Humanities & Social Sciences Communications

ARTICLE

https://doi.org/10.1057/s41599-024-02658-6 OPEN

Advanced age predicts increased susceptibility to attribute, goal, and risky-choice framing in negative frame valences

Lance Xu [1]✉

The framing effect has been extensively studied in the context of attribute, goal, and risky-choice framing, revealing its significant impact on decision-making. However, the interplay between age and the framing effect remains relatively unexplored, and existing findings are inconclusive and conflicting. Addressing this gap, this study investigates the influence of age on all three types of framing using a large cohort of participants ($N = 696$). The Johnson-Neyman technique was employed to examine the effect across a continuous range of ages. The analysis demonstrated that advanced age significantly increased susceptibility to the framing effect. Moreover, it was found that this susceptibility primarily manifests in response to negative frames across all framing types. These findings not only align with the socio-emotional selectivity theory and dual-process model but also underscore the importance of affect heuristics in decision-making among older adults. By offering a robust examination of all three types of framing and their interactions with age, this study provides a theoretical foundation for the role of age as a potential moderator in framing contexts. These findings may therefore inform the development of targeted strategies to mitigate the impact of the framing effect on elderly populations.

[1] Johns Hopkins University, Baltimore, MD, USA. ✉email: lxu72@jhu.edu

Introduction

As society continues to expand rapidly, the population of older adults is continually rising, leading to heightened responsibilities in making critical decisions that can substantially impact their health, finances, and other aspects of their lives. A significant proportion of these decisions will be subject to the influence of the framing effect, a well-known cognitive bias where the presentation of information shapes an individual's perception and evaluation of that information (Tversky and Kahneman, 1981). Given the utmost significance and pervasiveness of the framing effect in everyday decision-making, it is imperative to gather more information to ascertain how aging affects susceptibility to this cognitive bias.

In healthcare specifically, older adults have been found to make immediate decisions related to healthcare decisions compared to younger adults, who were more methodical and felt that more information was needed to make an informed opinion (Meyer et al., 1995). This does not include about half of older inpatients in acute hospitals affected with dementia and delirium, which would cloud their judgment about healthcare decisions and make the framing effect more prominent in their choices to undergo treatment or select from options of treatments (Khizar and Harwood, 2017). In addition, older adults have been shown to have lower cognitive flexibility than younger adults, suggesting that older adults take longer and more cognitive brainpower to switch their selection to the new optimal choice (Kupis et al., 2021).

Psychologists classify framing into three primary types: Attribute framing, goal framing, and risky-choice framing (Levin et al., 1998). Risky-choice framing was first introduced by Tversky & Kahneman's pioneering study in 1981. The prototypical problem involved choices between a riskless and risky choice with the same expected value framed in either positive terms or negative terms (Levin et al., 1998). To examine this type of framing, the researchers devised the Asian Disease problem, where participants faced a decision task presented in two frame valences. The "positive frame" was worded with positive connotations while the "negative frame" was crafted with words evoking a negative connotation. Each frame contained two choices for one scenario: a certain riskless option or a risky choice with the same expected value as the riskless choice. The study found that participants preferred the certain option when presented with the positive frame, phrased as "lives saved". Conversely, in the negative frame, where the question was worded around "lives lost," subjects showed a preference for the risky choice. These findings indicate that participants were risk-averse when presented with the positive frame and more risk-seeking with the negative frame. That is, people will be more likely to take risks when the scenario focuses on the potential to avoid losses (negative frame) rather than the potential to realize gains (positive frame). The researchers explained this phenomenon using their prior work on prospect theory, suggesting that people are more motivated by the fear of loss (risk aversion) than the prospect of an equivalent gain (Kahneman and Tversky, 1979). For instance, the displeasure of losing $10 feels more impactful than the pleasure of gaining $10, leading participants to favor options that offer the highest expected benefit. The framing of the question, whether as a gain or loss scenario, significantly influenced the participants' evaluation of the question (Levin et al., 1998; Tversky and Kahneman, 1981).

Conversely, attribute framing represents the simplest type of framing wherein the dependent characteristic is emphasized either positively in the positive frame valence, or negatively in the negative frame valence (Levin et al., 1998). For instance, Wilson et al. (1987) demonstrated the substantial impact of framing the survival rate of surgery for terminal liver disease as either "20% surviving" or "80% dying" on participants' decision-making. The results revealed that more subjects were inclined to opt for the surgery when presented with the positive frame (20% surviving) as opposed to the negative frame (80% dying). To shed light on this phenomenon, Levin and Gaeth (1988) proposed that the frame valence encoded information that evoked either positive or negative associations in memory. In addition, differences in encoding based on the frame valence may result in subjects attending differently to the positive or negative aspects of the scenario (Levin et al., 1985; Stremitzer et al., 2012). As a consequence, subjects exhibited different choices depending on their positive or negative association with the scenario (Russo et al., 1996).

Goal framing diverges from attribute framing by placing less emphasis on a single attribute and instead focuses on enhancing the evaluation of an issue, with both positive and negative frames aiming to achieve this improvement. More specifically, goal framing was designed to influence goals that an individual may have by presenting possible benefits in the positive frame or its potential to avoid a loss in the negative frame (Levin et al., 1998). Banks et al. (1995) demonstrated that women assigned to the negative frame (emphasizing the risks associated with forgoing a mammogram) were more likely to undergo mammography compared to those assigned to the positive frame (highlighting the benefits of obtaining a mammogram). The effects of goal framing can be elucidated through the concept of "loss aversion", wherein negative information tends to have a more substantial impact than positive information of an equivalent magnitude. Also known as a negativity bias, this notion can be operationalized by the value function of prospect theory, where the slope of the function leads to the loss domain exerting a substantially stronger psychological effect than the gain domain of an equal magnitude (Kahneman and Tversky, 1979; Levin et al., 1998; Meyerowitz and Chaiken, 1987).

Although each type of framing may be influenced by distinct underlying mechanisms, framing, in general, may be attributed to affective heuristic processing, wherein one's emotional state holds more sway over their decisions than objective evaluation (Pu et al., 2017; Slovic et al., 2002). Consequently, the wording of a frame can markedly impact an individual's perception of the scenario and result in an increase in sensitivity to framing effects (McElroy and Seta, 2003). Positive frames tend to evoke positive emotions, making them more appealing than aversive negative frames (Nabi et al., 2020). Heuristics are inherently designed to reduce the cognitive load required for rapid judgments. However, combined with the mental simplification of information that is often seen with framing effects (Reyna and Brainerd, 1991), this swift and automatic processing can be responsible for irrational or erroneous decisions in the context of framing. This is further supported by the fact that the framing effect can be mitigated when deeper analytical cognitive processing is encouraged. Studies have demonstrated that the framing effect was diminished when participants were forced to enable more cognitively demanding analytical processing to supplant fallible heuristics (Levin et al., 1985; McElroy et al., 2020).

Socioemotional selectivity theory (SST) may also contribute to the framing effect. SST proposes that as individuals age, their priorities and motivational goals shift based on their perceived time horizon (Carstensen, 2006; Carstensen et al., 2000). Older adults tend to prioritize present-oriented goals that directly lead to positive emotions, while younger individuals focus on future-oriented goals (Carstensen and DeLiema, 2018). As an example, older adults may invest more time in nurturing current friendships, creating memories, and enjoying positive experiences, whereas younger adults might concentrate on expanding their

social network to gain advantages in the future. Framing scenarios can leverage the positivity effect, where, in line with SST, older adults are more inclined to focus on positive information rather than negative details to align with their positively oriented goals (see Reed et al., 2014 for a meta-analysis). This emphasis on positive information allows framing to align with the shifting priorities of older adults, promoting thoughts and decisions that are congruent with their present-oriented and emotionally fulfilling goals.

Yet other theories could explain the differences in framing effect across the age span, such as the dual-process model or the lifespan developmental perspective. In the dual-process model, a person's behavior can be determined by the interaction between two processes: a *deliberative process* that is slower and makes more rational goal-based decisions but requires an internal exertion of effort (willpower), and an *affective process* that focuses solely on the emotional state of the person (Loewenstein et al., 2015). The interaction of these two processes, where the decrease in willpower leads to an increased weight on the affective processes and vice versa, can be extended to framing. It logically follows that an increased arousal when presented with a certain frame would lead to an increase in the use of deliberative processes and a lower framing effect than the opposite (Guo et al., 2017; Roberts et al., 2022). In the lifespan developmental perspective proposed by Ebner, Freund, and Baltes (2006), younger adults were found to gravitate towards a goal orientation of growth, while older adults were found to gravitate towards maintenance and loss prevention (Ebner et al., 2006). Thus, potential age differences in framing could also be attributed to the preferences for growth vs. maintenance that change across a persons' lifespan.

Research on the relationship between age and the framing effect across the three types of framing has yielded mixed results, and in the case of attribute framing, there is limited research available. Firstly, studies examining the effect of age on risky-choice framing have produced conflicting findings. Rönnlund et al. (2005) investigated the risky-choice framing effect in various contexts (human lives, paintings, and money) with two cohorts of participants (younger and older adults) and found similar framing effects in both age groups. Conversely, a few studies have reported that older adults are more susceptible to the risky-choice framing effect than younger adults in different contexts (Kim et al., 2005; Pu et al., 2017). Watanabe and Shibutani (2010), however, reported the opposite effect, where the older group showed no risky-choice framing effects, while the younger group exhibited typical framing effects.

Regarding goal framing, only one study to date has examined the effect of age on adults' susceptibility to this type of framing. Masumoto et al. (2020) demonstrated that younger adults were less susceptible to the framing effect when presented with the positive frame, and vice versa. Similarly, Sparks and Ledgerwood (2018) conducted the sole study addressing the effect of age on the attribute framing effect. They found that as people age, they become more susceptible to the framing effect. Moreover, participants were more susceptible when presented with positive frames than negative frames. Despite these findings, additional research is needed to gain a comprehensive understanding of how age influences susceptibility to different framing effects in the three mentioned categories.

Some of the variations in the findings above can be attributed to several factors. Firstly, certain studies have small sample sizes, such as 53 participants in Kim et al. (2005) and 32 participants in Rönnlund et al. (2005) Additionally, most studies recruited participants from several separate cohorts for younger and older adults, with many drawing the sample of younger adults from undergraduate students. Moreover, some studies recruited participants from specific cities or towns, potentially introducing unintended biases. The one study that recruited participants of all ages, Masumoto et al. (2020), divided them into arbitrary age groups of younger, middle-aged, and older adults. These contextual differences may also account for some of the discrepancies observed in the results. To gain a more comprehensive understanding of all three types of framing, larger sample sizes, diverse participant recruitment strategies, and standardized age groups would be essential. Moreover, conducting multi-context studies could provide valuable insights into the generalizability of the findings.

This study aims to investigate differences in the framing effect for all three types of framing (risky-choice, attribute, and goal framing) in medically related scenarios for individuals within the continuous age range of 18 to 71 years. Two hypotheses underscore this study: (1) the framing effect will become more pronounced as adults' age increases for all three framing types and (2) older adults will exhibit more framing effects in the negative frame rather than the positive frame. The former hypothesis is supported by the documented decline in cognitive brainpower in adults as they age (Reed and Carstensen, 2012) and the consequent increased reliance on affective heuristic processing. As a result, the shift of reliance more on emotions rather than logic would enhance the framing effect in the context of healthcare decisions. The latter hypothesis is supported by the interplay between the dual-process theory and SST with its associated positivity effect, which states older individuals tend to attend more to positive information than negative information to efficiently utilize their diminished cognitive resources more effectively (Reed and Carstensen, 2012).

Methods

Participants. Participants for the framing study were recruited from various locations across the United States via an online survey and distributed via Amazon Mechanical Turk (MTurk). Attention check questions were strategically placed within the survey to ensure data validity, and those who did not pass the checks were excluded from the analysis. An instructional manipulation check (IMC) question was used as the attention check to determine the attentiveness of participants to the survey (Oppenheimer et al., 2009). More specifically, a separate health-decision scenario similar to the three framing scenarios was created and a cue to select a specific correct answer was hidden within the question (see the Questionnaire Printout in the Supplemental Information document). Kung et al. (2018) have shown that IMC questions do not have a marked effect on scale validity. Out of the 850 participants that initially responded to the survey, 153 failed the attention check and were therefore excluded from the data analysis. In order to filter out possible bots filling out the survey, participants had to fill out information for their age twice: once in the form of a manually typed input and another in the form of a multiple-choice question. Responses with mismatched ages were removed, although there was only one such case.

Materials. Participants were recruited using Amazon's Mechanical Turk (MTurk) program, a recruitment tool that provides high-value data with greater participant diversity compared to university samples and standard Internet samples (Buhrmester et al., 2011). Participants were given a monetary incentive for completing a questionnaire designed using the Qualtrics XM software to assess how adults respond to attribute framing, goal framing, and risky-choice framing. Each type of framing was represented by a specific health-decision scenario, and each scenario contained a uniquely coded Likert-type item from 1 to 6 (Table 1). For all scenarios, two frame valences were presented: a

Table 1 The three main survey questions, organized by the positive and negative frame.

	Attribute framing (Q1: Drug efficacy)	Goal framing (Q2: Cancer risk)	Risky-choice framing (Q3: Asian disease variant)
Positive frame	100 ill patients were assigned to a treatment; 70 patients felt better. How would you evaluate the effectiveness of the drug?	A doctor tells you that even though you really like to drink hot cocoa, if you stop drinking, your body's cadmium level will be significantly reduced, and thus the risk of cancer associated with high levels of cadmium would be greatly decreased.	There are 600 citizens of a small town, and a viral disease is spreading that kills all those who are infected. Two programs are being considered. If program A is adopted, 200 citizens will be saved; if program B is adopted, there is a 1/3 chance that all the citizens will be saved and a 2/3 chance that none will be saved.
Negative frame	100 ill patients were assigned to a treatment; 30 patients did not feel better. How would you evaluate the effectiveness of the drug?	A doctor tells you that even though you really like to drink hot cocoa, if you continue to drink, your body's cadmium level will significantly rise, and thus the risk of cancer associated with high levels of cadmium would be greatly increased.	There are 600 citizens of a small town, and a viral disease is spreading that kills all those who are infected. Two programs are being considered. If Program A is adopted, 400 citizens will die; if Program B is adopted, there is a 1/3 chance that no citizens die and a 2/3 chance that all will die.
Scale	1 = "Very Bad" 6 = "Very Good"	1 = "Surely Stop Drinking" 6 = "Surely Continue Drinking"	1 = "Surely Choose A" 6 = "Surely Choose B"

positive frame and a negative frame, with the only difference being the wording of the scenario. The attribute framing scenario used in this study was a modified version of the ground beef scenario in Levin et al. (1985). The goal-framing scenario was adapted from Meyerowitz and Chaiken's (1987) Breast Self-Exam scenario. Lastly, the risky-choice framing scenario was a variation of Tversky and Kahneman's (1981) Asian Disease Problem.

Procedure. Participants were informed that they would be taking part in a research study "involving rating 4–5 scenarios from a scale of 1 to 6". The discrepancy in the number of scenarios was accounted for by the inclusion of an IMC attention check. The order in which participants encountered the scenarios was as follows: attribute, goal, attention check, and risky-choice framing scenarios. Each scenario was rated on a 6-point continuous scale, with unique markers at the ends of the scales (Table 1 and Supplemental Fig. S7).

To ensure randomness, participants were randomly assigned either the positive or negative frame for each question independently. In other words, each participant could have encountered all three positive frames, no positive frames at all, or a combination of positive and negative framed questions. Following the framing scenarios and the attention check, participants were asked for demographic information.

Data analysis. All data analysis was conducted using R and related packages. For each framing scenario, the data on the participants' ages, assigned frame valence, and their rating of the scenario on the 6-point scale (participants' attitudes) were utilized in the analysis.

To assess the moderating effects of age on the susceptibility to the framing effect, the Johnson-Neyman technique was employed. This statistical technique can be applied in situations where the measurements of a dependent (outcome) variable, $\hat{Y}$, and two independent (predictor) variables, X, are available for two groups of data. This technique will yield a set of values in which we would reject the null hypothesis that the two groups' expected X values are the same. We can then plot them onto a Johnson-Neyman plot to visualize the 95% confidence intervals on each group of data and the exact value at which the two expected X values differ (Kowalski et al., 1994). In other words, this technique helps determine the specific values of a moderating variable, M, (the one that influences an interaction) at which the difference between the dependent variables of two groups of predictor variables becomes statistically significant. In this study, the moderator was the participants' age, the two predictor variables were the frame valence, and the dependent variable was the participants' ratings of the scenario on a 6-point scale (Fraas and Newman, 1997; Lin, 2020). The Johnson-Neyman technique will be used to obtain an age at which we would reject the null hypothesis that the two frame valences have the same expected rating value at a significance of $\alpha = 0.05$. The general prediction equation for the Johnson-Neyman technique is as follows:

$$\hat{Y} = \beta_0 + \beta_1 X + \beta_2 M + \beta_3 X{*}M$$

and the specific equation for the model used in this study is:

$$\text{Response} = \beta_0 + \beta_1{*}(\text{Frame Valence}) + \beta_2{*}(\text{Age}) + \beta_3{*}(\text{Frame Valence}{*}\text{Age}).$$

To test if the age of the participants moderated the effect of the frame valence on the participants' attitude (on a 6-point scale) for a specific framing scenario, a multiple linear regression model was fit for each scenario with the dependent variable bringing the participants' response and the two independent variables being the frame valence (dummy-coded: 0 = negative frame, 1 = positive frame) and the age of the participants with a third variable representing the interaction between the frame valence and age, labeled (Frame Valence)*(Age). In addition, political affiliation, gender, ethnicity, and education level were included in the regression model as control variables. If there was sufficient evidence of an interaction effect, the Johnson-Neyman statistical technique was applied to determine the ages at which the effect of the frame valence on participants' ratings of the scenario became significant (Carden et al., 2017; Johnson and Neyman, 1936). In other words, the application of the Johnson-Neyman method in this study aimed to identify the specific age when the difference between the rating of the two frame valences became significant.

To visualize and estimate the effect of frame valence on the ratings of the scenario as age progresses, regression lines and 95% confidence intervals of this difference were plotted on a Johnson-Neyman plot. This plot helps identify regions of significance and provides insights into how the effect of frame valence changes with age. However, to investigate the framing effect on a Johnson-Neyman plot, the difference between the two frames' regression lines must be standardized to be zero at the youngest age investigated,

which, in this study, was 18 years. As a result, any differences between the frame valences can be attributed solely to age.

Results

The three scenarios measured differing attitudes towards each type of framing. As a result, statistical analyses were performed on each scenario individually. Table 2 shows the demographic breakdown of each frame valence of each scenario and chi-square tests for homogeneity. The chi-square tests showed that the distribution of demographics was the same across all groups, thus all results can be attributed to the frame valence only and not a variation in the demographics in each group. To test for the existence of the traditional framing effect, the means of the participants' attitudes in each frame valence were compared. The sample of adults was found to demonstrate framing effects in terms of their differing attitudes toward all three scenarios. Specifically, the frame valence was a significant predictor of participant's attitudes in attribute framing [$R^2 = 0.173$, $F(1,692) = 139.67$, $p < 0.001$], goal framing [$R^2 = 0.047$, $F(1,692) = 27.78$, $p < 0.001$], and risky-choice framing [$R^2 = 0.058$, $F(1,691) = 36.51$, $p < 0.001$]. This confirmed that the traditional framing effect was present and allowed further analysis.

The multiple linear regression model with sociodemographic controls was fitted (Table 3). The regression coefficient for the interaction variable, (Frame Valence)*(Age), showed some evidence that the difference between the slopes of the positive frame and the negative frame was significant in attribute framing [$B = 0.008$, SE = 0.005, $t(692) = 1.71$, $p = 0.087$], goal framing [$B = 0.013$, SE = 0.008, $t(692) = 1.60$, $p = 0.111$], and risky-choice framing [$B = -0.019$, SE = 0.009, $t(691) = -2.15$, $p = 0.032$]. Therefore, the difference of attitudes between the two frames was not constant across the range of ages and age can be regarded as a moderator in the effect of the frame valence on the participants' attitudes towards the scenarios.

The regression coefficient for the age variable revealed that there was a statistically significant relationship between the age of the participants and their attitudes toward the scenarios (Table 3). The regression coefficients in both the attribute [$B = -0.006$, SE = 0.003, $t(692) = -1.806$, $p = 0.071$] and goal [$B = -0.013$, SE = 0.006, $t(692) = -2.29$, $p = 0.022$] framing scenarios were negative. Older adults tended to rate the drug's efficacy lower on the scale ("Very Bad") in attribute framing and older adults were more likely to stop drinking hot cocoa in goal framing while controlling for the frame valence. In contrast, the regression coefficient in the risky-choice framing scenario was positive [$B = 0.017$, SE = 0.006, $t(691) = 2.69$, $p = 0.007$], indicating that adults tended to gravitate towards the risky option as age increased, no matter the frame valence assigned.

Post-hoc simple slope tests were conducted to determine the effect of age on participants' attitudes towards each scenario's frame valence individually. In attribute framing, as people age, there existed a significant trend towards increased susceptibility to the framing effect in the negative frame [$R^2 = 0.010$, $B = -0.006$, SE = 0.003, $t(365) = -1.90$, $p = 0.059$] but not in the positive frame [$R^2 = 0.001$, $B = 0.001$, SE = 0.003, $t(327) = 0.42$, $p = 0.667$]. This trend was similar in the other two scenarios, where there was an increased susceptibility in the negative frame in both goal framing [$R^2 = 0.023$, $B = -0.013$, SE = 0.005, $t(336) = -2.81$, $p = 0.005$] and risky-choice framing [$R^2 = 0.014$, $B = 0.014$, SE = 0.006, $t(344) = 2.19$, $p = 0.029$] and not in the positive frames [goal framing: $R^2 = < 0.0001$, $B = 0.000$, SE = 0.006, $t(356) = 0.05$, $p = 0.959$; risky-choice framing: $R^2 = 0.001$, $B = -0.004$, SE = 0.006, $t(347) = -0.66$, $p = 0.509$]. Thus, we can conclude that an advanced age will enhance the effect of negative, but not positive frames on participants' attitudes.

The Johnson-Neyman technique was conducted to investigate the moderating effects of age on the differences between the participants' attitudes toward the two frame valences, which translated into the magnitude of the framing effect (Fig. 1). The effect of the frame valence on participants attitudes became significant at an alpha level of 0.05 at an age of 34.04, 33.70, and 32.50 years for attribute, goal, and risky-choice framing, respectively, and continued to be increasing in significance as age increased.

Discussion

The current work represents the first study to examine the role of age as a moderator for the framing effect in three types of framing: attribute, goal, and risky-choice framing, with a single large cohort of participants. In addition, it represents one of the first studies to investigate age as a continuous and not grouped variable (such as grouping participants into younger and older groups) and is the first study to employ the Johnson-Neyman statistical method to examine the framing effect. The two hypotheses proposed that an increased age would lead to an increased susceptibility to the framing effect and an increased susceptibility to the framing effect when presented with the negative (versus positive) frame. These hypotheses were supported in that the difference between the adults' ratings of the scenarios increased as age increased, and that only negatively (versus positively) framed messages were rated at more extreme ratings as age progressed. The Johnson-Neyman analysis revealed a trend towards an increased susceptibility to the framing effect as the age of participants increased for all three types of framing. More specifically, the slopes of the two regression lines representing the two frame valences diverged as age progressed. This translated into a greater difference between the attitudes in older adults, leading to a greater framing effect. This result suggests that older adults may have an underlying cognitive factor that plays a role in processing information. In addition, simple slope analyses revealed that only the slope of the negative frame was significant when regressed with age, indicating that there existed an increasing framing effect as age increased in the negative frame but not the positive frame for all three types of framing.

A possible explanation for some of these findings deals with the socioemotional selectivity theory (SST), which suggests that motivational priorities change over one's life in the way that older adults prioritize goals that will lead to positive emotions in the present and not toward the future that younger adults tend to prioritize (Carstensen, 2006). More specifically, the interplay between SST and the dual-process theory may explain why older (vs. younger) adults were more susceptible to the negative frame only and not the positive frame. Based on the positivity bias associated with SST, we expect older adults to prioritize maximizing positivity in the present, resulting in a heightened response to positive stimuli and thus the positive frame (Mather et al., 2004). However, based on the dual-process theory, this heightened response would result in the slower, more rational deliberative system being employed only for the positive frame. It follows that the negative frame, which does not exhibit a heightened response in older adults, would encourage the use of the other rapid, frame-sensitive system of the dual-process theory to be employed when processing negative frames (Loewenstein et al., 2015; Roberts et al., 2022). The increased reliance on the affective system as a result of the lack of willpower exhibited in the negative frame would result in an increased framing effect in the negative frame (Guo et al., 2017). Therefore, it's reasonable to assume that SST and the dual-process theory play an inherent and important role in promoting a greater susceptibility to the

Table 2 Demographic information sorted by frame type and frame valence.

Demographic	Attribute Framing				Goal Framing				Risky Choice Framing				Total		Chi-Squared Tests of Homogeneity
	Positive Frame		Negative Frame		Positive Frame		Negative Frame		Positive Frame		Negative Frame				
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	
Age - Classes (10-year)															
≤ 19 years	4	1.22	4	1.22	4	1.22	4	1.22	6	1.82	2	0.61	8	1.15	χ^2 (30) = 12.22
20-29 years	61	18.54	81	24.62	70	21.28	72	21.88	81	24.62	61	18.54	142	20.40	p = 1.00
30-39 years	120	36.47	131	39.82	130	39.51	121	36.78	124	37.69	127	38.60	251	36.06	Cramer's V = 0.03
40-49 years	67	20.36	62	18.84	67	20.36	62	18.84	64	19.45	65	19.76	129	18.53	n = 696
50-59 years	48	14.59	53	16.11	56	17.02	45	13.68	45	13.68	56	17.02	101	14.51	
60-69 years	29	8.81	34	10.33	30	9.12	33	10.03	28	8.51	35	10.64	63	9.05	
70+ years	0	0.00	2	0.61	1	0.30	1	0.30	1	0.30	1	0.30	2	0.29	
Political Affiliation															
Democrat	145	44.07	167	45.50	161	44.97	151	44.67	172	49.28	140	40.11	312	44.83	χ^2 (20) = 12.16
Republican	86	26.14	77	20.98	85	23.74	78	23.08	80	22.92	83	23.78	163	23.42	p = 0.91
Independent	83	25.23	105	28.61	96	26.82	92	27.22	79	22.64	109	31.23	188	27.01	Cramer's V = 0.04
Something else	11	3.34	15	4.09	12	3.35	14	4.14	14	4.01	12	3.44	26	3.74	n = 696
Prefer not to say	4	1.22	3	0.82	4	1.12	3	0.89	4	1.15	3	0.86	7	1.01	
Gender															
Female	192	58.36	206	56.13	205	57.26	193	57.10	193	55.30	205	58.74	398	57.18	χ^2 (15) = 6.72
Male	133	40.43	152	41.42	145	40.50	140	41.42	149	42.69	136	38.97	285	40.95	p = 0.96
Non-binary	2	0.61	8	2.18	7	1.96	3	0.89	5	1.43	5	1.43	10	1.44	Cramer's V = 0.03
Prefer not to say	2	0.61	1	0.27	1	0.28	2	0.59	2	0.57	1	0.29	3	0.43	n = 696
Ethnicity															
White	263	79.94	291	79.29	282	78.77	272	80.47	281	80.52	273	78.22	554	79.60	χ^2 (30) = 6.65
Asian	26	7.90	33	8.99	34	9.50	25	7.40	30	8.60	29	8.31	59	8.48	p = 1.00
Black	26	7.90	27	7.36	26	7.26	27	7.99	23	6.59	30	8.60	53	7.61	Cramer's V = 0.03
American Indian	3	0.91	2	0.54	3	0.84	2	0.59	3	0.86	2	0.57	5	0.72	n = 696
Pacific Islander	1	0.30	1	0.27	2	0.56	0	0.00	1	0.29	1	0.29	2	0.29	
Other	8	2.43	12	3.27	10	2.79	10	2.96	10	2.87	10	2.87	20	2.87	
Prefer not to say	2	0.61	1	0.27	1	0.28	2	0.59	1	0.29	2	0.57	3	0.43	
Education															
Less Than High School	0	0.00	2	0.54	1	0.28	1	0.30	1	0.29	1	0.29	2	0.29	χ^2 (30) = 33.15
High School Graduate	21	6.38	43	11.72	35	9.78	29	8.58	27	7.74	37	10.60	64	9.20	p = 0.32
Some College	62	18.84	61	16.62	65	18.16	58	17.16	57	16.33	66	18.91	123	17.67	Cramer's V = 0.06
2 Year Degree	32	9.73	40	10.90	22	6.15	50	14.79	37	10.60	35	10.03	72	10.34	n = 696
4 Year Degree	140	42.55	152	41.42	164	45.81	128	37.87	148	42.41	144	41.26	292	41.95	
Professional Degree	71	21.58	61	16.62	65	18.16	67	19.82	71	20.34	61	17.48	132	18.97	
Doctorate	3	0.91	8	2.18	6	1.68	5	1.48	8	2.29	3	0.86	11	1.58	
All	329	100	367	100	358	100	338	100	349	100	347	100	696	100	

Note: Chi-square tests of homogeneity were run with six groups, two frame valences for each of the three framing types.

Table 3 Regression results for the three types of framing with sociodemographic control variables.

	Attribute framing				Goal framing				Risky-choice framing			
Variable	***B***	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***	***B***	**SE**	***t***	***p***
Frame valence	0.343	0.193	1.776	0.076†	−0.025	0.336	−0.076	0.940	0.193	0.385	0.503	0.615
Age	−0.006	0.003	−1.806	0.071†	−0.013	0.006	−2.293	0.022*	0.017	0.006	2.692	0.007**
(Frame valence)*(Age)	0.008	0.005	1.712	0.087†	0.013	0.008	1.595	0.111	−0.019	0.009	−2.153	0.032*
Political affiliation												
Republican	−0.087	0.073	−1.196	0.232	−0.007	0.127	−0.057	0.955	0.174	0.145	1.196	0.232
Independent	0.034	0.068	0.496	0.620	−0.060	0.119	−0.506	0.613	0.469	0.137	3.435	0.001***
Something else	−0.160	0.151	−1.063	0.288	0.403	0.264	1.527	0.127	0.065	0.301	0.216	0.829
Prefer not to say	−0.229	0.310	−0.737	0.461	−0.721	0.542	−1.330	0.184	0.199	0.618	0.322	0.748
Gender												
Male	0.000	0.057	0.001	0.999	0.047	0.100	0.475	0.635	0.128	0.114	1.120	0.263
Non-binary	0.115	0.235	0.490	0.625	0.108	0.411	0.263	0.792	−0.100	0.467	−0.214	0.831
Prefer not to answer	0.544	0.486	1.119	0.264	1.130	0.851	1.328	0.185	0.271	0.970	0.280	0.780
Ethnicity												
Asian	−0.056	0.102	−0.553	0.580	−0.023	0.178	−0.128	0.898	0.206	0.203	1.015	0.310
Black	0.190	0.107	1.780	0.075†	−0.151	0.187	−0.807	0.420	0.315	0.213	1.480	0.139
American Indian	−0.820	0.327	−2.505	0.013*	−0.328	0.572	−0.573	0.567	−0.715	0.652	−1.097	0.273
Pacific Islander	0.292	0.514	0.569	0.570	0.914	0.898	1.017	0.309	0.183	1.023	0.179	0.858
Other	−0.183	0.168	−1.090	0.276	−0.083	0.293	−0.284	0.777	−0.073	0.334	−0.219	0.827
Prefer not to say	−0.104	0.447	−0.232	0.817	−1.026	0.782	−1.312	0.190	−0.389	0.891	−0.437	0.662
Education												
Less than high school	−0.569	0.519	−1.096	0.273	0.202	0.904	0.223	0.823	−0.707	1.031	−0.686	0.493
High school graduate	−0.134	0.101	−1.322	0.187	−0.274	0.177	−1.551	0.121	−0.120	0.201	−0.594	0.552
Some college	−0.002	0.079	−0.020	0.984	−0.071	0.139	−0.509	0.611	−0.016	0.159	−0.103	0.918
2-year degree	0.062	0.097	0.635	0.526	−0.215	0.172	−1.253	0.211	−0.307	0.194	−1.584	0.114
Professional degree	−0.140	0.077	−1.821	0.069†	−0.169	0.135	−1.252	0.211	−0.261	0.153	−1.701	0.089†
Doctorate	0.225	0.223	1.005	0.315	0.115	0.390	0.294	0.769	−0.136	0.445	−0.307	0.759
Constant	4.108	0.140	29.338	<0.001***	2.638	0.252	10.466	<0.001***	2.674	0.294	9.111	<0.001***

Attribute framing: $F(22,673) = 7.84^{***}$, $R^2 = 0.204$, Residual $SS = 351.60$.
Goal framing: $F(22,673) = 2.211^{**}$, $R^2 = 0.067$, Residual $SS = 1073.55$.
Risky-choice framing: $F(22,672) = 3.01^{***}$, $R^2 = 0.090$, Residual $SS = 1393.46$.
Note: Categorical variables were dummy-coded and the factor with the largest size was chosen to be the reference (Democrat, Female, White, 4-year degree).
$^{\dagger}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$ $^{***}p < 0.001$.

negative frame and not affecting the susceptibility to the positive frame as age increases.

However, current work on affective heuristic processing and the resource allocation hypothesis (Hess et al., 2001) could offer an alternative explanation. As a result of the high emotional arousal framing tasks (Pu et al., 2017), participants may be more susceptible to affective heuristic processing, clouding their rational judgment and resulting in a framing effect. More specifically, positive frames may appear more attractive, and negative frames may appear more unattractive. Previous studies have shown that as individuals age, they may show an increasing reliance on affective heuristical processing to make up for their declining cognitive brainpower (Besedeš et al., 2012; Hess et al., 2001). This increased reliance on heuristics and simplification of information would lead to a larger framing effect (McElroy and Seta, 2003; Reyna and Brainerd, 1991), which is confirmed in the study for all three scenarios. However, it would also require older adults to be more susceptible to both frame valences than younger adults. Older adults were more susceptible only to the negative frame and not to the positive frame, therefore affective heuristical processing would not be a complete explanation for the results of this study. We cannot, however, discount affect heuristics as a potential facet of the relationship between age and the framing effect. Therefore, we propose that SST may be involved as a factor for the predisposition of older adults to affect heuristics in the context of framing, but more research is required to explore this connection.

Yet another explanation lies in the lifespan developmental perspective, where the goals of an individual are found to shift from growth and exploration to loss prevention and maintenance as they age (Ebner et al., 2006). Younger adults have not acquired enough resources to warrant its protection, while older adults shift this mindset towards protecting their acquired resources as they near the end of their lifespan. Extrapolating this idea to the framing effect, older (vs. younger) adults may preferentially choose a more extreme response to negative frames due to their goal of loss prevention. For example, it was found that older (vs. younger) adults would rate drugs as being less effective when presented with the negative frame in attribute framing. This can be applied to the two other framing types with the same reasoning. The lack of a difference in framing effects of younger vs. older adults in the positive frame can also be explained via this perspective. While older adults shift towards maintenance as they age, positive frames still encourage maintenance while also appealing to the growth aspect that younger adults prefer. Thus, it would make sense that there would be no significant age-related differences in the framing effect of positive frames.

The present study added findings into the field that were both congruent and incongruent with previous studies. The only previous study to assess the role of age in attribute framing, Sparks and Ledgerwood (2018), report a trend towards an increased susceptibility to both the positive and negative frames as adults age. This finding is incongruent with the current study, where there was an increase in susceptibility to the negative frame, but not to the positive frame in attribute framing. One possible explanation is that Sparks and Ledgerwood (2018) combined multiple cohorts of participants previously used in separate studies, each with differing contexts for scenarios. By combining results from these studies, they may have inadvertently introduced variables they did not account for, such as how the differing framing tasks may affect participants in differing ways.

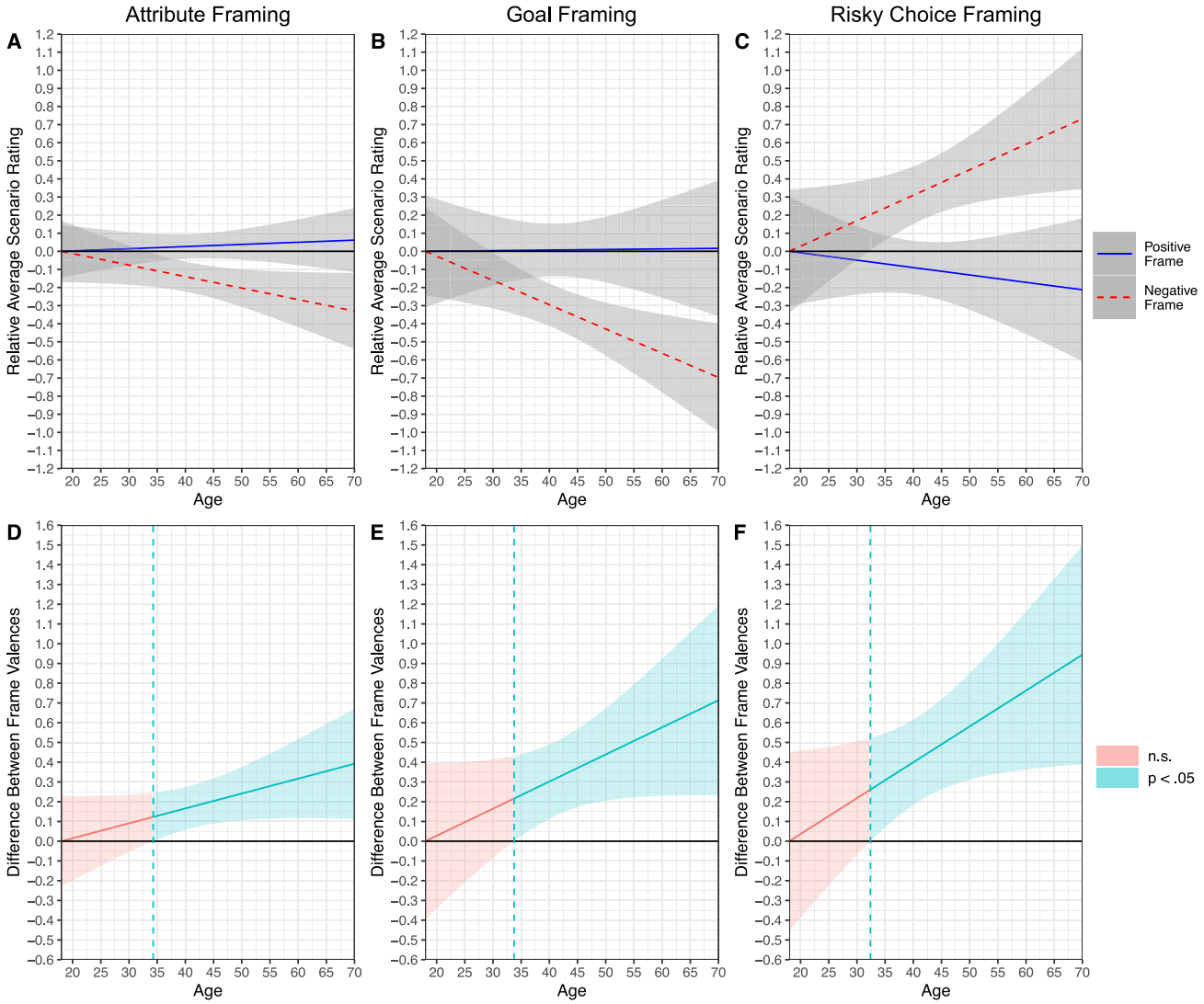

Fig. 1 Participants' attitudes toward the scenarios graphed against age and Johnson-Neyman plots. A–C represent participants' attitudes in both the positive and negative frame valence towards attribute, goal, and risky-choice framing, respectively, graphed against age. The rating was standardized to start at zero for both frame valences at the minimum age of 18, thus any variation in advanced ages would be relative to this zero-starting point. **D–F** represent Johnson-Neyman plots for attribute, goal, and risky-choice framing, respectively, graphed against age. The dashed line represents the age at which the absolute value of the difference between the frame valences is statistically significant at an alpha value of 0.05. The specific cutoff values are 34.04, 33.70, and 32.50 years for attribute, goal, and risky-choice framing, respectively. All confidence intervals are 95% CI. n.s. No significance.

This study found similar findings with goal framing, which adds to Masumoto et al. (2020), the only previous study examining the effect of aging on goal framing. They showed that older participants tended to remember the positive frame better than younger participants, and younger adults more accurately than older adults in the negative frame. The findings of the current study loosely translate and confirm that memory may play a role in goal framing, but future work is required to confirm this phenomenon in both goal framing and the other types of framing.

In terms of risky-choice framing, the study found that adults tended to pick the riskier option as their age increased in the negative frame, which suggests that adults may be less risk-averse as age increases when presented with a negative framing. This finding disagreed with Pachur et al. (2017), who found the opposite: older adults chose the riskier option in the gain frame and younger adults in the loss frame, and studies in which no age difference in risky decision-making was found in the negative frame (Best and Charness, 2015; Mata et al., 2011). The current study examined the risky-choice framing effect through the lens of a life-saving scenario, which would result in high emotional arousal in the negative frame (Pu et al., 2017; Stremitzer et al., 2012), prompting older adults to choose the riskier option via previously discussed theories of how SST, the dual-process theory, affect heuristics, and the lifespan developmental perspective may be involved in the framing effect. This finding is congruent with some previous studies (Kim et al., 2005; Pu et al., 2017), while others observe the complete opposite effect (Watanabe and Shibutani, 2010). Some of these discrepancies may be a result of small sample sizes or different task arenas used in those studies that may elicit differing responses.

Limitations and future work. This study sought to examine the developmental effects of framing using cross-sectional data. This, however, assumes that the participants accurately reflect the average population as they age, and it assumes that participants grew up in very similar conditions and experienced similar life experiences during their development (the cohort effect). Lansford et al. (1998) conducted a longitudinal study for a period of

four decades and found evidence that supported the SST. With the potential reliance of the current study's findings on SST, we predict that a longitudinal study would mirror the results presented. However, it would be worthwhile conducting a comprehensive longitudinal study that mirrors the current to confirm or find new results and eliminate the influence of potential external variables.

Age was a variable chosen to represent the progression of human development on an individual's susceptibility to the three types of framing; however, it may not represent the full picture in terms of human development. Different individuals may be at differing stages in their life independent of age, especially in individuals with accelerated aging (as in the early stages of disease), which would affect their perception drastically. More specifically, the changes in an individual's goals or choices due to SST are not a direct result of age alone, but rather their perception of how much time they have left in their life (Carstensen, 2006). Future studies could examine the relation between participants' perceived time left in life and their framing effect for a more direct focus on SST's relation to framing.

Moreover, other cognitive processes that change with age may be examined to determine their individual influences on a person's susceptibility to the framing effect. For example, Perez et al. (2018) found that some cognitive abilities, such as delayed memory, were significant predictors of the susceptibility to the framing effect in risky-choice framing. Although many differences in cognitive factors can be attributed to age external factors can also be at play, future studies could examine variables related to cognitive ability along with age to better predict the framing effect.

Finally, we must consider the context-dependency of the framing effect. Studies have shown that the framing effect is dependent on the context of the framing scenario, such as if it was presented in a financial or mortality context (see the meta-analysis by Best and Charness, 2015). We only considered scenarios in the healthcare/mortality sense, so our results may not be generalizable to other contexts of framing. Future studies could examine other contexts and compare the results found in this study to examine context-dependent effects of attribute, goal, and risky-choice framing across an age span.

Conclusion

This study presents novel data on the effects of age on attribute, goal, and risky-choice framing, utilizing a large cohort of participants examined across the continuous age scale for all three types of framing. Unlike previous studies with mixed results and a focus on only one type of framing, the current research provides robust conclusions applicable across different framing scenarios due to the use of a single participant cohort.

The results indicate that the framing effect becomes more prominent as age increases, leading to increased susceptibility to the negative frame, but not the positive frame, in each framing scenario. This finding may be attributed, at least in part, to the association between aging and both the SST and dual-process model, along with the potential influence of affect heuristics clouding the judgment of older adults. The current findings suggest that SST could be an underlying factor contributing to older adults' predisposition to affect heuristics within the context of the framing effect.

This study opens avenues for future research to explore additional potential moderators of the framing effect and to gain a deeper understanding of the interconnectedness between SST, dual-model theory, and affect heuristics in the framing effect. It also offers the potential to uncover other explanations for the observed phenomena. Given the aging population, it is crucial for researchers to comprehend the disparities in how younger and older adults perceive and process information. Understanding these differences can aid in presenting essential information in the most optimal form to alleviate the impact of framing and other cognitive biases that may arise, particularly in healthcare contexts, among older populations.

Data availability

The datasets and R code needed to replicate the analyses in the study are available in the Open Science Framework repository: https://osf.io/z5s7h/.

Received: 20 September 2023; Accepted: 10 January 2024;
Published online: 06 February 2024

References

Banks SM, Salovey P, Greener S, Rothman AJ, Moyer A, Beauvais J, Epel E (1995) The effects of message framing on mammography utilization. Health Psychol 14(2):178–184. https://doi.org/10.1037/0278-6133.14.2.178

Besedeš T, Deck C, Sarangi S, Shor M (2012) Decision-making strategies and performance among seniors. J Econ Behav Organ 81(2). https://doi.org/10.1016/j.jebo.2011.07.016

Best R, Charness N (2015). Age differences in the effect of framing on risky choice: a meta-analysis. Psychol Aging, 30(3). https://doi.org/10.1037/a0039447

Buhrmester M, Kwang T, Gosling SD (2011) Amazon's mechanical Turk: a new source of inexpensive, yet high-quality, data? Perspect Psychol Sci 6(1). https://doi.org/10.1177/1745691610393980

Carden SW, Holtzman NS, Strube MJ (2017) CAHOST: an Excel workbook for facilitating the Johnson-Neyman technique for two-way interactions in multiple regression. Front Psychol 8(7). https://doi.org/10.3389/fpsyg.2017.01293

Carstensen LL (2006) The influence of a sense of time on human development. Science 312(5782):1913–1915. https://doi.org/10.1126/science.1127488

Carstensen LL, DeLiema M (2018). The positivity effect: a negativity bias in youth fades with age. Curr Opin Behav Sci 19. https://doi.org/10.1016/j.cobeha.2017.07.009

Carstensen LL, Pasupathi M, Mayr U, Nesselroade JR (2000) Emotional experience in everyday life across the adult life span. J Personal Soc Psychol 79(4):644–655. https://doi.org/10.1037/0022-3514.79.4.644

Ebner NC, Freund AM, Baltes PB (2006) Developmental changes in personal goal orientation from young to late adulthood: from striving for gains to maintenance and prevention of losses. Psychol Aging 21(4):664–678. https://doi.org/10.1037/0882-7974.21.4.664

Fraas J, Newman I (1997) Use of the Johnson-Neyman confidence bands and multiple regression models to investigate interaction effects: important tools for educational researchers. Annual Meeting of the Eastern Educational Research Association, 24. https://files.eric.ed.gov/fulltext/ED411256.pdf

Guo L, Trueblood JS, Diederich A (2017) Thinking fast increases framing effects in risky decision making. Psychological Sci 28(4):530–543. https://doi.org/10.1177/0956797616689092

Hess TM, Rosenberg DC, Waters SJ (2001) Motivation and representational processes in adulthood: the effects of social accountability and information relevance. Psychol Aging 16(4). https://doi.org/10.1037/0882-7974.16.4.629

Johnson PO, Neyman J (1936) Tests of certain linear hypotheses and their application to some educational problems. Statistical Research Memoirs 1:57–93

Kahneman D, Tversky A (1979) Prospect theory: an analysis of decision under risk. Econometrica 47(2):263. https://doi.org/10.2307/1914185

Khizar B, Harwood RH (2017) Making difficult decisions with older patients on medical wards. Clin Med 17(4):353–356. https://doi.org/10.7861/clinmedicine.17-4-353

Kim S, Goldstein D, Hasher L, Zacks RT (2005) Framing effects in younger and older adults. J Gerontol Ser B Psychol Sci Soc Sci 60(4):P215–P218. https://doi.org/10.1093/geronb/60.4.P215

Kowalski CJ, Schneiderman ED, Willis SM (1994) ANCOVA for nonparallel slopes: the Johnson-Neyman technique. Int J Bio-Med Comput 37(3). https://doi.org/10.1016/0020-7101(94)90125-2

Kung FYH, Kwok N, Brown DJ (2018) Are attention check questions a threat to scale validity? Appl Psychol 67(2). https://doi.org/10.1111/apps.12108

Kupis L, Goodman ZT, Kornfeld S, Hoang S, Romero C, Dirks B, Dehoney J, Chang C, Spreng RN, Nomi JS, Uddin LQ (2021) Brain Dynamics underlying cognitive flexibility across the lifespan. Cereb Cortex 31(11):5263–5274. https://doi.org/10.1093/cercor/bhab156

Lansford JE, Sherman AM, Antonucci TC (1998) Satisfaction with social networks: An examination of socioemotional selectivity theory across cohorts. Psychology and Aging 13(4):544–552. https://doi.org/10.1037/0882-7974.13.4.544

Levin IP, Gaeth GJ (1988) How consumers are affected by the framing of attribute information before and after consuming the product. J Consum Res 15(3):374. https://doi.org/10.1086/209174
Levin IP, Johnson RD, Russo CP, Deldin PJ (1985) Framing effects in judgment tasks with varying amounts of information. Organ Behav Hum Decis Process 36(3):362–377. https://doi.org/10.1016/0749-5978(85)90005-6
Levin IP, Schneider SL, Gaeth GJ (1998) All frames are not created equal: a typology and critical analysis of framing effects. Organ Behav Hum Decis Process 76(2):149–188. https://doi.org/10.1006/obhd.1998.2804
Lin H (2020) Probing two-way moderation effects: a review of software to easily plot johnson-neyman figures. Struct Equation Model 27(3). https://doi.org/10.1080/10705511.2020.1732826
Loewenstein G, O'Donoghue T, Bhatia S (2015) Modeling the interplay between affect and deliberation. Decision, 2(2). https://doi.org/10.1037/dec0000029
Masumoto K, Shiozaki M, Taishi N (2020) The impact of age on goal-framing for health messages: the mediating effect of interest in health and emotion regulation. PLoS ONE 15(9):e0238989. https://doi.org/10.1371/journal.pone.0238989
Mata R, Josef AK, Samanez-Larkin GR, Hertwig R (2011) Age differences in risky choice: a meta-analysis. Ann N Y Acad Sci 1235(1):18–29. https://doi.org/10.1111/j.1749-6632.2011.06200.x
Mather M, Canli T, English T, Whitfield S, Wais P, Ochsner K, Gabrieli JDE, Carstensen LL (2004) Amygdala responses to emotionally valenced stimuli in older and younger adults. Psychol Sci 15(4). https://doi.org/10.1111/j.0956-7976.2004.00662.x
McElroy T, Dickinson DL, Levin IP (2020) Thinking about decisions: An integrative approach of person and task factors. J Behav Decis Mak 33(4):538–555. https://doi.org/10.1002/bdm.2175
McElroy T, Seta JJ (2003) Framing effects: an analytic-holistic perspective. J Exp Soc Psychol 39(6). https://doi.org/10.1016/S0022-1031(03)00036-2
Meyer BJF, Russo C, Talbot A (1995) Discourse comprehension and problem solving: Decisions about the treatment of breast cancer by women across the life span. Psychol Aging 10(1):84–103. https://doi.org/10.1037/0882-7974.10.1.84
Meyerowitz BE, Chaiken S (1987) The effect of message framing on breast self-examination attitudes, intentions, and behavior. J Personal Soc Psychol 52(3):500–510. https://doi.org/10.1037/0022-3514.52.3.500
Nabi RL, Walter N, Oshidary N, Endacott CG, Love-Nichols J, Lew ZJ, Aune A (2020) Can emotions capture the elusive gain-loss framing effect? a meta-analysis. Commun Res 47(8):1107–1130. https://doi.org/10.1177/0093650219861256
Oppenheimer DM, Meyvis T, Davidenko N (2009) Instructional manipulation checks: Detecting satisficing to increase statistical power. J Exp Soc Psychol 45(4). https://doi.org/10.1016/j.jesp.2009.03.009
Pachur T, Mata R, Hertwig R (2017). Who dares, who errs? Disentangling cognitive and motivational roots of age differences in decisions under risk. Psychol Sci 28(4). https://doi.org/10.1177/0956797616687729
Perez AM, Spence JS, Kiel LD, Venza EE, Chapman SB (2018) Influential cognitive processes on framing biases in aging. Front Psychol 9(MAY). https://doi.org/10.3389/fpsyg.2018.00661
Pu B, Peng H, Xia S (2017) Role of emotion and cognition on age differences in the framing effect. Int J Aging Hum Dev 85(3):305–325. https://doi.org/10.1177/0091415017691284
Reed AE, Carstensen LL (2012) The theory behind the age-related positivity effect. Front Psychol 3. https://doi.org/10.3389/fpsyg.2012.00339
Reed AE, Chan L, Mikels JA (2014) Meta-analysis of the age-related positivity effect: age differences in preferences for positive over negative information. Psychol Aging 29(1):1–15. https://doi.org/10.1037/a0035194
Reyna VF, Brainerd CJ (1991) Fuzzy-trace theory and framing effects in choice: gist extraction, truncation, and conversion. J Behav Decis Mak 4(4). https://doi.org/10.1002/bdm.3960040403
Roberts ID, Teoh YY, Hutcherson CA (2022) Time to pay attention? Information search explains amplified framing effects under time pressure. Psychol Sci 33(1):90–104. https://doi.org/10.1177/09567976211026983
Rönnlund M, Karlsson E, Laggnäs E, Larsson L, Lindström T (2005) Risky decision making across three arenas of choice: are younger and older adults differently susceptible to framing effects? J Gen Psychol 132(1):81–93. https://doi.org/10.3200/GENP.132.1.81-93
Russo JE, Medvec VH, Meloy MG (1996) The distortion of information during decisions. Organ Behav Hum Decis Process 66(1):102–110. https://doi.org/10.1006/obhd.1996.0041
Slovic P, Finucane M, Peters E, MacGregor DG (2002) The affect heuristic. In: Heuristics and Biases. Cambridge University Press. pp. 397–420
Sparks J, Ledgerwood A (2018) Age attenuates the negativity bias in reframing effects. Personal Soc Psychol Bull 45(7):1042–1056. https://doi.org/10.1177/0146167218804
Stremitzer A, Brooks RRW, Tontrup S (2012) Framing contracts: why loss framing increases effort. J Institut Theor Econ 168(1). https://doi.org/10.1628/093245612799440032
Tversky A, Kahneman D (1981) The framing of decisions and the psychology of choice. Science 211(4481):453–458. https://doi.org/10.1126/science.7455683
Watanabe S, Shibutani H (2010) Aging and decision making: Differences in susceptibility to the risky-choice framing effect between older and younger adults in Japan. Jpn Psychol Res 52(3):163–174. https://doi.org/10.1111/j.1468-5884.2010.00432.x
Wilson DK, Kaplan RM, Schneiderman LJ (1987) Framing of decisions and selections of alternatives in health care. Soc Behav 2(1):51–59

Acknowledgements

The author would like to thank Mark Hayden for his support and guidance through the early stages of this project, Dr. Wenxuan Huang for her guidance in proofreading and providing valuable suggestions in the later stages, and finally the author's friend who inspired the hot cocoa goal framing scenario used in this study. In addition, the author would like to thank everyone else who provided insightful comments on the manuscript, all of whom would prefer to remain anonymous.

Author contributions

The author held the sole responsibility for the entire study, including conceptualizing the study, designing the study, analyzing the data, writing the manuscript, and revising the manuscript.

Competing interests

The author declares no competing interests.

Ethical approval

This study was approved by the International Science and Engineering Fair Institutional Review Board (IRB). A copy of the IRB approval form can be provided upon request.

Informed consent

All participants were asked to read and agree to an informed consent statement with information about the study. This statement was the only required question in the questionnaire and participants could decline to respond to any of the following questions afterwards. Participation was completely voluntary.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1057/s41599-024-02658-6.

Correspondence and requests for materials should be addressed to Lance Xu.

Reprints and permission information is available at http://www.nature.com/reprints

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.