). Second, man-made traffic accidents resulted in less negative affect than the man-made medication shortage ($t(2, 188) = 6.83$, $p < .001$) and the man-made groundwater pollution ($t(2, 188) = 5.71$, $p < .001$). Finally, naturally-caused medication shortages resulted in significantly less negative affect than man-made medication shortages ($t(2, 188) = -2.94$, $p < .01$).

Similarly, we conducted a 2 (cause) x 3 (catastrophe) ANOVA on log-transformed data to examine whether impact ratings differed between man-made and naturally caused catastrophes. There was no main effect of cause ($F(1, 178) = 0.08$, $p = .776$) and no interaction effect between causes and catastrophes ($F(2, 356) = 0.12$, $p = .887$). However, we observed a main effect of catastrophe type ($F(2, 356) = 33.54$, $p < .001$ with Huynh-Feldt correction): Post-hoc tests indicated that traffic accidents resulted in lower impact ratings than both the medication shortage ($t(2, 178) = 7.36$, $p < .001$) and the groundwater pollution scenario ($t(2, 178) = 5.67$, $p < .001$).

2.2 Dread-Inference Task

As planned, we regressed participants' statistical inference judgments on age, feelings of dread, direct, and indirect exposure. Predictors were both tested separately (Table 9) as well as considered jointly (Table 10).

In addition, we administered a forced-choice task in which participants were presented with ten item pairs comparing the five stimuli we used in the dread-inference task. For each pair, participants were tasked to decide "Which one of these two causes of deaths claims more lives per year in the US?" Results by Pachur and colleagues (2012) indicate that feelings of dread help decision makers differentiate between more and less common causes of death. In the present study, dread allowed participants to correctly distinguish between more and less common causes of death in

24.95 % of all cases (*Range:* 0 – 6 correct decisions, $M = 2.47$, $SD = 1.75$). Whereas age ($b = .01$, $p = .323$, $pseudo\text{-}R^2 = .01$) did not predict a greater likelihood of making correct decisions, stronger reliance on the affect heuristic did ($b = 1.39$, $p < .001$, $pseudo\text{-}R^2 = .71$). In addition, those relied more strongly on the affect heuristic in the dread-inference task were also more likely to rely on affect in the forced-choice task ($b = 2.26$, $p < .001$, $pseudo\text{-}R^2 = .85$).

2.3 Risk-Benefit Task

In the risk-benefit task, we compared regression results predicting affect heuristic reliance before and after accounting for Average(Risk, Benefit) (Table 11).

Table 9

Regression results predicting frequency judgments based on age, feelings of dread, direct, and indirect exposure in the dread-inference task (individual entry)

	Age	Dread	Direct Exposure	Indirect Exposure
Flood	b = -1,142 p = .374 $pseudo\text{-}R^2$ = .00	b = 9,801 p = .377 $pseudo\text{-}R^2$ = .25	b = 1,269,858 p < .05* $pseudo\text{-}R^2$ = .65	b = 95.80 p = .193 $pseudo\text{-}R^2$ = .79
Animal bite, sting, or attack	b = -475.50 p = .455 $pseudo\text{-}R^2$ = .00	b = 6,931 p = .279 $pseudo\text{-}R^2$ = .24	b = -14,082 p = .739 $pseudo\text{-}R^2$ = .00	b = 426 p < .05* $pseudo\text{-}R^2$ = .82
Poisoning by solid or liquid	b = 100.30 p = .909 $pseudo\text{-}R^2$ = .00	b = 11,951 p = .149 $pseudo\text{-}R^2$ = .25	b = 20,333 p = .799 $pseudo\text{-}R^2$ = .00	b = 359.60 p = .126 $pseudo\text{-}R^2$ = .82
Fire and flames	b = 69.30 p = .956 $pseudo\text{-}R^2$ = .00	b = 33,206 p < .05 $pseudo\text{-}R^2$ = .27	b = 52,640 p = .156 $pseudo\text{-}R^2$ = .01	b = 159.62 p < .05* $pseudo\text{-}R^2$ = .82
Excess cold	b = -249.60 p = .750 $pseudo\text{-}R^2$ = .00	b = 10,147 p = .169 $pseudo\text{-}R^2$ = .25	b = 17,033 p = .466 $pseudo\text{-}R^2$ = .00	b = 167 p < .05 $pseudo\text{-}R^2$ = .81

Note. * $p < .05$

Table 10

Regression results predicting frequency judgments based on age, feelings of dread, direct, and indirect exposure in the dread-inference task (joint entry)

	Age	Dread	Direct exposure	Indirect exposure	*pseudo-R^2*
Flood	*b* = -613.20 *p* = .655	*b* = 5,916 *p* = .627	*b* = 946,831 *p* = .083	*b* = 111.90 *p* = .148	.95
Animal bite, sting, or attack	*b* = -432.70 *p* = .457	*b* = 4,935.80 *p* = .405	*b* = -433,70.80 *p* = .309	*b* = 437.70 *p* < .05*	.87
Poisoning by solid or liquid	*b* = -183.70 *p* = .825	*b* = 12,068.20 *p* = .128	*b* = 14,681.20 *p* = .852	*b* = 317.40 *p* = .192	.87
Fire and flames	*b* = 133.20 *p* = .915	*b* = 22,506.42 *p* = .089	*b* = 19,935.29 *p* = .604	*b* = 139.22 *p* = .085	.87
Excess cold	*b* = -335.80 *p* = .671	*b* = 5,624.10 *p* = .463	*b* = 582.20 *p* = .994	*b* = 171.50 *p* = .110	.86

Note. * $p < .05$

Table 11

Regression results predicting affect heuristic reliance before and after accounting for Average(Risk, Benefit) in the risk-benefit task

Variable	Affect Heuristic Reliance	
Demographic variables	*pseudo-R^2* = .03	*pseudo-R^2* = .06
Age	$b = .01, p = .387$	$b = .00, p = .716$
Gender (0 = Male, 1 = Female)	$b = -1.10, p < .05$	$b = -1.19, p < .05$
Ethnicity (0 = Non-Hispanic White, 1 = All Other)	$b = -.40, p = .464$	$b = -.20$ $p = .714$
Income	$b = -.01, p = .920$	$b = .00, p = .993$
Education	$b = .04, p = .867$	$b = .08, p = .731$
Average(Risk, Benefit)		$b = -.42, p < .05$
Socioemotional and health variables	*pseudo-R^2* = .04	*pseudo-R^2* = .11
Physical health	$b = -.25, p =.374$	$b = -.23, p =.410$
Emotional health	$b = .19, p = .513$	$b = .18, p = .517$
Affect: valence	$b = .50, p < .05$	$b = .52, p < .05$
Affect: activation	$b = -.29, p = .054$	$b = -.21, p = .176$
Life position	$b = .03, p < .05$	$b = .03, p < .05$
Growth (versus maintenance) goals	$b = .01, p = .568$	$b = .01, p = .462$
Information (versus affect) goals	$b = .00, p = .710$	$b = .00, p = .776$
Average(Risk, Benefit)		$b = -.31, p = .806$
Personality	*pseudo-R^2* = .13	*pseudo-R^2* = .17
Extraversion	$b = -.03, p = .902$	$b = .05, p = .851$
Openness to new experiences	$b = .67, p < .01$	$b = .68, p < .01$
Conscientiousness	$b = .93, p < .01$	$b = 1.01, p < .001$*
Neuroticism	$b = .02, p = .921$	$b = .04, p = .871$
Agreeableness	$b = .20, p = .464$	$b = .09, p = .734$
Average(Risk, Benefit)		$b = –.44, p < .01$
Cognitive measures	*pseudo-R^2* = .42	*pseudo-R^2* = .45
Learning ability	$b = .83, p < .01$	$b = .86, p < .01$
Memory	$b = -.18, p = .536$	$b = -.06, p = .842$
Crystallized intelligence (Nelson-Denny Vocabulary)	$b = .05, p = .660$	$b = -.04, p = .748$
Cognitive reflection ability – naïve	$b = -.30, p = .471$	$b = -.39, p = .342$
Numeracy	$b = .15, p = .582$	$b = .19, p = .485$
Preference for verbatim (versus gist-based) processing	$b = .93, p = .263$	$b = -1.14, p = .162$
Average(Risk, Benefit)		$b = –.55, p < .01$

Note. * $p < .001$.

3 ORDER OF SURVEY ELEMENTS

Table 12

Order of survey elements

Position	Survey Element	Notes
1	Consent	Consent information + 1 item
2	Demographic Variables	6 items
3	Affect	2 items
4	Life Goals	2 items
5	Life Position	1 item
6	Subjective Health/ Memory	4 + 1 attention check item
7	Personality	10 items
8	Affect-Impact Task	6 items x 2 scales; 2 testing blocks (order of items within blocks is fixed as traffic accidents-groundwater contamination-medication shortage, order of blocks (human versus nature) is randomized and counter-balanced)
9	Forced-Choice Task	10 forced-choice item pairs (order of item pairs is randomized and counter-balanced; order of items within each pair is randomized and counter-balanced)
10	Dread-Inference Task	5 items x 4 scales (order of blocks fixed as frequency judgment task-dread-direct exposure-indirect exposure; order of items within blocks fixed as flood-animal-poison-fire-cold)
11	Risk-Benefit Task	5 items x 3 scales (order of blocks fixed as risks-benefits-attitude, order of items within blocks fixed as flavoring-electrolytes-vitamins-minerals-genetically modified food)
12	Information Avoidance Tasks	3 items x 5 scales; not analyzed in context of this thesis (order of blocks randomized and counter-balanced; order of items within blocks fixed as avoidance decision-feel bad-limit enjoyment-change decision-change future habits)
13	Information-Processing	6 items
14	Crystallized Intelligence	12 items + 1 sample item
15	Cognitive Reflection Test	3 items
16	Numeracy	3 items + 1 attention check item
17	Year of birth	1 attention check item
18	Cheating	1 item
19	Debrief	Debriefing statement