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Attention Influences Emotion, Judgment, and Decision Making to Explain Mental Simulation

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Attention is integral to mental simulation. Imagining how an event will be, was, or could have been requires attention to the event and its alternatives. How does mere attention influence people's perception and experience of events? How does attention influence people's emotions, judgments, and decisions? And do these attentional influences explain the effects of mental simulation? We consider these questions by reviewing the scientific literature that examines how attention influences experience, emotion, and behavior. Attention enhances perceptual experience by making objects more vivid, salient, and clear. Attention also reduces interference from unattended stimuli and increases memory accessibility of attended objects. Partly because of these effects, attention increases emotional intensity of attended objects. Attending to goals, budget categories, and attributes also increases their prioritization and weight in judgment and decision making. Given these pervasive and robust effects of attention, we suggest that attention contributes to the effects of mental simulation on emotional intensification, prioritization, consideration of the future, and risk perception. Differentiating attention and mental simulation is an important challenge for future work.

Keywords: attention, emotion, judgment, decision making, mental simulation

Much of our mental life occurs outside the "here and now" (Liberman & Trope, 2008). We mentally simulate future events to envision and plan for what lies ahead (Taylor, Pham, Rivkin, & Armor, 1998). Job candidates, for example, imagine what they might be asked in an interview, prospective students imagine what college will be like, and citizens think about how they would react to upcoming elections (Gilbert & Wilson, 2007; Schkade & Kahneman, 1998). We also mentally simulate what was, reliving and reexperiencing the past (Suddendorf, Ad-

dis, & Corballis, 2009; Van Boven & Ashworth, 2007). We not only simulate what was, we also mentally simulate what might have been. These counterfactual simulations produce emotions such as regret and pride when compared with actual events (Markman, Gavanski, Sherman, & McMullen, 1993; Roeser, 1997).

Attention inheres in mental simulation. Mentally simulating what might happen, did happen, or might have happened requires attention to those events and outcomes. Imagining what questions interviewers might ask, what a vacation was like, how one would feel after an election, or what one should have said in an argument necessitates attention to questions, vacations, elections, and conversations. Understanding mental simulation would therefore benefit from understanding the nature and consequences of attention.

In this article, we examine how attention profoundly influences emotions, experiences, judgments, and decisions. We suggest that these attentional influences contribute to many effects of mental simulation. Research on mental sim-

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ulation has, for example, demonstrated that simulating future events can make them seem more vivid, fluent, and prominent (Kappes & Morewedge, 2016; Mrkva, Travers, & Van Boven, 2018). Mentally simulating the distant future can increase how much people prioritize saving for retirement (Hershfield, John, & Reiff, 2018) and other long-term goals (Rutchick, Slepian, Reyes, Pleskus, & Hershfield, 2018; Shah, Hershfield, Gomez, & Fertig, 2018). Mentally simulating risks can make them seem more severe and more likely to occur, especially if the risks are easy to imagine (Gregory, Cialdini, & Carpenter, 1982; Mevissen, Meertens, Ruiter, Feenstra, & Schaalma, 2009; Sherman, Cialdini, Schwartzman, & Reynolds, 1985). People's tendency to mentally simulate future events more than past events contributes to the more intense emotions experienced when thinking about the future than when thinking about the past (Van Boven & Ashworth, 2007; Vosgerau, Wertenbroch, & Carmon, 2006; Weingarten & Berger, 2017). And mentally simulating alternative realities can intensify emotion, including counterfactual feelings of regret, relief, or gratitude that result from comparing what did happen with simulations of what could have happened (Markman et al., 1993; Roese, 1997).

Focusing attention on objects, goals, or events has many of the same effects. Attention increases objects' vividness and perceived prominence (Carrasco, Ling, & Read, 2004; Gobell & Carrasco, 2005), how much goals are prioritized (Mrkva & Van Boven, 2017), how severe risks seem (Mrkva, Cole, & Van Boven, 2019), and how emotionally evocative objects are (Mrkva, Westfall, & Van Boven, 2019). It is plausible that attention explains many of the effects of effects of mental simulation.

Attention

William James (1890/1952, pp. 403–404) wrote,

Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence.

Attention, in other words, is the process of selectively focusing conscious processing on

one object more than other objects (Anderson, 2005; Posner, 1980).

There are several types of attention including voluntary and involuntary attention, as well as external and internal attention. Voluntary attention is top–down and controlled, whereas involuntary attention is bottom–up and automatic. For example, searching for a friend in a crowd requires top–down attention whereas flashing lights attract involuntary attention. External attention selects stimuli in the external environment for focal processing, such as a friend in a crowd or a voice at a party (Chun, Golomb, & Turk-Browne, 2011). Internal or mental attention selects internally generated objects such as ideas and thoughts for focal processing.

Attention is distinct from exposure, awareness, and gaze. Whereas exposure differentiates objects based on how long they are in the visual field (Auclair & Siéoff, 2002; Prinzmetal, Henderson, & Ivry, 1995), attention differentiates objects based on whether a person selectively focuses on those objects more than others in the visual field. Whereas awareness differentiates whether people consciously perceive an object, attention differentiates between two types of perceivable objects, those that are focal (attended) and those that are not (unattended; Koch & Tsuchiya, 2007; Webb, Igelström, Schurger, & Graziano, 2016). People can also attend to an object without fixating gaze on it (Hanning, Szinte, & Deubel, 2019; Posner, 1980). People often mentally attend to things that are not visually fixated, such as listening to the radio while gazing at the road when driving (Strayer & Johnston, 2001). Attention can also be covert, in which people remain fixated on an object in the middle of their visual field while attending to an object elsewhere (Carrasco, Penpeci-Talgar, & Eckstein, 2000; Montagna & Carrasco, 2006; Posner, 1980).

Modern theories differentiate attention from awareness, allowing for conscious perception of objects without attention (Cowan, 2011; Oberauer, 2002; Treisman, 1964). People can process several objects simultaneously in working memory, although only one or a few of them at a time are the focus of attention (Cowan, 2011; Lewis-Peacock, Drysdale, Oberauer, & Postle, 2012; McElree, 2006; Nee & Jonides, 2011; Oberauer, 2002). Attention usually holds only one object or chunk that is especially prominent

and accessible (McElree, 2006; Oberauer, 2002).

Does Attention Influence Experience?

Whether attention influences conscious experience is a long-standing debate in philosophy and psychological science (Carrasco et al., 2004; Ebbinghaus, 1908; Fechner, 1877; James, 1890/1952; Prinzmetal, Long, & Leonhardt, 2008; Wundt, 1897). William James (1890/1952) asserted that attention “makes a sense-impression more intense,” suggesting that “[I]n listening for certain notes in a chord, or overtones in a musical sound, the one we attend to sounds probably a little more loud as well as more emphatic than it did before” (p. 425). Fechner (1877) disagreed, claiming “Everybody can immediately observe that a white or gray sheet of paper does not look brighter, that a sound does not hear louder” (p. 27) when attention is focused on it. Others, such as Ebbinghaus and Stumpf, took a middle ground, claiming that only weak sensations, such as the soft tick of a clock, become more noticeable and intense when attended than when unattended (Ebbinghaus, 1908, p. 90; Pillsbury, 1906/1973).

Mounting evidence supports James’s idea that attention intensifies perception or mental representation (Carrasco, 2011; Carrasco et al., 2004; Fuller & Carrasco, 2006; Liu, Abrams, & Carrasco, 2009; Mrkva et al., 2019). Attention makes objects more mentally vivid, large, clear, and emotional than equivalent unattended objects (Anton-Erxleben, Henrich, & Treue, 2007; Carrasco et al., 2004; Fuller & Carrasco, 2006; Liu et al., 2009; Mrkva et al., 2019; Störmer & Alvarez, 2016). As anticipated by Ebbinghaus and Stumpf, these effects are largest for initially weak sensations, such as low-contrast images, small objects, and less emotionally evocative objects (Anton-Erxleben & Carrasco, 2013; Anton-Erxleben et al., 2007; Carrasco, Williams, & Yeshurun, 2002; Mrkva et al., 2019; Yeshurun & Carrasco, 1998), though they are also present for stronger sensations and highly emotional images (Lee & Maunsell, 2010; Ling & Carrasco, 2007; Mrkva et al., 2019).

Manipulating Attention

Various procedures manipulate attention. Among the most common uses a spatial cue to draw attention toward one side of a screen just

before stimuli are presented either near the cue or on the other side of the screen (Liu et al., 2009; Posner, 1980). The cue is sometimes a brief onset that looks like a flash of light and captures bottom-up, involuntary attention (Posner, 1980; Santangelo, Botta, Lupiáñez, & Spence, 2011). Other times, the cue is a symbol that informs participants where the key stimulus is likely to appear (i.e., where they should direct top-down, voluntary attention; Mrkva & Van Boven, 2017; Posner, 1980).

One version of this incidental spatial cueing procedure that we have used is displayed in Figure 1. We refer to this procedure as incidental cueing because the cue directs attention toward the cued object only as a byproduct of their primary task. A cue informs participants where a series of letters or words will appear, and participants are told their task is to look at the letters or words and press a key if an “X” appears. This directs voluntary attention toward one side of the screen. Meanwhile, two stimuli appear: one very close to the focus of participants’ attention and one on the other side of the screen. Afterward, participants report their judgments or decisions about two images. Researchers then compare responses to cued (attended) to noncued (unattended) images. This procedure equates exposure duration and awareness. Cued and noncued stimuli are presented for the same amount of time and nearly all participants can see both images. Few participants exhibit demand characteristics in our studies or show evidence of response bias.

Another method of manipulating attention is through a task that requires participants to repeatedly search for some randomly assigned images and not others. For example, participants may view several images sequentially and be asked to press a key every time they see one image but not when other images appear. Or, they may view four images that sometimes appear upside down and be asked to indicate with a keypress whether two of the images are presented upside down (but not make the keypress for the other two images). One such procedure that we have used is displayed below (see Figure 2). These procedures equate exposure duration and ensure that participants look at both attended and unattended images.

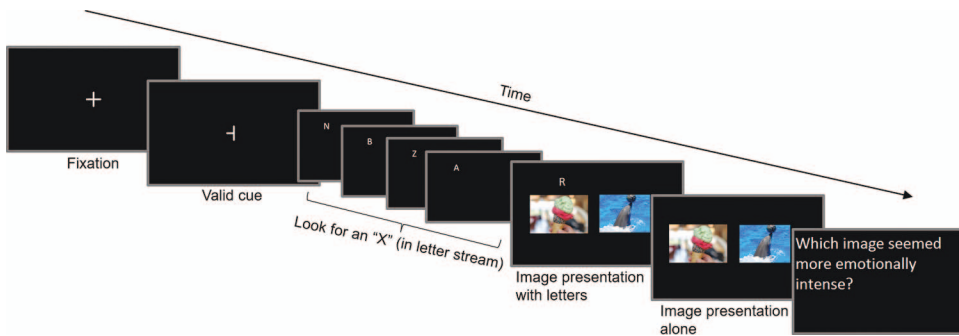


Figure 1. Diagram of the incidental cueing procedure used to manipulate voluntary spatial attention (Mrkva et al., 2019). Participants viewed a series of letters presented in rapid succession (RSVP) looking for an “X”; meanwhile, one image appeared near the focus of attention and one image appeared on the other side of the screen. Participants then completed dependent measures. The procedure was adapted from similar procedures (Liu et al., 2009; Mrkva & Van Boven, 2017; Posner, 1980). See the online article for the color version of this figure.

Attentional Processes

Attention influences perception and mental representation through at least three interrelated processes: signal enhancement, noise reduction, and enhanced accessibility and memory (Carrasco, 2011; Mulligan, 2008; Serences, 2011). These three processes are not mutually exclusive (Doshier & Lu, 2000; Lu & Doshier, 1998; Pestilli & Carrasco, 2005), and are intertwined and mutually reinforcing.

Signal Enhancement

Signal enhancement is the idea that attention directly increases the strength and quality of mental representation by increasing the gain on the signal within the locus of attentional selection (Bashinski & Bacharach, 1980; Carrasco et al., 2000; Doshier & Lu, 2000; Ling & Carrasco, 2006). Attention has been likened to a spotlight that brightens and amplifies objects in focus (Brefczynski & DeYoe, 1999). When a spot-

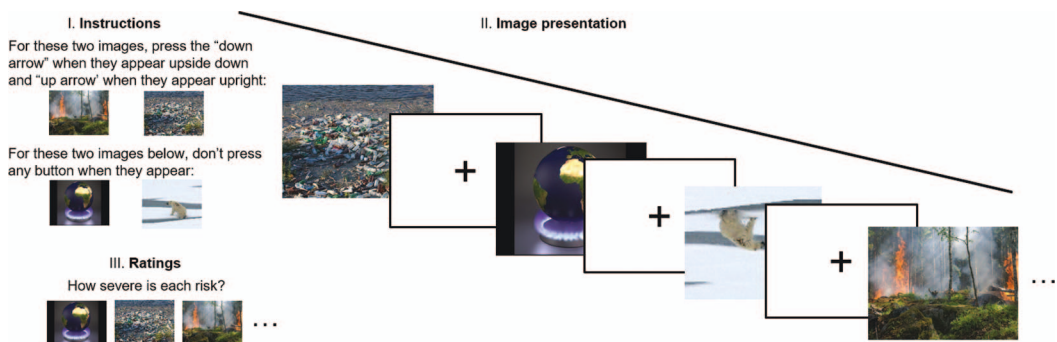


Figure 2. Diagram of a search manipulation of attention (Mrkva et al., 2019). Participants saw images for 1.0 s each time, separated by a 0.5-s fixation cross. For two randomly determined images (of the four), participants pressed the up arrow on their keyboard when they appeared upright and the down arrow when they appeared upside-down. After image presentation, participants answered questions about each of the images. All images appeared upright half of the time and upside-down the other half of the time. See the online article for the color version of this figure.

light shines on one person in a group, that person appears brighter. Attending to a stimulus similarly makes it appear more visually saturated and brighter (Fuller & Carrasco, 2006; Tse, 2005). Visual attention amplifies action potentials evoked in the primary visual cortex (Brefczynski & DeYoe, 1999) and auditory attention amplifies activation of auditory cortex (Woldorff et al., 1993).

Attention has also been likened to a zoom lens (Eriksen & St James, 1986), which causes attended objects to be perceived with higher resolution, acuity, and detail than unattended objects (Yeshurun & Carrasco, 1998). For example, when objects are presented with a very small gap in the middle, people are better able to notice the gap when attention is directed toward the object than when the object is unattended (Carrasco et al., 2002; Shalev & Tsal, 2002). And just as zooming in with a zoom lens increases the apparent size of the person being photographed, attention can make objects appear larger (Gobell & Carrasco, 2005), an effect that is reflected in the receptive fields of neurons (Anton-Erxleben & Carrasco, 2013).

Noise Reduction

Noise reduction is the idea that attention enables the observer to disregard and inhibit the influence of distractions and other information outside the focus of attention (Doshier & Lu, 2000; Serences, 2011; Shiu & Pashler, 1994). Attention makes focal objects stand out relative to other objects partly by inhibiting the influence and interference of nonfocal stimuli (Serences, 2011; Shiu & Pashler, 1994). Research on the cocktail party effect, in which listeners are asked to attend to one out of two simultaneous conversations, suggests that most unattended information is not comprehended, though it is not immediately or fully filtered out (Treisman & Riley, 1969). Engaging visual attention also reduces how much visual distractors interfere (Lavie & Tsal, 1994; Shiu & Pashler, 1994). Attention dampens signals evoked by peripheral stimuli and decreases sensitivity to changes and contrasts in the periphery (Carrasco, 2011; Carrasco et al., 2004; Liu et al., 2009; Pestilli & Carrasco, 2005; Smith, Singh, & Greenlee, 2000).

Memory and Accessibility

Attention increases the likelihood of remembering (Hertel & Rude, 1991; Mulligan, 2008) and increases the accessibility of memories (Taylor & Fiske, 1978). Objects that are the focus-of-attention are more likely to be “top-of-mind,” being recognized and recalled more quickly than unattended objects (Downing, Judd, & Brauer, 1992; Nee & Jonides, 2011; Taylor & Fiske, 1978).

Attention also increases how easily and how much people access, acquire, and process information about objects (Carrasco & McElree, 2001; Posner, 1980; Taylor & Fiske, 1978). Voluntary attention is sometimes directed toward whichever information is most informative or goal-relevant, allowing people to acquire new and relevant information (Gottlieb, 2012; Vogt, De Houwer, Moors, Van Damme, & Crombez, 2010). As attention is directed toward objects or information, information processing accelerates (Carrasco, Giordano, & McElree, 2006; Posner, 1980; Titchener, 1908). This can be observed in the illusion of “visual prior entry.” When two objects appear simultaneously, people perceive the attended event to occur just before the unattended event (Shore, Spence, & Klein, 2001).

Summary

Attention exerts interrelated influences over information processing and mental representations. Given the breadth and depth of these attention-induced processes, it stands to reason that attention profoundly influences emotion, judgment, and decision making. We next consider these attentional consequences.

Attention Intensifies Emotion

We have demonstrated that attention increases the intensity of emotional reactions (Mrkva et al., 2019; Mrkva & Van Boven, 2020). Attention increases perceived vividness (Fuller & Carrasco, 2006). Vivid objects, in turn, are more emotionally evocative (Kees, Burton, Andrews, & Kozup, 2010; Mrkva et al., 2019).

Clinicians have long suspected that attention intensifies emotion. Some treatments therefore

seek to reduce problematic negative emotions by reducing attention. To reduce patients' anxiety, pain, and fear, doctors commonly provide distractions (Koller & Goldman, 2012; Oliver & Page, 2008) or instruct patients to focus on something else (McCaul & Malott, 1984; Stone, Demchik-Stome, & Horan, 1977). For mental illnesses such as social anxiety disorder, generalized anxiety disorder, and phobias, clinical psychologists have used treatments in which patients are instructed to repeatedly attend away from a stressor (Amir, Beard, Burns, & Bomyea, 2009; Schmidt, Richey, Buckner, & Timpano, 2009). These techniques are often successful; repeatedly attending away from angry faces can reduce social anxiety symptoms (Heeren, Mogoșe, Philippot, & McNally, 2015) and attending away from threat-eliciting stimuli can reduce generalized anxiety disorder symptoms (Amir et al., 2009).

If reducing attention reduces emotion, increasing attention should intensify emotion. This is precisely what we found across several experiments. We used the incidental cueing procedure described earlier (see Figure 1) to present some images near the focus of attention (Mrkva et al., 2019). Attended images, those randomly assigned to appear on the cued side of

the screen, were more emotionally intense than unattended images and control images (see Figure 3). Using a causal chain of experiments as well as mediation models, we provided converging evidence that attention enhances perceived vividness and distinctiveness, which explains why attention intensifies emotion. This effect of attention emerged as an increase in the intensity of attended images, not a decrease in the intensity of unattended images. Across experiments, we asked memory and manipulation check questions to ensure that participants could see both attended and unattended stimuli, and to ensure that they attended more to the cued stimulus than the noncued stimulus. We also addressed the alternative explanation that demand characteristics accounted for our results. For example, we asked participants about what they thought the experiment was examining and whether they thought the experimenter wanted them to rate cued images as more emotionally intense; the effects were robust even when we excluded participants who thought the experimenter wanted them to rate the cued stimulus as more emotionally intense and when we excluded the few participants who guessed what we were studying. And, as alluded to earlier, the intensifying effects of attention were larger for

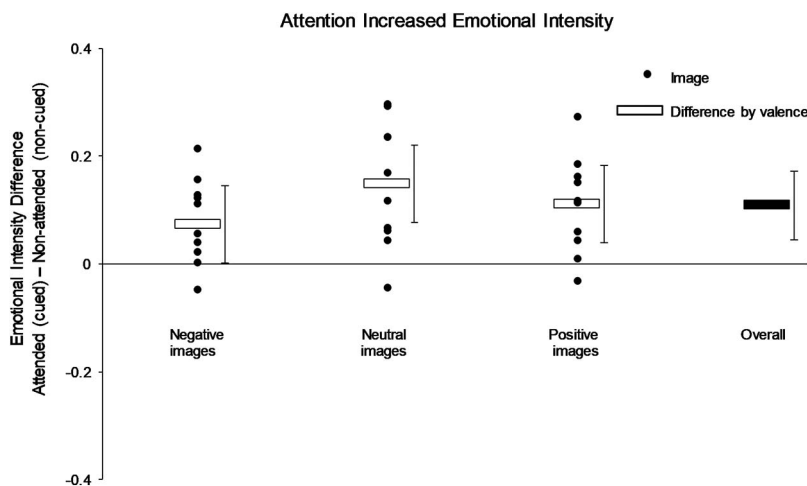


Figure 3. The difference between the proportion of cued (attended) images minus the proportion of noncued (unattended) images participants selected as more emotionally intense, separately for each image and each valence (negative, neutral, positive). Horizontal bars indicate means for each valence. Error bars are 95% confidence intervals of the difference in proportion. In an internal meta-analysis of seven experiments ($N = 469$), the effects were larger for neutral images than for positive and negative images.

more neutral images than for emotionally evocative positive and negative images. These findings may explain why ruminating about even mundane events can intensify reactions to them (Lyubomirsky & Nolen-Hoeksema, 1993; Nolen-Hoeksema & Morrow, 1993) and why distraction can reduce fear and pain (Koller & Goldman, 2012; Oliver & Page, 2008).

Attention Influences Judgment and Decision Making

Partly because it intensifies emotion, attention influences judgment and decision making. Researchers lean heavily on attention to explain many judgment and decision making phenomena (Birnbaum, 2008; Johnson & Busemeyer, 2016; Johnson, Schulte-Mecklenbeck, & Willemssen, 2008; Kahneman, 1973; Orquin & Mueller Loose, 2013; Weber & Johnson, 2009). In research on focalism in affective forecasting, for example, people are theorized to overestimate the intensity and duration of emotional events because their attention is focused on the initial reaction to the event itself and not on the postevent processes and distractions that reduce emotional intensity (Schkade & Kahneman, 1998; Wilson, Wheatley, Meyers, Gilbert, & Axsom, 2000). In research on the endowment effect, owners are theorized to attend to what they own (and demand more to sell) whereas buyers attend to cost (and what they are willing to pay, Carmon & Ariely, 2000). In research on cold-hot empathy gaps, people in unemotional “cold” states underestimate the impact of emotional “hot” states on their own and others’ behavior because they underestimate how much attending to emotionally evocative attributes increases the weight of those attributes in judgments and decisions (Van Boven & Loewenstein, 2003, 2005).

There is extensive evidence that attention is correlated with, if not causally related to, judgments and decisions. Attention fixations, especially those immediately prior to choices, predict choices (Krajibich, Armel, & Rangel, 2010; Krajibich & Rangel, 2011; Payne, 1976; Smith & Krajibich, 2018). Notice, however, that attention might be correlated with choice because preferences influence attention, because attention influences preferences, or the relationship could be bidirectional, or due to some other factor (Orquin & Mueller Loose, 2013; Towal,

Mormann, & Koch, 2013). Several studies have directly manipulated attention to examine causal effects of attention on judgment and decision making. As we detail in the following sections, these studies demonstrate that attention can causally increase prioritization, attribute weighting, choice, and subjective ratings of emotional intensity.

Attentional Accounting

Attention influences what people consider to be high priority investments of their time and money. When one’s smartphone vibrates to indicate a new text or e-mail, answering the text often takes priority even if there are other more important tasks to do (Zhu, Yang, & Hsee, 2018). In the context of spending decisions, people may prioritize attention-grabbing items such as clothes or jewelry that are frequently advertised and attended rather than prioritizing more important things that fail to attract attention (Mrkva & Van Boven, 2017).

We used the incidental cueing procedure described earlier to orient attention toward one budget category and away from another (Mrkva & Van Boven, 2017). For example, in one trial participants were randomly assigned to attend either to the budget category “vacations” or toward “kitchen supplies” and they were asked which category is more important and higher priority. Participants subsequently prioritized cued budget categories over noncued categories, even when choices were incentivized with gift cards corresponding to the two categories. Further, both visual attention and mental attention increased prioritization. Manipulating visual attention using the spatial cueing procedure described earlier and manipulating mental attention by having participants repeatedly rehearse the name of one category both increased prioritization. When participants’ attention was cued to both categories over multiple trials, they prioritized the category that had been more frequently cued, indicating the impact of relative attention.

Attention, Evaluation, Weighting, and Choice

Attention can affect choice by influencing evaluation of alternatives. Actively ignoring distracting objects decreases their value (Ray-

mond, Fenske, & Tavassoli, 2003). After searching for target stimuli and ignoring distractors presented at the same time, people subsequently like distractors less than control images. The act of inhibiting attention from distracting objects causes people to like distractors less (Kihara, Yagi, Takeda, & Kawahara, 2011; Raymond, Fenske, & Westoby, 2005).

In some studies, attention leads people to like attended objects more (Shimojo, Simion, Shimojo, & Scheier, 2003; Störmer & Alvarez, 2016). For example, after attention is cued toward one face and away from another with a briefly flashed cue, people subsequently rate the attended face as more attractive than the unattended face (Störmer & Alvarez, 2016).

In the context of choosing a preferred option, attention is associated with choice (Cavanagh, Wiecki, Kochar, & Frank, 2014; Fiedler & Glöckner, 2012; Fiedler, Glöckner, Nicklisch, & Dickert, 2013; Folke, Jacobsen, Fleming, & De Martino, 2016; Lim, O'Doherty, & Rangel, 2011; Payne, 1976; Smith & Krajbich, 2019; Stewart, Hermens, & Matthews, 2016). Further, experimentally increasing attention toward a choice option also increases the likelihood that it will be chosen (Ghaffari & Fiedler, 2018; Janiszewski, Kuo, & Tavassoli, 2012; Mormann, Navalpakkam, Koch, & Rangel, 2012). In one investigation, participants were given choices between two moral stances such as whether murder is "sometimes justifiable" or "never justifiable," of which one option was randomly assigned to prompt choice (Pärnamets et al., 2015). They viewed the two options naturally and the choice prompt appeared after they had looked at both options and were again attending to one randomly assigned option. Participants were more likely to choose whichever option they attended to as they were prompted with the decision. Similar procedures have shown that attention can bias choices between consumer products (Janiszewski et al., 2012; Mormann et al., 2012), simple perceptual choices (Tavares, Perona, & Rangel, 2017), and complex moral choices (Pärnamets et al., 2015; but see the failed replication in Newell & Le Pelley, 2018).

Attention can also affect choice by influencing the weighting of attended versus unattended information. Taylor and Fiske (1978) found that attending to people increases their perceived impact on social interactions. In one study, peo-

ple estimated that those who were prominent in their visual field contributed more to conversations than those who were not in their visual field (Taylor & Fiske, 1975).

In decision research, manipulating attributes of value and probability by making the attribute more vivid and salient increases their weight. For example, increasing the font size of information about outcomes relative to information about probability increased the influence of outcomes in choice (Fujii & Takemura, 2003; Weber & Kirsner, 1997). One investigation that examined the relationship between attention and weighting found that manipulations that increased how long people attend to an appealing food made people more likely to choose that food. However, increasing the length of attention toward an unappealing food reduced the likelihood that people chose the negative food (Armel, Beaumel, & Rangel, 2008).

Attention Increases Risk Response

Perceptions of and behavioral responses to risk are shaped by emotion as much as, if not more than, cognitive evaluations (Hsee & Rottenstreich, 2004; Loewenstein, Weber, Hsee, & Welch, 2001; Pachur, Hertwig, & Wolkewitz, 2014; Rottenstreich & Hsee, 2001; Suter, Pachur, & Hertwig, 2016). Intensifying the fear elicited by a risk, even if the emotion is incidental to the context at hand, makes people more likely to avoid the risk and perceive it as more severe (Lerner & Keltner, 2001). Given this affective analysis, we have examined two hypotheses about attention and response to risk.

The first is that attention increases environmental risk perception (Mrkva et al., 2019). In one experiment, we used the incidental cueing procedure described earlier to direct participants' attention toward images depicting some environmental risks (e.g., air pollution) and away from others (e.g., deforestation). In another experiment, we used the exogenous cueing paradigm to draw attention toward one object with a briefly flashed unfilled rectangle (see Figure 4). This drew attention toward one (cued) risk on the screen and away from another (noncued) risk. Participants perceived cued risks as more frightening and severe than noncued risks. This was true even when we excluded those who thought the experimenter wanted participants to rate cued risks as more

severe, addressing the alternative possibility that results were attributable to demand characteristics.

Attention can also affect risk response by increasing risk aversion, which is largely grounded in emotional response to risk, which can reduce sensitivity to probability (Hsee & Rottenstreich, 2004; Loewenstein et al., 2001; Pachur et al., 2014; Rottenstreich & Hsee, 2001; Suter et al., 2016). We therefore hypothesized that attending toward a risky prospect would increase risk aversion. We manipulated attention to different alternatives in risky choice, such as toward a 50% chance of \$1,000 or toward \$500 for certain (Ramos & Van Boven, 2019). We presented participants with 36 hypothetical choices between one certain monetary reward and one risky monetary reward. Across trials, we manipulated attention using the spatial cueing procedure described earlier. We cued participants' attention to the certain alternative on 75% of trials (and to the risky alternative on 25% of trials), to the risky alternative on 75% of trials (and to the certain alternative on 25% of trials), or to neither option on any trials. Preliminary results indicate that participants were more risk averse when they were cued to attend to risky alternatives on most trials than when they were cued to attend to certain alternatives

on most trials or when they were not cued. This pattern is consistent with the idea that attention intensifies people's affective responses to stimuli and risks, thus decreasing choice for positive alternatives when those alternatives are risky.

Attention Reduces Delay Discounting

Decisions in daily life require tradeoffs between immediate and future rewards (Frederick, Loewenstein, & O'Donoghue, 2002). When making investment decisions, for example, people often must choose between possessing capital immediately versus some uncertain prospect of future dividends. And investing in long term environmental outcomes such as mitigation of future climate change requires near term costs, such as taxes to reduce carbon emissions. Because the future is psychologically distant and uncertain, future outcomes are discounted relative to immediate outcomes (Kim & Zauberman, 2009; Zauberman, Kim, Malkoc, & Bettman, 2009). People discount future outcomes relative to immediate outcomes such that, all else equal, they prefer immediate rewards (e.g., receiving \$50 now) over somewhat larger—sometimes drastically larger—delayed rewards (e.g., receiving \$60 in 1 year, Ainslie, 1975, 1992; Frederick et al., 2002; Kirby, Petry, &

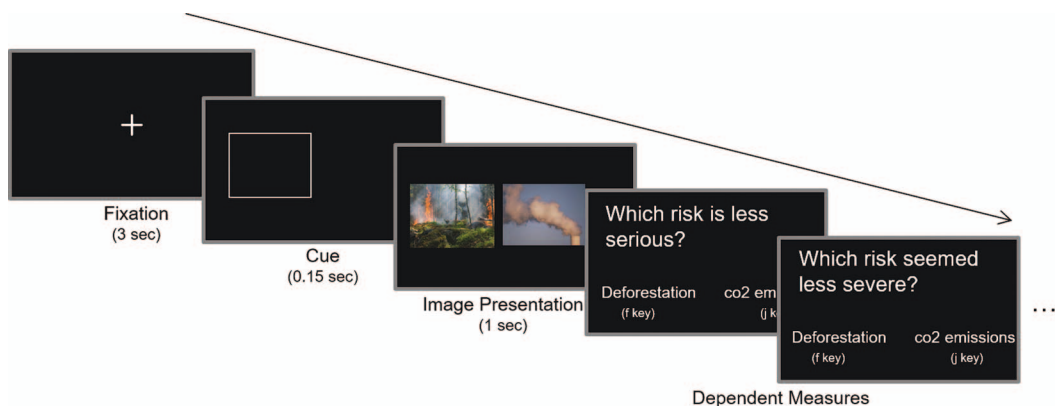


Figure 4. Diagram of the spatial cueing procedure used to manipulate involuntary attention (Mrkva et al., 2019). The procedure was adapted from the common Posner cueing paradigm (Posner, 1980). A flash of a white rectangular cue appeared on the left or right side of the screen, designed to draw participants' attention toward that side. Immediately after the cue disappeared, two images corresponding to two environmental risks appeared. Participants then rated which image was (more/less) severe, serious, novel, and widespread. They also completed a recognition memory task and rated the amount of fear that each evoked. Cued risks evoked more fear and were rated more severe but were not rated more novel or familiar. See the online article for the color version of this figure.

Bickel, 1999). The degree to which people discount future outcomes varies across individuals and contexts and may partially reflect a lack of emotional engagement with and inattention to the future (Appelt, Hardisty, & Weber, 2011; Radu, Yi, Bickel, Gross, & McClure, 2011; Weber et al., 2007). For example, people who report lower propensity to think about future outcomes exhibit larger delay discounting (Dassen, Houben, & Jansen, 2015; Jones, Landes, Yi, & Bickel, 2009; Petry, Bickel, & Arnett, 1998). And delay discounting is reduced by explicitly reminding people that choosing an immediate reward entails zero reward in the future (Read, Olivola, & Hardisty, 2016).

We have recently conducted several experiments demonstrating that orienting attention to future outcomes reduces delay discounting (Ramos, Mrkva, & Van Boven, 2019). Because delay discounting partly reflects lack of emotional engagement with the future (Hershfield et al., 2011) and because attention increases emotional engagement, attention should reduce delay discounting. In one experiment, we presented participants with 27 choices between a smaller immediate reward (e.g., \$30 now) and a larger future reward (e.g., \$85 in 7 days). Using the spatial cueing procedure described earlier, we cued people to attend to delayed alternative in 75% of trials (and to the immediate alternative in 25% of trials), to the immediate alternative in 75% of trials (and to the delayed alternative in 25% of trials), or to neither alternative. Cueing participants to attend to future outcomes reduced delay discounting relative to those who were cued to immediate outcomes and those who were not cued to either outcome. We replicated this pattern of results in a study involving nonmonetary choices between improved environmental outcomes (air quality) in the immediate present versus 1 year in the future (cf., Hardisty & Weber, 2009). These findings suggest that increasing attention to the future increases the relative value of the future.

Computational Models of Attention and Decisions

Several computational models have been proposed to predict people's choices as a function of their attentional patterns. These include the attentional drift diffusion model (aDDM; Krajbich et al., 2010; Krajbich, Lu, Camerer, &

Rangel, 2012; Krajbich & Rangel, 2011; Rangel & Clithero, 2014), decision field theory (Busemeyer & Townsend, 1993; Diederich, 1997; Roe, Busemeyer, & Townsend, 2001), and several others (Ashby, Jekel, Dickert, & Glöckner, 2016; Noguchi & Stewart, 2018). The aDDM (Armel et al., 2008; Krajbich et al., 2010; Krajbich & Rangel, 2011) posits that people accumulate more information about attended alternatives than unattended ones, which causes them to give relatively more weight to attended alternatives (Krajbich et al., 2010; Krajbich & Rangel, 2011). Decision field theory posits that fluctuations in attention to attributes is associated with how much those attributes are weighted (Busemeyer & Townsend, 1993; Diederich, 1997; Roe et al., 2001).

These computational models are consistent with many empirical findings. They predict that attention increases weight and perceived importance, for which there is both correlational (e.g., Fisher, 2017; Glöckner, Fiedler, Hochman, Ayal, & Hilbig, 2012) and experimental evidence (Mrkva & Van Boven, 2017). The aDDM makes the prediction that focusing attention on negative stimuli increases accumulation of negative information, which is consistent with studies showing that attending to negative alternatives such as aversive foods and high prices reduces evaluation and choice share (Armel et al., 2008; Fisher, 2017; Krajbich et al., 2012).

These computational models have considerable predictive power. However, they do not predict some empirical findings. The aDDM, for example, does not generate predictions about emotional intensity or evaluation so does not readily account for the findings that attention increases ratings of emotional intensity, risk severity, and other variables are important results that choice models appear to be agnostic about. Nor does the aDDM explain why attention influences some response dimensions such as emotional intensity and perceived severity of risks more than others, such as judgments of familiarity, liking, or perceived novelty of risks (Mrkva et al., 2019; Mrkva et al., 2019). Models such as the aDDM would also seem to predict that attending to positive objects would increase the likelihood of selecting them regardless of whether people are asked to choose the option they want to "reject" or "accept" (Shafir, Simonson, & Tversky, 1993), and regardless of whether they are asked to choose the option that

is least emotional or most emotional. This is because according to aDDM models, attention should lead people to acquire information consistent with the question being considered, such as whether to reject (not accept) an option of whether an object is less (not more) emotional. Yet we have found that manipulations of attention decrease the likelihood that options are chosen as less emotionally intense, less severe, and lower priority relative to a second unattended option (Mrkva & Van Boven, 2017; Mrkva et al., 2019; Mrkva et al., 2019). Finally, whereas most computational models assume that attention is random (an assumption with some support; Krajbich et al., 2010), others have demonstrated that attention is influenced by the relative value, relative importance, or emotionality of stimuli (Anderson, Laurent, & Yantis, 2011; Calvo & Lang, 2004; Cavanagh, Malalasekera, Miranda, Hunt, & Kennerley, 2019; Öhman, Flykt, & Esteves, 2001; Orquin & Mueller Loose, 2013; Towal et al., 2013).

There remains much additional work for computational models to both explain and predict the bidirectional relationships between attention, emotion, judgment, and decision making. Emerging experimental work on the causal effects of attention will be especially useful in this endeavor.

Attention Explains Mental Simulation

We suggest that attention can explain many effects of mental simulation. This is because mental simulation—imagining the episodic unfolding of what might happen, did happen, or could have happened—requires attention. As suggested earlier, one cannot imagine an interview, recall a vacation, or think about what one should have said in an argument without attending to those interviewers' questions, beaches and hotels, or witty verbal retorts. As we reviewed, attention enhances processing, enriches representation, intensifies emotion, increases prioritization, increases risk response, and reduces delay discounting. Because of these attentional effects, mere attention is a plausible interpretation for at least some of the consequences of mental simulation.

Note that the reverse is not true. That is, the effects of attention are not readily attributable to mental simulation. Mental simulation requires directing attention toward episodic events, the

moment to moment unfolding of occurrences over time. Attention, meanwhile, can be directed toward facts, abstract thoughts, or semantic memory—all without mental simulation (Schacter, Addis, & Buckner, 2007). As illustrated by the procedures discussed earlier, attention to objects can be manipulated without invoking simulation, because neither the attentional cueing procedure nor the attended objects lend themselves to simulation.

We consider some examples of how mental simulation effects may be partly caused by attention. Mentally simulating past and future events makes them seem more vivid, fluent, and prominent (Kappes & Morewedge, 2016; Mrkva et al., 2018). Attention to abstract images and objects enhances their vividness (Fuller & Carrasco, 2006; Tse, 2005). Simulating future events makes them more emotionally evocative and psychologically closer than past events (Caruso, Van Boven, Chin, & Ward, 2013; Van Boven & Ashworth, 2007). Attention to images intensifies emotional reactions to those images (Mrkva et al., 2019). Mental simulation can increase the value of the future (Daniel, Said, Stanton, & Epstein, 2015), as when simulating one's future self can increase prioritization of retirement savings and other long-term goals (Hershfield et al., 2018). Attention to future outcomes reduces delay discounting, consistent with placing increased value on the future (Radu et al., 2011). Mental simulation increases consumer prioritization; presenting consumer products in a way that facilitated mental simulation increased purchase intentions (Elder & Krishna, 2011). Attention to budget categories increases their prioritization (Mrkva & Van Boven, 2017). Mentally simulating risks can increase their perceived severity (Mevisse et al., 2009). Attention to environmental risks makes them more severe (Mrkva et al., 2019). In all of these cases, the effects of mental simulation may be due to attention.

There are, of course, many effects of mental simulation for which there is not (yet) an attentional counterpart. Mentally simulating better and worse alternative realities, upward and downward counterfactual worlds, lead people to experience disappointment, regret, relief, gratitude, and other counterfactual emotions (Markman et al., 1993; Roese, 1997). Mentally simulating other temporal, spatial, and social realities imbues them with meaning (Waytz,

Hershfield, & Tamir, 2015). Mentally simulating working through future events and challenging situations can increase success coping mechanisms, arguably by facilitating problem solving (Taylor et al., 1998). There is not yet empirical evidence that mere attention would produce similar effects.

Researchers have also manipulated components of mental simulation orthogonal to attention, such as whether the event is simulated from a first-person or third-person visual perspective (Libby & Eibach, 2011), whether the event is easy or difficult to imagine (Sherman et al., 1985), and whether the simulation pertains to a future event or a past event such as a counterfactual (Ferrante, Giroto, Stragà, & Walsh, 2013).

We do not mean to imply that attention can explain all the effects of mental simulation. We do, however, mean to imply that attention largely explains the magnitude of mental simulation effects. Differentiating the unique contributions of attention and mental simulation is an important task for future work.

Conclusion

Attention profoundly shapes experience, emotion, judgment, and decision making. The act of attending to an object makes it seem more vivid, emotionally evocative, and important. People are more likely to prioritize things to which they are made to attend. At least three broad mechanisms account for attention's impact: attention enhances the signal elicited by stimuli, attention reduces the influence of noise and distractions in the environment, and attention improves memory. Partly as a result of these processes, attention intensifies emotional experience. Together, these effects on processing, experience, and emotion lead attention to increase the weight of attributes and emotions in judgment and decision making. Computational models offer increasingly comprehensive and sophisticated, yet still incomplete, characterizations of how attention influences decisions.

Many open questions remain, of course, about the nature and consequences of attention, emotion, judgment, and decision making—and the degree to which these effects explain mental simulation. Do different attention processes explain why attention intensifies emotion, why attention influences perceptual choices, and

why attention increases prioritization? Or do the same processes underlie each effect to equal degree? How can these multiple processes be integrated in computational models? What is the time course of attentional effects? Are the intensifying effects of attention transient or long-lasting? Are the effects of attention stimulus-bound, or do they generalize to similar stimuli? For example, does reducing delay discounting by attending to simple options in a choice takes lead people to value the future more when making retirement savings decisions? These questions are just the beginning of a comprehensive integration of the science of attention, emotion, experience, and behavior.

The research reviewed here implies that merely attending to future events, actual events, alternative pasts, other people, and successful navigation of challenges should increase the vividness, proximity, emotional intensity, prominence, and weight of simulated attributes. Attention is a plausible contributing factor to the effects of mental simulation. Directly testing these possibilities and differentiating attention and simulation is an important task to advance understanding of everyday experience of consciousness and behavior.

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