IN PRESS: RISK ANALYSIS

Age and adaptation: Stronger decision updating about real world risks in older age

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ABSTRACT

In later life, people are faced with a multitude of risky decisions that concern their health, finance, and personal security. Older adults often exercise caution in situations that involve risk. In this research, we asked whether older adults are also more responsive to warnings about potential risk. An answer to this question could reveal a factor underlying increased cautiousness in older age. In Study 1, participants decided whether they would engage in risky activities (e.g., using an ATM machine in the street) in four realistic scenarios about which, participants could be expected to have relevant knowledge or experience. They then made posterior decisions after listening to audio extracts of real reports relevant to each activity. In Study 2, we explored the role that emotions play in decision updating. As in Study 1, participants made prior and posterior decisions, with the exception that for each scenario the reports were presented in their original audio format (high emotive) or in a written transcript format (low emotive). Following each posterior decision, participants indicated their emotional valence and arousal responses to the reports. In both studies, older adults engaged in fewer risky activities than younger adults, indicative of increased cautiousness in older age, and exhibited stronger decision updating in response to the reports. Older adults also showed stronger emotional responses to the reports, even though emotional responses did not differ for audio and written transcript formats. Finally, age differences in emotional responses to the reports accounted for age differences in decision updating.

1. INTRODUCTION

In later life, people face a multitude of important decisions about their health, finance, and personal security. The outcomes of poor health choices are likely to be most apparent in older age as negative health outcomes, such as diabetes and heart disease, are more prevalent in later life.[1] Older adults are commonly exposed to warnings and advice about their health and are encouraged by health authorities to undergo regular health assessments.[2,3] Older adults also face numerous financial decisions, some of which are designed specifically to harm them. Financial fraud in the guise of sweepstakes and bogus lotteries is often targeted specifically at the elderly whom fraudsters perceive as vulnerable and gullible.[4,5] Many older adults must also decide whether to surrender their driving privileges and compromise their mobility on the basis of doctors' recommendations and the advice of friends and family.[6] Psychological literature has often reported that older adults exercise caution in situations that involve risk,[7-9] particularly in health, recreational, and financial contexts.[10] Yet, are older adults also more responsive to warnings about potential risk? Answering this question could cast new light on a factor underlying increased cautiousness in older age.

One method of assessing how people update their risky decision making has been to use behavioral tasks, in which individuals are provided feedback about the outcomes of their decisions across multiple trials.[11-13] Behavioral tasks simulate real world experience-based learning in situations that afford multiple learning opportunities. However, behavioral tasks have yielded mixed findings about age differences in experience-based learning. Older adults respond like younger adults to the negative outcomes of their decisions on some tasks[14,15] and are less responsive than younger adults on other tasks,[16,17] which is indicative of risk seeking behavior. This is the case on the widely used Iowa Gambling Task—a card game in which individuals must learn to avoid choosing cards from decks that yield large potential monetary wins but higher losses in favor of decks that yield smaller potential wins, but higher

average gain.[12,16] Differences in risk taking on this and similar tasks have commonly been attributed to impaired learning in older age.[14,16,17]

Behavioral tasks that impose heavy demands on memory can impair the learning abilities of older adults. As in the Iowa Gambling Task, when individuals must learn to avoid a disadvantageous option in favor of an alternative that offers a higher gain in the long run, the decision options and their outcomes must be tracked across multiple trials.[18-19] Multi-play decision tasks for which the decision maker has a long-run aspiration also elicit greater search,[20] which further burdens working memory resources.[21] The number of choice options also imposes additional demands on memory that impair decision making abilities in older adults. For example, older adults have been shown to make similar choices to younger adults when choosing between two risky options after first learning about their potential outcomes.[22] When the number of options is increased from two to four or eight options, raising the demands on memory, age differences in risky choice behavior emerge.[22]

In real world situations rewards and losses are inversely related to their probabilities as large rewards (or losses) typically have small probabilities.[23] Severe events, such as car crashes, are rare[24]—and an individual may never experience the consequences of not wearing a seat belt. Other consequences of risk taking have a long time horizon, such as in the case of lung cancer and heart disease linked to smoking. Thus, many risky decisions may be made in everyday life without experiencing negative outcomes. Further, when experience is sampled over a period of time, such as months or even years, rare events (e.g., a car crash) are likely to be under-sampled, leading people to underestimate the probability of rare, but highly consequential events.[25,26]

Expert advice, government campaigns, and media reports are intended to inform people's decision making about serious risks.[27] For example, following an outbreak of the Zika virus in South America in 2015, the Centres for Disease Control and Prevention issued a

website to inform the public about the symptoms, diagnosis, and treatment of the Zika virus and preventive measures against infection.[28] The website was specifically aimed at women, warning of the risk that the Zika virus can be transmitted to the foetus of pregnant women. The introduction of pictorial health warnings to cigarette packaging is a further example of how government campaigns are designed to inform people's decisions about health risks.[29] Some campaigns and awareness-raising strategies are targeted specifically at elderly people who may be vulnerable to injury as road users and to financial fraud.[4,6] When people base their decisions on expert advice or statistical risks reported in government campaigns and the media, they are making decisions from description.[30]

Can descriptive information delivered by government campaigns and media reports overcome personal experience? In one study, Yechiam, Barron, and Erev[31] recorded visits made to Israeli hotels before and after a series of terrorist attacks in Israel. Hotel visits among foreign tourists decreased by 80% following the attacks, indicating that media reports of the attacks strongly influenced the travel choices of foreign tourists. Yet, hotel visits among domestic tourists actually increased by 20% during the same period. Unlike the foreign tourists, the Israeli tourists had accrued a vast amount of personal experience about the rarity of such terrorist attacks, many of whom may never have experienced of a terrorist attack. Thus, media reports may have little impact on decision making in situations that people have accrued personal experience. Even statistical risks, such as those used in government campaigns, may have less impact than the influence of personal experience. For example, Betsch, Haase, Renkewitz, and Schmid[32] asked participants to assess the riskiness of a vaccine used to prevent a fictitious severe disease. To help inform their judgment, they were also told about the statistical likelihood of adverse effects of the vaccine. Participants were then asked to imagine finding on an internet bulletin board, information about instances of positive and negative effects of taking the vaccine. Crucially, even though the participants

knew the objective risk of the vaccine, they were strongly influenced by their exposure to the individual instances in which the vaccine had led to positive and negative outcomes. This finding suggests that experiencing a single event (e.g., a positive or negative outcome of a vaccine) can overpower the influence of a statistical report that summarises many such events. When a negative outcome is rare (e.g., a car crash) an individual may experience a vast number occasions in which the negative outcome does not occur (i.e., a crash-free journey). Consequently, the provision of a statistical report, such as in the form of a road safety campaign, could have very little impact on risk perception and decision making.

If personal experience weighs heavily on people's decision making about risks that have rare consequences, then older adults may actually be less responsive than younger adults to warnings about potential risk. For rare, but highly consequential events, older adults will have encountered many more instances than younger adults, in which their decision making (e.g., not wearing a seatbelt) did not lead to a negative event (e.g., a road traffic injury). In some contexts, an older adult may never have experienced negative consequences of their risky choices. Similar to the domestic tourists in Israel, warnings delivered in media reports and government campaigns may have relatively little impact on the decision making of older adults in contexts that are highly familiar to them.

On the other hand, developmental research indicates that a tendency to update beliefs about familiar risks (e.g., likelihood of a home burglary) in response to undesirable news increases from adolescence to young adulthood.[33] In this task, participants first estimated the likelihood of adverse life events. They were then informed about the actual numerical risk of each event that was either desirable (i.e., the actual likelihood was lower than their own estimate) or undesirable (i.e., the likelihood was higher than their estimate) and were asked to make a second re-estimate of the likelihood of each event. Belief updating following desirable news was independent of age. Conversely, a tendency to update beliefs in the

direction of the true likelihood of an adverse event following undesirable news was found to increase from age 9 years to age 26 years. If the tendency to update beliefs in response to undesirable news extends to decision making in later life, older adults may show a stronger tendency to update their risky decision making in response to warnings about risk.

Why might belief updating about negative events increase with age? One possibility is that age-related dopaminergic decline motivates avoidance of negative outcomes. Previous research has found that lower levels of dopamine are related to an increased likelihood of avoiding negative outcomes, and that increased dopamine levels are related to increased sensitivity to positive outcomes. In general, dopamine levels decline with age. Using a probabilistic selection task, Frank and Kong[34] reported that older adults showed an enhanced tendency to learn from negative compared to positive consequences of their decisions. Moreover, negative mood, which is associated with depleted dopamine levels,[35] is linked to heightened risk perceptions in older age. For example, Chou, Lee, and Ho[36] found that a negative mood-inducing manipulation, in the form of a mood-arousing video clip, reduced risk taking among older adults for hypothetical real life dilemmas, but had no such effect on younger adults. Conversely, Carpenter, Peters, Västfjäll, and Isen[37] found that inducing positive feelings in older adults increased their frequency of card choices from “gain” decks that yielded monetary wins over “loss” decks that yielded monetary losses. Hence, despite older adults’ lifetime of accrued experience, the above findings suggest that they may exhibit stronger decision updating tendencies than younger adults in response to warnings about risk, perhaps due to negative mood-inducing effects of warnings.

In the current research, we studied risky decision making in younger and healthy older adults in the local community. In contrast with previous approaches that have used monetary gambles[9,17] or examples of extreme activities (e.g., bungee jumping),[38] we designed four everyday scenarios about which people of all ages would have some relevant knowledge or

experience. Scenarios described visiting a family member in a local hospital despite poor weather (weather scenario), using an ATM machine in the street (fraud scenario), ordering a high-salt meal at a restaurant (health scenario), and accepting a car ride without access to a seat belt (safety scenario). Participants made initial (prior) decisions about whether to engage in each activity. They then listened to audio extracts of real reports relevant to each scenario; either a forecast of severe weather (weather scenario), a report on ATM fraud (fraud scenario), a report on salt consumption (health scenario), or a report on seat belt use (safety scenario). Decision updating was assessed by asking participants to make posterior decisions following each audio report.

STUDY 1

2. METHOD

2.1. Participants

The research was approved by the appropriate IRB committee. All participants provided informed consent. Thirty nine younger (18-35 years of age; mean age=23.18 years; 54% male) and 39 older (65-82 years of age; mean age=72.58 years; 39% male) volunteers participated. The target sample size was based on previous studies. The mini-mental state examination was used to screen for cognitive impairment with scores greater than 25 indicative of intact cognition. All participants passed the screen.

2.2. Materials and Procedure

For each of four scenarios, participants were asked to make an initial (prior) decision about whether they would engage in an activity described in the scenario. A weather scenario read:

> *"A member of your family who you are very close to is unwell and requires surgery at the Royal Victoria Hospital in Belfast. Tomorrow is your only opportunity to visit them at the hospital before their surgery. On the other hand, you hear on the radio and see on television that there is a weather warning of heavy rain and strong winds for tomorrow."*

For which participants were asked to make a decision about whether or not they would visit their family member despite the potential bad weather. A fraud scenario read:

> *"You are late for an appointment in town and need to withdraw some money on your way. You pass by a bank."*

For which they were asked whether or not they would use the ATM machine outside the bank rather than use a machine inside the bank. A health scenario read:

> *"You visit a restaurant that offers a choice of meal options. Among the options is your favourite dish, but which you know to be typically high in salt. Other meal options are also appealing."*

For which they were asked whether or not they would order their favorite meal at the restaurant. And a safety scenario read:

> *"You visit a friend who lives a short walk from your home. It is late and your friend offers you a lift home. Your friend is safety conscious, but has been reupholstering the seats in their car, which means that the seatbelts are currently not attached."*

For which they were asked whether or not they would accept a short ride home from their friend.

Following their initial (prior) decisions, participants listened to an audio report relevant to each scenario that indicated a significant domain relevant risk. A report of severe weather in the local area was heard for the weather scenario (duration 1 min 24 sec; see supplementary material for transcript); a crime report on ATM fraud was heard for the fraud scenario (duration 2 min 20 sec); a health report on the dangers of a high sodium diet was heard for the health scenario (duration 1 min 43 sec); and a government road safety campaign on seat belt use was heard for the safety scenario (duration 28 sec). Following each report, participants were asked: "Please describe what you just heard in the report in a way that could inform someone else's decision making who has not heard the report". This was done in order to encourage participants to reflect on the information provided in the audio reports. They were then asked to make a second (posterior) decision about whether to engage in each activity having heard the report. Prior and posterior decisions were made before moving onto

the next scenario and scenarios were completed in a randomly generated order for each participant.

3. RESULTS

First, we assessed age and scenario differences in participants' prior decisions. In order to take account of the clustering within our data, we conducted a random effects logistic regression analysis on prior decisions and included age group (older vs. younger) and scenario (weather, fraud, health, safety) as factors. This analysis revealed that older adults decided in favor of engaging in significantly fewer activities (76%) than their younger counterparts (94%; OR = 0.15, t = 3.90, $p < .001$), which is indicative of increased cautiousness in older age. The analysis also revealed scenario differences in risky decision making. Decisions in favor of engaging in the activities described in the reports were most frequent in the weather scenario (94%), followed by the health (90%; vs. weather, OR = 0.56, $t = 0.92$, $p = .360$), fraud (87%; vs. weather, OR = 0.42, $t = 1.42$, $p = .155$), and safety scenarios (71%; vs. weather, OR = 0.11, $t = 3.66$, $p < .001$).

Crucially, if older adults are more responsive to warnings than younger adults, they should alter their decision making more than younger adults in response to the reports. To assess posterior decision making, we conducted a random effects logistic regression analysis on participants' posterior decisions, including age and scenario as factors, and controlling for prior decisions. This analysis revealed that older adults were significantly less likely ($48\%_{posterior}$ vs. $76\%_{prior}$) than their younger counterparts ($88\%_{posterior}$ vs. $94\%_{prior}$) to decide in favor of engaging in the activities described in the reports (OR = 0.09, $t = 5.39$, $p < .001$). Inspection of Figure 1 confirms that in all four scenarios older adults were more responsive to the reports than younger adults in their posterior decision making.

STUDY 2

In Study 1, older adults were more cautious than younger adults in their initial risk taking. Older adults were also more responsive to descriptive information about risk delivered in the audio reports. One possibility is that age-related differences in emotion processing partly explain the stronger tendency to update decisions about risk in older age. Depleted dopamine levels are associated with negative mood[35] which, in turn, is associated with avoidance behavior[34] and reduced risk taking[36] in older age. Perhaps older adults are more responsive to the negative mood-inducing effects of warnings about potential risk, which leads them to engage in greater decision updating to avoid negative potential outcomes. We explored this possibility in Study 2 by measuring participants' emotional valence and arousal responses to the reports. Specifically, we were interested in whether (a) negative emotional responses are associated with a stronger tendency to update posterior decision making, and whether (b) stronger negative emotional responses in older adults relate to age differences in decision updating.

The audio reports used in Study 1 may have been intensely mood-arousing, not only because of the descriptive information they provide about severe negative events (e.g., ATM fraud), but also because of their auditory format. For example, participants listened to a government road safety campaign on seat belt use in the safety scenario, which included realistic sounds of a car crash. Indeed, such campaigns are intentionally designed to induce intense-emotional responses in the listener. In Study 2, we further explored whether the auditory format of the reports, in addition to their descriptive content, influences decision updating tendencies. To do so, each participant received audio reports presented in the same format used in Study 1 for two of the four scenarios and received written transcripts of the audio reports for the remaining two scenarios. We hypothesized that if the auditory format of the reports added to their emotional intensity then delivering them in a written transcript

format should reduce their emotional intensity and thus reduce age differences in decision updating.

4. METHOD

4.1. Participants

The research was approved by the appropriate IRB committee and all participants provided informed consent. Forty younger (18-35 years of age; mean age = 21.80 years; 45% male) and 40 older (65-90 years of age; mean age = 73.93; 40% male) volunteers participated in the study. A score of greater than 25 on the mini-mental state examination was used to indicate intact cognition in our screening of older adults. All participants passed the screen.

4.2. Materials and Procedure

Participants were shown the same four scenarios used in Study 1. For each scenario, they were asked to make an initial (prior) decision about whether they would engage in the activity described in the scenario. Participants were then provided the same four reports used in Study 1 on which to base their second (posterior) decision. For two of the four scenarios participants received the corresponding audio report presented in the same format used in Study 1. For the two remaining scenarios, they instead received a written transcript of the audio report, rather than listen to the report directly (see supplementary material for transcript). Using a mixed design, participants were pseudo-randomly assigned to receive two of the four reports in the audio format and the remaining two in the written transcript format. Hence, 10 participants received audio reports for the weather and fraud scenarios and written transcripts for the health and safety scenarios, 10 participants received audio reports for the weather and heath scenarios and written transcripts for the fraud and safety scenarios, and so on, to ensure balanced participant numbers across all four combinations of scenario and report format.

We used the Self-Assessment Manikin (SAM)[39] to assess emotional valence and arousal responses to the reports. After making each posterior decision, participants were shown a row of nine basic drawings depicting a person (i.e., the manikin) ranging from very sad (value of -4), to neutral (value of 0), to very happy (value of 4) from the left to right side of the computer monitor. Participants were instructed that "*The faces below are arranged on a continuum from unhappy (left) through to happy (right).*" Participants were asked to indicate their emotional valence response to the report in an instruction that read: "*Please indicate how you felt whilst [listening to, reading] the report you just [heard, read]. To make your choice, select the corresponding option box located below the faces. If you felt completely neutral, neither happy nor sad, select the option box below the middle figure*." Next, participants were shown a row of nine basic drawings depicting a person ranging from very calm (value of 1; left) to very anxious (value of 10; right) and were instructed that "*The faced below are arranged on a continuum from calm (left) through to anxious (right).*" They were asked to indicate their arousal response to the report in an instruction that read "*Please indicate how you felt whilst [listening to, reading] the report you just [heard, read]. To make your choice, select the corresponding option box located below the faces*." Finally, participants were asked "*How informative did you find the report in your decision making about whether to [make the journey tomorrow, use the cash machine outside the bank, order your favourite meal at the restaurant, accept the short lift home from your friend]*" and provided their rating on a 100-point scale ranging from "Not at all informative" (value of 1) to "Extremely informative (value of 100).

5. RESULTS

First, we assessed age and scenario differences in participants' prior decisions. We conducted a random effects logistic regression analysis on their prior decisions, including age group (older vs. younger) and scenario (weather, fraud, health, safety) as factors. This

analysis confirmed that older adults engaged in fewer risky activities (70%) in their initial risk taking compared to younger adults (88%; OR = 0.19, $t = 3.33$, $p = .001$), indicating greater cautiousness in older age. The analysis also confirmed a trend in risky decision making across scenarios that was similar to the trend discovered in Study 1. Decisions in favor of engaging in the activities were most frequent in the weather scenario (95%), followed by the health (84%; vs. weather, OR = 0.20, $t = 2.41$, $p = .016$), fraud (81%; vs. weather, OR = 0.16, $t = 2.77$, $p = .006$), and safety scenarios (56% vs. weather, OR = 0.03, $t = 5.06$, $p < .001$).

Next, we assessed participants' posterior decisions on the basis of their age and the presentation format (transcript vs. audio) of the reports. Controlling for prior decisions in a random effects logistic regression analysis, older adults were significantly less likely than their younger counterparts to decide in favor of engaging in the activities described in the reports (Table 1; Model 1). However, the age differences between prior ($88\%_{younger}$; $70\%_{older}$) and posterior decisions ($76\%_{younger}$; $53\%_{older}$) were much smaller than those observed in Study 1. In comparison to Study 1, younger adults were more responsive to the reports in their posterior decision making. Participants were not significantly more responsive to the audio format ($79\%_{initial}$; $66\%_{posterior}$) than to the written transcript format ($79\%_{initial}$; $63\%_{posterior}$) in making their posterior decisions (Table 1; Model 1). Including an interaction term between age and presentation format did not reveal that age differences in decision updating depended on the presentation format of the reports (OR = 1.38, $t = 0.45$, $p = .654$).

Did younger and older adults differ in their emotional responses to the reports? We conducted a random effects linear regression on participants' valence ratings, including age (older vs. younger), scenario (weather, fraud, health, safety), and report format (transcript vs. audio) as factors. This analysis revealed that older adults were significantly more negative in their valence response to the reports ($M = -0.28$) than younger adults ($M = 0.43$; Table 2).

There were also significant scenario differences in participants' valence responses (Table 2). Participants were least negative in their response to the health report (*M* = 0.90), followed by the weather (*M* = 0.29), fraud (*M* = 0.03), and safety reports (*M* = -0.90). Valence responses were stronger for audio reports (*M* = 0.05) than for written transcript reports (*M* = 0.11), but this difference was not significant (Table 2).

Next, we tested for age, scenario, and report format differences in arousal responses using a random effects linear regression analysis. Older adults exhibited stronger arousal responses to the reports (*M* = 5.48) than did younger adults (*M* = 4.68; Table 2). The analysis also revealed scenario differences in arousal response (Table 2). Arousal was strongest in response the safety report (*M* = 6.01), followed by the weather (*M* = 5.2), fraud (*M* = 4.99), and health reports (*M* = 4.11). Finally, while arousal responses were stronger for audio reports (*M* = 5.19) than for written transcripts (*M* = 4.96), this difference was not significant (Table 2).

Did younger and older adults differ in how informative they perceived the reports? To test for age, scenario, and report format differences in informative ratings we conducted a random effects linear regression analysis. While older adults rated the reports as slightly less informative (*M* = 55.61) than did their younger counterparts (*M* = 59.60), our analysis indicated that this age difference was not significant (Table 2). Participants rated the weather report as most informative (*M* = 65.34), followed by the safety (*M* = 59.55), fraud (*M* = 59.15), and health reports (*M* = 46.39). Finally, participants also rated audio reports as more informative (*M* = 60.04) than written transcript (*M* = 55.18), but this differences was not significant (Table 2).

Did emotional responses and informative ratings account for tendencies to update posterior decision making in response to the reports? Posterior decisions against engaging in the activities described in the scenarios were associated with a stronger negative valence

response and higher informative ratings for the reports (Table 1: Model 2). In a third block, we included all possible interaction terms involving age group (older vs. younger), valence, arousal, and informative ratings (Table 1: Model 3). There were no significant interactions with age. However, valence interacted with arousal, such that arousal only influenced posterior decisions when the valence was negative. Indeed, valence was a strong negative predictor of arousal (b = -0.79, t = 12.11, p < .001), which indicates that the reports were arousing when they were negative, leading to a stronger influence on decision making.

Finally, we tested whether valence and arousal responses and informative ratings accounted for age differences in posterior decisions. Recall that older adults showed stronger valence and arousal responses to the reports, but did not differ from younger adults in their informative ratings for the reports. We conducted a random effects logistic regression analysis on posterior decisions, including valence, arousal, and informative ratings in separate models, and in each model we controlled for prior decisions. Age differences in posterior decisions remained significant after partialing out informative ratings (OR = 0.32, t = 2.44, p = .015), but not after partialing out valence (OR = 0.57, t = 0.96, p = .338) or arousal responses (OR = 0.52, t = 1.40, p = .161).

In sum, older adults made fewer risky decisions than their younger counterparts and were also more responsive to warnings about risk, albeit less so than in Study 1. Older adults also showed stronger emotional valence and arousal responses to the reports, even though emotional responses did not differ between audio and written transcript formats of the reports. Reports that were perceived as highly informative or that elicited a stronger emotional response were more influential on posterior decision making. Controlling for informative ratings, age differences in emotional valence and arousal patialed out age differences in decision updating.

6. DISCUSSION

Older adults face many risky decisions, including ones about their health, finance, and personal security. In later life, people are exposed to numerous warnings and advice about their health and safety, such as whether to continue driving.[6] Government campaigns and awareness raising strategies often target the elderly who may be vulnerable to financial fraud.[4,5] In the current research, we investigated whether older adults are more responsive to warnings about potential risk with a view to uncovering an underlying cause of increased cautiousness in older age. Our studies revealed that older adults were less likely than their younger counterparts to engage in risky activities described in realistic scenarios and were also more responsive to warnings about potential risk delivered in reports taken from the media and government campaigns. This finding points to decision updating tendencies as a potential underlying cause of increased cautiousness in later life. We can expect that most individuals will have been exposed to similar such warnings (e.g., severe weather forecasts, health and dietary warnings) in their daily lives. Older adults may have exhibited greater caution in their initial decision making as a result of previous exposure to similar warnings experienced in their daily lives.

Why are older adults more responsive to warnings about potential risk? One possible explanation is that warnings elicit stronger emotional responses in older adults, motivating them to avoid negative consequences of their decision making. Age-related decline in dopamine levels is associated with negative mood in older age[35] and avoidance of negative outcomes.[34] When negative mood is induced in older adults (e.g., using mood-arousing video clips), risk taking behavior further declines.[36] In our studies, we exposed participants to reports taken from real media and government campaigns, some of which were designed to elicit strong emotional responses. In the safety scenario, for example, participants listened to a government campaign designed to increase seat belt use that realistically portrayed a road

traffic accident. In Study 2, we found that when controlling for participants' ratings of how informative the reports were, stronger emotional responses were associated with greater decision updating in response to the reports. Additionally, older adults reported stronger negative mood and arousal in response to the reports and their emotional responses accounted for age differences in decision updating.

While older adults appear to experience more intense negative emotions in response to warnings about risk, emotional well-being and emotional stability have been shown to improve across adulthood.[40] Older adults review positive features of choice options for longer and attend less to negative features compared to younger adults.[41] They also report experiencing less negative emotional arousal than younger adults when evaluating loss cues in anticipation of monetary outcomes. [42] This prioritising of positive emotions in later life has been explained in terms of socio emotional selectivity theory. [43,44] The theory posits that as an individual's time horizon shortens positive emotional experiences are prioritised over negative emotional experiences. Despite prioritising positive emotions, older adults are more vulnerable to some negative consequences of their decision making than people in younger age ranges, especially in situations involving risk of physical harm and illness. Older drivers, passengers, and pedestrians, for example, are much more likely than younger road users to be fatally injured as a result of a road traffic collision, owing to their increased susceptibility to incur physical injury.[45] We can expect that individuals adapt to their own physical and social vulnerabilities in later life by heightening their emotional responses to harmful potential outcomes. Indeed, the scenarios we used in our studies all involved decisions that had severe negative consequences.

In the current research, we selected risk taking scenarios about which younger and older adults would have some prior knowledge or experience. For example, most people will have experienced using an ATM machine outside a bank (fraud scenario) or choosing among

meal options at a restaurant (health scenario). Previous research has suggested that prior experience can overcome the influence of media reports[31] and statistical information[32] on risk perception and decision making. Even when experience is accrued over a long period of time, an individual may never experience severe negative outcomes of their decision making when the outcomes are rare (e.g., bank fraud as a result of using an ATM machine) or have a long time horizon (e.g., heart failure due to a diet rich in salt). This tendency can lead people to underestimate the probability of rare events and underweight the importance of descriptive information.[25,26,30] Our findings do not necessarily challenge this view. At least in Study 1, younger adults were relatively non-responsive to the reports (Figure 1). Although older adults were more responsive than younger adults to descriptive information, the results of Study 2 suggest that when descriptive information is delivered in the form of warnings it can evoke stronger negative emotional responses in older adults that lead to greater decision updating in older age. An interesting direction for future research would be to explore age differences in decision updating in contexts that people have acquired less personal experience. For example, individuals who live in areas unaffected by the Ebola virus or Zika virus may be highly responsive to media reports and statistics issued in government reports.[27] In such situations, age differences in decision updating may even be stronger than those reported in our studies, as the greater personal experience accrued by older adults may have helped downplay the impact of descriptive information.

The influence of personal experience may help explain why people are far less responsive to advice than they should be,[46] a phenomenon known as ‘egocentric advice discounting’, which is proposed to result from strong beliefs in the importance of one’s own opinion.[47-49] In one study, Yaniv and Kleinberger[49] questioned participants about the dates of historical events. They then gave participants a second attempt at each question, this time presenting participants with their previous response and a response suggested by an advisor.

Participants were shown to place considerably greater weight on their own responses than the suggestions of their advisor. However, participants were sensitive to the quality of their own responses in their uptake of the advice and were more receptive of good advice than they were of bad advice. Similarly, in Study 2, we found that participants were more responsive to warnings that they perceived as informative. Perceived informativeness may even be a necessary condition for responding to warnings that are highly emotive. We found that warnings that elicited intense emotional responses influenced decision updating when a warning was also perceived as highly informative.

Research on advice taking in decision making has shown how characteristics of the advisor (e.g., their reputation) influence the uptake of advice.[49] Our studies show in a risky decision making context that the age of the individual receiving advice also determines its uptake. We used a similar experimental procedure to procedures used in advice taking studies; namely, participants first made an initial (prior) decision and then made a second (posterior) decision after receiving advice in the form of an audio warning. Our findings suggest that age differences in emotional processing underlie stronger decision updating in older age. An alternative possibility is that older adults are more compliant with requests in experimental settings. The experimental procedure, in which posterior decision making was assessed following the delivery of advice, is likely to have been salient to participants. However, social desirability, which underpins compliance, has not been found to differ with age.[50] Thus, it would seem unlikely that individual differences in compliance explain our current findings. Another possibility is that younger adults strive to be consistent in their behavior and as a result responded less to the warnings in their posterior decision making. However, conscientiousness, which promotes consistent behavior, actually increases with age across adulthood.[51] As such, greater conscientiousness in older age may even have dampened the size of the age effects we observed on decision updating.

In conclusion, our findings demonstrate that older adults are more responsive than younger adults to warnings about potential risk, which may partly explain why older adults are often cautious in situations that involve risk. Our findings also contribute to a growing body of literature pointing to the importance of emotional factors in risk taking and possibly as a basis of cautiousness in older adults.

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Table 1. Experiment 2: Logistic regression models used to predict posterior decisions

	Model 1	Model 2	Model 3
Included	Odds Ratio (95% CI)	Odds Ratio (95% CI)	Odds Ratio (95% CI)
Constant	0.02 (0.00: 0.20)*	0.42 (0.02: 11.45)*	0.07 (0.00: 38.81)*
Prior decisions	632.53 (60.41: 6622.67)**	9,787.37 (349.59: 274,010.71)**	7,448.72 (270.07: 205,443.00)**
Age			
Older vs. younger	0.38 (0.16: 0.92)*	0.35 (0.10: 1.25)	0.28 (0.00: 23.60)
Scenario			
Weather	1.00	1.00	1.00
Fraud	0.43 (0.18: 1.06)	0.33 (0.10: 1.10)	0.47 (0.15: 1.50)
Health	3.41 (1.07: 10.93)*	1.19 (0.28: 5.05)	1.68 (0.40: 7.02)
Safety	0.56 (0.21: 1.53)	1.00 (0.26: 3.88)	2.14 (0.49: 9.45)
Report format			
Transcript vs. audio	0.74 (0.36: 1.51)	0.61 (0.24: 1.55)	0.72 (0.29: 1.80)
Valence		1.95 (1.15: 3.32)*	0.53 (0.10: 2.75)
Arousal		0.76 (0.57: 1.01)	0.97 (0.40: 2.38)
Informative		0.95 (0.92: 0.97)**	0.97 (0.91: 1.03)
Age x valence			0.83 (0.34: 2.01)
Age x arousal			1.04 (0.61: 1.78)
Age x informative			1.00 (0.95: 1.04)
Valence x arousal			1.41 (1.19: 1.66)**
Valence x informative			1.00 (0.98: 1.01)
Arousal x informative			1.00 (0.99: 1.01)

678 Note. *$p \leq .05$, **$p \leq .001$.

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Table 2. Experiment 2: Linear regression models used to predict valence, arousal, and informative ratings

	Valence	Arousal	Informative
Included	beta (95% CI)	beta (95% CI)	beta (95% CI)
Constant	1.23 (0.84: 1.61)**	5.73 (5.09: 6.37)**	69.76 (61.87: 77.65)**
Age			
Older vs. younger	-0.71 (-0.28: -1.13)*	0.79 (0.04: 1.55)*	-3.99 (-12.31: 4.33)
Scenario			
Weather	-0.61 (-0.27: -0.96)*	-0.81 (-0.31: -1.31)*	1.00
Fraud	-0.88 (-0.53: -1.22)**	-1.03 (-0.52: -1.53)**	-6.19 (-13.62: 1.24)
Health	1.00	-1.90 (-1.40: -2.40)	-18.95 (-11.52: -26.38)**
Safety	-1.80 (-1.45: -2.15)**	1.00	-5.79 (-13.22: 1.64)
Report format			
Transcript vs. audio	0.06 (-1.19: 0.30)	-0.23 (-0.59: 0.12)	-4.86 (-10.12: 0.39)

Note. *$p \leq .05$, **$p \leq .001$.

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713 **Figure 1.** Percentage of decisions in favor of engaging in each activity in the four scenarios
714 before (prior) and after (posterior) hearing each audio report. Vertical bars represent 1
715 standard error above and below the mean.

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