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EMPIRICAL ARTICLE

Apocalypse now or later? Nuclear war risk perceptions mirroring media coverage and emotional tone shifts in Italian news

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Abstract

This study delves into the progression of nuclear war risk perceptions during the initial 6 months of the Ukraine war. It particularly investigated the influence of Italian media coverage changes and the affective tone of war representation. Utilizing a mixed-methods approach, two separate yet interconnected studies were conducted. The first study employed web scraping and keyword selection techniques to assess emotional language and quantify war-related content in the headlines of Italian online newspapers from March to July 2022. Results demonstrated a linear decrease in war-related news and an emotional shift, with a significant decrease in fear and an increase in joy noted between March and May. The second study examined nuclear war risk perceptions at an individual level, surveying a panel of 397 Italians at three distinct points during the same time frame. The findings revealed a similarity between the media's affective tone and individuals' affective risk perceptions. Analytic risk perception, in contrast, showed a linear decrease that matched the decline in war-related news volume. The study found preexisting individual differences, among women and older participants, to be significant determinants in shaping risk perception evolution. These groups exhibited higher initial risk perceptions and more resistance to change as the scenario unfolded. This research contributes to the existing body of work that underscores the media's role in influencing risk perceptions by illuminating the relationship between media representation of the Ukraine war and individual-level affective risk perception. Furthermore, it highlights individual differences as significant moderators of risk perception change during a crisis.

1. Introduction

The specter of a nuclear war materialized on February 24, 2022, after the Russian army entered Ukrainian territory, and was amplified 3 days later when the Russian government had ordered its nuclear deterrence forces to be on high alert. For the first time since the Cuban Missile Crisis, the world was confronted with the looming prospect of a nuclear holocaust (Rendall, 2022; Ruff, 2022). European and American citizens experienced strong emotional reactions in the subsequent few weeks, such as anger, anxiety, and an escalating sense of fear (Moshagen and Hilbig, 2022). Anxiety, anger, and disgust were also reported by Italian citizens in the aftermath of the war (Cricenti et al., 2022).

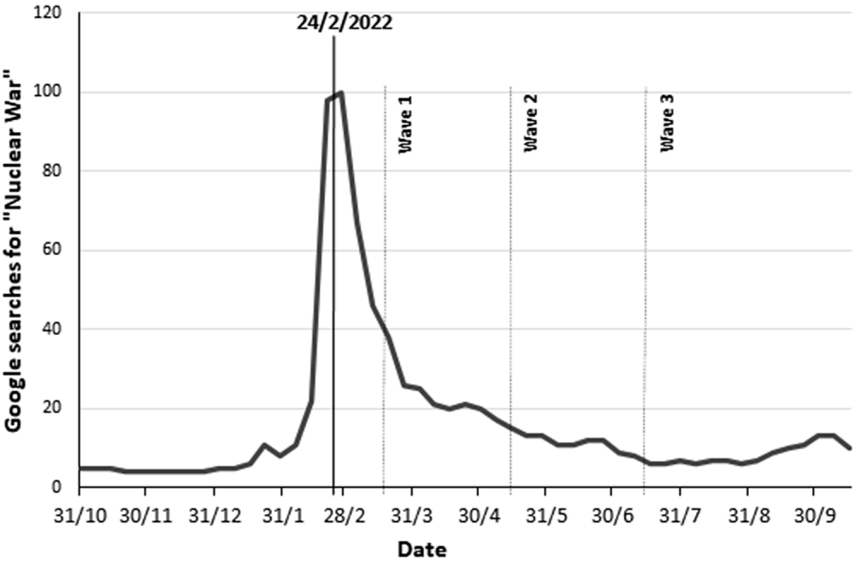

Figure 1. *Google search trend for 'nuclear war' in Italy from October 31, 2021, to October 31, 2022, highlighting key events such as the entry of Russian troops into Ukraine and the dates of our data collection campaigns.*

Global sentiment analyses of social media have further validated the intense negative feelings sparked by images or videos showing military operations and rows of displaced people leaving their homes (Garcia and Cunanan-Yabut, 2022; Vahdat-Nejad et al., 2023). One of these studies revealed that Italy had one of the highest ratios of negative to positive sentiments, suggesting a pessimistic view of the international crisis in the first month of the war (Vahdat-Nejad et al., 2023).

The chronology of official statements by Russia and Western governments regarding a nuclear escalation viewed the period between February and March as the highest level of activity in terms of nuclear threats and red lines being drawn (Arndt and Horovitz, 2022). However, the same chronology highlighted that the momentum behind these statements faded rapidly, with May showing a marked drop in intensity and July resulting in an ostensible loss of steam regarding the nuclear narratives. According to the Google Trend Index, which has proven useful in describing public interest in the context of the COVID-19 pandemic and Syrian crisis (Slovic et al., 2017; Sousa-Pinto et al., 2020), online searches for the term 'nuclear war' began to rise dramatically in Italy from February 6, peaking on February 24, then dropped by half around March 13, to one-fifth around April 17 (see Figure 1). In July, the index was at about the same precrisis levels. According to these sources, the sociopolitical context in which nuclear war risk perceptions were formed seemed to evolve. However, unlike the COVID-19 pandemic, where risk perception was extensively studied in relation to the fluctuating infection rates and deaths (e.g., Schneider et al., 2021; Siegrist and Bearth, 2021; Wise et al., 2020), nuclear war risk perception has not been investigated in the context of the diminishing public interest and evolving nuclear discourses.

1.1. Nuclear war risk perception

According to classic psychometric studies, all hazards can be mapped onto a bidimensional orthogonal space defined by knowledge and dreadfulness, emerging from the aggregation of several lower order risk dimensions (Fischhoff et al., 1978; Slovic, 1987). Having been developed in the 'cold war era', the two-factor model represented the danger of nuclear war as the most dreadful for humanity (Slovic et al., 1985). More recently, Fox-Glassman and Weber (2016) showed that the same two factors still accounted for the covariance of risk attributes. Even though nuclear war was not included among the hazards, nuclear energy was found to be among the most dreadful hazards in the study. Incidentally,

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some scholars have recently cautioned that even a relatively minor regional nuclear conflict could potentially result in a global climatic and nutritional crisis, posing a threat to the survival of a large portion of humanity (Ruff, 2022).

Evidence that evoked feelings of dread was the main predictor of the overall perceived risk (Fischhoff et al., 1978; Slovic, 1987), and the negative correlation between judgments of risk and benefit led scholars to place greater emphasis on the role of affective feelings. In particular, Slovic and colleagues (Finucane et al., 2000a; Slovic et al., 2004; Slovic et al., 2007) proposed the 'affect heuristic', a mental shortcut through which risk judgments are made. In essence, people are thought to attach varying degrees of positive or negative feelings to their mental representations of objects and events, referred to as 'affect' in decision-making literature. When making decisions or judgments, individuals are thought to use, whether consciously or unconsciously, the positive and negative emotional tags associated with those mental representations. Accordingly, individuals assess the possibility that a hazard will occur based not only on facts and logical reasoning but also on their emotional reactions to it. The more negative the affect, the higher the perceived risk of the hazard (Finucane et al., 2000a; Slovic et al., 2007).

The most compelling evidence that negative affect associated with a hazard can fuel risk perceptions comes from experimental studies in which manipulating the emotional tags (e.g., through real or mental imagery) resulted in increased risk perception (Keller et al., 2006; Traczyk et al., 2015; Västfjäll et al., 2014). Several studies have validated the link between affect and risk perception in real-world contexts, such as cybersecurity (van Schaik et al., 2020), genetically modified food (Connor and Siegrist, 2011), terrorism (Cohen-Louck, 2019), and the COVID-19 pandemic (Savadori and Lauriola, 2022), to name a few. However, it is essential to note that while affect can be associated with risk perception, these two constructs should not be conflated because they operate through distinct mechanisms and exhibit different empirical patterns. For instance, affect is usually persistent over time (e.g., Sherman and Kim, 2002), whereas risk perceptions change more readily (e.g., Savadori and Lauriola, 2022). Furthermore, longitudinal studies showed that affect and risk perceptions had independent trajectories over time (e.g., Baucum et al., 2021).

The affect heuristic exhibits similarities with the 'risk as feelings' model introduced by Loewenstein et al. (2001) and more broadly aligns with one of the two cognitive processing modes proposed by dual-process theories of human cognition (e.g., Evans and Stanovich, 2013b). Such theories posit that individuals perceive reality through two interconnected and simultaneous processing systems. The analytic/rational system is thoughtful and deliberative, operating on a set of logical rules and evidence, like probability theory. In contrast, the heuristic/experiential system is associative, operating through mental representations linked with positive or negative feelings. The affect heuristic is thought to utilize the heuristic/experiential mode (Slovic et al., 2007).

There is substantial evidence that heuristic/experiential risk perceptions often diverge from analytic/rational ones and can have a separate, and at times more significant, impact on risk-taking behaviors in comparison to rational/analytic evaluations (Brewer et al., 2007; Dillard et al., 2012; Ferrer and Klein, 2015; Ferrer et al., 2016; Loewenstein et al., 2001; Portnoy et al., 2014). Scholars have dedicated substantial effort to measuring responses that stem independently from the analytic/rational and heuristic/experiential systems (e.g., Ferrer et al., 2016). In general, two categories of risk perception measures have been developed. One primarily focuses on heuristic/experiential dimensions, utilizing specific items that tap into emotional responses toward the possibility that a negative event will occur, such as worry and fear (Dillard et al., 2012; Ferrer and Klein, 2015; Portnoy et al., 2014; Zhang et al., 2022). The other category emphasizes analytic/rational aspects, employing specific items to assess logical and rule-based judgments concerning the perceived probability of a negative event occurring (Dillard et al., 2012; Ferrer and Klein, 2015; Portnoy et al., 2014; Zhang et al., 2022). This scholarly endeavor has proven effective in differentiating the two components of risk perception in various studies (e.g., Savadori and Lauriola, 2021). In the context of the present study, we refer to the former type of measures as affective risk perception and to the latter as analytic risk perception.

Central to measuring analytic/rational aspects of risk perception is the concept of probability. However, laypeople's probability judgments are often inaccurate, typically different from those of

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experts (e.g., Recchia et al., 2021), and may not entirely follow an analytic/rational process (Weber and Johnson, 2009). For example, while experts viewed the possibility of the conflict in Ukraine giving rise to a global nuclear war as a very remote possibility, basing their assessments on careful analyses and facts (e.g., Boulton, 2022; Strielkowski, 2022), laypeople may think otherwise. Research has long demonstrated that laypeople often rely on heuristic/experiential processes when estimating the likelihood of future events. For example, according to the 'availability heuristic' (Tversky and Kahneman, 1973), the perceived probability of an event is based on how easily that event can be imagined or remembered rather than on a reasoned analysis of empirical evidence (Pachur et al., 2012). Several factors can bias probability judgments obtained through availability, including the perceived frequency, recency, and familiarity with a hazard (Hertwig et al., 2004; Lerner et al., 2015; Schwarz and Vaughn, 2012). For example, significant nuclear accidents, such as Three Mile Island, Chernobyl, and Fukushima, had a considerable impact on the availability of a nuclear disaster and its perceived probability (Boes et al., 2015; Lee, 2015; Yang et al., 2015).

Most people have no direct memory of nuclear weapons being used in warfare (Rendall, 2022). As a result, frequency, recurrence, and familiarity are irrelevant elements in biasing the perceived probability of a nuclear war. Yet, the availability heuristic may come into play due to vivid information presented through the media, such as movies, documentaries, or news stories, about the deployment of nuclear weapons and the threat of using them. Because vivid imagery closely resembles personal experience, vividness can enhance the availability of the nuclear war hazard, leading to overestimating its perceived probability (Carroll, 1978). Hence, any type of experience, be it acquired from second-hand information or exposure to media (often termed 'indirect experience'), can influence individuals' assessment of potential hazards, thus shaping their analytic/rational perception of risk (Pachur et al., 2012; Tversky and Kahneman, 1973).

1.2. Media coverage and risk perception

The influence of mass media on risk perception is a significant area of research (Guo et al., 2020; Tsoy et al., 2021). For example, during the French Mad Cow crisis, the emotionally charged term 'Mad Cow' in news articles led to a decline in beef consumption, whereas using medical terms for naming the disease did not impact consumption (Sinaceur et al., 2005). In fact, various media factors have been found to be related to the public's risk perceptions, including the amount of media coverage and the affective tone of communication (Haglin et al., 2019; Liu et al., 1998; Mello and Hornik, 2016; Slovic et al., 2017).

In general, public concern about potential hazards tended to rise with increased news coverage and fall with decreased coverage (Mazur, 2006). The number of news articles and Internet searches about human papillomavirus vaccination, for example, was associated with the frequency with which patients reported adverse events after being vaccinated (Faasse et al., 2017). Similarly, public perceptions of risk and benefit varied according to media coverage of genetically modified foods, with risk perceptions initially increasing and then decreasing as the volume of news changed (Frewer et al., 2002).

The media can amplify negative emotions in the news (Oh et al., 2021; Paek et al., 2016). Indeed, public reactions can vary according to the tone of news articles. For instance, negative media coverage of a food scare correlated with a rapid change in food consumption, while positive media coverage required more time to restore dietary habits (Liu et al., 1998). On the other hand, the media favors coverage of topics that evoke strong negative emotions, such as dread, worry, anger, distrust, and distress, in order to nurture public attention (Sandman, 1988). These emotions in the news stories can also influence online news information seeking and processing. In particular, research has shown that anger promotes deeper message processing compared to fear (de los Santos and Nabi, 2019). This was evident through increased time spent reading news articles conveying anger and better recognition of details within them. Anger and fear were also discovered to play a moderating role in risk perceptions. Typically, anger leads to downplaying or underestimating the potential negative consequences of a risky

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situation, and fear makes people focus on the potential negative outcomes or be wary of risky situations (e.g., Baucum et al., 2021; Lerner and Keltner, 2001).

When writing articles, journalists may also prioritize emotions over factual information and statistics (Coddington, 2014). Moreover, press coverage can be more sensationalized and conflict-oriented than press releases from authorities, indicating a media amplification of the risk information (Rossmann et al., 2018). This tendency can lead to 'social amplification of risk,' in which the media influences how people perceive and experience risk by increasing or decreasing their level of concern (Kasperson et al., 1988). For example, media reports of shark and leopard attacks on humans are more likely to have graphic content (Bombieri et al., 2018), making viewers remember the stories better. Similarly, individuals who excessively used social media during the current Ukraine war were found to experience higher fear of nuclear war due to their more frequent exposure to vivid images or emotional videos of the conflict (Hajek et al., 2022).

When a distinction between analytic/rational and heuristic/experiential processes was attempted, it was discovered that media coverage was associated with both affective-laden risk perception and probability judgment. For example, in the context of tourism, Zhang et al. (2022) discovered that greater media coverage of COVID-19 cases in tourist destinations was related to both worry and perceived probability of contracting the virus, but only worry was found to be associated with outbound travel intention. This finding echoed previous research on climate change risk perception, suggesting that affective-laden risk perception held greater predictive power over behavior compared to the stated perceived probability (Marx et al., 2007). The importance of individuals' evaluations of hazard probability in the risk assessment process was highlighted by the fact that risk perception was heavily reliant on prior estimates of attack probability (Baucum et al., 2021).

It would be important to investigate the associations between media coverage of an event, emotional tone, and responses to threats originating from the heuristic/experiential. In general, the heuristic/experiential responses to threats are more predictive of behaviors than analytic/rational ones (Dillard et al., 2012; Ferrer and Klein, 2015; Loewenstein et al., 2001; Marx et al., 2007; Portnoy et al., 2014; Zhang et al., 2022). In the context of a nuclear war threat, if the media prioritize emotions over factual information, it is possible that worry and fear of a nuclear war might be associated with political behaviors, such as participating in protests, rallies, and demonstrations to raise awareness about the dangers of nuclear war and call for disarmament, or supporting diplomatic efforts and negotiations to reduce international tensions. On the other hand, worry and fear can drive impulsive decision-making, such as panic buying (e.g., stockpiling supplies and hoarding resources like food, water, and medicines). In addition, unwarranted fear and anxiety can lead to or exacerbate mental health issues (e.g., less purpose in life, depression, and drug use (Hajek et al., 2022; Newcomb, 1986)).

It would also be important to explore the connections between media coverage of an event, emotional tone, and risk perceptions influenced by the analytic/rational system. In general, the analytic/rational system relies on evidence, data, and probability judgments but could be affected by the emotional tone in the news (Lerner et al., 2003b). For instance, the literature has demonstrated that anger can stimulate a more thorough processing of news stories and encourage information-seeking behavior compared to fear (Lerner et al., 2003b). Therefore, it is plausible that if anger were the prevailing tone in the news, it could be linked to a reduced perception of the probability of a nuclear war outbreak, whereas if fear were predominant, it might have the opposite effect, increasing such perceptions.

1.3. Overview of the studies

While experts have generally deemed a nuclear escalation in the Russia-Ukraine war as remote (Boulton, 2022; Strielkowski, 2022), the general public may hold completely different views. On what does the layperson's perception of the risks of global thermonuclear war depend? Although, during the Cold War, scholars addressed the public's perception of the risk of nuclear war, there is a lack of recent studies on the subject, nor have longitudinal studies been conducted comparing changes in risk perception in the context of the Ukraine war. In the past, terrorist attacks, financial crises, and the

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COVID-19 pandemic offered ecological contexts to study the evolution of risk perceptions according to variations in contingent factors (Baucum et al., 2021; Burns et al., 2012; Savadori and Lauriola, 2022). However, the nuclear war threat poses a unique situation to study the dynamics of risk perception in the setting of an unprecedented geopolitical crisis.

In the present research, we aim to establish a parallelism between the development of nuclear war risk perceptions and the representation of the Ukraine war in the media. Using web scraping and keyword-based selection, Study 1 looked into the change in media coverage volume and affective tone during the first 6 months of conflict. Taking an individual perspective, Study 2 investigated the evolution in nuclear war risk perception, parsing affective and analytic components and their precursors in terms of indirect experience through the media and negative affect associated with a nuclear war outbreak.

2. Study 1

In Study 1, we examined news headlines from major Italian online newspapers in three 15-day periods that were evenly distributed over time. We developed our hypotheses based on two observations: Google searches for 'nuclear war' decreased in Italy from February to July 2022 (see Figure 1) and nuclear threats in official statements over the same period decreased in intensity (Arndt and Horovitz, 2022). We expected that media coverage related to the possibility of a third nuclear world war being triggered by the current conflict in Ukraine would exhibit higher volume (H1) and emotional tone (H2) at the outbreak of the conflict than in the subsequent months. In terms of emotional tone, our focus was on the eight primary emotions outlined in Plutchik's (1994) taxonomy, which differentiates joy, trust, fear, surprise, sadness, disgust, anger, and anticipation. In general, it has been observed that negative emotions are linked to an increased perception of risk. On the other hand, positive emotions are often associated with a reduced perception of risk (Slovic et al., 2007). However, previous literature has distinguished between fear and anger. Typically, fear tends to encourage caution and a focus on negative outcomes in risky situations, while anger tends to diminish consideration of potential negative consequences (Lerner et al., 2003a, 2015; Lerner and Keltner, 2001). Italian citizens commonly experienced emotions such as fear, anger, and disgust following the outbreak of the conflict (Cricenti et al., 2022). However, the levels of these emotions have not been assessed in the months after the initial aftermath of the war. Worldwide, sadness was the most frequent and salient emotion on social media, followed by fear and anger (Garcia and Cunanan-Yabut, 2022). Positive emotions were almost absent, both in Italy and worldwide, at the outbreak of the conflict, but their level might increase in the subsequent months (Garcia and Cunanan-Yabut, 2022; Vahdat-Nejad et al., 2023).

2.1. Methods

2.1.1. Web scraping

The time frame for web scraping news headlines was set in the 15 days preceding the collection of individual-level risk perception data (i.e., from February 27 to March 13, from May 1 to May 15, and from July 1 to July 15). In doing so, we sought to match the war representations in the media with individual-level risk perceptions. We collected a total of 2,669 news headlines over a period of 45 days. Unlike full-length news articles, news headlines convey the main points of a story quickly and succinctly, following specific conventions to capture the reader's attention and communicate key information. We took advantage of this uniform structure to ensure consistency and comparability across a diverse set of news outlets. To ensure comprehensive coverage of the Italian media environment, we targeted 22 news outlets, which represented the main national and local dailies available online. According to the Italian Association of Press Circulation (Accertamenti Diffusione Stampa, 2021), the selected news outlets have a total circulation of more than 1.4 million copies sold, both print and digital, making them the main players in the Italian media environment.

The news headlines web scraping process utilized DuckDuckGo, a web search engine known for its commitment to privacy and open-source philosophy (Parsania et al., 2016). We selected headlines that

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met the criterion of taking the entire search engine results page. We did this by querying the keywords 'Ucraina AND guerra' (Ukraine AND war) and iterating on each media (e.g., site: corriere.it 'Ucraina AND guerra'). Notably, DuckDuckGo does not track user data, which eliminates the influence of our own previous searches or user profiles on subsequent search outcomes. This characteristic offers a more neutral dataset compared to other search engines, which are known to personalize search results based on tracked user data. A key advantage of DuckDuckGo's approach is that it avoids the 'filter bubble' phenomenon, which occurs when search engines present results that are aligned with the user's perceived preferences.

Using Python scripts for the Selenium package (Egger et al., 2022), we ensured a systematic, unbiased, and replicable approach to data collection. Specifically, our scripts utilized the Selenium WebDriver (https://www.selenium.dev/about/), a tool designed for automating actions in web browsing. This allowed our scripts to mimic human behavior by entering search terms, clicking on links, and navigating through search results. The results of these automated searches were then scraped and stored for subsequent analysis. To ensure the consistency and robustness of the data collected, we implemented error-handling routines in our scripts. These routines addressed potential issues such as connection time-outs or unresponsive elements on the web page, thereby ensuring the stability and reliability of our data collection process. Following data collection, we processed and cleaned the scraped data using Python's Pandas library (McKinney, 2011), preparing it for sentiment analysis. This involved removing any irrelevant information, handling missing or erroneous data, and structuring the data in a format suitable for analysis.

Because of spurious results, consisting of headlines not pertaining to Russia's invasion of Ukraine, we employed a keyword-based approach in considering the cases to analyze. To exclude false positives and thus select only relevant items, we proceeded by considering the presence/absence of the following keywords in the title: 'Ucrain-' (Ukrain-), 'bomb-', 'Mariupol', 'nucle-', 'Mosca' (Moskow), 'Donbass', 'russ-', 'invasion-', 'guerr-' (war), 'Putin', 'Zelens-', 'Kiev', 'Kyiv'. Such keywords were chosen based on recent studies performing supervised and unsupervised classification of social media text pertaining to the current conflict in Ukraine (Chen and Ferrara, 2022; Ngo et al., 2022; Tao and Peng, 2023). Thus, the final sample consisted of N = 1383 headlines from the most popular Italian newspapers' homepages.

2.1.2. Automatic text analysis

The Linguistic Inquiry and Word Count (LIWC) 2022 software (Boyd et al., 2022) was used to examine the content of the selected headlines. LIWC has been used extensively in research settings to investigate topics such as personality (Koutsoumpis et al., 2022), mental health (Spruit et al., 2022), and language in social media (Bahgat et al., 2022). It also allows users to install custom dictionaries to perform the analyses in non-English languages (Pennebaker et al., 2001). Since our aim was to identify the emotional tone embedded in the text of Italian headlines, we used the Italian Emotive lexicon, ItEM (https://github.com/Unipisa/ItEM), developed at the University of Pisa by computational linguists (Passaro et al., 2015). The lexicon is based on a corpus of over 8,000 terms, including nouns, adjectives, and verbs, that have been classified as pertaining to one of the eight emotions considered in Plutchik's (1994) emotion taxonomy. These are joy, sadness, anger, fear, trust, disgust, surprise, and anticipation. The association of each target term and one of the eight emotions considered was validated using a statistical method called Latent Semantic Analysis (Passaro et al., 2015). ItEM can be used for a variety of tasks, such as sentiment analysis, emotion detection, and text classification. It has been used in a number of research studies, and it has been shown to be effective in a variety of settings. For each 15-day period preceding the collection of individual-level risk perception data, we computed the frequency of words falling into each of the eight emotion categories and expressed this as a percentage of the total words. This process enabled us to quantify the relative usage of different emotional tones in the selected news headlines. Table 1 provides representative examples of emotional tone in news headlines.

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Table 1. *Examples of emotion-related news headlines in the Italian press with English translation and LIWC scores.*

Emotion	LIWC score	News headline (English Translation)	News headline (Original Italian Text)
Joy	10.00	Child escapes war and reunites with father in Canada	Bambino fugge dalla guerra e ritrova il papà in Canada
Sadness	10.00	Ukraine: great-grandson Tolstoy, 'I live war crying, my great-grandfather would be sorry'	Ucraina: pronipote Tolstoj, 'vivo guerra piangendo, mio bisnonno sarebbe dispiaciuto'
Anger	8.33	Ukraine, Biden's wrath: 'Putin will become a pariah on the international stage'	Ucraina, l'ira di Biden: «Putin diventerà un paria della scena internazionale»
Fear	22.22	Ghostly and Silent Kiev, many flee or hide	Kiev spettrale e silenziosa, tanti in fuga o nascosti
Trust	16.67	The European Union will grant temporary residency to Ukrainian refugees	L'Unione Europea darà un permesso di soggiorno temporaneo ai profughi ucraini
Disgust	10.00	The hypocrisy of intellectual elites in the face of war massacres	L'ipocrisia delle élite intellettuali davanti ai massacri della Guerra
Surprise	13.33	The USA accelerates arms shipment to Ukraine: response 'tit for tat' to Putin	Gli Usa accelerano l'invio delle armi all'Ucraina: risposta «colpo su colpo» a Putin
Anticipation	14.29	In Lviv, a crossroads of horrors and hope	A Leopoli, crocevia di orrori e Speranza

Note: The full texts of these news headlines are available for consultation in the data repository link provided.

2.1.3. Statistical analysis

To determine significant changes in the volume and emotional tone of war news pertaining to Russia's invasion of Ukraine between the three data collection periods, we used a regression model to analyze count data. The model was used to predict the headline count and the word count for each of the eight emotion categories based on the data collection period (i.e., March, May, and July 2022). Initially, we considered using both Poisson and negative binomial models. The Poisson model assumes that the mean and variance of the count data are equal, while the negative binomial model relaxes this assumption by allowing for overdispersion and varying mean rates of occurrence. Overdispersion occurs when the observed variability in the data is greater than what would be expected based on the assumed Poisson distribution. We ultimately opted for the negative binomial model because of significant overdispersion in the analysis of headline count (chi-square/DF = 2.17) and slightly better fit compared to the Poisson model in the analysis of headline, anger, fear, trust, disgust, surprise, and anticipation counts. The negative binomial model had lower AIC (Akaike information criterion), BIC (Bayesian information criterion), deviance values, and a smaller chi-square/DF ratio. The link function was set to log, indicating that the coefficients were estimated on the log(count) scale.

2.2. Results and discussion

2.2.1. Volume coverage

Following web scraping and keyword selection, we collected a total of 921 headlines in March, 355 headlines in May, and 127 headlines in July. The log-likelihood ratio tests (LRTs) showed that the

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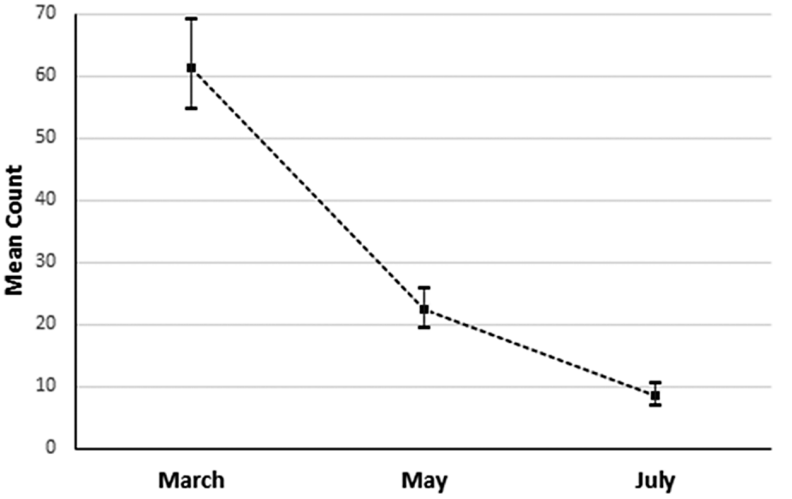

Figure 2. *News headlines count from the Italian press pertaining to Russia's invasion of Ukraine during March, May, and July 2022.*

data collection period had a significant effect on the headline count, $\chi^2(2) = 357.83$, $p < .001$. The model accounted for approximately 89% of the variation in the dependent variable. Planned contrasts compared March against the combined May and July periods, revealing a statistically significant result (B = 1.50, z = 17.35, $p < .001$). The exp(B) was 4.47, indicating that, on average, the headline count during the March period was approximately four times higher than that in the subsequent periods. Comparing May against July also yielded a statistically significant result (B = 0.97, z = 7.74, $p < .001$). The exp(B) = 2.64, which implies that the headline count during May was approximately three times higher than that in July. Although the difference between March and May appeared higher than that between May and July (see Figure 2), only the linear trend was significant (B = −1.40, z = −16.86, $p < .001$).

2.2.2. Emotional tone

To test our hypothesis that the emotional tone of the media coverage shifted over time, we analyzed the word count for joy, sadness, anger, fear, trust, disgust, surprise, and anticipation in the headlines, computed for each of the three periods (average word counts in Figure 3). The LRT showed that the data collection period had a significant effect on the joy and fear counts, $\chi^2(2) = 12.27$, $p < .01$ and $\chi^2(2) = 8.45$, $p < .05$. The model accounted for approximately 3% and 2% of the variation in the dependent variable. Planned contrasts showed that words of joy were significantly less frequent in March than in May and July combined periods (B = −0.69, z = −2.19, $p = .029$). This means that the sentiment of joy in the headlines was approximately half as much in March as in the subsequent periods, exp(B) = 0.50. Words of joy in the headlines were not significantly different between May and July. Planned contrast comparing words of fear in March against those in the combined May and July periods revealed a statistically significant result (B = 0.79, z = 2.47, $p = .014$), with an exp(B) value of 2.19. This means that the occurrences of fear terms in the headlines in March were approximately two times higher than in the subsequent periods, which did not differ at all. In sum, the analysis revealed that March had a higher occurrence of fear-related terms compared to May and July. Additionally, March exhibited a lesser occurrence of joy-related terms compared to the subsequent periods, which did not differ at all.

Taken together, our findings supported H1 and are consistent with the view that in March 2022, the world was closely following the invasion of Ukraine by Russia, with extensive media coverage on the diplomatic efforts to stop the invasion and prevent a wider war in the region. In May 2022, the volume of news headlines from the Italian press pertaining to Russia's invasion of Ukraine decreased

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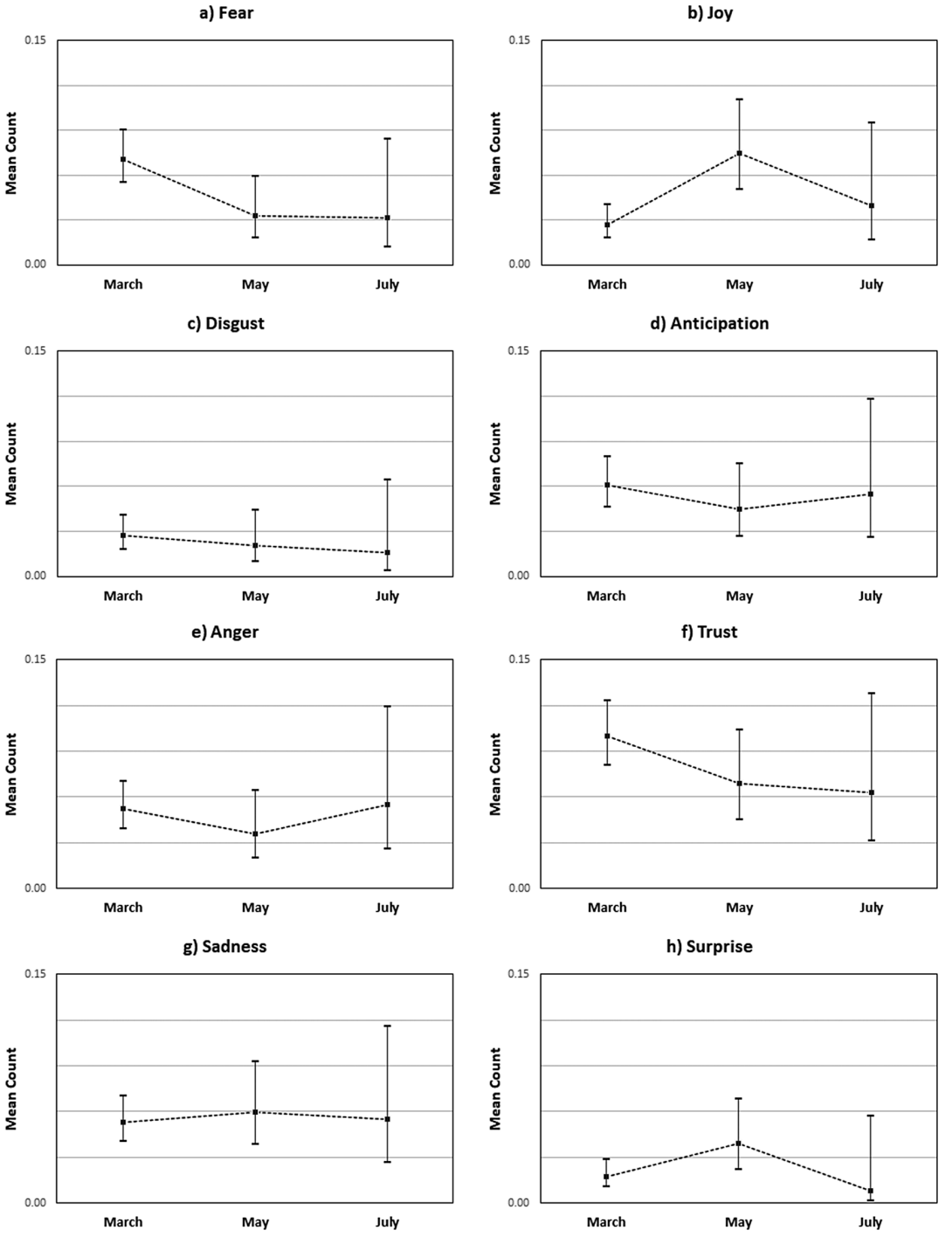

Figure 3. *Word count of joy, sadness, anger, fear, trust, disgust, surprise, and anticipation in news headlines from the Italian press pertaining to Russia's invasion of Ukraine during March, May, and July 2022.*

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significantly, shifting the focus to the humanitarian impact of the war and diplomatic efforts to end the conflict. By July 2022, the conflict had largely fallen off the front pages of many Italian newspapers, with coverage focused more on the ongoing fighting in specific regions of Ukraine. Partly confirming H2, the emotional tone of the Italian headlines had changed ostensibly between March and May 2022, with a significant decrease in fear and a corresponding increase in joy. Disgust, anticipation, anger, trust, sadness, and surprise did not change significantly from March 2022 to July 2022. Typically, fear tends to make people focus on potential negative outcomes and be cautious in risky situations (e.g., Lerner et al., 2015; Lerner and Keltner, 2001). The same literature highlights that anger often leads individuals to downplay or underestimate the potential negative consequences of risky situations. Accordingly, we can hypothesize that risk perceptions in the Italian population during the study period are likely to decrease, parallel to the change in the fear tone in the media. The tendency to perceive less risk in May and June 2002 may also align with the affect heuristic, as positive affect tended to reduce risk perception (Finucane et al., 2000a, Slovic et al., 2004).

3. Study 2

The purpose of Study 2 was to evaluate the change in nuclear war risk perceptions at an individual level. Specifically, we conducted three surveys of a panel of Italian citizens spaced approximately 2 months apart. The first survey wave (SW1) was launched on March 13, 2022, followed by the second wave (SW2) on May 15, 2022, and the third wave (SW3) on July 15, 2022. As shown in Figure 1, the three waves were equally spaced over time and captured three different moments of the Russia-Ukraine conflict. As demonstrated in Study 1, participants in Study 2 were potentially exposed to a greater amount of news and a more emotionally intense tone during the first wave (SW1) than during the second and third waves (SW2-SW3). The decline in media coverage and changing emotional tone in the headlines should be reflected in a greater decline in risk perceptions (H3), affect (H4), and indirect experience (H5) between SW1 and SW2 than between SW2 and SW3.

3.1. Methods

3.1.1. Participants and procedure

At the study's outset, 397 Italian citizens accepted to participate in the study. Participants were recruited from Prolific (https://www.prolific.com/), a crowdsourcing platform for online research. They were invited to participate in a survey about their opinions on the possibility of a third nuclear world war. Participants were assured that their contribution was crucial to the study and would enable the application of statistical techniques that necessitate a minimum of three waves. The survey was anonymous, and each participant received a total payment of £3.29. The survey included questions on affective and analytic risk perceptions, negative affect, and indirect experience (as described below), with each of these sections presented in a randomized order (as well as the items within each section). The questionnaire items in both English and Italian are available in the data repository link provided. The use of Prolific as a subject pool has proven reliable in previous longitudinal studies, ensuring an overall high retention rate and accuracy (Stanton et al., 2022). Compliance was high, with 397 individuals participating in SW1, 391 (98%) in SW2, and 383 (96%) in SW3. The mean age of the sample was 28.2 years, with ages ranging from 19 to 65 years old.53.4% were male, and 97.1% had at least a high school degree. For data analysis purposes, we defined higher education as having achieved an undergraduate, graduate, or doctoral university degree. Lower education was defined by a high school diploma, technical or community college, secondary education, or whatever lower title. Each participant provided written electronic informed consent before taking part in the study. The research protocol was approved by the Ethical Committee of the Department of Social and Developmental Psychology, Sapienza University of Rome (Prot. N .1260).

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3.2. Measures

3.2.1. Risk perception

The affective component of risk perception was measured using three items, respectively, asking 'The possibility of a nuclear third world war breaking out . . .' (1 = 'doesn't worry me at all' to 7 = 'it worries me a lot'), 'I am afraid of the possibility of a nuclear third world war breaking out' (1 = 'no, not at all' to 7 = 'yes, definitely'), and 'The possibility of a nuclear world war III breaking out makes me feel . . .' (1 = 'not at all nervous' to 7 = 'extremely nervous'). The analytic component of risk perception was measured using three items asking 'I think the probability of a nuclear third world war breaking out as a result of the conflict in Ukraine is . . .' (1 = 'extremely low' to 7 = 'extremely high'), 'If I analyze the facts coldly, as if I were a military analyst, I would say that the probability of a nuclear third world war breaking out as a result of the conflict in Ukraine is . . .' (1 = 'extremely low' to 7 = 'extremely high'), and 'If the negotiations in Ukraine do not reach an agreement, in my opinion, the probability of a nuclear third world war breaking out is . . .' (1 = 'extremely low' to 7 = 'extremely high'). Two composite scores were calculated for affective and analytic risk perception, with higher scores indicating greater worry and greater perceived probability, respectively. The Cronbach's α reliability coefficient for affective risk perception were .89, .89, and .89 at SW1, SW2, and SW3, respectively. The test–retest reliability coefficients between subsequent waves were found to be rtt = .70 and .72 for SW1-SW2 and SW2-SW3, respectively. For analytic risk perception, we obtained (Cronbach's α = .91, .91, and .92 at SW1, SW2, and SW3, respectively). Test–retest reliability coefficients between subsequent waves were found to be .61 and .61.

3.2.2. Negative affect

Three affect items asked participants to assess their feelings regarding a thermonuclear world war. All items had a common stem ('When I think of a thermonuclear world war, I have feelings. . ..', each followed by a specific bipolar rating scale (1 = 'extremely negative' to 7 = 'extremely positive'; 1 = 'of extreme displeasure' to 7 = 'of extreme pleasure'; 1 = 'of extreme tension' to 7 = 'of extreme calm' for items 1, 2 and 3, respectively). In reality, the majority of participants used only the negative or neutral response options (i.e., 1 through 4), with response option 5 being utilized in only a few cases, especially at SW2 and SW3. As a result, response option 5 was combined with option 4 for all waves. The items were reverse scored and subsequently aggregated to generate a composite score of negative affect (Cronbach's α = .73, .77, and .77 at SW1, SW2, and SW3, respectively). The test–retest reliability coefficients between subsequent waves were found to be both .64 for SW1-SW2 and SW2-SW3.

3.2.3. Indirect experience

Two indirect experience items asked participants whether they 'watched the news more often than before' and 'stopped watching the news' (reverse scored). The items were preceded by a common stem: 'Think about your behavior in the past two weeks since the Russian-Ukrainian conflict broke out and indicate how much you . . ..'. The response was collected on a 7-point scale from (1 = 'no, not at all' to 7 = 'yes, definitely'). A composite score was obtained with higher scores reflecting greater indirect experience (Cronbach's α = .44, .50, and .43 at SW1, SW2, and SW3, respectively). The test–retest reliability coefficients between subsequent waves were found to be .60 and .54 for SW1-SW2 and SW2-SW3, respectively.

3.3. Statistical analyses

3.3.1. Missing data handling

One of the most important concerns in a longitudinal study is addressing attrition bias. In our study, six participants did not participate in the second wave of data collection in our study, and an additional 14 dropped out by the third wave. Nonrandom differences between the remaining sample and the original sample may occur when study participants drop out over time. Little's Missing Completely at Random

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(MCAR) test (1988) indicated that the missing data in our study were completely random (chi-square = 38.927, DF = 77, Sig. = 1.000). This finding reduced the likelihood that the missing data, and hence the dropout, was associated with specific participant characteristics or outcomes, thereby minimizing the potential for attrition bias. Under the MCAR assumption, it is acceptable to carry out a mixed model analysis without imputation (Twisk et al., 2013). The mixed model itself is robust to missing data under this assumption, using all the available data to estimate model parameters, which is more efficient than deleting any cases with missing data (listwise deletion) or imputing missing data points (Twisk et al., 2013).

3.3.2. Mixed model analysis

Four linear mixed model analyses were carried out to assess the effects of wave on each of the outcome variables: affective risk, analytic risk, indirect experience, and affect. Models were fitted using restricted maximum likelihood, and p values were obtained using the Satterthwaite approximation. The models incorporated fixed effects for the linear and quadratic components of the wave factor. In addition to this, we employed age (a continuous variable), sex (a categorical variable), and education (also a categorical variable) as control variables to evaluate their main effects as well as their interactions with the wave factor. The models also included random effects, namely intercepts and slopes for the wave factor. Random intercepts represent the unique deviations from the overall average (fixed) intercept, essentially modeling unique starting points for each participant. The random slopes, on the other hand, provide information about how the individual's change across waves in the outcome variables varied among participants. They signify the unique deviations from the overall average (fixed) slopes, thereby accounting for different rates of change across participants. The intraclass correlation coefficient (ICC) associated with random intercepts and slopes quantifies the proportion of the total variation in the outcome variable attributable to between-participant differences at the baseline or individual change over time in the outcome variables. Starting with a basic fixed-effects model, we sequentially tested whether adding random intercepts and slopes enhanced the model's fit to the data. R-squared marginal (R^2m) denotes the proportion of the total variance explained by the fixed effects in the model, similar to the R-squared value in a simple linear regression. This provides a broad measure of how well the fixed effects elucidate the variance in the outcome variable. Conversely, the R-squared conditional (R^2c) metric represents the proportion of the total variance explained by both fixed and random effects in the model. It offers a more comprehensive understanding of the model's explanatory power by accounting for variability due to random effects, such as individual differences.

3.4. Results and discussion

3.4.1. Affective risk perception

The fit of a mixed model with a random intercept was compared to that with fixed effects only. The LRT yielded a statistically significant result, $\chi^2(1) = 1871$, $p < .001$, indicating that the random intercept model provided a significantly better fit to the data. The random intercept had a standard deviation (SD) of 1.16 and an ICC of 0.56, indicating that 56% of the variance in affective risk perception was due to between-person differences at baseline. A second comparison between the model, including both random intercept and random slope effects for wave and the model with the random intercept only, was also statistically significant, $\chi^2(5) = 284$, $p < .001$. This finding indicated that the change in affective risk perception over time was not the same for all participants. In addition to variability in affective risk perception at baseline, some participants experienced a greater change in affective risk perception over time, while others experienced lesser change or no change at all. The SD for the linear component of the random slope (0.67) was higher than that for the quadratic component (0.57). The random coefficients yielded an ICC = 0.64. Thus, incorporating random slopes into the model accounted for an additional 8% of the variance in affective risk perception due to between-person differences. Furthermore, the linear change in affective risk perception was more variable than the quadratic change,

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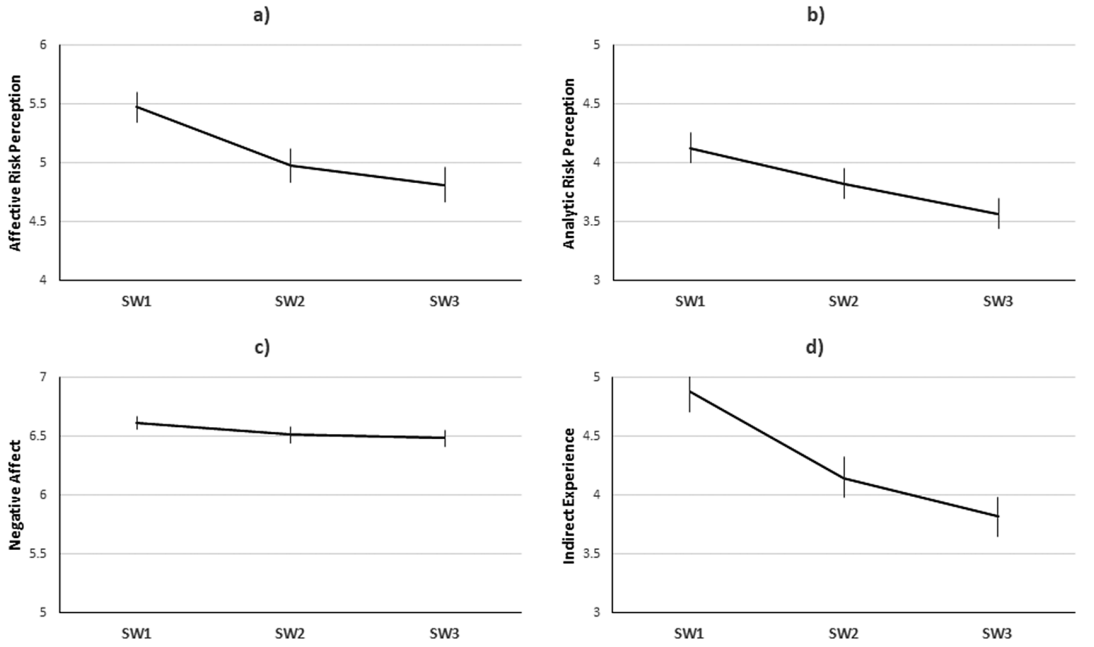

Figure 4. *Trends in affective risk perception (Panel a), analytic risk perception (Panel b), negative affect (Panel a), and indirect experience (Panel a) across three survey waves.*

indicating greater variability in the initial rate of change than in the rate of deceleration (or acceleration) of these changes over time.

The model explained 8% of the variance in affective risk perception at the fixed effects level and about 70% when considering both fixed and random effects. Wave ($F = 66.01$, $p < .001$), sex ($F = 24.30$, $p < .001$), and age ($F = 5.56$, $p = .019$) significantly predicted affective risk perception. Education was not significant. Model coefficients revealed that males and younger participants exhibited lower affective risk perception than females ($b = -.60$, $t = -4.93$, $p < .001$) and older participants ($b = .02$, $t = 2.36$, $p = .019$), respectively. For wave, both linear and quadratic trend components were analyzed. The linear trend was significant, with a negative coefficient ($b = -.47$, $t = -10.87$, $p < .001$) indicating an initial decrease in affective risk perception across waves. In addition, the quadratic trend revealed a deceleration in risk perception change over time ($b = .13$, $t = 3.34$, $p < .001$). As illustrated in Figure 4 (Panel a), the affective risk perception declined sharply and then slowed down over time.

The wave × sex interaction (Figure 5, Panel a) turned out to be overall significant ($F = 5.45$, $p = .005$). However, upon inspecting the model coefficients, we found that only the linear trend was confirmed ($b = .28$, $t = 3.22$, $p = .001$), while the quadratic trend was not ($b = -.05$, $t = -0.64$. $p = .525$). Thus, sex moderated only the linear change in affective risk perception over time. Affective risk perception decreased less sharply for males compared to females. However, there were no significant differences between males and females in the subsequent deceleration. The wave × age interaction (Figure 5, Panel b) was also statically significant ($F = 4.08$, $p = .018$). The linear trend coefficient was different by age ($b = 0.01$, $t = 2.78$, $p = .006$), indicating that the decrease in affective risk perception over time was less pronounced in older individuals than in younger individuals. The quadratic trend was not statistically significant ($b = 0.00$, $t = .72$, $p = .474$), showing that the curvilinear trajectory of affective risk perception was the same for younger and older participants. These findings showed that age moderated only the linear change in affective risk perception over time. The wave × education interaction was not significant, $F = 1.00$, $p = .369$, showing that the trend of affective risk perception did not change for more educated and less educated participants.

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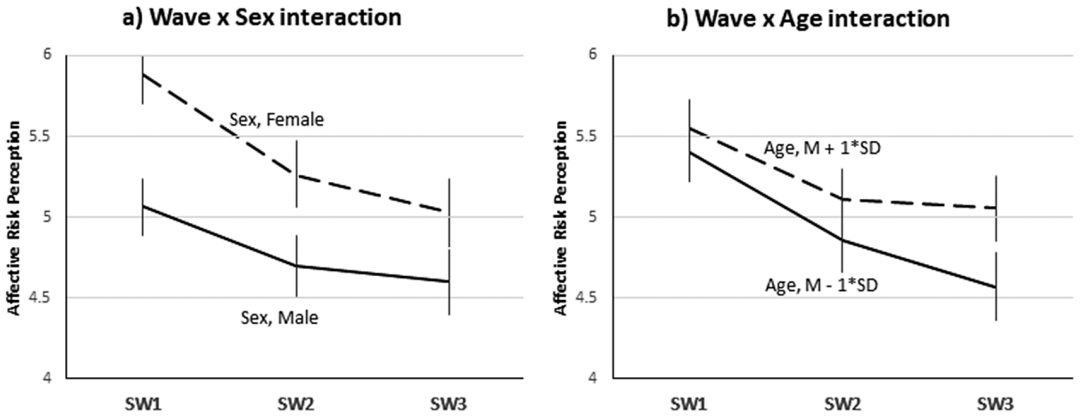

Figure 5. *Trends in affective risk perception across survey waves, demonstrating the interactive effects of wave and sex (Panel a) and the interactive effects of wave and age (Panel b).*

To summarize, our findings overall supported H3 and suggested that the automatic affect-laden emotional response to the prospect of a nuclear war decreased over time according to a nonlinear trend. This decrease was initially less pronounced in males, who started with lower levels of worry and fear about nuclear war, and in older participants, who reported higher affective risk perceptions at baseline.

3.4.2. Analytic risk perception

The random intercept model exhibited a significantly better fit to the data compared to the fixed effects model (LRT $\chi^2(1) = 1677$, $p < .001$). The random intercept SD and ICC were 1.04 and 0.53, respectively. Between-person differences at baseline accounted for 53% of the variance in analytic risk perception. The model that included both random intercept and random slope effects for wave improved the model's fit relative to the random intercept model (LRT $\chi^2(5) = 780$, $p < .001$). The SD for the linear component of the random slope (0.69) was higher than that for the quadratic component (0.46), with an ICC = 0.68. The model incorporating random intercepts and slopes accounted for an additional 15% of the variance in analytic risk perception. Furthermore, the linear change in analytic risk perception was more variable than the quadratic change, suggesting greater variability in the initial rate of change than in the rate of deceleration.

The model accounted for 6% of the variance in analytic risk perception based on the fixed effects, increasing up to 76% when both fixed and random effects were considered. Wave ($F = 35.18$, $p < .001$), sex ($F = 22.01$, $p < .001$), and age ($F = 4.36$, $p = .037$) significantly influenced analytic risk perception as they did for affective risk perception. Education was not significant again. Model coefficients revealed that males and younger participants had lower analytic risk perception scores than females ($b = -0.51$, $t = -4.69$, $p < .001$) and older participants ($b = 0.01$, $t = 2.09$, $p = .019$), respectively. Unlike affective risk perception, however, only the linear trend of the wave was significant. The negative coefficient ($b = -0.47$, $t = -8.38$, $p < .001$) indicated a steady decrease in analytic risk perception over time, as shown in Figure 4 (Panel b).

The wave × sex interaction had a significant impact on analytic risk perception, $F = 5.45$, $p = .005$. Like affective risk perception, the interaction was significant at the linear level ($b = 0.22$, $t = 2.31$, $p = .021$) but not at the quadratic level ($b = -0.02$, $t = -0.20$, $p = .841$), suggesting that the initial decrease in analytic risk perception was less pronounced for males than females (Figure 6, Panel a). Similarly, the wave × age interaction (Figure 6, Panel b) was significant for the linear trend ($b = 0.01$, $t = 2.10$, $p = .037$). This indicated that at older ages, the decrease in analytic risk perception over time was less pronounced. However, the quadratic trend was not significant ($b = 0.00$, $t = 1.07$, $p = .285$). Like affective risk perception, the effect of education on analytic risk perception was not significant. In

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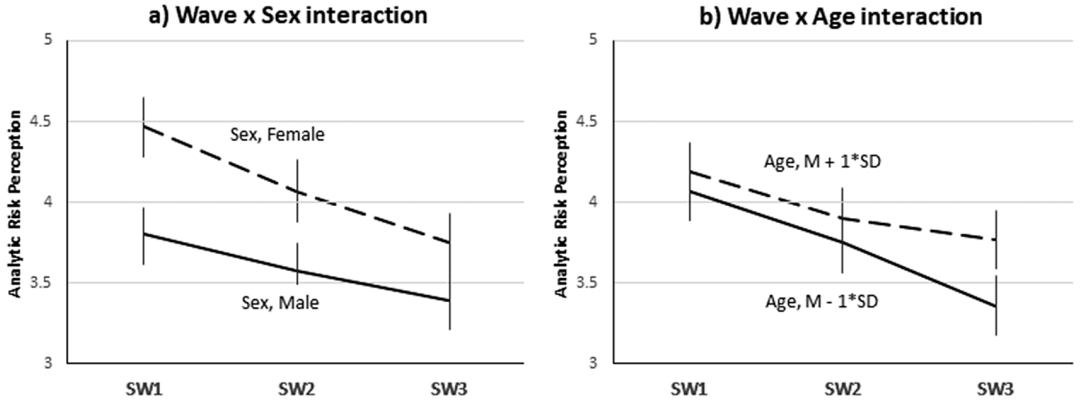

Figure 6. *Trends in analytic risk perception across survey waves, demonstrating the interactive effects of wave and sex (Panel a) and the interactive effects of wave and age (Panel b).*

keeping with H3, our findings suggest that the perceived probability of a nuclear war linearly decreased over time, with this decrease being less pronounced in males and older individuals.

3.4.3. Negative affect

The random intercept model exhibited a significantly better fit to the data compared to the fixed-effects model (LRT $\chi^2(1) = 937$, $p < .001$). The SD of the random intercept was 0.49 (ICC = 0.38). Between-person differences at baseline accounted for 38% of the variance in negative affect associated with a nuclear war threat. The model that included both random intercept and random slope effects for wave improved the model's fit relative to the random intercept model (LRT $\chi^2(5) = 36$, $p < .001$). The SD for the linear component of the random slope (0.19) was higher than that for the quadratic component (0.14), with an ICC of 0.40. This finding indicated that incorporating random slopes into the model accounted for an additional 2% of the variance in negative affect due to between-person differences.

The model accounted only for 3% of the variance in negative affect based on fixed effects, rising to 43% by incorporating the random effects. Like affective risk perception, wave ($F = 12.61$, $p < .001$) and sex ($F = 13.71$, $p < .001$) predicted negative affect significantly. We also found a marginally significant effect for education ($F = 4.42$, $p = .036$). Males reported less negative affect than females ($b = -0.20$, $t = -3.70$, $p < .001$). More educated participants also reported lower levels of negative affect relative to less educated ones ($b = 0.12$, $t = 2.10$, $p < .001$). Unlike affective risk perception, only the linear effect of wave was significant, with a negative coefficient ($b = -0.09$, $t = -4.61$, $p < .001$) indicating a steady minor decline in negative affect over time, as illustrated in Figure 4 (Panel c). No interaction effects were observed.

To summarize, negative affect associated with nuclear war linearly decreased over time while remaining at a medium to high level throughout the duration of the study, supporting H4. Furthermore, this decline was less sharp than observed for affective and analytic risk perceptions.

3.4.4. Indirect experience

The analysis of indirect experience employed a linear mixed model featuring solely the random intercept parameter. This choice was motivated by the observed lack of variability in random slopes and their failure to enhance the model fit in comparison to the model with only random intercepts, which outperformed the fixed-effects model (LRT $\chi^2(1) = 309$, $p < .001$). The random intercept had an SD of 1.14, with an ICC of 0.29, indicating that 29% of the variance in indirect experience was due to variability among participants at baseline. In line with affective and analytic risk perception, the indirect experience model accounted for 5% and 32% of the variance, considering fixed effects only and both fixed and random effects, respectively. Among the fixed effects, only wave emerged as a statistically

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significant predictor of indirect experience ($F = 69.96$, $p < .001$). Sex, age, and education did not yield any significant contribution. The linear trend of wave was significant, with a negative coefficient ($b = -0.75$, $t = -11.54$, $p < .001$), indicating a decrease in indirect experience across waves. In addition, the quadratic effect revealed a nonlinear trend over time ($b = 0.16$, $t = 2.46$, $p = .014$). As illustrated in Figure 4 (Panel d), the trend of indirect experience matched that of affective risk perception and declined more sharply between SW1 and SW2 than between SW2 and SW3.

To summarize, our results agreed with H5 and indicated a nonlinear trend in the decrease of indirect experience of the Ukraine war news through media over time. At baseline, there was also less variation between individuals' experiences compared to other constructs, implying a certain level of homogeneity in their initial exposure to news about the war. This could potentially be attributed to the fact that media narratives and themes surrounding the Ukraine war news were often similar, which tended to streamline individuals' initial reactions.

4. Conclusions

Public risk perception plays a crucial role in managing geopolitical crises, as it can influence policy decisions, international relations, and the effectiveness of crisis communication (Renn, 2017; Slovic, 1987). For example, when the public perceives a high level of risk, it may pressure policymakers to take swift and decisive action, which can be crucial in mitigating the impacts of a crisis (Kasperson et al., 1988). In this paper, we sought to establish a parallelism between the evolution of nuclear war risk perceptions and changes in war representation in the media. Indeed, previous research has considered the amount of media coverage and the affective tone of the news as primary factors affecting risk perceptions (e.g., Haglin et al., 2019; Liu et al., 1998; Mello and Hornik, 2016; Slovic et al., 2017). However, no study has addressed this issue during a war. This is significant because times of conflict typically see heightened levels of propaganda and news manipulation (e.g., Tumber and Palmer, 2004). These conditions can significantly influence public perceptions, making it a critical and unique period for understanding the dynamics of risk perception. Study 1 employed web scraping and keyword-based selection to describe the changes in media coverage volume and affective tone in specific moments of the conflict, while Study 2 evaluated changes in nuclear war risk perceptions at an individual level.

In March 2022, European and American citizens experienced profound distress as a result of the outbreak of the Ukraine war (Cricenti et al., 2022; Moshagen and Hilbig, 2022), and negative sentiments flooded social media (Garcia and Cunanan-Yabut, 2022; Vahdat-Nejad et al., 2023). Two months later, the crisis evolved to a political level, with Russia achieving only partial military success and nuclear threats from both sides diminishing in intensity (Arndt and Horovitz, 2022). In line with such a rapidly transforming scenario, Study 1 revealed a significant decrease in both the volume of war-related news and the fear conveyed by the news between March and May 2022. Given that the LIWC fear index represented the percentage of words in news headlines that conveyed fear or anxiety to the audience, it can be inferred that the Ukraine war was portrayed in the Italian media with less emotionally charged language in May compared to March 2022. Paralleling lower volume and lesser use of emotional words, Study 2 demonstrated a significant decrease in affective and analytic risk perceptions, indirect experience, and negative affect between SW1 and SW2. Affective risk perception, which reflected a person's level of worry, fear, and anxiety about the outbreak of a nuclear war, exhibited the largest effect size, closely followed by analytic risk perception, and then by indirect experience—whether people glanced at the news more frequently than before or stopped watching the news altogether, and affect. Because previous research has demonstrated that changes in public concern about potential hazards and news coverage are often co-occurring (e.g., Haglin et al., 2019; Liu et al., 1998; Mello and Hornik, 2016; Slovic et al., 2017), it is possible that the contemporary decrease in media coverage and the use of emotional language have played a role in determining the observed decreases in risk perception and related variables.

To the best of our knowledge, no study surveyed European and American citizens regarding their emotional reactions to the ongoing war after March 2022. Nor were we able to find sentiment analysis

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of social media covering the same period. Therefore, Study 1 represents the first description of war's portrayal in Western media after the war outbreak. Unlike March 2022, Study 1 showed that the conflict had largely fallen off the front pages of Italian newspapers from May 2022 onward, with coverage focused more on the ongoing fighting in specific regions of Ukraine, diplomatic efforts to resolve the conflict, and worries about the provision of gas supplies for the following winter. Resonating the relative disinterest of the Italian media, the indirect experience of the conflict resulted much lower in SW3 than in SW2. Our participants reduced their news consumption by a greater amount between March and May than between May and July. In fact, some participants stopped watching the news altogether. In contrast, analytic risk perception decreased steadily across all waves, demonstrating a steady reduction in the perceived probability of a nuclear war.

The volume of media coverage can influence people's perceived probability of a nuclear war as predicted by the availability heuristic (Pachur et al., 2012; Tversky and Kahneman, 1973), where individuals judge the probability of events based on how easily they can recall instances, often influenced by recent or vivid media portrayals. This impact of media volume could be particularly pronounced for war news, as most individuals lack direct experience with such events (Rendall, 2022), making them more reliant on media portrayals to form perceptions. Different from media coverage volume, however, the fear index decreased significantly only between March 2022 and May 2022, remaining quite stable thereafter. Accordingly, Study 2 has shown that affective risk perception decreased nonlinearly over time. This finding suggests that as fear elicited by the possibility of a third world war evolved, so did the level of concern or anxiety about the occurrence of such an event. Previous research has established connections between affect and affective risk perceptions of natural and human-made disasters (Geipel et al., 2022; Hadjichristidis et al., 2015; Siegrist and Sütterlin, 2014).

Negative affect associated with the threat of nuclear war was found to decrease linearly over time and to remain relatively high throughout the study. This finding seems at odds with the affect heuristic idea that risk perception is mostly determined by affect (Finucane et al., 2000a; Slovic et al., 2002, 2004). Indeed, both affective and analytic risk perceptions decreased to a greater extent than negative affect. However, previous research has demonstrated that automatic and deliberative processes interact in determining the ultimate response (Evans and Stanovich, 2013a; Kahneman, 2003; Kahneman and Frederick, 2002). The automatic process provides an initial assessment, which can be critically adopted by the deliberative system. If this assessment is plausible, the deliberative system may adopt it. However, the deliberative system often scrutinizes and corrects the assessment provided by the automatic system (Evans and Stanovich, 2013a; Kahneman and Frederick, 2002). Seemingly, dual system views of risk perception posit that risk as feelings and risk as analysis interact to produce the ultimate risk perception judgment (Slovic et al., 2004). However, we cannot exclude an alternative explanation of our results, namely, that the stability of negative affect with respect to both affective and analytic risk perceptions may be due to the fact that while negative affect is related to the concept of nuclear war, which is unlikely to change, both risk perceptions are more closely tied to the context. That is, they are related to the concern that nuclear war might occur within the context of the present Russo-Ukrainian conflict and its subjective probability, also in relation to the geopolitical evolution of the crisis.

In light of the finding that negative affect changed to a limited extent, especially between SW1 and SW2, it can be inferred that Italian citizens have been rather reluctant to change their attitudes and feelings toward such frightening danger, even if considered less likely. It is not the first time this dissociation of affective and analytic processes has emerged in risk perception studies. For example, a longitudinal survey during the COVID-19 pandemic (Savadori and Lauriola, 2022) has shown that affective evaluation of the coronavirus remained stable 6 months after the outbreak despite a decrease in the probability of becoming infected (given the relatively lower number of positive individuals out of the total population). This resistance to change affective reactions toward nuclear war could, perhaps, reflect the deeply ingrained pessimistic appraisal of the international crisis that Italian citizens experienced when confronted with the idea of potentially catastrophic events deriving from the war outbreak (Vahdat-Nejad et al., 2023). This interpretation remains speculative given the absence of

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studies on nuclear war risk perception on international samples or conducted with a cross-cultural focus.

Previous research has evidenced the causal role that affect plays in shaping people's perceptions of risks associated with various hazards (Finucane et al., 2000a; Keller et al., 2006; Västfjäll et al., 2014). According to the affect heuristic, individuals tend to rely on quick, emotion-laden appraisals rather than analytical reasoning and probability judgment when assessing potential risks and benefits (Slovic et al., 2004). Through this lens, one can view the nonlinear decrease in affective risk perception and negative affect throughout the study as reflecting the corresponding trend in the emotional tone of media coverage. Despite reassuring experts' opinions (Boulton, 2022; Strielkowski, 2022), the prospect of a nuclear holocaust was brought to the forefront of public consciousness just 3 days after military operations commenced. This rapid introduction of the nuclear narrative into the public discourse highlights the powerful role that fear and anxiety play in shaping people's perceptions of risks and potential catastrophes. It is possible that emotional reactions to the potential devastation caused by a nuclear conflict could have overshadowed any analytical reasoning or expert opinions (Finucane et al., 2000a; Slovic et al., 2002, 2004).

The variance in risk perceptions explained by the fixed effects was less than that explained by the random effects. This suggests considerable individual variation in the outcome variable, driven by distinct personal characteristics present at the outset of the study. For instance, sex and age were factors that significantly influenced initial risk perceptions and moderated changes in these perceptions over time. Females exhibited higher levels of both affective and analytic risk perception compared to their male counterparts, and their responses seemed to more closely match the changing media scenario. This observation aligns with prior research, which has indicated lower perceptions of risk in males (e.g., Finucane et al., 2000b; Harris and Jenkins, 2006). A novel insight from this study was the finding that risk perception in female participants declined at a faster rate than in males following the peak of a crisis. It's important to note, however, that these findings should not be generalized beyond biological sex differences and do not necessarily indicate differences in gender identities or roles. Regarding age, previous research has indicated that the disparity in affective risk perception between young and older adults hinges on the specific risk domain (Bonem et al., 2015). It appears that older adults have a heightened perception of health and safety risks, as well as ethical risks, compared to younger adults. Our study adds to this research by demonstrating that the catastrophic risk domain is perceived as more threatening by older adults than by younger adults. However, we cannot exclude that other variables may be associated with a higher affective perception of the risk of nuclear war, given that older people have memories and experiences from the Cold War. For example, in the 1980s, they received government guidance on preparing for a nuclear attack.

In a broader sense, our findings suggest that when both media coverage and emotional tone were at their peak, the general public's perception of nuclear war risk exhibited an inflated subjective probability (likely owing to the increased accessibility of news stories about nuclear weapon deployment) as well as intensified feelings of anxiety and fear for the possibility of a nuclear world war (presumably resulting from the vivid portrayal of the potential use of nuclear weapons). However, when media coverage faded, but the emotional tone of the media remained on a relatively higher level, the subjective probability of a nuclear war tended to decrease, while the fear of a global nuclear war continued to fuel affective-based risk perception. This would seem to indicate that subjective probability is more related to media coverage, while feelings of anxiety and fear might be more associated with the emotional tone of the news.

4.1. Limitations

Before concluding, we must acknowledge important limitations of our findings. First, while our mixed method approach to examining parallel trends in media coverage, emotional tone, and risk perceptions at the individual level suggested a relationship between these levels, this type of research cannot assume a causal relationship between levels. Although we do not believe that the similarities between Studies

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1 and 2 are purely coincidental, confounding variables such as how individuals consumed media and perceived risk may have influenced how individuals consumed the news and perceived risk, potentially leading to an illusory correlation between the levels. For example, we did not control for external social influences, such as family interactions, community discussions, and social media exposure. Although these unconsidered variables were beyond the scope of our study, they may have significantly contributed to the formation of participants' risk perceptions. Future studies could investigate how these external factors interact with news coverage and the emotional tone in headlines.

Second, although we collected data from a reliable and valid subject pool, it is worth noting that prolific.co can only provide a convenience sample for Italy. While sex was roughly distributed as in the Italian census, age and education were not. As a result, we cannot rule out the possibility that using an older, less educated sample will produce risk perception trends that differ from those obtained by scraping news and extracting emotional tone from headlines. Relatedly, the survey's topic could have discouraged individuals with a heightened perceived risk of nuclear war from participating in the study. However, the use of crowdsourced participants may have had a counterbalancing effect by attracting individuals who held a stronger interest in the subject matter. This approach potentially helped mitigate any sample bias, reducing the overrepresentation of those with an exceptionally heightened perceived risk of nuclear war or highest levels of fear.

As a third limitation, it is worth mentioning that we only looked at digital sources. Although we chose headlines from major media outlets that also had print editions, digital media is associated with a greater emphasis on sensational headlines and clickbait than printed news sources. This could lead to more emotionally charged coverage that placed a greater emphasis on emotional appeals and shock value. Last, we admit that the measure of indirect experience used in the study has low internal consistency. While this limitation may affect the generalizability of the findings regarding changes in news consumption, it does not necessarily invalidate the conclusions regarding the parallelism between the evolution of nuclear war risk perceptions and changes in war representation in the media.

In concluding the limitations of this study, it is crucial to acknowledge the intricacies involved in separately measuring the heuristic/experiential and analytic/rational systems. In the field of risk perception studies, obtaining pure measurements of these two systems can be extremely challenging. This challenge is particularly evident in probability judgments, often used as proxies for the analytic/rational system, but also susceptible to influence from the heuristic/experiential system, as exemplified by the availability heuristic. Developing more refined methodologies for measuring these systems in risk perception studies would be beneficial. Such advancements could help to better disentangle the interplay between these systems.

4.2. Final remarks

Despite the acknowledged limitations, our study offers insights into understanding judgment and decision-making processes during crises, the potential influence of these processes on support or opposition to military actions, as well as their effects on self-protective behaviors versus feelings of helplessness and apathy.

First, the significant decrease in media coverage volume and emotional language, paralleled by a decrease in affective and analytic risk perceptions, highlights how rapidly evolving crises can shape public perceptions. This finding can inform the broader field of judgment and decision-making by illustrating how individuals can respond to imminent apocalyptic disasters or international crises, particularly in terms of forming judgments under the influence of emotional media portrayal.

Second, the emotional charge stemming from media coverage during the early stages of the Ukraine war matched with heightened risk perceptions. Therefore, it is plausible to argue that such reactions could influence individual attitudes and behavioral intentions, such as the level of support for diplomatic solutions, peaceful negotiations, or military interventions.

Last, the decrease in affective risk perception, coupled with the persistence of negative affect, suggested that risk perceptions during a crisis can influence self-protective behaviors or foster feelings

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of helplessness and apathy. Additionally, the persistent emotional reaction to the potential nuclear war threat highlighted the challenge of changing deeply ingrained emotional responses when developing crisis communication strategies, highlighting the need for tailored communication strategies in public risk communication.

Data availability statement. The data supporting the conclusions of this research are openly available on the Open Science Framework, accessible for consultation at https://osf.io/pduwq/?view_only=b068d81526a34460a5ddd07e0ef3c2d5.

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Competing interest. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The research was conducted in the absence of any commercial or financial relationships that could be construed as potential conflicts of interest.

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