Examining the association between anxiety and attentional engagement in the context of COVID-19 public service announcements

By

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Public service announcement (PSA) effectiveness depends on both message features and audience characteristics. Yet, few studies have systematically examined theorized predictors of effectiveness, and none has combined self-report with eye-tracking to assess engagement with custom-constructed COVID-19 PSAs. The present study used self-report and eye-tracking data from the Canadian COVID-19 Experiences Project (CCEP) to examine whether baseline anxiety predicted engagement with COVID-19 PSAs and whether behavioral focus (masking, vaccination, hand hygiene, distancing) moderated this relationship. Temporal bridging and vividness factors were also examined as secondary analyses. Self-report (n = 120) and eye-tracking data (n = 101) were analyzed using confirmatory factor analysis and linear mixed-effects models; primary models involving baseline anxiety used 116 participants with complete GAD-7 data. Findings indicated that a two-factor model distinguishing self-report and physiological engagement fit significantly better than a one-factor model ($\Delta\chi^2(1) = 28.39$, $p <$ .001), suggesting related but distinct aspects of engagement. Contrary to the primary hypothesis, baseline anxiety did not show a reliable overall main effect across outcomes. However, behavioral focus moderated several self-report outcomes. Notably, the positive association between anxiety and subjective engagement was attenuated for vaccination PSAs ($\beta = -0.013$, p = .041). Secondary analyses showed that vividness was strongly associated with higher self-reported engagement in the vaccination subset, and that this relationship was stronger among more anxious participants for the self-report factor score ($\Delta\chi^2(1) = 5.73$, p = .017). Temporal bridging, however, did not meaningfully influence engagement. Overall, anxiety appears to be associated with subjective responses to COVID-19 PSAs depending on message characteristics, while corresponding eye-tracking differences were less apparent.

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List of Abbreviations

Abbreviation	Definition
ACT	Attentional Control Theory
AIC	Akaike Information Criterion
BDEFS	Barkley Deficits in Executive Functioning Scale
CCEP	Canadian COVID-19 Experiences Project
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CI	Confidence Interval
EEG	Electroencephalography
EPPM	Extended Parallel Process Model
FIML	Full Information Maximum Likelihood
GAD-7	Generalized Anxiety Disorder-7
GSR	Galvanic Skin Response
HRV	Heart Rate Variability
ICC	Intraclass Correlation Coefficient
LRT	Likelihood Ratio Test
MAR	Missing at Random
MCAR	Missing Completely at Random
MLR	Maximum Likelihood with Robust standard errors
PET	Processing Efficiency Theory
PSA	Public Service Announcement
REML	Restricted Maximum Likelihood

Abbreviation	Definition
ROI	Region of Interest
RMSEA	Root Mean Square Error of Approximation
SRMR	Standardized Root Mean Square Residual
TLI	Tucker-Lewis Index

Introduction

Following the Second World War, the United States began using public service announcements (PSAs) to raise awareness of important social issues and influence beliefs, attitudes, and behaviors (DeJong, 2017). In more recent decades, PSAs have remained an important tool for promoting health, including efforts to limit the spread of infectious diseases and encourage healthy behaviors (Tait et al., 2022; Wakefield et al., 2010; Zhang et al., 2014). PSAs vary in both their mode of delivery and message framing (Ghio et al., 2021; Manganello et al., 2020), and the rise of the internet and social media has made them easier to create and disseminate with relatively little infrastructure or specialized skill (Manganello et al., 2020). In digital settings, audience responses to PSAs—such as likes, shares, and comments—may reflect one form of engagement with health communication, although their relationship to broader message effectiveness depends on campaign design and the outcomes being measured (Kite et al., 2023). More broadly, message features such as temporal framing and vividness can influence how audiences engage with public health PSAs and how persuasive they find them (Noar et al., 2016; Tannenbaum et al., 2015; Wang et al., 2024). Effective PSA campaigns therefore depend not only on message design, but also on the extent to which theory-based content is suited to the target audience and linked to broader programs, services, or policy efforts (DeJong, 2017). This thesis focuses on the design and engagement effects of PSAs in the context of the COVID-19 pandemic.

Research on COVID-19-specific PSAs has shown that they can increase compliance with public health advice and that their effects depend on both message features and audience characteristics. For example, Greene et al. (2022) found that nonpolitical messages can encourage COVID-19 mitigation behaviors, such as masking, in both naturalistic and

experimental contexts. Dennis et al. (2021) showed that tailoring COVID-19 PSAs to match audiences' personal identities, such as religiousness or economic motivation, can increase compliance with public health advice. Fridkin et al. (2024) likewise demonstrated that different professionally developed, publicly disseminated PSAs can affect audiences with different political and psychological dispositions in different ways; emotional, informational, and humorous PSAs can elicit distinct emotional responses, promote different levels of learning, and differentially influence attitudes toward mitigation behaviors such as vaccination. Furthermore, the framing used by public health institutions can have profound downstream effects. For instance, Böhm et al. (2026) demonstrated that a specific shift in CDC communication—from consensus-based to uncertainty-based messaging on the vaccine-autism link—reduced vaccination intentions, eroded institutional trust, and increased endorsement of science-denial reasoning among US adults. Together, these studies show that message features and audience characteristics can interact in complex ways to shape PSA effectiveness in the COVID-19 context. However, because most publicly available COVID-19 PSAs were designed for public dissemination rather than experimental control, it is unclear whether they varied systematically in specific message features such as vividness.

The Canadian COVID-19 Experiences Project (CCEP; Hall et al., 2022) offers an opportunity to address this gap: its custom-constructed COVID-19 PSAs explicitly vary in message features, and the project includes multimodal measurement of PSA engagement through self-report and eye-tracking, as well as relevant audience variables such as anxiety, making it well suited to examine how message features influence engagement with PSAs.

The primary purpose of this thesis was to examine engagement with COVID-19 PSAs as a function of generalized anxiety using both self-report and eye-tracking data. This thesis also

examined whether message features, including behavioral focus, temporal bridging, and vividness, shaped engagement. The following background section describes engagement with PSAs, the role of message features and audience characteristics, multimodal approaches to measuring engagement, the relationship between anxiety and engagement, and the rationale and objectives of the present study.

Background

Public service announcements and engagement

In communication research, engagement is often conceptualized as a multi-component outcome that can be used to evaluate community health messaging (Brooks et al., 2024; Perski et al., 2017). As an umbrella construct, engagement with a message encompasses attention, cognitive and affective evaluation, motivation, and a sense of connection to the message content (Perski et al., 2017). Public service announcement (PSA) campaigns are often judged by the degree to which they successfully engage audiences, making engagement both a proximate outcome and a possible pathway to subsequent behavioral change (Wakefield et al., 2010; Brooks et al., 2024). In the context of COVID-19, content analyses show that PSAs vary widely in their design features, underscoring the importance of examining how message framing and salient or emotionally resonant elements may shape audience engagement (Tait et al., 2022; Wakefield et al., 2010). Taken together, these perspectives position engagement as a central criterion for assessing PSA impact and encourage closer examination of how specific message features and audience characteristics influence engagement in the present thesis.

Why engagement matters: message features and audience characteristics

The influence of time-related message features on PSA effectiveness has been documented in the temporal framing literature and is predicted by established frameworks in health communication. Notably, meta-analyses investigating the effects of temporal framing in health messaging reveal that messages emphasizing more proximal consequences show a small average advantage over those emphasizing more distant outcomes (Huang & Xu, 2024; Wang et al., 2024). In the CCEP and the present thesis, PSAs were manipulated based on temporal bridging; that is, whether a PSA explicitly linked the recommended behavior to longer-term

consequences or not. Experimental work shows that framing health risks in "day" rather than "year" terms can increase perceived risk and precautionary intentions, in line with the idea that nearer, more concrete consequences are weighted more heavily in judgment (Chandran & Menon, 2004). These findings align with theoretical accounts such as hyperbolic discounting and construal level theory, which propose that people prioritize proximal outcomes and process them more concretely than distal ones (Ainslie, 2020; Trope et al., 2007). At the same time, existing evidence indicates that temporal framing effects are often small and context-dependent (Huang & Xu, 2024; Wang et al., 2024). Accordingly, temporal bridging was treated as a secondary analysis in this thesis.

Vivid, as opposed to more information-focused, health messages often include rich imagery, emotional salience, and contextual details that make a message concrete and compelling to the recipient (Block & Keller, 1997). Such messages can capture audience attention (e.g., by drawing visual attention; Brosch et al., 2008) and encourage adaptive behavior (e.g., more vivid graphic tobacco warning labels increase engagement and quit intentions; Ophir et al., 2019), but their overall effectiveness may hinge on audience factors (e.g., self-efficacy; Block & Keller, 1997), message content (e.g., level of threat; Blondé & Girandola, 2018) and other design features (e.g., argument quality; Myers, 2014). Importantly, Block and Keller (1997) noted that vivid health messages tend to be perceived as more effective when individuals believe they can carry out the recommended behavior. This pattern is consistent with the Extended Parallel Process Model (EPPM), which suggests that health messages are most persuasive when they communicate a meaningful threat while also conveying strong efficacy information (Witte, 1992; Witte, 1994). In the present thesis, these ideas are most directly relevant to the distinction between PSA behavioral focus and perceived control over the

recommended behavior. Accordingly, it was hypothesized that vivid PSAs would elicit greater engagement than their non-vivid counterparts. Behavioral focus was therefore treated as the primary message-level moderator, whereas vividness was treated as a secondary moderator, examined using the subset of PSAs in which a vivid versus non-vivid contrast was available.

Fear appeals are often used in PSAs and can capture audience attention, but they are not necessarily effective in encouraging adaptive behaviors (Qian et al., 2025; Kessels et al., 2014; Stolow et al., 2020). Some audiences may even show active avoidance of threatening health warnings on cigarette packaging (Maynard et al., 2014). Meta-analyses indicate that fear appeals are most likely to motivate risk-reduction behaviors when they combine high perceived threat with strong efficacy information, including clear, specific instructions and a sense that the threat is personally relevant (Peters et al., 2013; Ruiter et al., 2014; Tannenbaum et al., 2015). Otherwise, audiences may engage in maladaptive fear-control response, such as avoidance or denial (Ruiter et al., 2014). This pattern is congruent with the EPPM, which posits that threatening messages promote danger-control responses (behavior change) only when audiences believe they can successfully carry out the recommended actions (Witte, 1992). In the context of the present thesis, this framework suggests that engagement with COVID-19 PSAs may differ depending on the behavioral focus of the PSA and the extent to which the recommended behavior feels personally immediate and controllable. This distinction was grounded in the degree of direct personal agency involved in carrying out the recommended behavior. Behaviors such as masking and hand hygiene are typically self-initiated and can be implemented immediately by the individual, whereas vaccination is more dependent on health-system access and logistical conditions (Kuehn et al., 2022), and distancing may be constrained by social, occupational, and environmental circumstances (Coroiu et al., 2020).

The characteristics of PSA audiences may also play a role in whether they pay attention to and are persuaded by public health PSAs. For instance, social and educational factors can create communication inequalities that reduce one's ability to attend to and process health information (Viswanath & Emmons, 2006), while health literacy may determine whether one correctly comprehends health information and recognizes one's own susceptibility to health threats (Paasche-Orlow & Wolf, 2007). Psychological factors, such as reactance and cognitive functioning, can likewise shape how people attend to and evaluate PSAs. Rains' (2013) findings suggest that individuals high in reactance are less likely to accept persuasive messages and may engage in avoidant behaviors, while research on working memory shows that individuals with working-memory constraints may struggle to control their attention and, in turn, process and respond to health messages effectively (Luo et al., 2017; Dijkstra & Elbert, 2019; Fisher et al., 2018). Among these individual-difference predictors, temperamental anxiety is especially relevant because attentional processing of threat is a core feature of anxious cognition, rendering it a useful lens for understanding how audiences may respond differently to threatening PSA content (Bar-Haim et al., 2007).

Measuring engagement: self-report and eye-tracking

A multimodal approach is useful for evaluating public health PSAs because different aspects of message processing may be captured by different measures. According to capacity-based models of mediated processing, media messages draw on limited cognitive resources, meaning that different components of processing may be reflected in different outcomes (Lang, 2000). Related work in psychophysiology and consumer neuroscience likewise suggests that physiological and neurophysiological measures can index cognitive and emotional processes that may not be fully accessible through self-report alone (Potter & Bolls, 2012; Venkatraman et al.,

2015). It is equally plausible, however, that self-report judgements take into consideration nuanced mental processing beyond that gleaned from eyetracking alone, making subjective dimensions important to consider in assessments of media engagement. Taken together, these perspectives support the use of a multimodal framework for examining how audiences engage with PSAs.

Prior multimodal studies illustrate how physiological and neurophysiological measures have been used to evaluate PSA responses. For example, Cartocci et al. (2018) investigated young viewers' (n = 39) responses to antismoking PSAs using electroencephalography (EEG), galvanic skin response (GSR), heart rate (HR), and eye-tracking measures. Their findings showed that different neurophysiological patterns were associated with PSAs that differed in the adaptive responses they prompted among the general public (e.g., changes in ambulatory visits for smoking cessation; see Cartocci et al., 2018). Falk et al. (2016) used functional magnetic resonance imaging (fMRI) to show how neural activity in smokers' medial prefrontal cortex during exposure to antismoking messages can predict whether the same messages will succeed at the population level. Similarly, Langleben et al. (2009) used fMRI to show that vivid PSAs can shift processing toward occipital visual processing regions and affect PSA learning and recall. Alptekin et al. (2024) likewise found that Turkish participants (n = 69) responded differently at neurometric (EEG) and biometric levels (GSR, eye-tracking) to COVID-19 PSAs using different rhetorical strategies. Other related studies on public health PSAs (Imhof et al., 2020; Brigaud et al., 2021) provide further evidence that physiological markers, such as eye movement, can serve as indicators of audience engagement with PSAs. Overall, these studies show that researchers can leverage both traditional self-report measures and physiological indicators to more fully examine how audiences respond to public health PSAs.

Whether self-reports of engagement and physiological indices of engagement capture the same construct is itself an empirical question that needs to be addressed. Evidence from multimodal studies suggests that each modality captures partly distinct components of message processing, with subjective ratings indexing conscious evaluations (e.g., perceived effectiveness, liking) and eye-tracking metrics indexing the moment-to-moment allocation of visual attention that may influence downstream choices or intentions (Kessels & Ruiter, 2012; Bol et al., 2016; Sillero-Rejon et al., 2021). Both approaches, however, are subject to significant biases. Self-report is vulnerable to social desirability pressures, demand characteristics (Van de Mortel, 2008), and limited introspective access; that is, people often lack conscious access to the mental processes that actually drive their judgments and behavior, so a self-reported rating may not accurately reflect the automatic or affective processes engaged while viewing a PSA (Nisbett & Wilson, 1977). Meanwhile, eye-tracking indices may be disproportionately influenced by low-level visual salience (Dziemian et al., 2024), display layout, and data-quality limitations, such as calibration drift, blinks, or head movement that reduce the precision of fixation and gaze-duration estimates (Orquin & Mueller Loose, 2013; Holmqvist et al., 2011). As such, the present thesis examines the degree of convergence between subjective and physiological indices of engagement within a multimodal framework, using COVID-19 PSAs as the test case.

Anxiety, engagement, and PSA message features

Anxiety may be a relevant individual characteristic for understanding engagement with PSAs, and examining it may help strengthen the evidence base for how audience differences shape message processing. Extensive research shows that anxious individuals are prone to attentional biases toward threat cues and emotionally salient stimuli, and that such biases can occur in both clinical and subclinical anxiety (Bar-Haim et al., 2007; Goodwin et al., 2017; Shi et

al., 2019). Current cognitive models suggest that the physiological arousal associated with generalized anxiety can increase bottom-up processing of threatening stimuli and reduce top-down attentional control (Sarapas et al., 2017). In addition, the attention maintenance model suggests that anxious individuals may have difficulty disengaging from threat, which could lead them to orient more quickly to threatening PSA content and sustain attention to it for longer periods (Fox et al., 2001). In the context of public health PSAs, these models suggest that anxious individuals may pay greater attention to PSAs containing threatening segments while also being more vulnerable to disengagement or avoidance under certain message conditions. PSAs that use controlling or autonomy-threatening wording may provoke reactance and reduce initial engagement (Lienemann & Siegel, 2016), and anxious individuals may purposefully avoid PSAs that cause distress (Sweeny et al., 2010) or amplify uncertainty (Dugas et al., 1998). Taken together, anxiety and PSA attention are likely to interact in ways that depend on message composition.

Anxiety may also shape engagement physiologically. For instance, research suggests that heart rate variability (HRV) is associated with anxiety-related differences in attentional control, with lower resting HRV often linked to less efficient regulation of threat-related attention (Chalmers et al., 2014; Gillie & Thayer, 2014; Cheng et al., 2022; Forte et al., 2021). Eye-tracking research likewise shows significant relations between anxiety symptoms and both reflexive orienting toward threat and sustained attention to threatening stimuli (Clauss et al., 2022; Armstrong & Olatunji, 2012; Bar-Haim et al., 2007). This bias has also been observed among healthy individuals with higher levels of trait anxiety (Veerapa et al., 2020). These patterns suggest that anxiety may shape how audiences visually engage with PSAs in ways that are not fully captured by self-report alone. Consequently, physiological indices may provide a

useful complement to subjective engagement ratings when examining anxiety and PSA processing.

In the context of COVID-19, anxiety-related attentional biases toward threat may partly reflect COVID-specific fear and worry. Converging models of threat processing suggest that biased attention is most likely when a stimulus matches an individual's current concerns, and COVID-related fear has been linked to preferential attention to virus-related cues and contamination information (Bar-Haim et al., 2007; Cisler & Koster, 2010; Hirsch et al., 2011; Albery et al., 2021; Cannito et al., 2020; Zhao et al., 2023). Greater perceived risk and fear of COVID-19 are also associated with the adoption of preventive behaviors (Dryhurst et al., 2020; Harper et al., 2021). At the same time, generalized anxiety reflects a broader dispositional tendency to perceive the world as threatening and may therefore represent a meaningful marker of vulnerability to threat-related attentional biases even in the absence of a direct measure of COVID-specific fear (American Psychiatric Association, 2022). From this perspective, generalized anxiety provides a theoretically grounded way to examine individual differences in engagement with COVID-19 PSAs, while acknowledging that COVID-specific fear may represent one pathway through which such effects arise.

Current gaps and the present study

In summary, there has been extensive research on the effects of message framing on engagement with public health PSAs. Related work in psychophysiology also suggests that anxiety-related attentional biases may influence how anxious individuals respond to threatening health messages. However, a gap remains in the literature with respect to directly linking generalized anxiety to engagement with COVID-19 PSAs. Multimodal studies of COVID-19 PSA engagement are also relatively limited (e.g., Alptekin et al., 2024), and few studies have

explicitly tested how message features may shape attentional engagement among individuals with different levels of anxiety. The Canadian COVID-19 Experiences Project (CCEP; Hall et al., 2022) offered a unique opportunity to address this gap. Hall et al. (2022) conducted both a population survey (Study 1) and a laboratory study (Study 2) to evaluate the effectiveness of custom-developed COVID-19 PSAs and identify social- and neuro-cognitive predictors of COVID-19 mitigation behaviors. In Study 2, Hall et al. (2022) used eye-tracking, brain imaging, and four self-report rating items to assess responses to the PSAs. These ratings included liking, engagement, motivation, and self-reflection. The PSAs were purpose-built for the CCEP and differed in their thematic contents, including temporal bridging, normative strategy, vividness, behavioral focus, and affect (see Appendix B for details). For example, temporal bridging was operationalized by appending a sentence emphasizing the future-oriented consequences of the recommended behavior (e.g., "Although you may experience some short-term side effects, the vaccine will nearly eliminate your chance of serious illness or death"; see Appendix D for sample PSA scripts). Each thematic category was quantified as a binary stimulus-level design code (e.g., "vivid" versus "non-vivid") based on the PSA production criteria described in Appendix B (see Appendix C for examples). Participants' generalized anxiety was also assessed using the GAD-7 (Spitzer et al., 2006). By leveraging both self-report and eye-tracking data, the present thesis examined how generalized anxiety relates to patterns of PSA engagement, with behavioral focus treated as the primary message-level moderator.

In a preliminary analysis of the population survey data from CCEP Study 1 (Hudson et al., 2023), few reliable effects emerged with respect to how participants subjectively rated PSAs across thematic categories. However, because participants in the CCEP were not explicitly asked to rate the PSAs on the intended thematic dimensions (e.g., "Would you consider this message

vivid"), these preliminary results cannot be taken as conclusive evidence that the thematic manipulations failed. Although temporal bridging and vividness were built into the PSAs a priori based on prior literature, these two thematic categories were treated as secondary in the present study because effects of temporal framing are modest and inconsistent, and because vividness was only manipulated in a subset of stimuli, limiting it to a secondary analysis. Behavioral focus was prioritized as the primary message-level moderator because it was systematically varied across the experimental PSAs—each of the four behavioral focus categories (masking, vaccination, hand hygiene, distancing) appeared across the full set of 32 vivid experimental PSAs in combination with every other thematic manipulation (temporal bridging, normative strategy, affect), rather than being confounded with any one of them—and most directly aligned with the central question of how anxiety relates to attentional engagement.

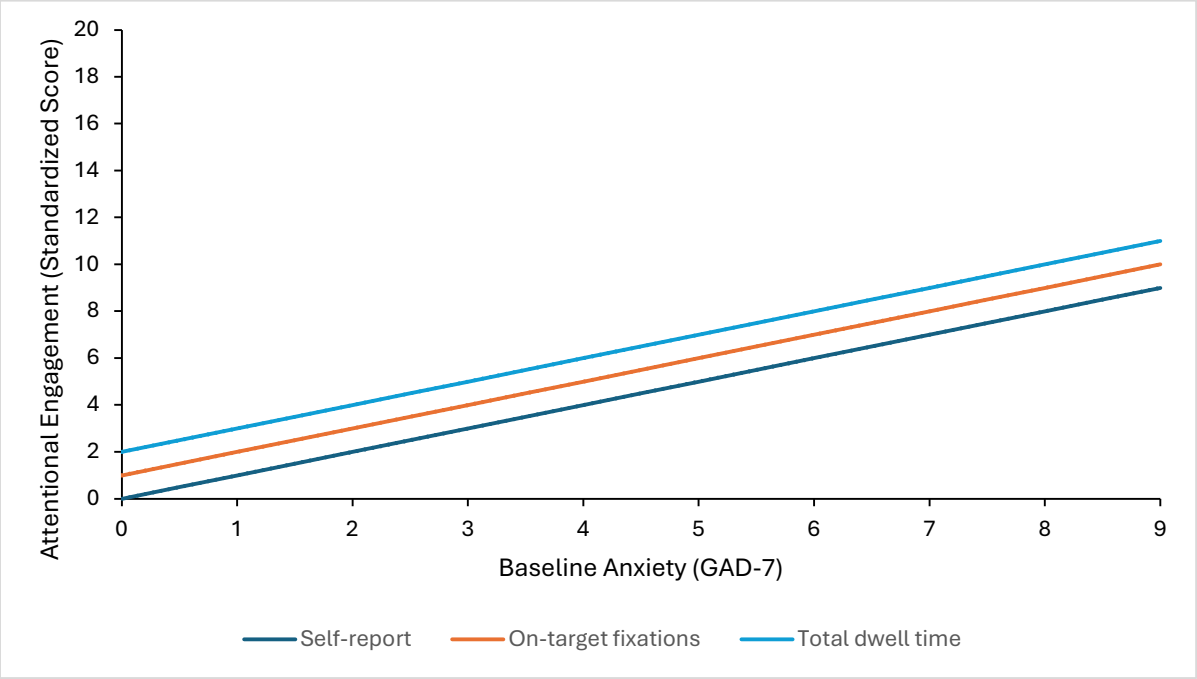
The present study aimed to leverage both self-report and eye-tracking data from the CCEP to examine whether baseline anxiety (assessed using GAD-7 scores) predicts engagement with custom-developed COVID-19 PSAs and whether this association is moderated by the recommended behavior emphasized in the PSA (i.e., masking, vaccination, hand hygiene, and distancing), which differ in their perceived personal immediacy and controllability. This study also examined differences in engagement for PSAs that varied in temporal bridging and vividness, and whether these factors moderated the anxiety–engagement relationship (the latter evaluated exclusively within vaccination-themed PSAs). The thesis further evaluated whether self-report and physiological outcomes represented a single latent factor or two separate factors (subjective and physiological) by conducting a confirmatory factor analysis (CFA), and explored differences between self-report and physiological outcomes of attentional engagement. In this thesis, attentional engagement was operationalized broadly as engagement with PSAs,

encompassing both initial visual attention and downstream components of message engagement (e.g., motivational impact). Participants' post-PSA self-report ratings served as the primary subjective indicators of engagement, while eye-tracking data provided complementary physiological indicators of attentional allocation during PSA viewing. The number of on-target fixations during PSA viewing served as the primary physiological indicator, and total dwell time served as the secondary physiological indicator. Together, these outcomes were used to examine how anxiety may shape attention and engagement with public health messaging and, in turn, inform message design and implementation.

Based on prior theory and empirical findings, it was hypothesized that higher baseline anxiety would be associated with higher attentional engagement with COVID-19 PSAs at both the physiological and self-report levels. Specifically, higher anxiety was expected to be associated with greater visual attention to PSA target areas (i.e., more on-target fixations and longer dwell time) and higher self-report ratings of attentional engagement (see Figure 1). Moreover, it was hypothesized that behavioral focus would moderate the anxiety–engagement relationship. Specifically, the anxiety–engagement relationship was expected to be stronger for PSAs that focus on behaviors that were more personally immediate and controllable (i.e., masking and hand hygiene) (see Figure 2).

Figure 1

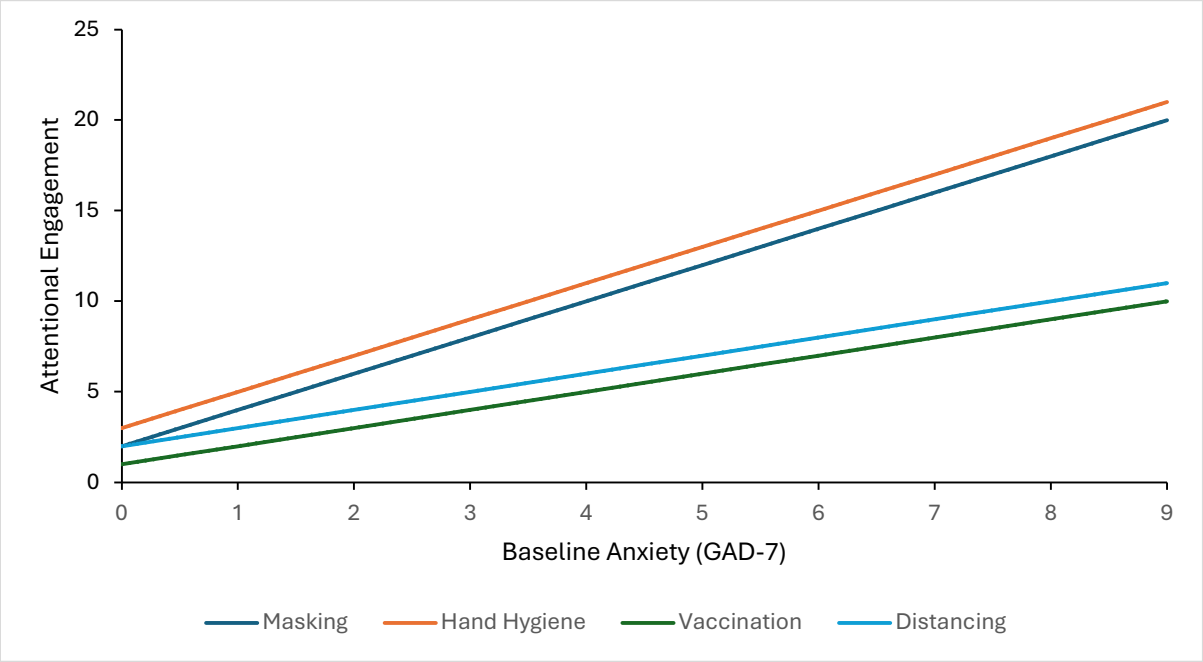
Hypothesized Relationships between Baseline Anxiety and Attentional Engagement



Note. Depiction of how baseline anxiety may be correlated with both self-reported attentional engagement towards COVID-19 PSAs and physiological indices of engagement (i.e., on-target fixations, total dwell time).

Figure 2

Moderating Effects of PSA Recommended Behavior on Attentional Engagement toward COVID-19 PSAs



Note. Depiction of how PSAs that emphasized more personally immediate and controllable behaviors (i.e., masking and hand hygiene) may be correlated with greater attentional engagement than PSAs that emphasized less personally immediate and controllable behaviors (i.e., vaccination and distancing).

A secondary hypothesis, tested using the 32 experimental PSAs that varied in temporal bridging, was that PSAs making long-term benefits salient (i.e., temporally bridging) would elicit greater self-reported and eye-tracking engagement than PSAs without this framing. A further secondary hypothesis, tested using the subset of vaccination-themed PSAs for which a vivid and non-vivid version existed, was that vivid PSAs would elicit greater self-reported and eye-tracking engagement than their non-vivid counterparts.

Methods

CCEP Study 2 Dataset

Study 2 of the CCEP implemented a within-subjects randomized experimental design, with stimulus order counterbalanced across participants using a Latin-square. In the study, Hall et al. (2022) recruited 120 participants (female n = 76) aged 18–84 (M = 32.0, SD = 20.7) with normal (or corrected-to-normal) vision and English proficiency. Participants with neurological disorders were excluded. All participants were fully vaccinated against COVID-19 (a minimum of two doses) at the time of data collection, per study eligibility criteria (and campus requirements at the time). The wide age range in this sample (18–84) extends somewhat the 18–65 range originally proposed (Hall et al., 2022). The age distribution was bimodal because of recruitment logistics, given that participants were recruited from the undergraduate student body (most of whom were 18-24 years) and participants in an aging research pool, which imposed a minimum age of 60 years. As such, the majority of participants were young adults aged 18–24 (n = 76), a further 20 were aged 25–34, a small number between 35 and 64 (n = 3), and a moderate group of older adults 67–84 years (n = 21). In terms of education, 28.3% (34 of 120) of participants had a high school degree, 30% (36 of 120) had technical/trade school or some university education, 25.8% (31 of 120) had a university degree, and 15% (18 of 120) had a post-graduate degree.

Beyond the general demographic characteristics above, participants also reported vaccination and mitigation behavior characteristics. Beyond the two-dose eligibility minimum, 79% (94 of 119 respondents to this item) had already received a third dose at the time of participation. Approximately 42% (49 of 117) of the respondents reported having been infected with SARS-CoV-2 at some point, 62% describing their illness as “not at all” or “slightly” severe

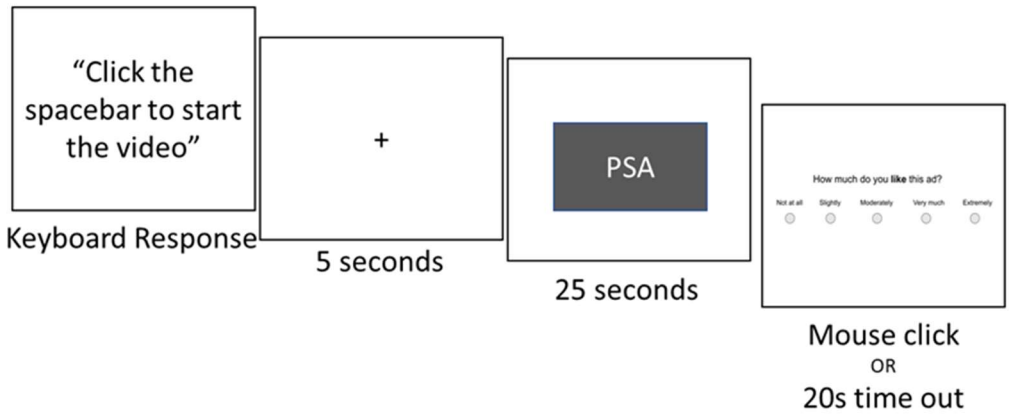
(28 of 45), with 77% of infections (37 of 48) having occurred within the 6 months preceding the survey. Baseline compliance with the four mitigating behaviors targeted by the PSAs (masking, hand hygiene, distancing, and vaccination) was generally high: 95% (112 of 118) reported mask-wearing compliance of "most of the time" or better, 92% (109 of 119) reported comparably high distancing compliance, and 83% (98 of 118) reported comparably high hand-washing compliance.

Throughout the study, participants viewed 32 25-second PSAs that varied across 8 thematic combinations (normative/not normative; presence/absence of temporal bridging; positive/negative; see Appendix B) in their depiction of four mitigation behaviors (masking, hand hygiene, vaccination, distancing). Participants also viewed eight additional "control" vaccination PSAs that reflected the 8 thematic combinations present in the "experimental" PSAs but were designed to be non-vivid. Vivid PSAs featured full-color imagery, background music, and emotionally salient images, whereas non-vivid PSAs were monochromatic, lacked background music, and presented information more neutrally (see Appendix C for details). These non-vivid PSAs were constructed a priori specifically to enable a test of vividness's effect on engagement, based on the hypothesis that vivid PSAs would be more engaging than non-vivid PSAs (Hall et al., 2022). The order in which each participant viewed the 40 PSAs was randomized using a Latin square design. The present study focused on the 32 "experimental" PSAs for the confirmatory analyses. In Study 2, each PSA was presented sequentially, and participants rated their engagement using four items after each PSA was shown (Figure 3). After the 10th, 20th, and 30th PSA, participants completed the Flanker task, a delay-discounting task, and a simple reaction-time task, respectively. Participants also underwent fNIRS and eye-tracking during PSA viewing. Here, changes in oxygenated hemoglobin (OxyHb) concentrations

in the dorso- and ventro-medial prefrontal cortex were used to index self-relevance and evaluative processing, while the number of on-target eye fixations indexed attentional capture for each PSA. In addition, all participants reported their generalized anxiety levels and completed the BDEFS Self-Restraint subscale. fNIRS data were collected as part of the broader CCEP protocol but are not examined in the present thesis.

Figure 3

Sample Trial of a PSA in CCEP Study 2



Note. Participants pressed the spacebar on the computer keyboard to initiate the trial. Each trial began with a blank screen with a fixation point that lasted 5 seconds. Each PSA was then presented for a duration of 25 seconds. PSAs were shown in the center of the screen surrounded by blank space on each side. After each PSA, participants responded to the following 4 questions: "How much did you like this ad?", "How engaging was this ad?", "How motivating was this ad?", "How much did this ad make you self-reflect?". Each question was presented sequentially after participants made a response to the prior question or after the question timed out after 20 seconds.

Measures

Baseline Anxiety

The primary predictor in the present study was baseline anxiety, assessed using the Generalized Anxiety Disorder-7 (GAD-7; Spitzer et al., 2006). The scale has shown good internal consistency (Cronbach $\alpha = .92$) as well as criterion and construct validity (Spitzer et al., 2006). Participants were asked about the frequency with which they experienced symptoms of anxiety within the past two weeks. Responses were scored from 0 to 3, and each participant's anxiety level was indexed by the sum of all items, yielding a possible range from 0 to 21. In clinical practice, scores of 5, 10, and 15 are commonly interpreted as mild, moderate, and severe anxiety, respectively, while a score of 10 or higher is typically used as a clinically significant cutoff for GAD (Spitzer et al., 2006). It is worth distinguishing the construct assessed here from related but conceptually different forms of anxiety. State anxiety refers to a transient, situationally triggered experience of anxious arousal lasting minutes rather than weeks (e.g., how anxious a participant feels while viewing a given PSA), whereas the GAD-7 asks participants to report the frequency of anxiety symptoms over the preceding two weeks, making it an index of a more stable, trait-like tendency toward anxious symptomatology rather than a momentary state. The GAD-7 is also distinct from a categorical clinical diagnosis of Generalized Anxiety Disorder. Although a score of ≥ 10 or higher on the GAD-7 can be used as a screening threshold, in raw score form, the scale yields a dimensional index of symptom frequency rather than a diagnostic classification, and the majority of the present sample scored below this threshold ($M = 5.28$, $SD = 5.24$; see Results). In the present study, GAD-7 scores were used dimensionally because attentional biases toward threat can be observed in both clinically and non-clinically anxious individuals (Bar-Haim et al., 2007).

Self-reported Attentional Engagement

Participants were asked to rate their responses to each COVID-19 PSA using four self-report items: 1) “How much did you like this ad?”, 2) “How engaging was this ad?”, 3) “How motivating was this ad?”, 4) “How much did this ad make you self-reflect?”. These items were treated as subjective indicators of engagement with the PSAs and were scored on a five-point scale ranging from “not at all” to “extremely” (see Appendix A).

Physiological Indicator of Attentional Engagement: Eye Movement

Participants underwent eye-tracking during PSA viewing. Gaze location was sampled at 60 Hz using a Tobii Spectrum eye tracker positioned below a flat-panel display approximately 70 cm from each participant. Each PSA was presented at the center of the screen and surrounded by digital blank area (frame). The PSA display area was treated as the region of interest (ROI), and the surrounding grey frame was considered off-target. The eye-tracking system registered all fixations in real time, both within and outside of the ROI. In the present study, “on-target” was defined as gaze directed anywhere within the PSA display area itself, whereas gaze falling within the surrounding grey frame was treated as off-target. The display operated at a resolution of 1920 × 1080 pixels—the standard monitor configuration for the Tobii Spectrum—and the PSA was presented at its native resolution of 640 × 360 pixels, occupying the central third of the display in both width and height. The surrounding two-thirds of the display constituted the off-target grey frame. The number of on-target fixations served as the primary physiological indicator of attentional engagement, and total dwell time within the PSA display area served as the secondary physiological indicator.

Baseline Cognitive Functioning

Participants also completed three brief cognitive tasks used as covariates in subsequent models. The Flanker task assessed selective attention and inhibitory control (Eriksen & Eriksen, 1974). Participants identified a central target letter flanked by congruent or incongruent "noise" letters, and an interference score (mean reaction time on incongruent minus congruent trials) indexed behavioral inhibition, with larger scores reflecting poorer inhibitory control. A delay-discounting task assessed impulsivity by asking participants to choose between smaller immediate rewards and larger delayed rewards across a series of trials; responses were converted to *k* values (log-transformed for analysis), with higher values reflecting a stronger tendency to discount delayed rewards (Koffarnus & Bickel, 2014). A simple reaction-time task provided a basic index of processing speed. Participants also completed the BDEFS Self-Restraint subscale, a self-report measure of everyday lapses in behavioral inhibition and impulse control (Barkley, 2011). These indices of baseline executive functioning and impulsivity were included as covariates because individual differences in inhibitory control and self-regulation could independently shape how participants processed and responded to time-limited PSA content, regardless of their level of anxiety. Controlling for them could, in theory, help to isolate the association between anxiety and attentional engagement from these baseline cognitive differences.

Preprocessing of the Dataset

Preprocessing of the CCEP Study 2 dataset was completed prior to the present analyses. Participants with low-quality gaze data, identified during preprocessing using an eye-tracking usability flag (n = 19), were excluded from all eye-tracking analyses but retained for self-report analyses. Participants were flagged if the eye tracker failed to register any on-target gaze (i.e., zero on-target dwell time and zero on-target fixations) in a substantial proportion of their 40 PSA

trials. This pattern was considered consistent with tracking loss resulting from poor calibration, participant movement, or equipment issues. For the remaining 4,040 usable gaze trials, three trial-level exclusion criteria were applied. First, trials with missing on-target dwell-time data (n = 39) were excluded. Second, trials with physiologically impossible dwell times (>25,000ms; n = 9) were excluded. Third, additional trials in which both on-target dwell time and on-target fixation count were simultaneously equal to zero (n = 58) were excluded because they likely reflected eye-tracker failure rather than genuine inattention. 57 of these 58 trials also had zero off-target dwell time and zero off-target fixations, indicating that no gaze was registered anywhere on screen during those trials. In total, 106 trials were excluded; 3,934 of 4,040 trials were retained for dwell time (97.4%), and 3,933 were retained for on-target fixation count (97.4%) after one further trial with a missing fixation value. The primary physiological indicator of attentional engagement was the number of on-target fixations, as the originally proposed proportion metric (of on-target fixations over off-target fixations) exhibited a severe ceiling effect (67.9% of valid observations were at the maximum possible value), rendering it unsuitable for subsequent analyses. Total on-target dwell time was retained as the secondary physiological indicator.

Missing data were handled separately for self-report and eye-tracking outcomes. For self-report ratings, individual PSA–by–participant observations in which a participant failed to respond were recoded as missing and excluded on an analysis-by-analysis basis. For the GAD-7, responses entered as “Refused” or “Don’t know” were recoded as missing, as these response options do not correspond to a valid point on the GAD-7's four-point symptom-frequency scale. Participants with two or more missing GAD-7 items (n = 4) were excluded from all GAD-7 analyses. A Little’s MCAR test indicated that missingness was not completely at random ($\chi^2(4)$ =

14.4, $p = .006$). Accordingly, the data were assumed to be Missing at Random (MAR) for full-information estimation, although MAR cannot be verified directly from the observed data. The confirmatory factor analysis (CFA) used full-information maximum likelihood (FIML), meaning that all available observations contributed to parameter estimation without requiring listwise deletion. The linear mixed-effects models, by contrast, were estimated using standard maximum likelihood, and the four participants with incomplete GAD-7 data were excluded from all GAD-7-related models.

Statistical Analyses

Prior to conducting the primary statistical analyses, descriptive statistics for PSA rating dimensions (e.g., "liking"), GAD-7 scores, eye-tracking metrics, and all covariates were computed and reported. Internal consistency of the GAD-7, BDEFS self-restraint subscale, and the four self-report PSA ratings were assessed using Cronbach's α and item-total correlations; values of $\alpha \geq .70$ were interpreted as acceptable. Convergent validity between the two eye-tracking metrics (fixation count and dwell time) was assessed via Pearson's *r*. Intraclass correlations (ICC) were computed to quantify the proportion of variance attributable to participants and PSAs, and to verify the appropriateness of the random-intercepts structure. All analyses were conducted in R, with confirmatory factor analyses estimated using the *lavaan* package for structural equation modeling (Rosseel, 2012) and linear mixed-effects models estimated using *lme4* for mixed-effects modeling of repeated and clustered data (Bates et al., 2015), with inferential support from *lmerTest*, which provides p-values and test statistics for *lme4* models (Kuznetsova et al., 2017).

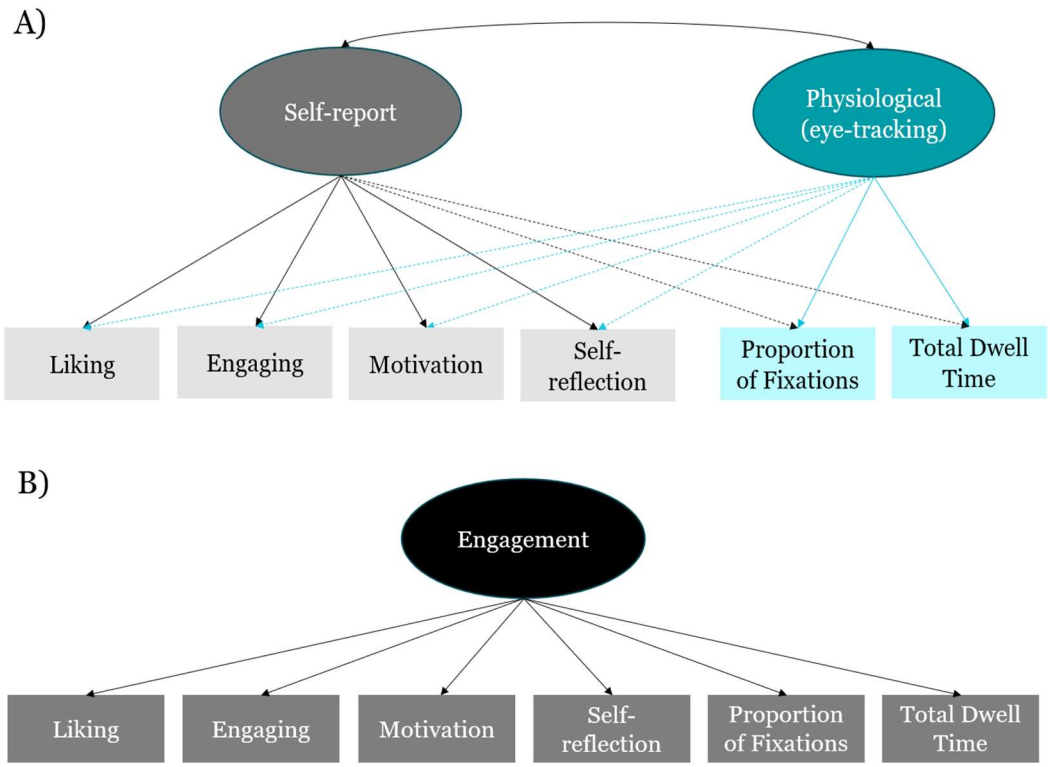
To determine the most appropriate analytic approach, the extent to which the self-report and eye-tracking dimensions reflected a single versus separate latent factors was examined using

confirmatory factor analysis. Confirmatory factor analysis (CFA) is a statistical technique used to test whether a specified pattern of relationships among observed measures can be explained by one or more underlying, unobserved (latent) variables, and to evaluate how well a hypothesized measurement model fits the observed data. In the present context, CFA was used to test whether the four self-report (liking, engaging, motivating, self-reflect) and two eye-tracking (on-target fixations, dwell time) indicators reflect a single underlying engagement construct or two empirically separable constructs. A model in which all indicators loaded onto a single underlying factor (Figure 4B) was compared with a competing model in which the indicators loaded onto two factors (one representing eye tracking and the other representing self-report; Figure 4A). Prior to entry into the CFA, both eye-tracking indicators (fixation count and dwell time) were *z*-standardized to address their approximately 400-fold scale difference. The CFA was estimated using the MLR estimator (Maximum Likelihood with Robust standard errors; Satorra-Bentler scaled χ^2) with full-information maximum likelihood (FIML) to handle missing data, retaining all 4,040 usable eye-tracking observations. Standard errors and fit statistics were adjusted for the non-independence of repeated observations by clustering on participants. Model fit was evaluated using the Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI; both $\geq .90$ acceptable), the Root Mean Square Error of Approximation (RMSEA; $\leq .06$ acceptable), the Standardized Root Mean Square Residual (SRMR; $\leq .08$ acceptable), and the Akaike Information Criterion (AIC), which was used to compare alternative models, with lower values indicating better relative fit. Regression-method factor scores from the better-fitting model, along with the four raw self-report items and the two raw eye-tracking metrics, were then used in subsequent analyses. A factor score is a single composite value, estimated for each observation, that represents its position on the underlying latent factor, derived from a weighted combination

of the relevant observed indicators. The regression method weights each indicator according to its factor loading—the strength of its relationship with the latent factor—such that indicators more strongly related to the underlying construct contribute more to the resulting score.

Figure 4

Theoretical Factor Models regarding Attentional Engagement



Note. A) Depiction of the hypothesized measurement model for self-report and eye-tracking indicators. All self-report items were expected to load onto a latent factor of self-report, while all eye-tracking items were expected to load onto a separate latent factor of eye-tracking. B) An alternative model, wherein all self-report and eye-tracking outcomes load onto a single latent factor of engagement.

Following this, hierarchical linear mixed-effects models were constructed to examine the relationship between baseline anxiety and attentional engagement. Generalized anxiety (GAD-7 scores) and behavioral focus (masking, vaccination, hand hygiene, distancing) were included as fixed effects, and interaction terms were included to assess the moderating effects of behavioral focus. CFA-derived factor scores and the raw engagement metrics served as the primary outcome variables. All models specified random intercepts for both participants and PSAs to account for the crossed, nested data structure. Demographic variables (age, sex) and baseline cognitive functioning (simple reaction time, Flanker interference score, delay-discounting score, BDEFS Self-Restraint composite) were included as covariates. Models were estimated using Maximum Likelihood (ML) for likelihood-ratio tests (LRTs) comparing nested models and Restricted Maximum Likelihood (REML) for final parameter estimates and confidence intervals. A sensitivity analysis was conducted for all confirmatory and secondary models by re-running each analysis with reaction time winsorized at $M + 3SD$ (649.30 ms) to assess robustness to the highly skewed distribution of the reaction-time covariate and potential outliers. An additional sensitivity analysis assessed robustness to the MAR/FIML assumption underlying the CFA. Here, the one- and two-factor models were re-estimated using listwise deletion (complete cases on all six indicators) in place of FIML, and the resulting factor scores were substituted into every confirmatory and secondary model with a factor-score outcome—the GAD-7 main effect, and the GAD-7 × Behavioral Focus, GAD-7 × Modality, GAD-7 × Temporal Bridging, and GAD-7 × Vividness models—to evaluate whether the primary findings depended on this missing-data approach.

To test the primary anxiety–engagement hypothesis, baseline anxiety (GAD-7, mean-centered) was entered as the primary predictor in a two-step hierarchical model: Model A1

included covariates only, whereas Model A2 added GAD-7. Model fit was compared using LRTs. To test whether behavioral focus (i.e., masking, vaccination, hand hygiene, distancing) moderated the anxiety–engagement relationship, two further steps were added: Model B2 included the main effects of behavioral focus (K−1 dummy codes, using "masking" as the reference category), and Model B3 added the GAD-7 × Behavioral Focus interaction terms. For models in which the omnibus interaction LRT was significant ($p < .05$) or meaningfully marginal, simple slopes of GAD-7 at each level of behavioral focus were probed using the *emmeans* package (Lenth & Piaskowski, 2026) with Kenward-Roger degrees of freedom. Primary confirmatory analyses were restricted to the 32 experimental PSAs to maintain consistency with the stimulus set for which behavioral focus was fully crossed.

The moderating effects of temporal bridging and vividness on the anxiety–engagement relationship were examined as secondary analyses. For each thematic category, the main effects of anxiety and the relevant theme (anxiety, temporal bridging/vividness) were entered first, followed by the corresponding interaction term in a second step. Because thematic manipulations were applied to different subsets of PSAs, targeted mixed-effects models were estimated for themes that were manipulated only within a subset of stimuli (e.g., vividness, which was manipulated only among vaccination-themed PSAs as matched non-vivid controls were not developed for other behaviors). Specifically, secondary analyses of temporal bridging were conducted using the 32 "experimental" PSAs that varied in temporal bridging. Secondary analyses of vividness were restricted to the 16 "vaccination" PSAs that varied in vividness. Temporal bridging was included as a covariate in all vaccination-only vividness models to partial out its contribution. All secondary models were run on the same parallel outcomes (factor scores and raw outcomes) as the confirmatory analyses.

To examine whether the anxiety–engagement relationship differed depending on whether engagement was indexed using self-report ratings or eye-tracking, an additional mixed-effects model was estimated in which measurement modality (physiological versus self-report) was entered as a within-participant factor, and tested the anxiety × modality interaction via LRT. This analysis was conducted conditionally as it is only interpretable under a two-factor CFA solution. The Pearson correlation between self-report and physiological (eye-tracking) factor scores served as a supplementary index of convergence between modalities.

Linear mixed-effects models were appropriate for the present study as engagement outcomes were measured repeatedly for each participant across multiple PSAs, and each PSA was, in turn, viewed by multiple participants. This created a crossed, nested data structure wherein trials were nested within both participants and PSAs. By specifying random intercepts for participants and PSAs, this approach explicitly accounted for the non-independence of observations and thus addressed concerns about clustering that traditional repeated-measures ANOVA could handle only by aggregation or by ignoring one source of clustering. In addition, linear mixed-effects models can flexibly accommodate unbalanced data and missing self-report or eye-tracking trials without requiring listwise deletion. This is important as eye-tracking data quality can vary across PSAs and participants. Finally, because the primary outcomes (self-report ratings, number of on-target fixations, dwell time) were continuous and model diagnostics (see Appendix M) were broadly acceptable after data cleaning, a linear mixed-effects framework with normally distributed errors was appropriate for the main analyses, although dwell time showed heavier-tailed residuals than the other outcomes. Generalized mixed models, which are primarily required for binary or discrete outcomes, were therefore not required for these outcomes.

Given the eight correlated outcomes and multiple analysis blocks, some inflation of Type I error is possible. No formal alpha correction was applied. Instead, the analyses emphasized omnibus LRTs and the consistency of patterns across outcomes as the primary basis for inference.

Results

Results are reported in five sections. First, descriptive statistics and internal consistency estimates for all analytical variables are presented, alongside data-screening decisions. Second, a confirmatory factor analysis (CFA) was used to determine the appropriate measurement structure for the attentional engagement outcomes. Third, hierarchical linear mixed-effects models examined whether baseline anxiety predicted attentional engagement with the 32 experimental PSAs, both as a main effect and as moderated by behavioral focus. Fourth, the moderating effects of temporal bridging and vividness on the anxiety–engagement relationship were examined as secondary analyses. Fifth, a conditional analysis examined whether the anxiety–engagement relationship differed between self-report and physiological measurement modalities. Sensitivity analyses are reported at the end of each relevant section.

Preliminary Analyses

Descriptive statistics for person-level variables are presented in Table 1. Baseline anxiety scores on the GAD-7 ranged from 0 to 21 ($M = 5.28$, $SD = 5.24$; $n = 116$ following the exclusion of four participants with two or more missing items). A Little's MCAR test indicated that missing data were unlikely to be completely at random ($\chi^2(4) = 14.4$, $p = .006$); the data were therefore assumed to be Missing at Random (MAR) and were handled via full-information estimation throughout.

Table 1

Descriptive Statistics for Person-Level Variables

Variable	*n*	*M*	*SD*	Min	Max	Skewness	Kurtosis
GAD-7 (mean-centered)	116	0.00	5.24	-5.28	15.72	1.11	0.50
Reaction time (ms)	120	326.16	107.71	228.80	1,180.10	5.41	35.84
Flanker Interference (ms)	120	59.47	32.22	-51.67	130.75	-0.48	1.08
Delay Discounting [ln(k)]	120	-5.73	1.56	-9.12	1.82	0.98	3.39
BDEFS Composite	120	1.58	0.49	1.00	3.50	0.94	1.12

Note. Flanker Interference = incongruent reaction time minus congruent reaction time; Delay Discounting reported as mean natural log-transformed k values; BDEFS = Barkley Deficits in Executive Functioning Scale (Self-Restraint subscale, 4 items). GAD-7 $n = 116$ (4 participants excluded with non-responses in ≥ 2 items). Reaction time was highly skewed and was retained as a covariate; sensitivity analyses using winsorized reaction time did not materially alter the main findings. Kurtosis values are reported as excess kurtosis.

Self-report PSA ratings were distributed across the lower portion of the 1–5 scale (overall item-level means, averaged across all participants and PSAs, ranged from 2.39 to 2.78), with acceptable skewness and kurtosis for mixed-effects modeling (all $|\text{skew}| \leq 0.40$, all $|\text{excess kurtosis}| \leq 0.64$). With respect to eye-tracking data, poor quality data were excluded as described

in the preprocessing section. A total of 106 trials were excluded, retaining 3,934 of 4,040 eye-tracking-usable trials for dwell time (97.4%) and 3,933 for on-target fixation count (97.4%).

Internal consistency of the GAD-7 was excellent (Cronbach's α = .918; item-total *r*s = .575–.849), and the four PSA self-report items demonstrated excellent inter-item consistency (α = .939; item-total *r*s = .771–.927). Internal consistency of the BDEFS Self-Restraint subscale was modest (α = .665). Convergent validity of the two eye-tracking metrics was modest (*r* = .312, *N* = 3,933 paired observations), likely reflecting a ceiling effect in total dwell time as viewers approached the full PSA duration. Intraclass correlations indicated substantial clustering at the participant level for both on-target fixation count (ICC = .426) and dwell time (ICC = .492), and modest clustering at the PSA level (.087 and .150, respectively). These values supported the decision to specify crossed random intercepts for participants and PSAs in all subsequent linear mixed-effects models. One PSA (PSA 2; hand hygiene, non-temporal-bridging, vivid) exhibited markedly lower eye-tracking engagement than all other experimental PSAs (*M* = 16.0 on-target fixations and 5,981ms dwell time, compared with approximately 44 on-target fixations and 18,000ms dwell time for the other experimental PSAs). Given the random PSA-intercept structure, this PSA was retained in all analyses but is noted as a potential stimulus artefact.

Confirmatory Factor Analysis (CFA)

To determine the appropriate measurement structure for the six attentional engagement indicators, a one-factor model (all indicators loaded onto a single Engagement factor) was compared with a two-factor model (four self-report items loaded onto a "Self-Report" factor, and two eye-tracking indicators loaded onto a "Physiological" factor). Preliminary inspection of the indicator correlation matrix also supported this distinction: the four self-report items were

moderately-to-strongly intercorrelated (*r*s = .601–.784), the two eye-tracking indicators showed a comparatively modest positive association (*r* = .312), and cross-correlations between self-report and eye-tracking indicators were minimal (*r*s = .034–.088). This pattern suggested limited overlap between subjective engagement ratings and physiological attention indices. Both models were estimated using the MLR estimator with FIML, clustering standard errors by participant, on all 4,040 valid eye-tracking observations. Model fit statistics are presented in Table 2.

Table 2

Fit Indices for One-Factor and Two-Factor CFA Models of Attentional Engagement

Model	χ^2 (scaled)	*df*	*p*	CFI	TLI	RMSEA [90% CI]	SRMR	AIC
One-factor	112.61	9	<.001	.958	.930	.115 [.095, .136]	.060	56,373
Two-factor	35.02	8	<.001	.992	.984	.054 [.036, .074]	.012	55,981

Note. CFA estimated using MLR estimator with full information maximum likelihood (FIML); standard errors clustered by participant. *N* = 4,040 observations, 101 participants, 40 PSAs. CFI = Comparative Fit Index; TLI = Tucker–Lewis Index; RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean Square Residual; AIC = Akaike Information Criterion.

The one-factor model demonstrated mixed-to-poor fit (CFI = .958, TLI = .930, RMSEA = .115 [90% CI: .095, .136], SRMR = .060, AIC = 56,373). In contrast, the two-factor model demonstrated substantially superior fit across all indices (CFI = .992, TLI = .984, RMSEA =

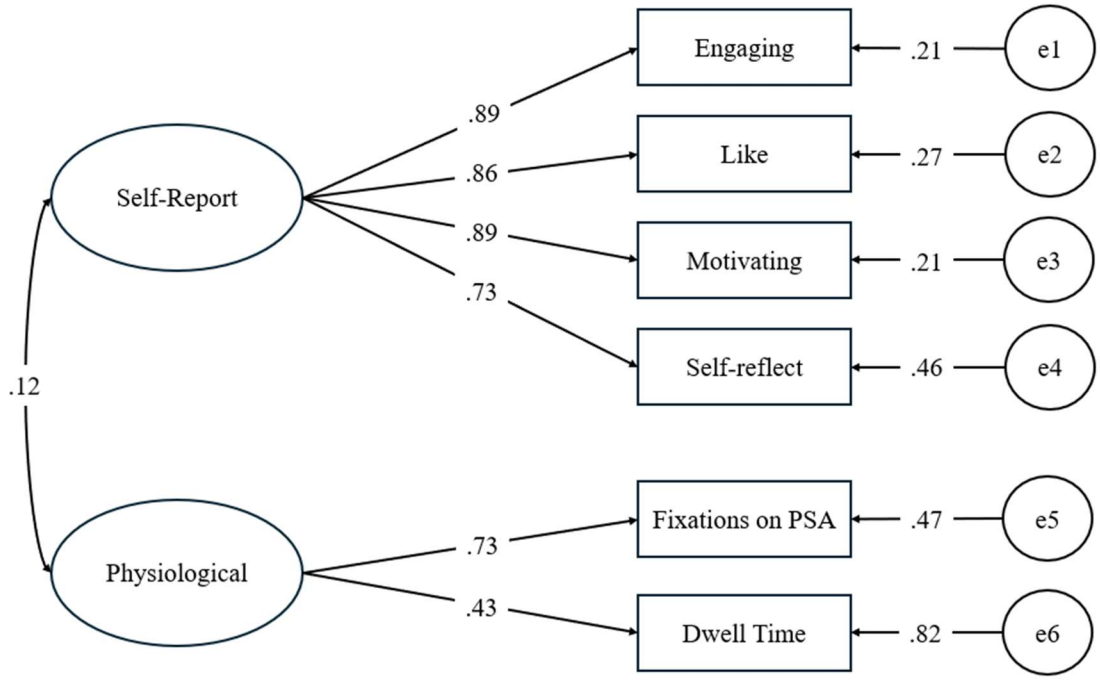
.054 [.036, .074], SRMR = .012, AIC = 55,981; Satorra–Bentler $\Delta\chi^2(1) = 28.39$, $p < .001$; ΔAIC = 392). Thus, the two-factor solution was selected for all subsequent analyses.

All standardized factor loadings in the two-factor model were statistically significant (see Figure 5). Self-report items loaded strongly onto the Self-Report factor (λs = .733–.891, all ps < .001). Eye-tracking indicators also loaded significantly onto the Physiological factor (fixation count: $\lambda = .730$, $SE = .273$, $p = .007$; dwell time: $\lambda = .427$, $SE = .177$, $p = .016$). The comparatively low standardized loading for dwell time likely reflects a ceiling effect. Because each PSA was presented for a fixed duration of 25 seconds regardless of how a participant responded to it, and the on-target region was the only source of visual content on an otherwise blank display, total on-target dwell time for many participants approached the maximum available viewing time, restricting the between-person variance available for this indicator to load onto the Physiological factor. On-target fixation count, by contrast, could vary more freely across participants even within a fixed viewing window, consistent with its stronger loading (λ = .730).

The two factors were weakly but reliably correlated ($r = .124$, $p = .019$), suggesting that self-report and physiological attentional engagement were related but empirically distinct constructs. Regression-method factor scores were extracted for both factors (Self-Report and Physiological) and used as outcomes in subsequent linear modeling alongside the four raw self-report items and two raw eye-tracking metrics, yielding a total of eight parallel outcomes.

Figure 5

Standardized Factor Loadings in the Two-Factor Model



Note. Values shown are standardized factor loadings and standardized factor correlation from the two-factor CFA model. Observed variables are represented by rectangles, latent factors by ovals, and residual variances by circles. The model was estimated using FIML with robust maximum likelihood on 4,040 observations.

Linear Mixed-Effects Models

Hierarchical linear mixed-effects models were constructed to examine the relationship between baseline anxiety and attentional engagement with the 32 experimental PSAs. All models included random intercepts for participants and PSAs to account for the crossed, nested data structure, as well as the following person-level covariates: age, sex, simple reaction time, Flanker interference score, delay-discounting score, and BDEFS Self-Restraint composite. Models were

estimated using Maximum Likelihood (ML) for likelihood ratio tests (LRTs) and Restricted Maximum Likelihood (REML) for final parameter estimates; Kenward-Roger degrees of freedom were used throughout. All eight outcomes were modeled in parallel: the two CFA-derived factor scores (Self-Report, Physiological) and the six raw engagement metrics (self-reported liking, engaging, motivating, and self-reflection, as well as on-target fixations and dwell time). A sensitivity analysis in which reaction time was winsorized at $M + 3SD = 649.30$ms was conducted for all models. Their results were substantively identical to the primary analyses throughout and are therefore not reported separately.

Main Effect of Baseline Anxiety on Attentional Engagement

To examine whether baseline anxiety predicted attentional engagement with COVID-19 PSAs, GAD-7 scores (mean-centered) were entered as the primary predictor in a model that already controlled for the six person-level covariates. A likelihood ratio test comparing the covariate-only model (Model A1) with the model adding GAD-7 (Model A2) did not reach statistical significance for any of the eight outcomes (all $\Delta\chi^2(1) \leq 3.64$, all ps $\geq .057$; see Table 3). There were, however, positive trending associations between GAD-7 and self-report factor scores ($\beta = 0.021$, $SE = 0.011$, $t = 1.85$, $p = .068$, marginal $R^2 = .061$, conditional $R^2 = .453$) and self-reported motivating ratings ($\beta = 0.020$, $SE = 0.012$, $p = .089$). By contrast, GAD-7 was not associated with either eye-tracking outcome (on-target fixation count: $\beta = 0.003$, $SE = 0.239$, $p = .989$; dwell time: $\beta = 111.54$ms, $SE = 76.72$, $p = .150$). Among the covariates, age was a positive predictor of self-report engagement and fixation count across models (all ps $\leq .046$). Reaction time was an unexpected negative predictor of dwell time ($\beta = -8.43$ms, $SE = 3.71$, $p = .026$), indicating that participants with faster simple reaction times tended to dwell longer on PSAs. Taken together, these results do not support the primary hypothesis that higher baseline anxiety

is associated with greater attentional engagement as a main effect, although the positive trends for self-report outcomes were congruent with the predicted direction.

Table 3

Likelihood Ratio Test Statistics for GAD-7 Main Effect and GAD-7 × Behavioral Focus Interaction Effects Across Engagement Outcomes

Outcome	A1→A2 (GAD-7 main)	A2→B2 (BF main)	B2→B3 (GAD-7 x BF interaction)
Self-report Factor Scores	$\Delta\chi^2(1) = 3.64$, $p = .057$	$\Delta\chi^2(3) = 18.12$, $p < .001$	$\Delta\chi^2(3) = 6.55$, $p = .088$
Physiological Factor Scores	$\Delta\chi^2(1) = 0.39$, $p = .531$	$\Delta\chi^2(3) = 10.34$, $p = .016$	$\Delta\chi^2(3) = 1.70$, $p = .637$
Engaging (Self-report)	$\Delta\chi^2(1) = 2.35$, $p = .125$	$\Delta\chi^2(3) = 14.43$, $p = .002$	$\Delta\chi^2(3) = 9.51$, $p = .023$
Like (Self-report)	$\Delta\chi^2(1) = 1.02$, $p = .314$	$\Delta\chi^2(3) = 15.09$, $p = .002$	$\Delta\chi^2(3) = 6.61$, $p = .085$
Motivating (Self-report)	$\Delta\chi^2(1) = 3.12$, $p = .077$	$\Delta\chi^2(3) = 19.74$, $p < .001$	$\Delta\chi^2(3) = 12.45$, $p = .006$
Self-Reflect (Self-report)	$\Delta\chi^2(1) = 2.09$, $p = .148$	$\Delta\chi^2(3) = 19.41$, $p < .001$	$\Delta\chi^2(3) = 3.10$, $p = .377$
Fixations on PSA	$\Delta\chi^2(1) = 0.00$, $p = .989$	$\Delta\chi^2(3) = 12.24$, $p = .007$	$\Delta\chi^2(3) = 1.08$, $p = .783$
Dwell Time	$\Delta\chi^2(1) = 2.26$, $p = .133$	$\Delta\chi^2(3) = 5.84$, $p = .120$	$\Delta\chi^2(3) = 0.79$, $p = .851$

Note. LRTs used Maximum Likelihood estimation. Models were adjusted for age, sex, simple reaction time, Flanker interference, delay discounting, and BDEFS Self-Restraint. A1 = covariates only; A2 = A1 + GAD-7; B2 = A2 + behavioral focus (BF) main effects; B3 = B2 + GAD-7 × BF interaction. BF dummy-coded with "masking" as reference category.

Moderating Effects of Behavioral Focus on Anxiety–Engagement

To test whether behavioral focus moderated the relationship between baseline anxiety and attentional engagement, behavioral focus main effects and GAD-7 × behavioral focus interaction terms were entered hierarchically (Models B2 and B3, respectively). Adding behavioral focus as a main effect (Model B2) significantly improved model fit for all self-report outcomes, with the smallest effect observed for self-reported engaging ($\Delta\chi^2(3) = 14.43$, $p = .002$) and the strongest for motivating ($\Delta\chi^2(3) = 19.74$, $p < .001$). For physiological engagement, behavioral focus significantly improved fit for fixation count ($\Delta\chi^2(3) = 12.24$, $p = .007$), but not for dwell time ($\Delta\chi^2(3) = 5.84$, $p = .120$). In the final model, vaccination PSAs were rated higher than masking PSAs on the motivating outcome ($\beta = 0.200$, $SE = 0.066$, $p = .006$), although the pattern varied by outcome and the anxiety–engagement association was attenuated for vaccination relative to masking on several self-report measures. For physiological engagement, hand hygiene PSAs were associated with fewer fixations than masking PSAs ($\beta = -6.60$, $SE = 2.56$, $p = .016$).

The addition of GAD-7 × behavioral focus interaction terms (Model B3) significantly improved model fit for self-reported motivating ($\Delta\chi^2(3) = 12.45$, $p = .006$) and self-reported engaging ($\Delta\chi^2(3) = 9.51$, $p = .023$). Model fit also showed marginal improvement for self-report factor scores ($\Delta\chi^2(3) = 6.55$, $p = .088$) and self-reported liking ($\Delta\chi^2(3) = 6.61$, $p = .085$). Interactions were non-significant for self-reported reflection ($p = .377$), physiological factor scores ($p = .637$), fixation count ($p = .783$), and dwell time ($p = .851$). Inspection of the individual interaction terms across the significant and marginal models revealed a uniform pattern; that is, the GAD-7 × Vaccination interaction was negative across all self-report

outcomes, suggesting that higher baseline anxiety was associated with relatively lower subjective engagement with vaccination PSAs compared with masking PSAs. This interaction reached significance for self-reported engaging (β = −0.016, *SE* = 0.007, *t* = −2.35, *p* = .019) and self-reported liking (β = −0.014, *SE* = 0.007, *t* = −2.07, *p* = .039). It also reached significance for self-reported motivating (β = −0.017, *SE* = 0.007, *t* = −2.46, *p* = .014), and self-report factor scores (β = −0.013, *SE* = 0.006, *p* = .041). Interaction terms for hand hygiene and distancing were non-significant in all models (all *p*s ≥ .466).

For the model in which the omnibus GAD-7 × behavioral focus interaction was strongest (self-reported motivating, *p* = .006), simple slopes of GAD-7 were probed at each level of behavioral focus. The slope of GAD-7 was positive and significant for hand hygiene PSAs (β = 0.027, *SE* = 0.013, *p* = .032) and distancing PSAs (β = 0.026, *SE* = 0.013, *p* = .043), indicating that more anxious participants rated these PSA types as more motivating. The slope did not reach significance for masking PSAs (β = 0.023, *SE* = 0.013, *p* = .074) or vaccination PSAs (β = 0.006, *SE* = 0.013, *p* = .662). Simple slopes for self-reported engaging and self-reported liking followed the same directional pattern. These findings show that behavioral focus moderates the anxiety–engagement relationship, although the hypothesized two-group split (masking/hand hygiene vs. vaccination/distancing) was not supported. Instead, hand hygiene and distancing showed slopes similar to masking, while vaccination alone showed an attenuated slope relative to the other behavioral focus conditions.

Table 4

Anxiety × Behavioral Focus Interaction Terms for Self-Report Outcomes

Outcome	GAD-7 x Vaccination β (SE)	*p*	GAD-7 x Hand Hygiene β (SE)	*p*	GAD-7 x Distancing β (SE)	*p*
Self-report Factor Scores	−0.013 (0.006)	.041	−0.000 (0.006)	.962	0.001 (0.006)	.880
Engaging	−0.016 (0.007)	.019	−0.001 (0.007)	.831	0.003 (0.007)	.620
Like	−0.014 (0.007)	.039	−0.002 (0.007)	.769	0.002 (0.007)	.802
Motivating	−0.017 (0.007)	.014	0.005 (0.007)	.501	0.003 (0.007)	.660
Self-Reflect	−0.007 (0.007)	.314	−0.002 (0.007)	.769	0.005 (0.007)	.466

Note. REML estimates from final Model B3. Models were adjusted for age, sex, simple reaction time, Flanker interference, delay discounting, and BDEFS Self-Restraint. Reference category = Masking. β = unstandardized fixed-effect coefficient. Self-reported reflection omnibus LRT for GAD-7 × behavioral focus interaction was non-significant ($p = .377$); individual interaction terms reported for completeness.

Secondary Analysis of the Moderating Effects of Temporal Bridging

The moderating effect of temporal bridging on the anxiety–engagement relationship was examined as a secondary analysis using the 32 experimental PSAs. Temporal bridging main effects were non-significant across all eight outcomes (all $\Delta\chi^2(1) \leq 3.31$, all ps ≥ .069), with self-reported motivating coming closest to significance (β = 0.108, $SE = 0.059$, $p = .077$). GAD-7 ×

Temporal Bridging interactions were uniformly non-significant (all $\Delta\chi^2(1) \leq 1.59$, all ps $\geq .207$; GAD-7 × Temporal Bridging βs ranging from −0.006 to 0.038). These findings indicate that temporal bridging did not independently influence attentional engagement, nor did it moderate the anxiety–engagement relationship for any outcome.

Secondary Analysis of the Moderating Effects of Vividness

The moderating effect of vividness on the anxiety–engagement relationship was examined using the 16 vaccination PSAs (8 vivid, 8 non-vivid), with temporal bridging included as a covariate in all models. Adding vividness to the model significantly improved fit for all outcomes except physiological factor scores (all $\Delta\chi^2(1) \geq 18.85$, all ps $< .001$; physiological factor scores: $\Delta\chi^2(1) = 0.14$, $p = .710$; see Table 5). The vividness main effect was large and positive for all self-report outcomes. Specifically, vivid PSAs were rated approximately one standard deviation higher on self-report factor scores (β = 1.069, *SE* = 0.101, $p < .001$). They were also rated between .77 and 1.22 scale points higher on the raw self-report items (self-reported engaging: β = 1.220; self-reported liking: β = 1.132; self-reported motivating: β = 1.071; self-reported reflection: β = 0.769; all *SE*s ≤ 0.114, all ps $< .001$). A notable divergence was observed for the eye-tracking outcomes. Here, vivid PSAs were associated with significantly fewer on-target fixations (β = −3.225, *SE* = 0.620, $p < .001$) but significantly longer dwell time (β = 1,092.79 ms, *SE* = 161.83, $p < .001$). It should be noted that the physiological factor score and the two eye-tracking outcomes produced boundary singular-fit warnings in the vividness models. This occurs when one or more random-effect variance components are estimated as zero or near zero, suggesting that the model may be more complex than the available data can support. In this case, the PSA-level random-intercept variance collapsed to zero in the vaccination-only subset, likely because each vividness condition contained only eight PSAs and

there was limited residual between-PSA variability after the fixed effects were accounted for. These results should therefore be interpreted cautiously.

The addition of GAD-7 × Vividness interaction terms significantly improved fit for self-report factor scores ($\Delta\chi^2(1) = 5.73$, $p = .017$; $\beta = 0.015$, $SE = 0.006$, $t = 2.40$), suggesting that the relationship between vividness and self-report engagement was stronger among more anxious participants. Simple slopes indicated that GAD-7 was not significantly associated with self-report factor scores for non-vivid PSAs ($\beta = 0.004$, $SE = 0.011$, $p = .747$) but showed a positive trend for vivid PSAs ($\beta = 0.019$, $SE = 0.011$, $p = .094$). This pattern suggests that the anxiety–engagement association was more pronounced for vivid than non-vivid vaccination content. The GAD-7 × Vividness interaction was trending for self-reported reflection ($\Delta\chi^2(1) = 3.31$, $p = .069$; $\beta = 0.012$, $SE = 0.006$) and non-significant for all other outcomes (all ps $\geq .295$). These results suggest that higher baseline anxiety may be specifically associated with greater subjective engagement with vivid, emotionally salient PSAs, a pattern that is consistent with theoretical accounts of anxiety-related attentional biases toward emotionally significant stimuli.

Table 5

Main Effect of Vividness and GAD-7 × Vividness Interaction Effects Across All Engagement Outcomes (Vaccination PSA Subset)

Outcome	V1→V2 LRT	Vividness β (*SE*)	*p*	V2→V3 LRT	GAD-7 x Vividness β (*SE*)	*p*
Self-report Factor Scores	$\Delta\chi^2(1)$ = 35.55*	1.069 (0.101)	< .001	$\Delta\chi^2(1)$ = 5.73*	0.015 (0.006)	.017
Physiological Factor Scores†	$\Delta\chi^2(1)$ = 0.14	−0.009 (0.025)	.710	$\Delta\chi^2(1)$ = 0.00	−0.000 (0.005)	.946
Engaging (Self-report)	$\Delta\chi^2(1)$ = 36.09*	1.220 (0.114)	< .001	$\Delta\chi^2(1)$ = 0.01	−0.001 (0.007)	.926
Like (Self-report)	$\Delta\chi^2(1)$ = 34.07*	1.132 (0.113)	< .001	$\Delta\chi^2(1)$ = 0.00	0.000 (0.007)	.948
Motivating (Self-report)	$\Delta\chi^2(1)$ = 36.98*	1.071 (0.096)	< .001	$\Delta\chi^2(1)$ = 0.03	−0.001 (0.007)	.868
Self-Reflect (Self-report)	$\Delta\chi^2(1)$ = 35.56*	0.769 (0.071)	< .001	$\Delta\chi^2(1)$ = 3.31	0.012 (0.006)	.069
Fixations on PSA†	$\Delta\chi^2(1)$ = 18.85*	−3.225 (0.620)	< .001	$\Delta\chi^2(1)$ = 0.34	−0.068 (0.118)	.561
Dwell Time†	$\Delta\chi^2(1)$ = 27.15*	1,092.79 (161.83)	< .001	$\Delta\chi^2(1)$ = 1.10	32.11 (30.67)	.295

Note. LRTs used ML estimation; parameter estimates from REML final models. Models were adjusted for age, sex, simple reaction time, Flanker interference, delay discounting, BDEFS Self-Restraint, and temporal bridging. * $p < .05$. † Boundary (singular) fit warning: PSA-level random intercept variance collapsed to zero with only 8 PSAs per vividness condition.

Conditional Analysis of Measurement Modality

Because the two-factor CFA solution was selected, an additional conditional analysis was conducted to examine whether the anxiety–engagement relationship differed between self-report and physiological measurement modalities. A dataset was constructed by stacking self-report and physiological factor scores as repeated observations for each participant–PSA pair, with measurement modality (Self-Report versus Physiological) entered as a within-participant fixed effect. The GAD-7 × Modality interaction did not achieve significance ($\Delta\chi^2(1) = 2.78$, $p = .095$), though the directional pattern aligned with modality specificity. GAD-7 was positively and significantly associated with self-report factor scores ($\beta = 0.024$, $SE = 0.010$, $z = 2.39$, $p = .017$) but not with physiological factor scores ($\beta = 0.003$, $SE = 0.010$, $z = 0.28$, $p = .780$). The Pearson correlation between self-report and physiological factor scores within this dataset was modest ($r = .198$), suggesting that the two modalities captured largely distinct aspects of attentional engagement. Taken together, these results suggest that the trending anxiety–engagement associations observed in earlier models were primarily driven by subjective self-report evaluations of the PSAs rather than by objective eye-tracking indices of visual attention, though the formal interaction test was only marginal.

Sensitivity Analyses

To assess robustness to extreme reaction-time values, all confirmatory and secondary models were re-estimated with reaction time winsorized at $M + 3SD = 649.30$ms. Results were substantively identical to the primary analyses across all outcomes and sections. The trending positive association between GAD-7 and self-report factor scores in the primary model (Model A2) was preserved ($\beta = 0.024$, $SE = 0.011$, $p = .050$). The significant GAD-7 × Vaccination interaction for self-reported motivating in the GAD-7 × Behavioral Focus model (Model B3)

also remained significant (β = −0.017, p = .014, and the significant GAD-7 × Vividness interaction for self-report factor scores in the secondary vividness models remained significant under this particular check (β = 0.015, p = .017). The vividness interaction's robustness to a different sensitivity check, listwise deletion of the underlying factor scores, is evaluated separately below. No substantive changes to any conclusion were observed.

A second sensitivity analysis assessed robustness to the MAR/FIML assumption underlying the CFA. The one- and two-factor models were re-estimated using listwise deletion (N = 3,677 observations, 95 participants, a 9% reduction from the FIML-based sample). Fit statistics, standardized loadings, and the factor correlation were virtually unchanged, and the two-factor model remained strongly preferred ($\Delta\chi^2(1) = 25.33$, $p < .001$). Substituting the resulting listwise-deletion factor scores into the GAD-7 main-effect model, the GAD-7 × Behavioral Focus and GAD-7 × Modality models (both factor scores), and the GAD-7 × Temporal Bridging model (both factor scores) reproduced the same pattern of results throughout. The GAD-7 × Vaccination interaction term in the Behavioral Focus model shifted from significant under FIML (β = −0.013, p = .041) to marginal under listwise deletion (p = .051), reflecting reduced power rather than a change in the estimated effect; no other term changed in significance.

One exception to this pattern was identified. The secondary GAD-7 × Vividness interaction for the self-report factor score was significant under FIML ($\Delta\chi^2(1) = 5.73$, p = .017; β = 0.015) but did not reach significance under listwise deletion ($\Delta\chi^2(1) = 2.48$, p = .115; β = 0.010), reflecting both the smaller sample (N = 1,424 vs. 1,561) and a smaller point estimate. The corresponding interaction for the physiological factor score was non-significant under both approaches. Given the secondary nature of this analysis, this result—based on a single significant

outcome within a 16-PSA subsample—indicates that the vividness interaction should be treated cautiously.

Discussion

Overview of Findings

The present study examined whether baseline anxiety (indexed by GAD-7) predicted attentional engagement with COVID-19 PSAs, and whether behavioral focus, temporal bridging, and vividness moderated this relationship. The results reveal a pattern that is congruent with a conditionally moderated account of how trait anxiety influences health message processing. Contrary to the primary hypothesis, GAD-7 did not predict attentional engagement as a main effect across any engagement outcomes. However, the anxiety–engagement relationship was moderated by PSA behavioral focus, with a clear attenuation of the slope for vaccination PSAs relative to the other three behavioral focus types. There was also tentative evidence that the relationship was moderated by vividness, with a positive association emerging for vivid vaccination content among more anxious participants, although this interaction was less robust than the behavioral-focus moderation and did not survive an alternative missing-data approach (see Limitations). The behavioral focus moderation and, more tentatively, the vividness moderation were both restricted to self-report outcomes, while the two eye-tracking outcomes showed no corresponding anxiety-related moderation, a distinction that was formally evaluated in a conditional modality analysis. The following discussion considers each of these findings in turn, before addressing practical implications, future directions, and a synthesis of the overall contribution of the present study.

Before interpreting the moderation findings, it is useful to situate them within the measurement architecture established by the confirmatory factor analysis. The two-factor model, in which self-report and physiological (eye-tracking) outcomes loaded onto separate latent factors, fit the data substantially better than a one-factor solution. The two factors were modestly

correlated, indicating that they represent related but empirically separable components of attentional engagement. This two-component solution is supported by evidence from multimodal health communication research suggesting that subjective engagement evaluations and physiological indices of visual attention capture distinct, though related, aspects of audience response (Alptekin et al., 2024; Brigaud et al., 2021; Potter & Bolls, 2012; Venkatraman et al., 2015). Rather than treating either modality as inherently more valid, the present study interprets both as capturing different facets of engagement; that is, self-report indexes conscious evaluative appraisal of PSA content, while eye-tracking indexes real-time visuospatial attention allocation during viewing. With this two-component structure established, the central question running through the remainder of this chapter is whether self-report and eye-tracking are differentially related to anxiety and to the PSA message features examined here, beginning with the anxiety main effect itself.

The Null Effect of Baseline Anxiety

The primary hypothesis that higher GAD-7 scores would be associated with greater attentional engagement was not supported as a main effect. GAD-7 did not reliably predict any of the eight engagement outcomes, though positive trends emerged for self-report factor scores and self-reported motivating ratings, in the direction of the primary hypothesis. The absence of a reliable main effect may reflect the theoretical complexity of anxiety as a predictor of attentional engagement. Anxiety encompasses competing processes that may exert opposing influences on message processing. For instance, threat-monitoring vigilance (the tendency to preferentially orient toward threatening or health-relevant stimuli) predicts increased engagement with PSA content (Bar-Haim et al., 2007; Cisler & Koster, 2010). Experiential avoidance and fear control responses, by contrast, may reduce motivated engagement when threat-relevant content feels

overwhelming or personally uncontrollable (Sweeny et al., 2010; Witte, 1992). When both processes are simultaneously operative, their opposing effects may cancel, yielding the near-zero main effect observed here. Mogg and Bradley (1998) proposed that the direction of anxiety's influence on attention is determined by the balance between vigilance and avoidance tendencies. Crucially, this balance may vary considerably across individuals and message contexts in ways that a single main-effect estimate cannot capture.

Several methodological considerations also bear on the interpretation of the null main effect. Witte and Morrison (2000) demonstrated that the direction of trait anxiety's influence on fear appeal processing depends critically on individuals' habitual coping orientation. Here, sensitizers—who amplify and engage with threat-relevant information, and repressors—who minimize and avoid it, respond to the same fear appeal in opposing directions, such that aggregating across both types would attenuate any overall effect of trait anxiety. The GAD-7, as a unidimensional symptom composite, does not distinguish between vigilance-oriented and avoidance-oriented anxiety, which limits its capacity to detect the differential effects predicted by coping theory. Additionally, the present sample was predominantly subclinical ($M = 5.28$, $SD = 5.24$), consistent with the study's aim of indexing anxiety dimensionally in a general population rather than a clinically anxious one. This subclinical skew may nonetheless have limited power to detect effects concentrated at the more severe end of the anxiety spectrum, if such effects exist. However, the persistently positive direction of the trending associations for self-report outcomes and the conspicuous absence of any corresponding trend for eye-tracking hints at a modality-specific pattern.

Behavioral Focus as a Moderator

Adding behavioral focus to the models as a main effect improved model fit for all self-report outcomes, with the smallest improvement for self-reported engaging and the strongest for self-reported motivating. Behavioral focus also improved model fit for fixation count, with hand hygiene PSAs showing fewer on-target fixations than masking PSAs, while vaccination PSAs were rated higher than masking PSAs on self-reported motivating. These findings indicate that PSA behavioral content shapes both subjective engagement and visual attention, congruent with the broader evidence that message features are important determinants of audience response to public health PSAs (Ghio et al., 2021; Tait et al., 2022; Wakefield et al., 2010). An important structural observation is that behavioral focus influenced both modalities at the main-effect level without producing a corresponding interaction with anxiety. This distinction, in which behavioral content shapes visual attention uniformly across anxiety levels but modulates self-report evaluations differentially, is a recurring theme across the present findings and is in line with the view that conscious evaluative appraisal and visuospatial attention allocation are influenced by different factors.

The addition of GAD-7 × behavioral focus interaction terms improved model fit for two self-report outcomes (self-reported motivating and engaging) and showed weaker improvement for two others (the self-report factor score and self-reported liking). Across these outcomes, the pattern was driven by a clear flattening of the anxiety–engagement slope for vaccination PSAs specifically: the GAD-7 × Vaccination interaction emerged for all four self-report outcomes, while interactions for hand hygiene and distancing were absent (see Appendix F). Critically, this represents a relative attenuation of the slope rather than absolute disengagement. At lower GAD-7 levels, vaccination PSAs were rated highest of all four behavioral focus types on self-reported

motivating, but this advantage diminished as anxiety increased. The result was a near-zero slope for vaccination relative to substantially positive slopes for the other three behavioral focus types (see Appendix H for simple slopes). In line with the Extended Parallel Process Model (EPPM; Witte, 1992; Witte, 1994), one interpretation is that vaccination PSAs may pair high perceived threat with lower perceived self-efficacy among more anxious individuals. Relative to immediately self-executable behaviors such as hand hygiene and masking, this pairing could activate fear control rather than danger control processes, potentially attenuating anxiety-driven engagement (Peters et al., 2013; Tannenbaum et al., 2015). The finding that masking, hand hygiene, and distancing all showed positive anxiety–engagement slopes, while vaccination showed a flat slope, supports this proposed efficacy-asymmetry interpretation.

Crucially, these moderation results help explain the null unconditional main effect of anxiety: the positive simple slopes for the other three behavioral focus types were offset by the near-zero vaccination slope, which would naturally pull the overall average toward zero. In that sense, the null main effect is better understood as an aggregation artifact than as evidence that anxiety has no relationship with engagement.

An important alternative explanation for the vaccination-specific attenuation concerns the composition of the present sample. Since all participants were fully vaccinated at the time of data collection, vaccination PSAs may have been perceived as less personally relevant because the recommended behavior had already been enacted, rather than due to perceived efficacy concerns (Brewer et al., 2007; Weinstein et al., 2007). The COVID-19-specific demographic data lends some support to this account, though with an important qualification. Beyond the binary vaccination eligibility criterion, 79% of participants with a recorded response (94 of 119) had already received a booster (third) dose at the time of participation, and the large majority also

reported high baseline compliance with the other three mitigating behaviors targeted by the PSAs (95% for mask-wearing, 92% for distancing, and 83% for hand-washing).

This comparison should be interpreted with an important caveat. Compliance with physical distancing declined over much of 2020, whereas mask-wearing generally increased during the same period. Subsequent changes in mask-wearing likely varied as mandates and perceived threat changed (Petherick et al., 2021). By 2022, ongoing compliance with these behaviors may therefore have been concentrated among individuals for whom the behaviors remained personally relevant, consistent with theoretical and longitudinal accounts suggesting that threat appraisals, coping appraisals, and affective risk perceptions can help maintain protective behavior when external regulation becomes less salient (Hedayati et al., 2023; Rogers, 1975; Savadori & Lauriola, 2022). A similar dynamic may apply to the 79% booster uptake reported above. Booster coverage remained below primary-series coverage among adults in Ontario by 2022, and booster uptake was higher among older adults and people with chronic disease (Léger et al., 2023; Wanigaratne et al., 2023). Rather than representing a strict ceiling, the high baseline compliance observed for masking and distancing may reflect restricted variability associated with self-selection. If individuals who continued these behaviors were also more likely to perceive them as personally relevant, the present sample may contain less variation in perceived relevance than the general population, potentially attenuating the observed associations (Sackett & Yang, 2000). Read this way, the positive anxiety–engagement slopes observed for masking and distancing support, rather than contradict, the personal-relevance account; these are precisely the Behavioral Focus categories for which the present sample may be expected to report the greatest personal relevance.

Vaccination's attenuated slope may reflect a related but distinct facet of this same relevance account. Behavior-change theories distinguish the determinants of initiating and completing a behavior from those that sustain an ongoing, repeated behavior (Kwasnicka et al., 2016; Rothman, 2000). Once a protective action has been completed, as with a booster dose already received, it may no longer be perceived as personally relevant in the way an ongoing, repeatable behavior like masking or distancing continues to be. If anxiety amplifies engagement with personally relevant threat information, and a behavior's relevance depends partly on whether it remains actionable, then vaccination's completed, one-time status could be what most reduces its relevance for an already-vaccinated sample, attenuating this amplification specifically for that Behavioral Focus category, regardless of any efficacy-related mechanism. Nonetheless, the EPPM account and the personal relevance account cannot be disentangled with the present data, and future research including vaccine-hesitant or unvaccinated participants would be needed to evaluate them independently. In addition, the GAD-7 × Behavioral Focus interaction was specific to self-report outcomes, which is consistent with the modality distinction noted above.

Vividness and Temporal Bridging as Moderators

As hypothesized, the secondary analyses showed that vividness exerted a substantial main effect on both self-reported and eye-tracking indices of engagement (with the exception of physiological factor scores). Vivid vaccination PSAs were rated higher on self-report factor scores and across the four raw self-report items. This parallels evidence that vivid, emotionally salient health messages tend to be perceived as more engaging and motivating than their non-vivid counterparts (Block & Keller, 1997; Blondé & Girandola, 2016; Ophir et al., 2019). For the eye-tracking outcomes, vivid PSAs were associated with markedly fewer on-target fixations but

longer dwell times. Although this pattern is consistent with more sustained attention to a smaller set of message elements, it does not identify the underlying mental processes as eye-tracking metrics are indirect indicators of attention; attention is not directly measurable and must be operationalized through proxies such as fixation measures, which can vary across studies and analytic choices (Holmqvist et al., 2011; Orquin & Mueller Loose, 2013; Hooge et al., 2025). As a result, the same gaze pattern can reflect different underlying states depending on task and context. In the context of fear-based health communication, one plausible interpretation is that vivid threat-relevant content may initially capture attention while also being compatible with defensive avoidance or disengagement when the message becomes affectively difficult to sustain, especially if efficacy is limited or the content feels personally demanding (Witte, 1992; Witte & Allen, 2000; Ruiter et al., 2014). The large magnitude of the vividness main effect on self-report accords with Guadagno and colleagues' (2011) argument that vividness effects on persuasion are most reliable when vividness is integral to the core message content rather than incidental to it. It also echoes Blondé and Girandola's (2016) meta-analytic evidence that vivid content produces small-to-medium positive effects on persuasive outcomes.

In a secondary analysis, the GAD-7 × Vividness interaction tentatively improved model fit for self-report factor scores, with simple slopes suggesting that GAD-7 was not meaningfully associated with self-report factor scores for non-vivid PSAs but showed a positive trend for vivid PSAs. The interaction also approached the conventional significance threshold for self-reported reflection. Although the result is confined to the 16-PSA vaccination subset and did not survive sensitivity analysis, it is theoretically noteworthy. It represents the clearest instance across the present analyses in which anxiety was positively associated with self-reported engagement, in line with vigilance-based accounts of anxious attention. One theoretical account of this pattern

draws on Attentional Control Theory (ACT; Eysenck et al., 2007) and its predecessor, Processing Efficiency Theory (PET; Eysenck & Calvo, 1992). ACT proposes that anxiety impairs the inhibition and shifting functions of attentional control, namely the ability to suppress distracting information and redirect attention as needed, while leaving processing effectiveness relatively intact. Applied to the present context, one possibility is that anxious individuals were less able to disengage from vivid, emotionally salient PSA content once it had captured attention, which could, in turn, have contributed to more sustained engagement with such material and higher subjective engagement evaluations. This account draws support from evidence that anxious individuals show preferential attentional engagement with emotionally salient and threatening stimuli (Armstrong & Olatunji, 2012; Bar-Haim et al., 2007; Clauss et al., 2022; Veerapa et al., 2020). Rapid spatial orienting toward affectively loaded stimuli reflects a broader tendency for such content to capture and hold attention (Brosch et al., 2008). ACT and PET offer a theoretically motivated post-hoc framework for interpreting this interaction, and future research incorporating direct measures of attentional control would be required to evaluate the proposed mechanism empirically.

In contrast to the self-report findings, the GAD-7 × Vividness interaction was absent for fixation count and dwell time. This null finding should not be interpreted as evidence that vividness had no effect on visual attention as the main effects of vividness on fixation count and dwell time were both substantial, as previously described. The null is specifically the absence of moderation of those effects by anxiety level. Here, vivid PSAs produced the same restructured visual attention pattern regardless of participants' GAD-7 scores. This fits a model in which the low-level visual salience of vivid stimuli drives visuospatial attention allocation in a manner that is relatively automatic and stimulus-driven, and therefore less sensitive to individual differences

in anxiety (Orquin & Mueller Loose, 2013). The influence of anxiety on engagement with vivid content appears to manifest specifically in how participants consciously evaluate the PSA after viewing it, rather than in where their eyes move during viewing. Divergences between self-reported engagement and gaze-based metrics in health communication contexts have been previously documented, with introspective access to automatic attentional processes proposed as a contributing factor (Kessels & Ruiter, 2012; Nisbett & Wilson, 1977; Sillero-Rejon et al., 2021). Together, these results indicate that, as with the more robust GAD-7 × Behavioral Focus interaction, the GAD-7 × Vividness interaction was confined to self-reported engagement.

Contrary to hypotheses, the secondary temporal bridging analyses yielded null results throughout. Temporal bridging did not produce reliable improvements in model fit as a main effect for any of the eight outcomes, and the GAD-7 × Temporal Bridging interaction was absent across all outcomes. The closest approach to significance was the temporal bridging main effect on self-reported motivating. Methodological constraints are the most parsimonious explanation for these null findings. Because the temporal bridging manipulation consisted of a single appended sentence, administered without a dedicated manipulation check, it is unclear whether participants reliably processed and integrated the temporal framing element given the PSAs' rapid presentation format. These null findings also align with Wang et al.'s (2024) meta-analysis of temporal framing in health messaging, which found effects on behavioral intentions to be small and context-dependent. They similarly parallel Chandran and Menon's (2004) evidence that temporal framing effects are most reliable when individuals are directly confronted with proximal risk decisions.

The Self-Report and Eye-Tracking Modality Distinction

Both behavioral focus and vividness showed reliable main effects on fixation count, suggesting that the eye-tracking measures were sensitive to PSA features. However, neither the GAD-7 × behavioral focus nor the GAD-7 × vividness interaction extended to any eye-tracking outcome. This pattern was tested directly across the full set of outcomes via the conditional modality analysis. Although the GAD-7 × Modality interaction fell short of conventional significance, the directional pattern matched the pattern of modality specificity: GAD-7 showed a positive association with self-report factor scores within this model but not with physiological factor scores. The modest Pearson correlation between the two factor scores supported the view that they captured largely distinct variance, in keeping with the CFA two-factor solution. This modest correlation is also consistent with a structural interpretation in which physiological indices of attention precede self-reported evaluation within the engagement process, in line with conceptual models such as the EPPM (Witte, 1992), which distinguish an initial appraisal/attention stage from a subsequent evaluative response. If perceptual engagement, captured by eye-tracking, functions as an upstream input that only partially shapes the downstream self-reported evaluation of a PSA, the two indicators would be expected to show exactly this kind of weak-to-modest association: correlated because they are sequentially linked, but far from redundant because self-report also incorporates additional evaluative processing not reducible to visual attention. Reconceptualizing the self-report and physiological factors as sequential rather than parallel indicators may help explain why they loaded onto separate, only weakly correlated latent factors in the two-factor CFA. Ultimately, these results point toward the view that anxiety is selectively associated with the evaluative, self-report component of PSA

engagement rather than with the visuospatial attentional processes captured by eye-tracking (Alptekin et al., 2024; Brigaud et al., 2021; Perski et al., 2017).

This modality-specific pattern suggests a theoretical interpretation that must be stated with appropriate care. As established above, self-report and eye-tracking index related but nonredundant facets of attentional engagement, and neither modality is more valid or objective than the other. In other words, even if physiological engagement temporally precedes self-reported evaluation within the engagement process, as proposed above, that processing sequence does not make one modality more valid or authoritative than the other; the two remain theoretically separable and do not stand in an evaluative hierarchy (Nisbett & Wilson, 1977; Potter & Bolls, 2012). This selective coupling fits a model in which anxiety shapes how participants consciously interpret and appraise message content, without equivalently disrupting the stimulus-driven visuospatial processes that determine where the eyes move. This interpretation matches the characterization of GAD as primarily a disorder of cognitive appraisal and repetitive worry (Dugas et al., 1998). Attentional Control Theory offers a complementary account, positing that anxiety specifically impairs top-down inhibitory and shifting functions of attentional control rather than bottom-up visual orienting to salient stimuli (Eysenck et al., 2007). These findings support the argument that a multimodal approach to measuring PSA engagement is necessary as each modality captures aspects of the audience response that the other does not (Mogg & Bradley, 1998; Perski et al., 2017). Considered together, the behavioral focus and vividness results converge on a consistent pattern: PSA message features shape both self-report and eye-tracking engagement, but only the self-report component carries an anxiety-dependent signature, while the automatic, visuospatial engagement indexed by eye-tracking responds to message features uniformly across anxiety levels.

This distinction between modalities carries a further implication for real-world PSA effectiveness, conditional on the EPPM account of the vaccination-specific attenuation discussed above. If that attenuation does reflect a shift toward fear control among more anxious viewers, it marks exactly the process through which a message can fail to produce, or even undermine, the protective response it is designed to elicit (Witte, 1992; Witte, 1994). Because this signature appeared only in self-report and not in eye-tracking, a PSA that captures visual attention identically across anxiety levels could still be failing its more anxious viewers at the evaluative stage in a way eye-tracking alone would not reveal. This implication remains conditional, as the present data cannot adjudicate between the EPPM and personal-relevance accounts of the attenuation, and no downstream behavioral outcome was measured to confirm whether the self-report pattern translates into differences in actual protective behavior. What the present pattern suggests is that self-report, rather than eye-tracking, may be the modality in which any such effect would first become detectable.

Practical Implications

The present findings suggest that vividly produced vaccination PSAs may be particularly effective at eliciting subjective engagement among anxious audience members. However, the practical implications of this finding are likely to be limited in population-level health communication initiatives, which are typically designed for broad audiences rather than narrowly defined subgroups (Kreps & Neuhauser, 2010; An et al., 2021). More targeted use would require reliable ways to identify elevated anxiety and a delivery system capable of serving different message variants to different audiences, both of which pose substantial feasibility and dissemination challenges (Dunn et al., 2018; An et al., 2021; Matz et al., 2017). Accordingly, the most realistic implication is not that public health campaigns should be customized to anxious

individuals, but that PSA producers should consider how vividness and efficacy information function for the general population, while recognizing that digitally targeted interventions may eventually allow finer tailoring in precision-public-health settings (Dunn et al., 2018; An et al., 2021).

Second, the null GAD-7 main effect implies that sorting audiences by trait anxiety level alone is not a well-supported basis for targeting PSA content in this domain. Identifying which features amplify engagement among anxious individuals represents a more productive approach than treating trait anxiety as a standalone targeting criterion (Manganello et al., 2020; Wakefield et al., 2010). Third, the age–engagement relationship suggests that older participants were more engaged on both self-report and fixation-count measures, indicating that age may be an important audience characteristic to consider in PSA design and message development (Wakefield et al., 2010; Kreps & Neuhauser, 2010). Future public health campaigns should carefully consider how the age composition of the intended audience might influence baseline engagement levels, and future research could explore how age-related differences influence message processing across a wide age range (e.g., 18-84) in both mass-media and digital settings (Kreps & Neuhauser, 2010; Dunn et al., 2018).

Future Directions and Summary

The present findings suggest several productive directions for future research. First, incorporating a measure of repression–sensitization alongside GAD-7 would allow direct examination of whether opposing vigilance- and avoidance-driven trends underlie the null main effect, as predicted by Witte and Morrison's (2000) coping moderation account. Second, the GAD-7 × Vividness interaction was estimated within a restricted subset of 16 vaccination PSAs and did not survive an alternative missing-data approach (see Limitations). Replication across a

larger sample and the full range of behavioral focus types would help establish whether this interaction extends to other behaviors, which could not be evaluated in the present study due to the absence of matched non-vivid control stimuli for non-vaccination behaviors. Third, the physiological engagement factor in the present study was derived from post-PSA eye-tracking metrics only. Incorporating concurrent measures of physiological arousal during PSA exposure (e.g., skin conductance) would provide a more independent physiological channel and offer a stronger test of the two-component engagement model (Chalmers et al., 2014; Gillie & Thayer, 2014). Fourth, the present study did not assess downstream behavioral outcomes. Whether the anxiety-moderated effects on self-reported engagement observed here translate into meaningful differences in health behaviors such as vaccination uptake or protective behavior compliance remains unknown. Longitudinal or intervention designs linking laboratory engagement indices to behavioral follow-up would be a natural extension of the present work (Coroiu et al., 2020; Ghio et al., 2021). Fifth, future research could test whether anxiety moderates sensitivity to temporal bridging, say, by making present-threat framing more salient for individuals with elevated worry.

In summary, the present study provides evidence that baseline anxiety does not predict attentional engagement with COVID-19 PSAs as a direct main effect, but that its relationship with subjective engagement is meaningfully moderated by PSA behavioral focus and content vividness. The attenuation of anxiety-driven engagement for vaccination PSAs, and the more tentative amplification for vivid content, are theoretically coherent findings. Together they point toward a picture in which anxiety shapes how audiences consciously appraise PSA content in ways that depend on message features, even when corresponding differences in visual attention allocation are not apparent. This modality distinction across all analyses further suggests that self-report and eye-tracking capture distinct, nonredundant components of attentional

engagement, and that a multimodal measurement approach is necessary to characterize the full scope of anxiety's relationship with health message processing. This distinction also carries a direct implication for PSA effectiveness. To the extent that the vaccination-specific attenuation reflects a shift toward fear control, self-report, rather than eye-tracking, is the modality through which a message's risk of failing its more anxious viewers would first become visible. These findings contribute to an emerging person-by-message framework for understanding PSA effectiveness, in which the behavioral content and emotional characteristics of the message interact with audience characteristics to produce engagement responses that are neither uniform nor simply additive.

Strengths and Limitations

This thesis has several methodological strengths. The two-factor confirmatory factor analysis empirically distinguished self-report from physiological engagement, estimated using full-information maximum likelihood with robust standard errors to appropriately handle missing data. Parallel hierarchical linear mixed-effects models were fit across all eight engagement outcomes (two CFA-derived factor scores and six raw indicators), providing convergent evidence rather than relying on a single outcome. The within-subjects design, featuring matched vivid and non-vivid versions of the same PSA content (vaccination), allowed content features to be isolated cleanly from between-person confounds. Crossed random-intercept models accounted for both participant- and PSA-level variance, and a comprehensive set of person-level covariates, together with sensitivity analyses (reaction-time winsorization, an alternative missing-data approach), supported the robustness of the reported effects.

There are also several limitations to the present study, some of which concern the PSA stimuli themselves, while others involve design, analytic and measurement considerations. These

limitations are especially relevant when interpreting the null main effects of anxiety and the more selective pattern of significant findings observed across self-report and eye-tracking outcomes.

The custom-developed PSAs may not represent the full range of content and themes found in public health messaging more broadly. Although professionally produced, they were not broadcast-quality and were developed under substantial constraints on time and funding, and no manipulation checks were conducted to confirm that the intended thematic contrasts were consistently perceived at the individual level. This may have limited the detection of broader effects, given that several hypothesized effects were weak, null, or evident only for selected outcomes. The PSAs' 25-second, single-channel format also reflects broadcast-media conventions rather than the short-form, interactive content native to social media, where much public health messaging is now consumed; PSAs redesigned for these platforms might elicit different, and potentially stronger, engagement, particularly among younger or heavier social-media-using audiences. Separately, one hand-hygiene PSA (PSA 2) exhibited significantly lower mean fixations than the other experimental PSAs. Although the models' random-intercept structure was designed to absorb this kind of item-specific variance, this stimulus-level anomaly warrants caution when interpreting hand-hygiene-specific comparisons.

The self-report ratings were distributed along the lower portion of the scale (item means ranged from 2.39 to 2.78); this restricted dynamic range may have limited the sensitivity of the self-report items to detect between-person differences in engagement, including those associated with baseline anxiety, and a scale with more room to differentiate strongly disliked from strongly liked PSAs might have revealed larger or more consistent effects. Relatedly, because the eye-tracking data were collected under artificial laboratory conditions, the ecological generalizability of the observed anxiety–visual attention relationship is limited: people typically encounter PSAs

in more dynamic, distracting real-world environments (e.g., social media feeds), and attentional patterns observed here may not closely map onto naturalistic exposure. This is particularly relevant given that the clearest effects in this thesis emerged for self-report rather than eye-tracking outcomes, suggesting the two modalities may capture different aspects of engagement under experimental conditions; future studies should attempt to replicate these findings in more naturalistic settings, including designs using wearable or passive eye-tracking.

The sample is not necessarily representative of the general population as participants were recruited from a university community and surrounding areas and were required to be fully vaccinated at the time of participation. This resulted in a relatively well-educated, vaccine-compliant group whose baseline compliance was also high across the other mitigating behaviors targeted by the PSAs (95% for mask-wearing, 92% for distancing, 83% for hand-washing, alongside 79% booster uptake). The observed associations may therefore not generalize to individuals with different educational backgrounds, cultural contexts, lower baseline compliance, or levels of trust in public-health messaging, and restricted variability in these characteristics may have attenuated some hypothesized effect—though the finding that masking and distancing showed different anxiety-engagement slopes than vaccination, despite similarly high compliance, suggests this restricted variability is not a complete explanation on its own. Relatedly, because anxiety could not be experimentally manipulated, the study can only establish correlational, not causal, relationships between generalized anxiety and PSA engagement; and because perceived COVID-19 risk and fear/worry were not assessed, the analyses cannot determine whether COVID-19-specific fear was a more proximal predictor of engagement than generalized anxiety—a limitation especially relevant given that anxiety-related effects appear conditional and message-dependent rather than broad and uniform.

The secondary GAD-7 × Vividness interaction should be interpreted with caution as it did not survive an alternative missing-data approach; it weakened from significant (p = .017) to non-significant (p = .115) when the underlying factor scores were re-estimated using listwise deletion in place of full information maximum likelihood. Finally, the analysis was limited by the number of covariates available in the CCEP data. Potentially important variables such as psychological reactance and sleep were unavailable and may have biased the effect estimates through omitted-variable confounding, which may help explain why some anticipated relationships did not emerge as clearly as hypothesized and why significant effects were concentrated in particular message categories or measurement modalities. Future studies should incorporate a broader range of theoretically relevant audience characteristics to clarify the conditions under which anxiety is most likely to shape engagement with public health PSAs.

Conclusion

The present thesis examined whether baseline anxiety, as indexed by the GAD-7, was associated with attentional engagement with COVID-19 PSAs across both self-report and physiological measurement modalities, and whether PSA behavioral focus, temporal bridging, and vividness moderated this relationship. Contrary to the primary hypothesis, baseline anxiety did not reliably predict attentional engagement as a main effect across any of the outcomes examined. However, the relationship between anxiety and subjective engagement was moderated by PSA behavioral focus, with the anxiety–engagement association attenuated for vaccination PSAs relative to the other behavioral focus conditions. Secondary analyses provided tentative evidence that vividness moderated this relationship, with a positive anxiety–engagement association for vivid vaccination content among more anxious participants, though this finding should be treated as preliminary. Temporal bridging produced neither a reliable main effect nor a significant interaction with anxiety.

Across analyses, anxiety-related effects were confined to self-report outcomes and were absent for the eye-tracking indicators. In line with the two-factor CFA solution, these findings suggest that self-report and physiological engagement are related but empirically separable aspects of PSA processing. This underscores the value of using multimodal measures when evaluating audience responses to health communication.

Taken together, the present findings indicate that anxiety does not uniformly increase engagement with COVID-19 PSAs, but that its relationship with subjective engagement depends on message features and emotional salience. These results contribute to an emerging understanding of how audience characteristics and PSA features interact to shape responses to public health communication.

Statement on Generative Artificial Intelligence

Generative AI was used to conduct a final check of the thesis for grammatical errors and to propose minor wording refinements. All AI-suggested edits were reviewed and validated before being applied.

References

Ainslie, G. (2020). Willpower with and without effort. *The Behavioral and Brain Sciences*, *44*, e30. https://doi.org/10.1017/S0140525X20000357

Albery, I. P., Spada, M. M., & Nikčević, A. V. (2021). The COVID-19 anxiety syndrome and selective attentional bias towards COVID-19-related stimuli in UK residents during the 2020-2021 pandemic. *Clinical Psychology & Psychotherapy*, *28*(6), 1367–1378. https://doi.org/10.1002/cpp.2639

Alptekin, H. D., Kucun, N. T., Kurt, M., & Ozkara, B. Y. (2024). Neurometric and biometric measurement of the effectiveness of COVID-19-related public service announcements. *International Review on Public and Nonprofit Marketing*, *21*(3), 625-643. https://doi.org/10.1007/s12208-024-00399-5

American Psychiatric Association. (2022). *Diagnostic and statistical manual of mental disorders* (5th ed., text rev.). https://doi.org/10.1176/appi.books.9780890425787

An, J., Kwak, H., Qureshi, H. M., & Weber, I. (2021). Precision Public Health Campaign: Delivering Persuasive Messages to Relevant Segments Through Targeted Advertisements on Social Media. *JMIR Formative Research*, *5*(9), e22313. https://doi.org/10.2196/22313

Armstrong, T., & Olatunji, B. O. (2012). Eye tracking of attention in the affective disorders: A meta-analytic review and synthesis. *Clinical Psychology Review*, *32*(8), 704-723. https://doi.org/10.1016/j.cpr.2012.09.004

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-

analytic study. *Psychological Bulletin*, *133*(1), 1–24. https://doi.org/10.1037/0033-2909.133.1.1

Barkley, R. A. (2011). *Barkley Deficits in Executive Functioning Scale (BDEFS)*. The Guilford Press.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Block, L. G., & Keller, P. A. (1997). Effects of self-efficacy and vividness on the persuasiveness of health communications. *Journal of Consumer Psychology*, *6*(1), 31-54. https://doi.org/10.1207/s15327663jcp0601_02

Blondé, J., & Girandola, F. (2016). Revealing the elusive effects of vividness: A meta-analysis of empirical evidences assessing the effect of vividness on persuasion. *Social Influence*, *11*(2), 111–129. https://doi.org/10.1080/15534510.2016.1157096

Blondé, J., & Girandola, F. (2018). Are vivid (vs. Pallid) threats persuasive? Examining the effects of threat vividness in health communications. *Basic and Applied Social Psychology*, *40*(1), 36–48. https://doi.org/10.1080/01973533.2017.1412969

Böhm, R., Schneider, A., Betsch, C., & Lilleholt, L. (2026). CDC communication undermines trust in vaccines. *Science (New York, N.Y.)*, *392*(6797), 475–477. https://doi.org/10.1126/science.aef5320

Bol, N., van Weert, J. C., Loos, E. F., Romano Bergstrom, J. C., Bolle, S., & Smets, E. M. (2016). How Are Online Health Messages Processed? Using Eye Tracking to Predict

Recall of Information in Younger and Older Adults. *Journal of Health Communication*, *21*(4), 387–396. https://doi.org/10.1080/10810730.2015.1080327

Brewer, N. T., Chapman, G. B., Gibbons, F. X., Gerrard, M., McCaul, K. D., & Weinstein, N. D. (2007). Meta-analysis of the relationship between risk perception and health behavior: The example of vaccination. *Health Psychology*, *26*(2), 136–145. https://doi.org/10.1037/0278-6133.26.2.136

Brigaud, E., Lafont, A., & Blanc, N. (2021). Your Eyes Do Not Lie! Dissecting Humor Effects in Health Messages Using Eye Tracker Technology. *Frontiers in Public Health*, *9*, 653584. https://doi.org/10.3389/fpubh.2021.653584

Brooks, J. S., Claudio, L., Araya, F., Idris, M. Y., Pierre, K., & Korin, M. (2024). Lights, Facts, and Goals: A Novel Framework to Enhance Community Health Messaging Campaign Design, Implementation, and Assessment. *Health Promotion Practice*, *25*(5), 750–754. https://doi.org/10.1177/15248399231209028

Brosch, T., Sander, D., Pourtois, G., & Scherer, K. R. (2008). Beyond fear: rapid spatial orienting toward positive emotional stimuli. *Psychological Science*, *19*(4), 362–370. https://doi.org/10.1111/j.1467-9280.2008.02094.x

Cannito, L., Di Crosta, A., Palumbo, R., Ceccato, I., Anzani, S., La Malva, P., Palumbo, R., & Di Domenico, A. (2020). Health anxiety and attentional bias toward virus-related stimuli during the COVID-19 pandemic. *Scientific Reports*, *10*(1), 16476. https://doi.org/10.1038/s41598-020-73599-8

Cartocci, G., Modica, E., Rossi, D., Cherubino, P., Maglione, A. G., Colosimo, A., Trettel, A., Mancini, M., & Babiloni, F. (2018). Neurophysiological Measures of the Perception of

Antismoking Public Service Announcements Among Young Population. *Frontiers in Human Neuroscience*, *12*, 231. https://doi.org/10.3389/fnhum.2018.00231

Chalmers, J. A., Quintana, D. S., Abbott, M. J. A., & Kemp, A. H. (2014). Anxiety disorders are associated with reduced heart rate variability: A meta-analysis. *Frontiers in Psychiatry*, *5*, 80. https://doi.org/10.3389/fpsyt.2014.00080

Chandran, S., & Menon, G. (2004). When a day means more than a year: Effects of temporal framing on judgments of health risk. *Journal of Consumer Research*, *31*(2), 375–389. https://doi.org/10.1086/422116

Cheng, Y. C., Su, M. I., Liu, C. W., Huang, Y. C., & Huang, W. L. (2022). Heart rate variability in patients with anxiety disorders: A systematic review and meta-analysis. *Psychiatry and Clinical Neurosciences*, *76*(7), 292–302. https://doi.org/10.1111/pcn.13356

Cisler, J. M., & Koster, E. H. (2010). Mechanisms of attentional biases towards threat in anxiety disorders: An integrative review. *Clinical Psychology Review*, *30*(2), 203-216. https://doi.org/10.1016/j.cpr.2009.11.003

Clauss, K., Gorday, J. Y., & Bardeen, J. R. (2022). Eye tracking evidence of threat-related attentional bias in anxiety-and fear-related disorders: A systematic review and meta-analysis. *Clinical Psychology Review*, *93*, 102142. https://doi.org/10.1016/j.cpr.2022.102142

Coroiu, A., Moran, C., Campbell, T., & Geller, A. C. (2020). Barriers and facilitators of adherence to social distancing recommendations during COVID-19 among a large international sample of adults. *PLOS ONE*, *15*(10), e0239795. https://doi.org/10.1371/journal.pone.0239795

DeJong, W. (2017). Public service announcements and exposure to health and risk messages. In M. Powers (Ed.), *Oxford Research Encyclopedia of Communication*. Oxford University Press. https://doi.org/10.1093/acrefore/9780190228613.013.334

Dennis, A. S., Moravec, P. L., Kim, A., & Dennis, A. R. (2021). Assessment of the effectiveness of identity-based public health announcements in increasing the likelihood of complying with COVID-19 guidelines: Randomized controlled cross-sectional web-based study. *JMIR Public Health and Surveillance*, *7*(4), e25762. https://doi.org/10.2196/25762

Dijkstra, A., & Elbert, S. (2019). Eye movement inductions influence health behaviour: The working memory account of persuasion. *Psychology & Health*, *34*(11), 1378–1394. https://doi.org/10.1080/08870446.2019.1609678

Dryhurst, S., Schneider, C. R., Kerr, J., Freeman, A. L. J., Recchia, G., van der Bles, A. M., Spiegelhalter, D., & van der Linden, S. (2020). Risk perceptions of COVID-19 around the world. *Journal of Risk Research*, *23*(7-8), 994–1006. https://doi.org/10.1080/13669877.2020.1758193

Dugas, M. J., Gagnon, F., Ladouceur, R., & Freeston, M. H. (1998). Generalized anxiety disorder: A preliminary test of a conceptual model. *Behaviour Research and Therapy*, *36*(2), 215-226. https://doi.org/10.1016/s0005-7967(97)00070-3

Dunn, A. G., Mandl, K. D., & Coiera, E. (2018). Social media interventions for precision public health: Promises and risks. *NPJ Digital Medicine*, *1*, 47. https://doi.org/10.1038/s41746-018-0054-0

Dziemian, S., Bujia, G., Prasse, P., Barańczuk-Turska, Z., Jäger, L. A., Kamienkowski, J. E., & Langer, N. (2024). Saliency Models Reveal Reduced Top-Down Attention in Attention-

Deficit/Hyperactivity Disorder: A Naturalistic Eye-Tracking Study. *JAACAP Open*, *3*(2), 192–204. https://doi.org/10.1016/j.jaacop.2024.03.001

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics*, *16*(1), 143-149. https://doi.org/10.3758/BF03203267

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition and Emotion*, *6*(6), 409–434. https://doi.org/10.1080/02699939208409696

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion*, *7*(2), 336–353. https://doi.org/10.1037/1528-3542.7.2.336

Falk, E. B., O'Donnell, M. B., Tompson, S., Gonzalez, R., Dal Cin, S., Strecher, V., ... & An, L. (2016). Functional brain imaging predicts public health campaign success. *Social Cognitive and Affective Neuroscience*, *11*(2), 204-214. https://doi.org/10.1093/scan/nsv108

Fisher, J. T., Huskey, R., Keene, J. R., & Weber, R. (2018). The limited capacity model of motivated mediated message processing: Looking to the future. *Annals of the International Communication Association*, *42*(4), 291-315. https://doi.org/10.1080/23808985.2018.1534552

Forte, G., Favieri, F., Oliha, E. O., Marotta, A., & Casagrande, M. (2021). Anxiety and Attentional Processes: The Role of Resting Heart Rate Variability. *Brain Sciences*, *11*(4), 480. https://doi.org/10.3390/brainsci11040480

Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety?. *Journal of Experimental Psychology: General*, *130*(4), 681–700. https://doi.org/10.1037/0096-3445.130.4.681

Fridkin, K., Horsting, T., Brown, A. L., & Williams, A. M. (2024). How college students react to COVID vaccine PSAs: An experimental investigation. *American Politics Research*, *52*(3), 203-224. https://doi.org/10.1177/1532673X231220650

Ghio, D., Lawes-Wickwar, S., Tang, M. Y., Epton, T., Howlett, N., Jenkinson, E., Stanescu, S., Westbrook, J., Kassianos, A. P., Watson, D., Sutherland, L., Stanulewicz, N., Guest, E., Scanlan, D., Carr, N., Chater, A., Hotham, S., Thorneloe, R., Armitage, C. J., Arden, M., … Keyworth, C. (2021). What influences people's responses to public health messages for managing risks and preventing infectious diseases? A rapid systematic review of the evidence and recommendations. *BMJ Open*, *11*(11), e048750. https://doi.org/10.1136/bmjopen-2021-048750

Gillie, B. L., & Thayer, J. F. (2014). Individual differences in resting heart rate variability and cognitive control in posttraumatic stress disorder. *Frontiers in Psychology*, *5*, 758. https://doi.org/10.3389/fpsyg.2014.00758

Goodwin, H., Yiend, J., & Hirsch, C. R. (2017). Generalized Anxiety Disorder, worry and attention to threat: A systematic review. *Clinical Psychology Review*, *54*, 107–122. https://doi.org/10.1016/j.cpr.2017.03.006

Greene, S., Hetherington, M., Maxwell, R., & Ryan, T. J. (2022). Public service announcements and promoting face masks during the COVID-19 pandemic. *PS: Political Science & Politics*, *55*(1), 7-12. https://doi.org/10.1017/S1049096521001086

Guadagno, R. E., Rhoads, K. V. L., & Sagarin, B. J. (2011). Figural vividness and persuasion: Capturing the "elusive" vividness effect. *Personality and Social Psychology Bulletin*, *37*(5), 626–638. https://doi.org/10.1177/0146167211399585

Hall, P. A., Fong, G. T., Hitchman, S. C., Quah, A. C. K., Agar, T., Meng, G., Ayaz, H., Dore, B. P., Sakib, M. N., Hudson, A., & Boudreau, C. (2022). Brain and behavior in health communication: The Canadian COVID-19 Experiences Project. *Brain, Behavior, & Immunity - Health*, *22*, 100467. https://doi.org/10.1016/j.bbih.2022.100467

Harper, C. A., Satchell, L. P., Fido, D., & Latzman, R. D. (2021). Functional Fear Predicts Public Health Compliance in the COVID-19 Pandemic. *International Journal of Mental Health and Addiction*, *19*(5), 1875–1888. https://doi.org/10.1007/s11469-020-00281-5

Hedayati, S., Damghanian, H., Farhadinejad, M., & Rastgar, A. A. (2023). Meta-analysis on application of protection motivation theory in preventive behaviors against COVID-19. International Journal of Disaster Risk Reduction, 94, Article 103758. https://doi.org/10.1016/j.ijdrr.2023.103758

Hirsch, C. R., MacLeod, C., Mathews, A., Sandher, O., Siyani, A., & Hayes, S. (2011). The contribution of attentional bias to worry: Distinguishing the roles of selective engagement and disengagement. *Journal of Anxiety Disorders*, *25*(2), 272–277. https://doi.org/10.1016/j.janxdis.2010.09.013

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H., & Van de Weijer, J. (2011). *Eye tracking: A comprehensive guide to methods and measures*. oup Oxford.

Hooge, I. T. C., Nuthmann, A., Nyström, M., Niehorster, D. C., Holleman, G. A., Andersson, R., & Hessels, R. S. (2025). The fundamentals of eye tracking part 2: From research question

to operationalization. *Behavior Research Methods*, *57*(2), 73. https://doi.org/10.3758/s13428-024-02590-2

Huang, G., & Xu, J. (2024). Disentangling the effects of temporal framing on risk perception, attitude, behavioral intention, and behavior: A multilevel meta-analysis. *Communication Research*, *51*(1), 3–27. https://doi.org/10.1177/00936502221102102

Hudson, A., Hall, P., Meng, G., Quah, A., Agar, T., & Fong, G. (2023). *"In the eye of the storm": What makes for an effective COVID-19 PSA?*. Unpublished manuscript.

Imhof, M. A., Schmälzle, R., Renner, B., & Schupp, H. T. (2020). Strong health messages increase audience brain coupling. *NeuroImage*, *216*, 116527. https://doi.org/10.1016/j.neuroimage.2020.116527

Kessels, L. T., & Ruiter, R. A. (2012). Eye movement responses to health messages on cigarette packages. *BMC Public Health*, *12*, 352. https://doi.org/10.1186/1471-2458-12-352

Kessels, L. T., Ruiter, R. A., Wouters, L., & Jansma, B. M. (2014). Neuroscientific evidence for defensive avoidance of fear appeals. *International Journal of Psychology : Journal International de Psychologie*, *49*(2), 80–88. https://doi.org/10.1002/ijop.12036

Kite, J., Chan, L., MacKay, K., Corbett, L., Reyes-Marcelino, G., Nguyen, B., Bellew, W., & Freeman, B. (2023). A Model of Social Media Effects in Public Health Communication Campaigns: Systematic Review. *Journal of Medical Internet Research*, *25*, e46345. https://doi.org/10.2196/46345

Koffarnus, M. N., & Bickel, W. K. (2014). A 5-trial adjusting delay discounting task: Accurate discount rates in less than one minute. *Experimental and Clinical Psychopharmacology*, *22*(3), 222. https://doi.org/10.1037/a0035973

Kreps, G. L., & Neuhauser, L. (2010). New directions in eHealth communication: Opportunities and challenges. *Patient Education and Counseling*, *78*(3), 329–336. https://doi.org/10.1016/j.pec.2010.01.013

Kuehn, M., LaMori, J., DeMartino, J. K., Mesa-Frias, M., Doran, J., Korrapati, L., Bhojwani, R., Lefebvre, P., & Kirson, N. (2022). Assessing barriers to access and equity for COVID-19 vaccination in the US. *BMC Public Health*, *22*, Article 2263. https://doi.org/10.1186/s12889-022-14636-1

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest package: Tests in linear mixed effects models. *Journal of Statistical Software*, *82*(13), 1–26. https://doi.org/10.18637/jss.v082.i13

Kwasnicka, D., Dombrowski, S. U., White, M., & Sniehotta, F. (2016). Theoretical explanations for maintenance of behaviour change: A systematic review of behaviour theories. *Health Psychology Review*, *10*(3), 277–296. https://doi.org/10.1080/17437199.2016.1151372

Lang, A. (2000). The limited capacity model of mediated message processing. *Journal of Communication*, *50*(1), 46–70. https://doi.org/10.1111/j.1460-2466.2000.tb02833.x

Langleben, D. D., Loughead, J. W., Ruparel, K., Hakun, J. G., Busch-Winokur, S., Holloway, M. B., Strasser, A. A., Cappella, J. N., & Lerman, C. (2009). Reduced prefrontal and temporal processing and recall of high "sensation value" ads. *NeuroImage*, *46*(1), 219–225. https://doi.org/10.1016/j.neuroimage.2008.12.062

Léger, C., Deslauriers, F., Gosselin Boucher, V., Phillips, M., Bacon, S. L., & Lavoie, K. L. (2023). Prevalence and motivators of getting a COVID-19 booster vaccine in Canada: Results from the iCARE study. *Vaccines*, *11*(2), Article 291. https://doi.org/10.3390/vaccines11020291

Lenth, R. V., & Piaskowski, J. (2026). *emmeans: Estimated marginal means, aka least-squares means* (R package version 2.0.3). https://rvlenth.github.io/emmeans/

Lienemann, B. A., & Siegel, J. T. (2016). State Psychological Reactance to Depression Public Service Announcements Among People With Varying Levels of Depressive Symptomatology. *Health Communication*, *31*(1), 102–116. https://doi.org/10.1080/10410236.2014.940668

Luo, X., Zhang, L., & Wang, J. (2017). The Benefits of Working Memory Capacity on Attentional Control under Pressure. *Frontiers in Psychology*, *8*, 1105. https://doi.org/10.3389/fpsyg.2017.01105

Manganello, J., Bleakley, A., & Schumacher, P. (2020). Pandemics and PSAs: Rapidly changing information in a new media landscape. *Health Communication*, *35*(14), 1711-1714. https://doi.org/10.1080/10410236.2020.1839192

Matz, S. C., Kosinski, M., Nave, G., & Stillwell, D. J. (2017). Psychological targeting as an effective approach to digital mass persuasion. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(48), 12714–12719. https://doi.org/10.1073/pnas.1710966114

Maynard, O. M., Attwood, A., O'Brien, L., Brooks, S., Hedge, C., Leonards, U., & Munafò, M. R. (2014). Avoidance of cigarette pack health warnings among regular cigarette smokers.

Drug and Alcohol Dependence, *136*, 170–174. https://doi.org/10.1016/j.drugalcdep.2014.01.001

Mogg, K., & Bradley, B. P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy*, *36*(9), 809–848. https://doi.org/10.1016/S0005-7967(98)00063-1

Myers, J. (2014). Stalking the "Vividness Effect" in the preventive health message: The moderating role of argument quality on the effectiveness of message vividness. *Journal of Promotion Management*, *20*(5), 628-646. https://doi.org/10.1080/10496491.2014.946199

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review*, *84*(3), 231–259. https://doi.org/10.1037/0033-295X.84.3.231

Noar, S. M., Hall, M. G., Francis, D. B., Ribisl, K. M., Pepper, J. K., & Brewer, N. T. (2016). Pictorial cigarette pack warnings: A meta-analysis of experimental studies. *Tobacco Control*, *25*(3), 341–354. https://doi.org/10.1136/tobaccocontrol-2014-051978

Ophir, Y., Brennan, E., Maloney, E. K., & Cappella, J. N. (2019). The effects of graphic warning labels' vividness on message engagement and intentions to quit smoking. *Communication Research*, *46*(5), 619-638. https://doi.org/10.1177/0093650217700226

Orquin, J. L., & Mueller Loose, S. (2013). Attention and choice: A review on eye movements in decision making. *Acta Psychologica*, *144*(1), 190–206. https://doi.org/10.1016/j.actpsy.2013.06.003

Paasche-Orlow, M. K., & Wolf, M. S. (2007). The causal pathways linking health literacy to health outcomes. *American Journal of Health Behavior*, 31(1), S19-S26. https://doi.org/10.5555/ajhb.2007.31.supp.S19

Perski, O., Blandford, A., West, R., & Michie, S. (2017). Conceptualising engagement with digital behaviour change interventions: A systematic review using principles from critical interpretive synthesis. *Translational Behavioral Medicine*, *7*(2), 254–267. https://doi.org/10.1007/s13142-016-0453-1

Peters, G. J. Y., Ruiter, R. A., & Kok, G. (2013). Threatening communication: A critical re-analysis and a revised meta-analytic test of fear appeal theory. *Health Psychology Review*, *7*(sup1), S8-S31. https://doi.org/10.1080/17437199.2012.703527

Petherick, A., Goldszmidt, R., Andrade, E. B., Furst, R., Hale, T., Pott, A., & Wood, A. (2021). A worldwide assessment of changes in adherence to COVID-19 protective behaviours and hypothesized pandemic fatigue. *Nature Human Behaviour*, *5*(9), 1145–1160. https://doi.org/10.1038/s41562-021-01181-x

Potter, R. F., & Bolls, P. D. (2012). *Psychophysiological measurement and meaning: Cognitive and emotional processing of media*. Routledge.

Qian, S., Chen, K., Meng, J., Shen, C., Chen, A., & Zhang, J. (2025). Fear in Media Headlines Increases Public Risk Perceptions but Decreases Preventive Behaviors: A Multi-Country Study During the COVID-19 Pandemic. *Journal of Health Communication*, *30*(1-3), 29-39. https://doi.org/10.1080/10810730.2024.2439468

Rains, S. A. (2013). The Nature of Psychological Reactance Revisited: A Meta-Analytic Review. *Human Communication Research*, *39*(1), 47–73. https://doi.org/10.1111/j.1468-2958.2012.01443.x

Rogers, R. W. (1975). A protection motivation theory of fear appeals and attitude change. *The Journal of Psychology*, *91*(1), 93–114. https://doi.org/10.1080/00223980.1975.9915803

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*(2), 1–36. https://doi.org/10.18637/jss.v048.i02

Rothman, A. J. (2000). Toward a theory-based analysis of behavioral maintenance. *Health Psychology*, *19*(1, Suppl.), 64–69. https://doi.org/10.1037/0278-6133.19.Suppl1.64

Ruiter, R. A., Kessels, L. T., Peters, G. J. Y., & Kok, G. (2014). Sixty years of fear appeal research: Current state of the evidence. *International Journal of Psychology*, *49*(2), 63-70. https://doi.org/10.1002/ijop.12042

Sackett, P. R., & Yang, H. (2000). Correction for range restriction: An expanded typology. *Journal of Applied Psychology*, *85*(1), 112–118. https://doi.org/10.1037/0021-9010.85.1.112

Sarapas, C., Weinberg, A., Langenecker, S. A., & Shankman, S. A. (2017). Relationships among attention networks and physiological responding to threat. *Brain and Cognition*, *111*, 63-72. https://doi.org/10.1016/j.bandc.2016.09.012

Savadori, L., & Lauriola, M. (2022). Risk perceptions and COVID-19 protective behaviors: A two-wave longitudinal study of epidemic and post-epidemic periods. *Social Science & Medicine*, *301*, Article 114949. https://doi.org/10.1016/j.socscimed.2022.114949

Shi, R., Sharpe, L., & Abbott, M. (2019). A meta-analysis of the relationship between anxiety and attentional control. *Clinical Psychology Review*, *72*, 101754. https://doi.org/10.1016/j.cpr.2019.101754

Sillero-Rejon, C., Leonards, U., Munafò, M. R., Hedge, C., Hoek, J., Toll, B., Gove, H., Willis, I., Barry, R., Robinson, A., & Maynard, O. M. (2021). Avoidance of tobacco health warnings? An eye-tracking approach. *Addiction (Abingdon, England)*, *116*(1), 126–138. https://doi.org/10.1111/add.15148

Spitzer, R. L., Kroenke, K., Williams, J. B., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. *Archives of Internal Medicine*, *166*(10), 1092–1097. https://doi.org/10.1001/archinte.166.10.1092

Stolow, J. A., Moses, L. M., Lederer, A. M., & Carter, R. (2020). How fear appeal approaches in COVID-19 health communication may be harming the global community. *Health Education & Behavior*, *47*(4), 531-535. https://doi.org/10.1177/1090198120935073

Sweeny, K., Melnyk, D., Miller, W., & Shepperd, J. A. (2010). Information Avoidance: Who, what, when, and why. *Review of General Psychology*, *14*(4), 340-353. https://doi.org/10.1037/a0021288

Tait, M. E., Abrahams, J., Brehm, R., Baum, L., Fowler, E. F., Niederdeppe, J., & Gollust, S. E. (2022). Serving the public? A content analysis of COVID-19 public service announcements airing from March–December of 2020 in the US. *Preventive Medicine Reports*, *29*, 101971. https://doi.org/10.1016/j.pmedr.2022.101971

Tannenbaum, M. B., Hepler, J., Zimmerman, R. S., Saul, L., Jacobs, S., Wilson, K., & Albarracín, D. (2015). Appealing to fear: A meta-analysis of fear appeal effectiveness

and theories. *Psychological Bulletin*, *141*(6), 1178–1204. https://doi.org/10.1037/a0039729

Trope, Y., Liberman, N., & Wakslak, C. (2007). Construal Levels and Psychological Distance: Effects on Representation, Prediction, Evaluation, and Behavior. *Journal of Consumer Psychology : the Official Journal of the Society for Consumer Psychology*, *17*(2), 83–95. https://doi.org/10.1016/S1057-7408(07)70013-X

Van de Mortel, T. F. (2008). Faking it: Social desirability response bias in self-report research. *The Australian Journal of Advanced Nursing*, *25*(4), 40-48.

Veerapa, E., Grandgenevre, P., El Fayoumi, M., Vinnac, B., Haelewyn, O., Szaffarczyk, S., ... & D'Hondt, F. (2020). Attentional bias towards negative stimuli in healthy individuals and the effects of trait anxiety. *Scientific Reports*, *10*(1), 11826. https://doi.org/10.1038/s41598-020-68490-5

Venkatraman, V., Dimoka, A., Pavlou, P. A., Vo, K., Hampton, W., Bollinger, B., Hershfield, H. E., Ishihara, M., & Winer, R. S. (2015). Predicting advertising success beyond traditional measures: New insights from neurophysiological methods and market response modeling. *Journal of Marketing Research*, *52*(4), 436–452. https://doi.org/10.1509/jmr.13.0593

Viswanath, K., & Emmons, K. M. (2006). Message effects and social determinants of health: Its application to cancer disparities. *Journal of Communication*, *56*(suppl_1), S238-S264. https://doi.org/10.1111/j.1460-2466.2006.00292.x

Wakefield, M. A., Loken, B., & Hornik, R. C. (2010). Use of mass media campaigns to change health behaviour. *The Lancet*, *376*(9748), 1261-1271. https://doi.org/10.1016/S0140-6736(10)60809-4

Wang, Y., Thier, K., Lee, S., & Nan, X. (2024). Persuasive effects of temporal framing in health messaging: A meta-analysis. *Health Communication*, *39*(3), 563-576. https://doi.org/10.1080/10410236.2023.2175407

Wanigaratne, S., Lu, H., Gandhi, S., Shetty, J., Stukel, T. A., Piché-Renaud, P.-P., Brandenberger, J., Abdi, S., & Guttmann, A. (2023). COVID-19 vaccine equity: A retrospective population-based cohort study examining primary series and first booster coverage among persons with a history of immigration and other residents of Ontario, Canada. *Frontiers in Public Health*, *11*, Article 1232507. https://doi.org/10.3389/fpubh.2023.1232507

Weinstein, N. D., Kwitel, A., McCaul, K. D., Magnan, R. E., Gerrard, M., & Gibbons, F. X. (2007). Risk perceptions: Assessment and relationship to influenza vaccination. *Health Psychology*, *26*(2), 146–151. https://doi.org/10.1037/0278-6133.26.2.146

West, S. G., Finch, J. F., & Curran, P. J. (1995). Structural equation models with nonnormal variables: Problems and remedies. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues, and applications* (pp. 56–75). Sage.

Witte, K. (1992). Putting the fear back into fear appeals: The extended parallel process model. *Communications Monographs*, *59*(4), 329-349. https://doi.org/10.1080/03637759209376276

Witte, K. (1994). Fear control and danger control: A test of the extended parallel process model (EPPM). *Communications Monographs*, *61*(2), 113-134. https://doi.org/10.1080/03637759409376328

Witte, K., & Morrison, K. (2000). Examining the influence of trait anxiety/repression–sensitization on individuals' reactions to fear appeals. *Western Journal of Communication (includes Communication Reports)*, *64*(1), 1–27. https://doi.org/10.1080/10570310009374661

Zhang, J. M., Zhang, D., & Chock, T. M. (2014). Effects of HIV/AIDS public service announcements on attitude and behavior: Interplay of perceived threat and self-efficacy. *Social Behavior and Personality: An International Journal*, *42*(5), 799-809. https://doi.org/10.2224/sbp.2014.42.5.799

Zhao, Y., Jia, X., Pan, S., Ji, H., & Wang, Y. (2023). Content specificity of attentional bias to COVID-19 threat-related information in trait anxiety. *Frontiers in Psychiatry*, *14*, 1254349. https://doi.org/10.3389/fpsyt.2023.1254349

Appendices

Appendix A: List of All PSA Evaluation Items in CCEP Study 2

	Not at all (1)	Slightly (2)	Moderately (3)	Very (4)	Extremely (5)
1. How much did you like this ad?					
2. How engaging was this ad?					
3. How motivating was this ad?					
4. How much did this ad make you self-reflect?					

Note. Self-report items used by participants to evaluate the effectiveness of COVID-19 PSAs in CCEP Study 2.

Appendix B: COVID-19 PSA Thematic Categories

Theme	Details
Affect	PSAs were presented in either a positive or a negative valence
Temporal bridging	PSAs differed in whether they emphasized future-oriented consequences (i.e., long-term benefits) after implementing mitigation behaviors, or not
Vividness	PSAs were designed to include differing amounts of vivid elements (e.g., polychromatic displays, background music, emotionally-salient pictures); this contrast was created a priori only for vaccination-themed PSAs
Behavioral focus	PSAs emphasized one of masking, distancing, hand hygiene, or vaccination
Normative strategy	PSAs differed in whether they highlighted that the majority of the population performs the mitigating behavior that is recommended

Note. Description of how the COVID-19 PSAs varied in terms of theme.

Appendix C: Sample of COVID-19 PSAs in CCEP

A)



B)



C)



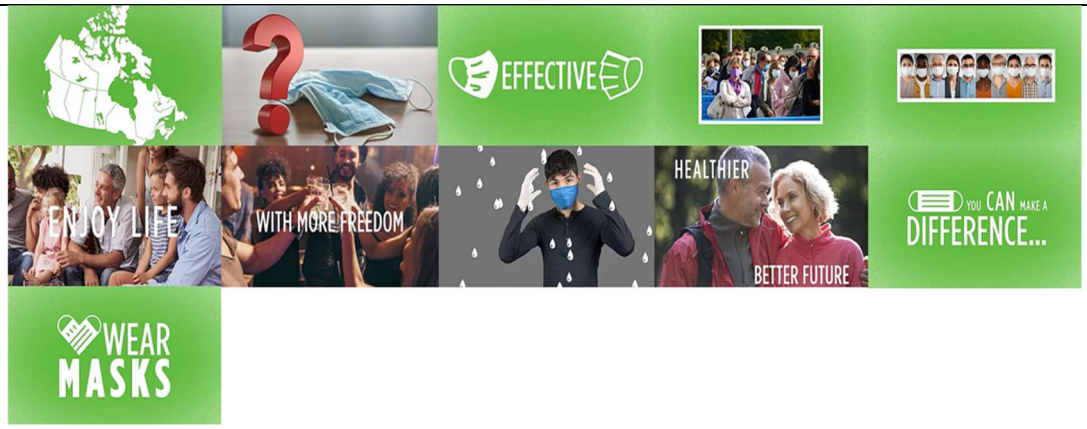
D)



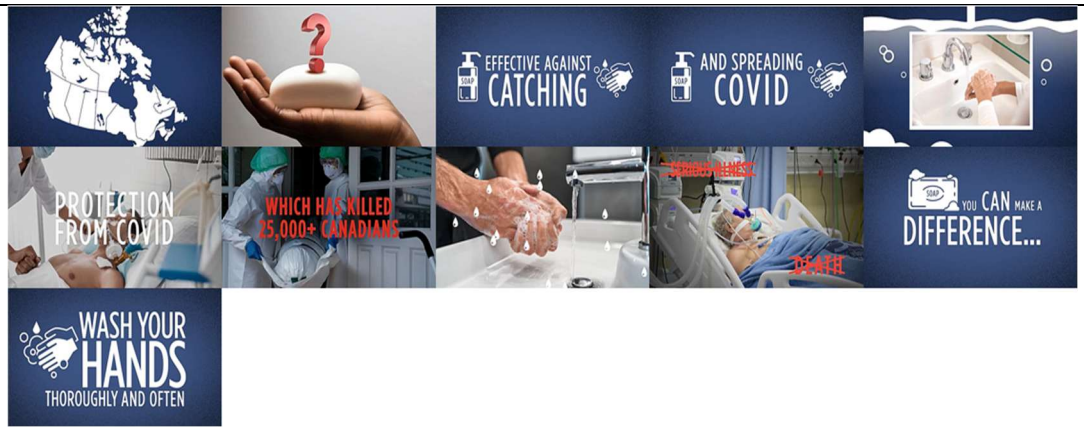
E)


EFFECTIVE
PROTECTION FROM COVID
WHICH HAS KILLED 25,000+ CANADIANS
SERIOUS ILLNESS
DEATH
YOU CAN MAKE A DIFFERENCE...
WEAR MASKS

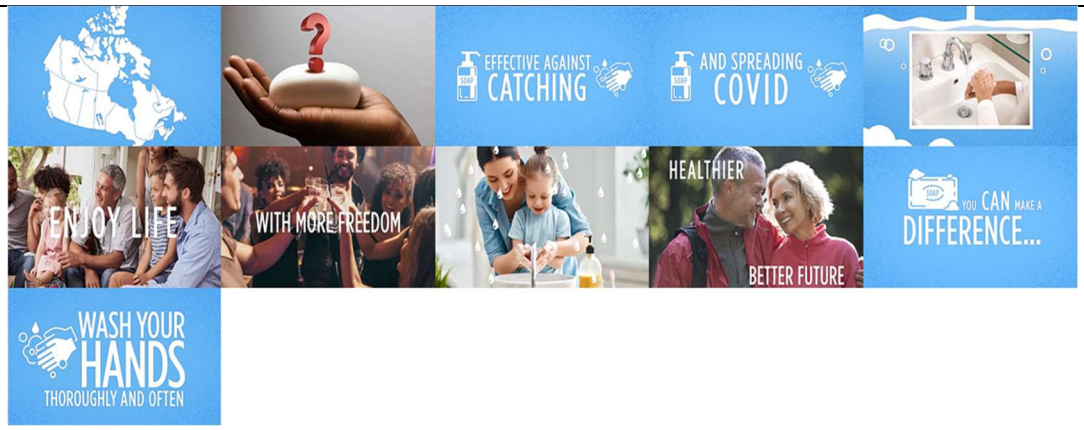
F)


EFFECTIVE
ENJOY LIFE
WITH MORE FREEDOM
HEALTHIER
BETTER FUTURE
YOU CAN MAKE A DIFFERENCE...
WEAR MASKS

G)


EFFECTIVE AGAINST CATCHING
AND SPREADING COVID
PROTECTION FROM COVID
WHICH HAS KILLED 25,000+ CANADIANS
SERIOUS ILLNESS
DEATH
YOU CAN MAKE A DIFFERENCE...
WASH YOUR HANDS THOROUGHLY AND OFTEN

H)



Note. (A) Screen captures of a vivid vaccination PSA that is negatively valenced. (B) Screen captures of a vivid vaccination PSA that is positively valenced. (C) Screen captures a vivid distancing PSA that is negatively valenced. (D) Screen captures a vivid distancing PSA that is positively valenced. E) Screen captures a vivid masking PSA that is negatively valenced. F) Screen captures a vivid masking PSA that is positively valenced. G) Screen captures a vivid hand-washing PSA that is negatively valenced. H) Screen captures a vivid hand-washing PSA that is positively valenced.

Appendix D: Sample of Vaccination PSA Scripts

#	PSA Theme	Script
25	Negative, No Normative, Temporal bridging	Getting all recommended shots of the safe and effective COVID vaccine will protect you from COVID, which has killed over 25,000+ Canadians. Although you may experience some short-term side effects, the vaccine will nearly eliminate your chance of serious illness or death. You can make a difference... get fully vaccinated.
26	Negative, No Normative, No Temporal bridging	Getting all recommended shots of the safe and effective COVID vaccine will protect you from COVID, which has killed over 25,000+ Canadians. You can make a difference... get fully vaccinated.
27	Negative, Normative, Temporal bridging	More and more Canadians who were uncertain about the COVID vaccine, now realize that it is safe and effective. They are now getting fully vaccinated to protect themselves from COVID, which has killed over 25,000+ Canadians. Although you may experience some short-term side effects, the vaccine will nearly eliminate your chance of serious illness or death. You can make a difference... get fully vaccinated.
28	Negative, Normative, No Temporal bridging	More and more Canadians who were uncertain about the COVID vaccine, now realize that it is safe and effective. They are now getting fully vaccinated to protect themselves from COVID, which has killed over 25,000+ Canadians. You can make a difference... get fully vaccinated.
29	Positive, No Normative, Temporal bridging	Getting all recommended shots of the safe and effective COVID vaccine will let you get back to enjoying life with more freedom. Although you may experience some short-term side effects, you will enjoy a much better future. You can make a difference... get fully vaccinated.
30	Positive, No Normative, No Temporal bridging	More and more Canadians who were uncertain about the COVID vaccine, now realize that it is safe and effective. They are now getting fully vaccinated to get back to enjoying life with more freedom. Although you may experience some short-term side effects, you will enjoy a much better future. You can make a difference... get fully vaccinated.

#	PSA Theme	Script
31	Positive, Normative, Temporal bridging	More and more Canadians who were uncertain about the COVID vaccine, now realize that it is safe and effective. They are now getting fully vaccinated to get back to enjoying life with more freedom. Although you may experience some short-term side effects, you will enjoy a much better future. You can make a difference... get fully vaccinated.
32	Positive, Normative, No Temporal bridging	More and more Canadians who were uncertain about the COVID vaccine, now realize that it is safe and effective. They are now getting fully vaccinated to get back to enjoying life with more freedom. You can make a difference... get fully vaccinated.

Note. Sample scripts of the "experimental" vaccination PSAs used in the CCEP. Within each behavioral focus category, each thematic manipulation (affect, normative strategy, temporal bridging) is fully crossed.

Appendix E: Descriptive Statistics for PSA-Level Variables

		Self-Report Ratings *M* (*SD*)					Eye-Tracking *M* (*SD*)		
#	PSA Theme	*n*	Engaging	Like	Motivating	Self-Reflect	*n*	Fixations on PSA	Dwell Time (ms)
1	Hand hygiene – Temporal bridging, Vivid	113	2.66 (0.84)	2.65 (0.92)	2.63 (1.00)	2.37 (1.11)	96	31.77 (14.12)	13,707.59 (3,463.46)
2	Hand hygiene – NO Temporal bridging, Vivid	114	2.75 (0.98)	2.74 (0.94)	2.80 (0.95)	2.54 (1.13)	98	16.01 (7.79)	5,980.52 (2,323.37)
3	Hand hygiene – Temporal bridging, Vivid	112	2.75 (0.91)	2.75 (0.84)	2.75 (0.92)	2.43 (1.08)	98	41.42 (18.72)	18,706.68 (4,566.66)
4	Hand hygiene – NO Temporal bridging, Vivid	113	2.68 (0.91)	2.74 (0.91)	2.66 (0.93)	2.39 (1.01)	99	43.30 (17.89)	18,647.92 (4,789.25)
5	Hand hygiene – Temporal bridging, Vivid	115	2.96 (0.92)	3.02 (0.92)	2.82 (0.97)	2.57 (1.10)	100	42.91 (18.60)	18,646.15 (5,086.92)
6	Hand hygiene – NO Temporal bridging, Vivid	115	2.79 (0.88)	2.93 (0.81)	2.77 (0.92)	2.37 (1.04)	98	43.44 (17.38)	18,773.16 (4,693.65)
7	Hand hygiene – Temporal bridging, Vivid	114	2.92 (0.83)	2.96 (0.90)	2.84 (0.94)	2.56 (1.11)	100	44.19 (17.99)	18,565.65 (5,176.93)
8	Hand hygiene – NO Temporal bridging, Vivid	113	2.98 (0.88)	2.93 (0.98)	2.81 (0.96)	2.45 (1.11)	100	43.71 (19.83)	18,294.98 (5,425.78)
9	Masking – Temporal bridging, Vivid	114	2.91 (1.04)	2.88 (1.08)	2.94 (1.15)	2.61 (1.16)	96	44.91 (17.35)	18,899.60 (4,558.91)
10	Masking – No Temporal bridging, Vivid	114	2.80 (1.06)	2.81 (0.97)	2.72 (1.01)	2.59 (1.10)	99	42.07 (16.87)	18,599.85 (5,028.53)
11	Masking – Temporal bridging, Vivid	113	2.94 (0.95)	2.88 (1.01)	2.83 (1.03)	2.63 (1.12)	98	42.92 (17.49)	18,154.50 (4,802.76)

			Self-Report Ratings *M* (*SD*)					Eye-Tracking *M* (*SD*)	
#	PSA Theme	*n*	Engaging	Like	Motivating	Self-Reflect	*n*	Fixations on PSA	Dwell Time (ms)
12	Masking – No Temporal bridging, Vivid	113	2.75 (1.04)	2.79 (1.04)	2.71 (1.09)	2.59 (1.16)	100	43.10 (17.02)	18,663.16 (4,752.25)
13	Masking – Temporal bridging, Vivid	112	3.23 (0.94)	3.27 (1.05)	3.06 (0.99)	2.68 (1.07)	99	45.22 (17.32)	18,484.11 (5,232.52)
14	Masking – No Temporal bridging, Vivid	113	3.12 (1.03)	3.11 (0.99)	2.83 (0.98)	2.46 (1.11)	99	45.98 (16.92)	18,632.46 (5,301.67)
15	Masking – Temporal bridging, Vivid	113	3.13 (0.89)	3.12 (0.98)	2.95 (0.98)	2.60 (1.13)	98	44.57 (17.49)	18,685.54 (5,008.69)
16	Masking – No Temporal bridging, Vivid	112	2.96 (0.91)	3.09 (0.97)	2.80 (0.98)	2.52 (1.03)	97	48.13 (15.74)	18,812.84 (4,497.73)
17	Distancing – Temporal bridging, Vivid	114	2.89 (0.93)	2.82 (0.96)	2.77 (1.03)	2.51 (1.02)	98	50.24 (17.13)	19,082.71 (3,990.77)
18	Distancing – No Temporal bridging, Vivid	113	2.58 (0.95)	2.64 (0.91)	2.55 (0.91)	2.34 (0.90)	99	43.24 (18.78)	18,777.58 (5,375.80)
19	Distancing – Temporal bridging, Vivid	112	2.81 (0.92)	2.88 (0.94)	2.91 (0.90)	2.46 (1.01)	97	44.25 (20.88)	18,693.16 (5,467.93)
20	Distancing – No Temporal bridging, Vivid	112	2.56 (0.91)	2.57 (0.85)	2.60 (0.91)	2.33 (0.96)	100	45.12 (18.03)	18,602.26 (5,187.32)
21	Distancing – Temporal bridging, Vivid	114	2.99 (0.89)	3.08 (0.90)	2.97 (0.95)	2.58 (1.10)	98	47.84 (18.75)	17,953.94 (5,494.87)
22	Distancing – No Temporal bridging, Vivid	114	2.87 (0.91)	3.01 (0.91)	2.79 (0.93)	2.32 (1.02)	99	47.80 (19.60)	18,896.97 (5,068.74)
23	Distancing – Temporal bridging, Vivid	115	2.91 (0.83)	2.96 (0.76)	2.90 (0.86)	2.43 (0.98)	100	47.02 (20.51)	18,011.17 (5,680.92)
24	Distancing – No Temporal bridging, Vivid	114	2.91 (0.84)	2.97 (0.78)	2.83 (0.85)	2.47 (1.04)	99	47.18 (20.53)	18,567.40 (5,283.59)

			Self-Report Ratings *M* (*SD*)					Eye-Tracking *M* (*SD*)	
#	PSA Theme	*n*	Engaging	Like	Motivating	Self-Reflect	*n*	Fixations on PSA	Dwell Time (ms)
25	Vaccination – Temporal bridging, Vivid	112	3.03 (1.01)	3.09 (0.93)	3.03 (1.04)	2.68 (1.12)	99	44.23 (19.86)	18,822.88 (5,266.88)
26	Vaccination – No Temporal bridging, Vivid	113	2.88 (0.98)	2.96 (0.97)	2.85 (1.02)	2.55 (1.08)	98	45.39 (17.82)	18,823.06 (5,050.90)
27	Vaccination – Temporal bridging, Vivid	115	3.07 (0.97)	3.12 (1.02)	3.10 (1.03)	2.64 (1.12)	98	45.48 (17.75)	18,609.58 (5,016.34)
28	Vaccination – No Temporal bridging, Vivid	113	2.89 (0.90)	2.89 (0.91)	2.88 (0.92)	2.52 (1.06)	100	42.71 (19.52)	18,433.79 (5,359.87)
29	Vaccination – Temporal bridging, Vivid	113	3.15 (0.87)	3.22 (0.91)	3.14 (0.94)	2.66 (1.04)	98	45.99 (17.84)	18,559.33 (4,941.90)
30	Vaccination – No Temporal bridging, Vivid	114	3.46 (0.96)	3.44 (1.02)	3.26 (1.05)	2.86 (1.11)	99	46.55 (18.31)	18,494.08 (5,058.36)
31	Vaccination – Temporal bridging, Vivid	114	2.98 (0.90)	3.10 (0.92)	2.95 (1.02)	2.43 (1.03)	99	46.27 (18.60)	18,518.55 (5,217.37)
32	Vaccination – No Temporal bridging, Vivid	112	3.28 (1.02)	3.37 (1.03)	3.18 (1.04)	2.64 (1.15)	100	45.88 (17.46)	18,118.35 (5,390.15)
33	Vaccination – Temporal bridging, NOT Vivid	112	1.95 (0.89)	2.21 (0.98)	2.06 (0.88)	1.88 (0.95)	97	49.12 (16.51)	17,327.00 (4,829.20)
34	Vaccination – No Temporal bridging, NOT Vivid	113	1.57 (0.85)	1.71 (0.93)	1.65 (0.82)	1.71 (0.90)	99	48.61 (18.67)	17,348.93 (5,586.32)
35	Vaccination – Temporal bridging, NOT Vivid	113	2.35 (0.95)	2.42 (0.98)	2.46 (1.02)	2.22 (1.08)	98	47.54 (16.84)	17,064.87 (5,167.63)

			Self-Report Ratings *M* (*SD*)					Eye-Tracking *M* (*SD*)	
#	PSA Theme	*n*	Engaging	Like	Motivating	Self-Reflect	*n*	Fixations on PSA	Dwell Time (ms)
36	Vaccination – No Temporal bridging, NOT Vivid	112	1.75 (0.89)	1.85 (0.87)	1.82 (0.88)	1.80 (0.90)	98	49.12 (16.79)	17,343.18 (5,051.06)
37	Vaccination – Temporal bridging, NOT Vivid	113	1.92 (0.88)	2.12 (0.91)	2.06 (0.90)	1.87 (0.94)	97	48.44 (17.24)	17,675.61 (5,267.16)
38	Vaccination – No Temporal bridging, NOT Vivid	112	1.62 (0.83)	1.72 (0.92)	1.72 (0.89)	1.73 (0.88)	96	48.95 (16.81)	17,583.26 (5,280.80)
39	Vaccination – Temporal bridging, NOT Vivid	112	2.22 (0.97)	2.48 (0.90)	2.28 (1.06)	2.00 (1.05)	94	49.01 (17.51)	17,942.15 (4,846.79)
40	Vaccination – No Temporal bridging, NOT Vivid	113	1.85 (0.90)	1.88 (0.96)	1.94 (0.84)	1.74 (0.92)	98	50.23 (15.94)	17,634.82 (4,951.98)

Note. Self-report ratings were measured on a 1–5 scale. Eye-tracking variables were computed using the prespecified exclusion rule used in the analyses. PSA characteristics were counterbalanced across the stimulus set, and any minor differences in sample size reflect missing data.

Appendix F: Full Fixed-Effect Coefficient Table: Final GAD-7 × Behavioral Focus Models (B3 REML)

Fixed Effect	SR Factor	Phys. Factor	Engaging	Like	Motivating	Self-Reflect	On-target Fixations	Dwell Time (ms)
				Covariates				
Age	0.009**	0.011***	0.010**	0.010**	0.009**	0.009*	0.273***	32.50
	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.063)	(20.09)
	p = .005	*p* ≤ .001	*p* = .002	*p* = .002	*p* = .009	*p* = .046	*p* ≤ .001	*p* = .109
Sex (female = 1)	-0.182	0.001	-0.161	-0.104	-0.058	-0.020	1.50	-1,067.00
	(0.114)	(0.092)	(0.111)	(0.114)	(0.121)	(0.157)	(2.38)	(764.00)
	p = .113	*p* = .989	*p* = .149	*p* = .365	*p* = .632	*p* = .898	*p* = .529	*p* = .166
Reaction time	0.00	-0.001	0.001	0.001	0.001	0.00	-0.015	-8.43*
(ms)	(0.001)	(0.00)	(0.001)	(0.001)	(0.001)	(0.001)	(0.012)	(3.71)
	p = .542	*p* = .122	*p* = .302	*p* = .446	*p* = .431	*p* = .618	*p* = .215	*p* = .025
Flanker	0.002	0.001	0.001	0.004†	0.001	-0.001	0.023	-9.77
interference	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.040)	(12.78)
(ms)	*p* = .371	*p* = .668	*p* = .431	*p* = .055	*p* = .545	*p* = .762	*p* = .572	*p* = .447
Delay	-0.011	0.029	-0.026	-0.013	-0.032	0.035	1.13	-229.40
discounting	(0.036)	(0.029)	(0.035)	(0.036)	(0.038)	(0.050)	(0.754)	(242.40)
[ln(k)]	*p* = .773	*p* = .330	*p* = .466	*p* = .725	*p* = .412	*p* = .485	*p* = .138	*p* = .347
BDEFS	0.171	-0.071	0.209†	0.202†	0.173	0.271†	-2.54	151.30
composite	(0.123)	(0.099)	(0.115)	(0.118)	(0.125)	(0.163)	(2.56)	(821.30)
	p = .166	*p* = .476	*p* = .071	*p* = .090	*p* = .169	*p* = .099	*p* = .324	*p* = .854
				Behavioral Focus (reference = masking)				
Vaccination	0.140*	0.030	0.125	0.160†	0.200**	0.037	0.700	-62.40
	(0.067)	(0.133)	(0.086)	(0.088)	(0.066)	(0.049)	(2.56)	(1,155.60)
	p = .046	*p* = .825	*p* = .158	*p* = .080	*p* = .006	*p* = .458	*p* = .787	*p* = .957
Hand hygiene	-0.143*	-0.326*	-0.171†	-0.167†	-0.108	-0.137*	-6.61*	-2,274.00†
	(0.067)	(0.133)	(0.086)	(0.088)	(0.066)	(0.049)	(2.56)	(1,155.60)
	p = .041	*p* = .021	*p* = .056	*p* = .069	*p* = .116	*p* = .010	*p* = .016	*p* = .059
Distancing	-0.111	0.060	-0.165†	-0.140	-0.062	-0.165**	1.91	-12.60
	(0.067)	(0.133)	(0.086)	(0.088)	(0.066)	(0.049)	(2.56)	(1,155.60)
	p = .108	*p* = .659	*p* = .065	*p* = .124	*p* = .355	*p* = .002	*p* = .463	*p* = .991
GAD-7	0.024*	0.008	0.020†	0.015	0.023†	0.023	0.058	119.30
	(0.012)	(0.010)	(0.012)	(0.012)	(0.013)	(0.016)	(0.251)	(79.03)
	p = .048	*p* = .405	*p* = .094	*p* = .229	*p* = .074	*p* = .160	*p* = .819	*p* = .134

Fixed Effect	SR Factor	Phys. Factor	Engaging	Like	Motivating	Self-Reflect	On-target Fixations	Dwell Time (ms)
				GAD-7 and Interactions				
GAD-7 × Vaccination	-0.013* (0.006) *p* = .041	-0.006 (0.005) *p* = .228	-0.016* (0.007) *p* = .019	-0.014* (0.007) *p* = .039	-0.017* (0.007) *p* = .014	-0.007 (0.007) *p* = .314	-0.118 (0.127) *p* = .355	-24.16 (30.91) *p* = .434
GAD-7 × Hand hygiene	0.00 (0.006) *p* = .962	-0.003 (0.005) *p* = .527	-0.001 (0.007) *p* = .831	-0.002 (0.007) *p* = .769	0.005 (0.007) *p* = .501	-0.002 (0.007) *p* = .769	-0.079 (0.127) *p* = .534	-1.14 (30.93) *p* = .971
GAD-7 × Distancing	0.001 (0.006) *p* = .880	-0.001 (0.005) *p* = .834	0.003 (0.007) *p* = .620	0.002 (0.007) *p* = .802	0.003 (0.007) *p* = .660	0.005 (0.007) *p* = .466	-0.021 (0.127) *p* = .870	-5.83 (30.91) *p* = .850
Marginal R^2	.078 / .454	.127 / .549	.068 / .404	.072 / .420	.051 / .403	.054 / .555	.132 / .533	.084 / .672

Note. $N \leq 3{,}707$ observations, 116 participants, 32 PSAs (B3: 32 vivid). Parameter estimates from REML re-fits of Model B3 (covariates + behavioral focus main effects + GAD-7 + GAD-7 × behavioral focus interactions). Models were adjusted for age, sex, simple reaction time, Flanker interference, delay discounting, and BDEFS Self-Restraint. All models include crossed random intercepts for participants and PSAs. Behavioral focus is dummy-coded with "masking" as the reference category. Marginal R^2 / Conditional R^2 = variance explained by fixed effects / full model. Fixation counts and dwell times are on raw scales. Self-report outcomes are on a 1–5 scale; Self Report (SR) and Physiological (Phys.) factor scores are standardized ($M = 0$, $SD \approx 0.75$). † $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$. p-values are from REML Wald tests.

Appendix G: Full Fixed-Effect Coefficient Table: Final GAD-7 × Vividness Models (V3 REML; 16-Vaccination-PSA Subset)

Fixed Effect	SR Factor	Phys. Factor	Engaging	Like	Motivating	Self-Reflect	On-target Fixations	Dwell Time (ms)
				Covariates				
Age	0.014***	0.013***	0.015***	0.015***	0.013***	0.012**	0.313***	41.08†
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.066)	(21.84)
	$p \leq .001$	$p \leq .001$	$p \leq .001$	$p \leq .001$	$p \leq .001$	$p = .003$	$p \leq .001$	$p = .063$
Sex (female = 1)	-0.185†	-0.061	-0.194†	-0.209†	-0.121	-0.140	0.250	-1,354.82
	(0.106)	(0.101)	(0.106)	(0.109)	(0.115)	(0.145)	(2.508)	(825.84)
	$p = .084$	$p = .546$	$p = .069$	$p = .058$	$p = .297$	$p = .336$	$p = .921$	$p = .104$
Reaction time	0.000	-0.001*	0.001	0.000	0.001	0.000	-0.022†	-11.42**
(ms)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.012)	(4.02)
	$p = .519$	$p = .033$	$p = .173$	$p = .434$	$p = .271$	$p = .544$	$p = .078$	$p = .006$
Flanker	0.002	0.001	0.001	0.004*	0.001	-0.000	0.031	-5.15
interference	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.042)	(13.78)
(ms)	$p = .222$	$p = .483$	$p = .526$	$p = .043$	$p = .468$	$p = .830$	$p = .461$	$p = .709$
Delay	-0.032	0.026	-0.046	-0.027	-0.060	0.008	1.036	-183.63
discounting	(0.034)	(0.032)	(0.034)	(0.035)	(0.037)	(0.046)	(0.794)	(261.42)
[ln(k)]	$p = .340$	$p = .412$	$p = .176$	$p = .432$	$p = .102$	$p = .860$	$p = .195$	$p = .484$
BDEFS	0.111	-0.112	0.152	0.154	0.124	0.239	-3.111	-265.50
composite	(0.114)	(0.109)	(0.109)	(0.113)	(0.119)	(0.150)	(2.692)	(886.34)
	$p = .331$	$p = .308$	$p = .168$	$p = .176$	$p = .300$	$p = .116$	$p = .251$	$p = .765$
Temporal	0.198†	0.009	0.188	0.256*	0.241*	0.108	-0.270	29.41
bridging (yes =	(0.101)	(0.025)	(0.114)	(0.113)	(0.096)	(0.071)	(0.621)	(161.93)
1)	$p = .073$	$p = .716$	$p = .122$	$p = .041$	$p = .026$	$p = .153$	$p = .663$	$p = .856$
				Vividness and GAD-7 Interaction				
GAD-7	0.004	0.005	0.013	0.008	0.013	0.010	0.069	75.39
	(0.011)	(0.010)	(0.011)	(0.011)	(0.012)	(0.015)	(0.258)	(84.16)
	$p = .747$	$p = .606$	$p = .229$	$p = .505$	$p = .281$	$p = .503$	$p = .791$	$p = .373$
Vividness (vivid	1.069***	-0.009	1.220***	1.132***	1.071***	0.769***	-3.225***	1,092.79***
= 1)	(0.101)	(0.025)	(0.114)	(0.113)	(0.096)	(0.071)	(0.620)	(161.83)
	$p \leq .001$	$p = .710$	$p \leq .001$	$p \leq .001$	$p \leq .001$	$p \leq .001$	$p \leq .001$	$p \leq .001$
GAD-7 ×	0.015*	-0.000	-0.001	0.000	-0.001	0.012†	-0.068	32.11
Vividness	(0.006)	(0.005)	(0.007)	(0.007)	(0.007)	(0.006)	(0.118)	(30.67)
	$p = .017$	$p = .946$	$p = .926$	$p = .948$	$p = .868$	$p = .069$	$p = .561$	$p = .295$

Fixed Effect	SR Factor	Phys. Factor	Engaging	Like	Motivating	Self-Reflect	On-target Fixations	Dwell Time (ms)
Marginal R^2	.352 / .598	.140 / .546	.361 / .584	.326 / .561	.280 / .532	.177 / .589	.153 / .555	.098 / .636

Note. $N \leq 1{,}848$ observations, 116 participants, 16 PSAs (V3: 16 vaccination). Parameter estimates from REML re-fits of Model V3 (covariates + temporal bridging covariate + vividness + GAD-7 + GAD-7 × vividness) within the 16-vaccination-PSA subset. Models were adjusted for age, sex, simple reaction time, Flanker interference, delay discounting, BDEFS Self-Restraint, and temporal bridging. Vividness is dummy-coded: 0 = non-vivid (reference), 1 = vivid. The physiological factor score model showed a boundary singular fit (PSA-level variance collapsed to zero); interpret Phys. Factor results with caution. † $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$. p-values are from REML Wald tests.

Appendix H: Simple Slopes of GAD-7 (Mean-Centered) at Each Level of Behavioral Focus

Behavioral Focus Level	SR Factor	Phys. Factor	Engaging	Like	Motivating	Self-Reflect	On-target Fixations	Dwell Time (ms)
Masking (reference)	0.024*	0.008	0.020†	0.015	0.023†	0.023	0.058	119.30
	(0.012)	(0.010)	(0.012)	(0.012)	(0.013)	(0.016)	(0.251)	(79.03)
	p = .048	*p* = .405	*p* = .094	*p* = .229	*p* = .074	*p* = .160	*p* = .819	*p* = .134
Vaccination	0.011	0.002	0.004	0.001	0.006	0.016	-0.060	95.15
	(0.012)	(0.010)	(0.012)	(0.012)	(0.013)	(0.016)	(0.251)	(79.03)
	p = .352	*p* = .829	*p* = .738	*p* = .960	*p* = .662	*p* = .319	*p* = .812	*p* = .231
Hand hygiene	0.024†	0.005	0.018	0.013	0.027*	0.021	-0.021	118.20
	(0.012)	(0.010)	(0.012)	(0.012)	(0.013)	(0.016)	(0.251)	(79.03)
	p = .050	*p* = .607	*p* = .120	*p* = .299	*p* = .032	*p* = .198	*p* = .932	*p* = .137
Distancing	0.025*	0.007	0.023†	0.016	0.026*	0.027†	0.037	113.50
	(0.012)	(0.010)	(0.012)	(0.012)	(0.013)	(0.016)	(0.251)	(79.03)
	p = .040	*p* = .468	*p* = .050	*p* = .179	*p* = .043	*p* = .089	*p* = .883	*p* = .153

Note. Simple slopes represent the estimated effect of a one-unit increase in GAD-7 on engagement at each level of behavioral focus, derived from the final B3 models. Models were adjusted for age, sex, simple reaction time, Flanker interference, delay discounting, and BDEFS Self-Restraint. The "masking" simple slope equals the GAD-7 main-effect coefficient in B3 (the reference category). "Vaccination", "hand hygiene", and "distancing" slopes are the sum of the GAD-7 coefficient and the respective GAD-7 × Behavioral Focus interaction term. *SE*s are from *emmeans* contrast output (Kenward–Roger *df*); they are equivalent to *SE*(GAD-7) for this balanced design. † $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Appendix I: Random-effects variance components from B3 and V3 REML Final Models

Outcome	Participant	PSA	Residual	Total σ^2
B3: GAD-7 x Behavioral Focus (32 vivid PSAs, $N \leq 3{,}707$ obs)				
	σ^2 (*SD*) [ICC%] per cell			
SR Factor	0.281	0.014	0.426	0.721
	(0.530)	(0.116)	(0.653)	
	[38.9%]	*[1.9%]*	*[59.2%]*	
Phys. Factor	0.182	0.068	0.267	0.517
	(0.426)	(0.261)	(0.517)	
	[35.1%]	*[13.2%]*	*[51.7%]*	
Engaging	0.289	0.024	0.555	0.869
	(0.537)	(0.156)	(0.745)	
	[33.2%]	*[2.8%]*	*[64.0%]*	
Like	0.307	0.026	0.554	0.887
	(0.554)	(0.161)	(0.745)	
	[34.6%]	*[2.9%]*	*[62.5%]*	
Motivating	0.343	0.012	0.603	0.959
	(0.586)	(0.110)	(0.777)	
	[35.8%]	*[1.3%]*	*[62.9%]*	
Self-Reflect	0.599	0.005	0.537	1.141
	(0.774)	(0.069)	(0.733)	
	[52.5%]	*[0.4%]*	*[47.1%]*	
Fixations	122.06	24.49	171.20	317.75
	(11.05)	(4.949)	(13.08)	
	[38.4%]	*[7.7%]*	*[53.9%]*	
Dwell Time	12,872.1	5,236.0	10,117.3	28,225.4
($\times 10^3$)	(3,588)	(2,288)	(3,181)	
	[45.6%]	*[18.6%]*	*[35.8%]*	
V3: GAD-7 x Vividness (16 vaccination PSAs, $N = 1{,}848$ obs)				
	σ^2 (*SD*) [ICC%] per cell			
SR Factor	0.228	0.037	0.431	0.696
	(0.477)	(0.191)	(0.657)	
	[32.7%]	*[5.3%]*	*[62.0%]*	
Phys. Factor†	0.216	0.000	0.242	0.458
	(0.465)	(0.000)	(0.492)	
	[47.2%]	*[0.0%]*	*[52.8%]*	

Outcome	Participant	PSA	Residual	Total σ^2
Engaging	0.243	0.047	0.539	0.829
	(0.493)	(0.216)	(0.734)	
	[29.3%]	*[5.7%]*	*[65.0%]*	
Like	0.261	0.046	0.573	0.880
	(0.511)	(0.214)	(0.757)	
	[29.7%]	*[5.2%]*	*[65.1%]*	
Motivating	0.292	0.031	0.599	0.923
	(0.540)	(0.177)	(0.774)	
	[31.6%]	*[3.4%]*	*[65.0%]*	
Self-Reflect	0.494	0.016	0.508	1.018
	(0.703)	(0.125)	(0.713)	
	[48.5%]	*[1.5%]*	*[49.9%]*	
Fixations†	132.14	0.000	146.21	278.36
	(11.50)	(0.000)	(12.09)	
	[47.5%]	*[0.0%]*	*[52.5%]*	
Dwell Time	14,699.0	0.0	9,951.4	24,650.4
($\times 10^3$)†	(3,834)	(0)	(3,155)	
	[59.6%]	*[0.0%]*	*[40.4%]*	

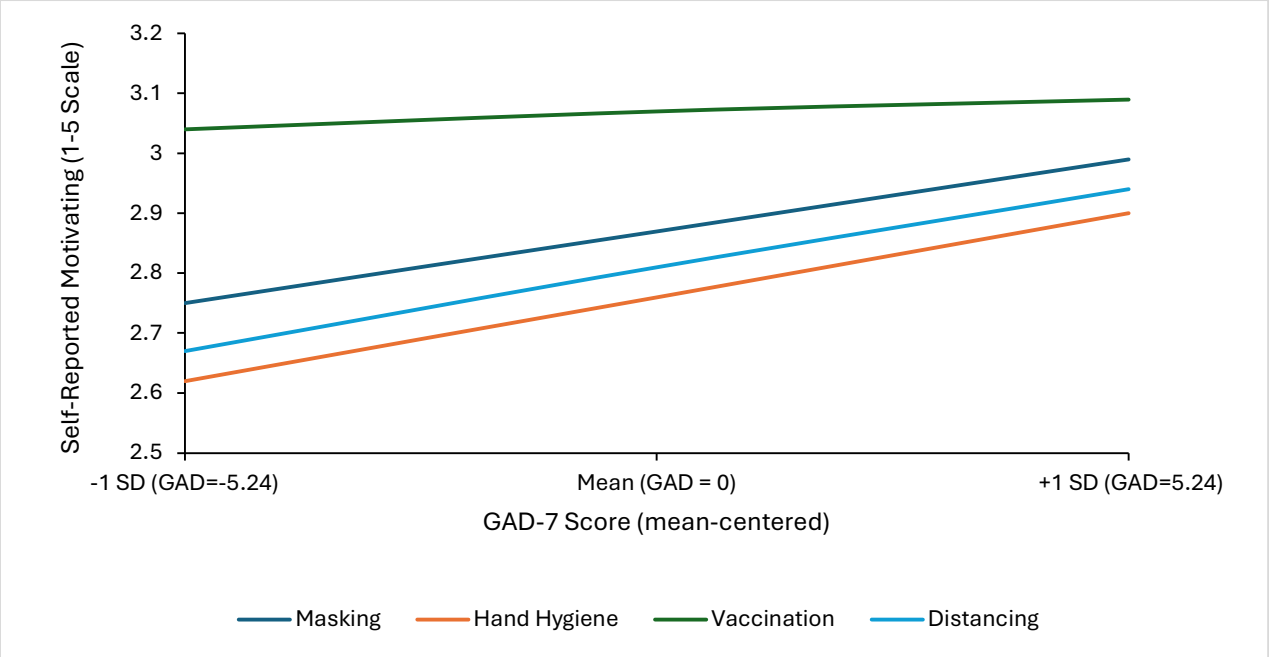
Note. σ^2 = variance; *SD* = standard deviation of the random-intercept distribution; ICC% = intraclass correlation as percentage of total σ^2 (participant + PSA + residual). Dwell Time variance reported in thousands of ms^2 ($\times 10^3$); *SD* in ms. Self-report outcomes on a 1–5 scale; factor scores standardized ($M = 0$). † Boundary singular fit: PSA-level variance estimated at zero; only 8 PSAs per vividness condition provided insufficient information to estimate a separate PSA-level variance after vividness entered as a fixed effect. Applies to Phys. Factor, Fixations, and Dwell Time in V3.

Appendix J: Person-Level Intercorrelations for Analytical Variables

Variable	*M*	*SD*	1.	2.	3.	4.	5.	6.
1. GAD-7 (MC)	0.00	5.24	—					
2. Age (years)	31.96	20.71	−.33***	—				
3. Reaction time (ms)	326.16	107.71	-.06	.16†	—			
4. Flanker interference (ms)	59.47	32.22	.15	−.11	-.06	—		
5. Delay-discounting [ln(k)]	−5.73	1.56	.08	.19*	.10	.08	—	
6. BDEFS	1.58	.49	.23*	−.13	−.17†	.01	.07	—

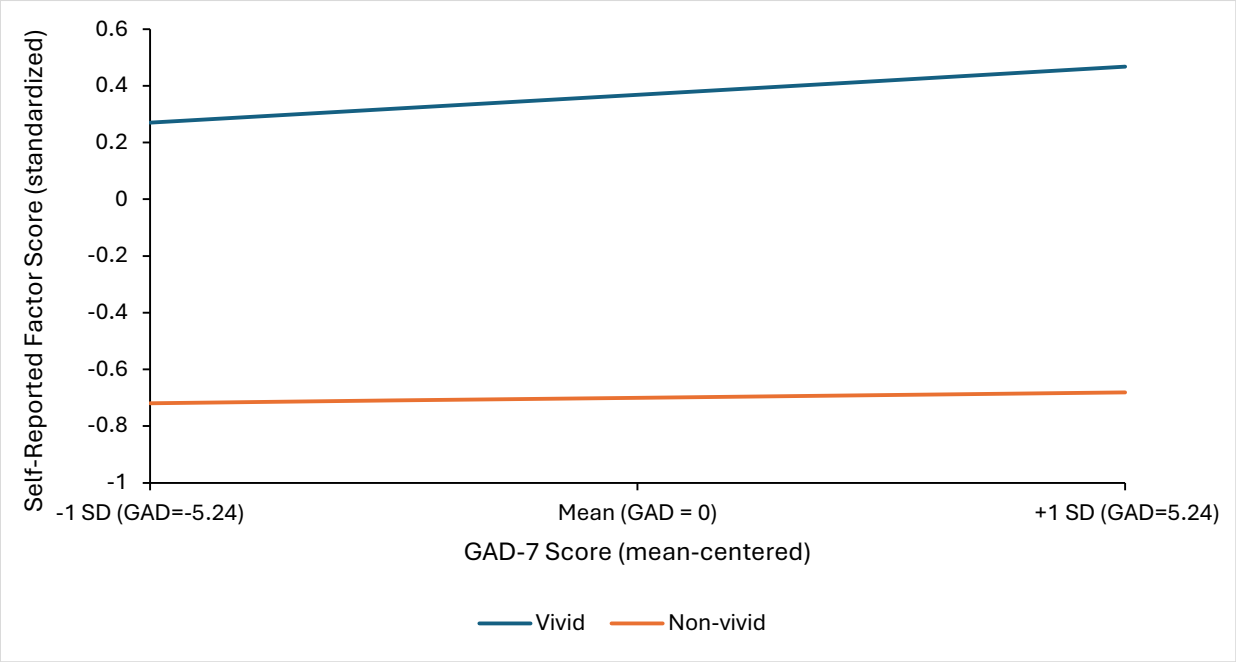
Note. $N = 116$ for all pairs. GAD-7 (MC) = mean-centered score (raw $M = 5.28$, $SD = 5.24$); $M = 0.00$ reflects centering. Pearson correlations reported; p-values are two-tailed and obtained from cor.test() in R. † $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Appendix K: Estimated Marginal Means of Self-Reported Motivating at Three Levels of GAD-7 as a Function of PSA Behavioral Focus



Note. Estimated marginal means are from the final B3 REML model, averaged over participant-level covariates at their observed means. Models were adjusted for age, sex, simple reaction time, Flanker interference, delay discounting, and BDEFS Self-Restraint. GAD-7 is mean-centered; −1 *SD* = −5.24, +1 *SD* = +5.24.

Appendix L: Estimated Marginal Means of Self-Report Factor Score at Three Levels of GAD-7 as a Function of PSA Vividness



Note. Estimated marginal means are from the final V3 REML model within the 16-vaccination-PSA subset, averaged over participant-level covariates and temporal bridging at their observed means. Models were adjusted for age, sex, simple reaction time, Flanker interference, delay discounting, BDEFS Self-Restraint, and temporal bridging. GAD-7 is mean-centered; −1 *SD* = −5.24, +1 *SD* = +5.24. Self-report factor score is standardized ($M = 0$, $SD \approx 0.75$).

Appendix M: Model Diagnostics for Linear Mixed-Effects Analyses

Section 1: Outcome Variable Distributions Prior to Model Fitting

The appropriateness of an LME framework for each outcome was first evaluated by inspecting the distributions of the primary outcome variables. Table M1 summarizes skewness and excess kurtosis for the four self-report ratings and two eye-tracking metrics after data cleaning. The conventional guidelines applied throughout the primary analyses were |skewness| < 2 and |excess kurtosis| < 4 (West et al., 1995). All four self-report outcomes fell comfortably within both thresholds. The fixation-count metric also satisfied both criteria after exclusions. Dwell time exhibited left skewness (−1.34) after the exclusion of 67 invalid trials, but its excess kurtosis remained well within the acceptable range (1.16). Log-transformation was evaluated for dwell time but worsened the distribution (skewness shifted from −1.34 to −3.90) because, after cleaning, valid trial durations clustered near the full 25-second PSA duration. Accordingly, raw dwell-time values were retained. Figure M1 illustrates the distributions of all primary outcome variables.

Table M1

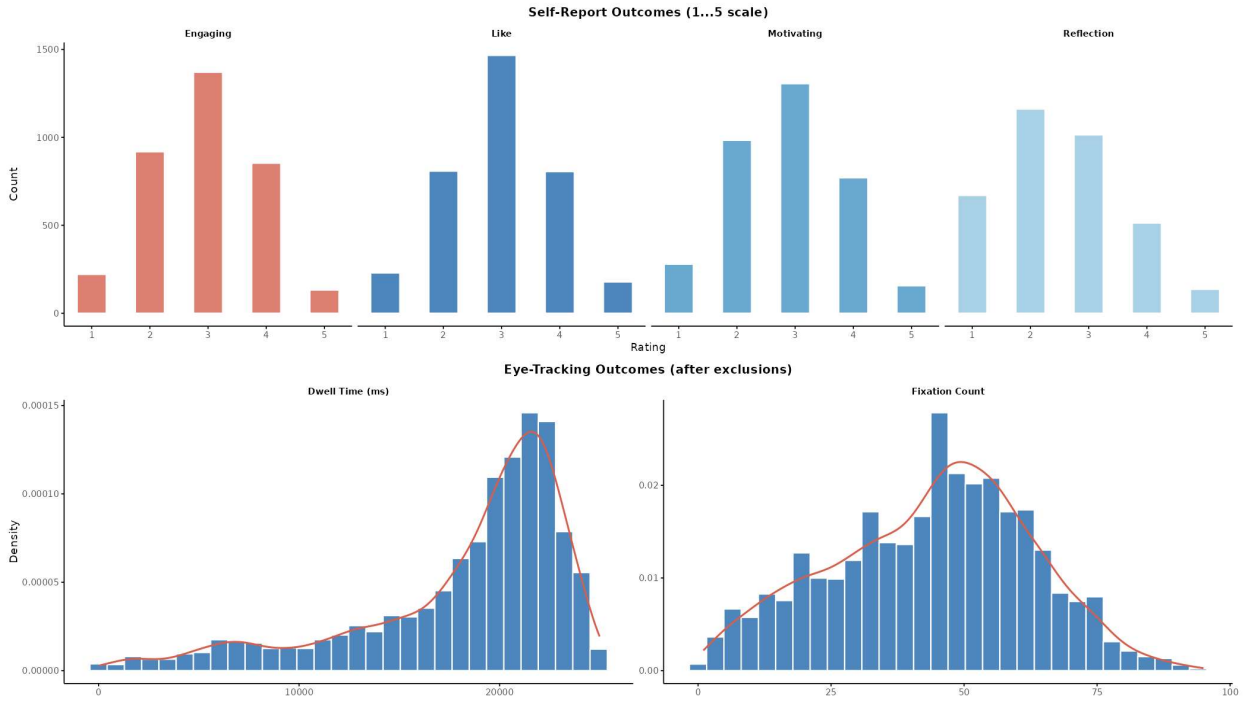
Descriptive Statistics and Distributional Properties of Primary Outcome Variables Prior to Model Fitting

Outcome	*N*	Skewness	Ex. Kurtosis	Note
Self-Report Outcomes (1–5 scale; N = 4,800 observations, 120 participants, 40 PSAs)				
SR Engaging	~4,533	0.01	−0.64	
SR Like	~4,523	0.00	−0.48	
SR Motivating	~4,538	0.10	−0.58	
SR Reflect	~4,540	0.40	−0.58	
Eye-Tracking Outcomes (after exclusions; ET-usable subset, 101 participants, 40 PSAs)				
On-target fixation	3,933	−0.23	−0.45	After 106-trial exclusion
Dwell Time (ms)	3,934	−1.34	1.16	After exclusions; log-transformation worsened distribution

Note. SR = self-report. Skewness and excess kurtosis computed on the full cleaned sample prior to the 32-vivid PSA restriction applied in the primary confirmatory models. Eye-tracking *N* reflects observations surviving the 106-trial exclusion step (missing duration, impossible duration, and zero-gaze trials). Excess kurtosis = observed kurtosis − 3 (normal distribution = 0). Acceptable thresholds: |skewness| < 2, |excess kurtosis| < 4 (West et al., 1995).

Figure M1

Distributions of Primary Outcome Variables (32-Experimental PSA Subset)



Note. Top row: histograms of the four self-report rating dimensions (scale 1–5). Bottom row: density histograms of on-target fixation count and dwell time after exclusion of 67 invalid trials.

Section 2: LME Model Residual Diagnostics

The primary assumption tested here is that the residuals of the fitted LME models are approximately normally distributed. This was evaluated using Pearson residuals from the final REML fits of the A2 models (GAD-7 main-effect models with all covariates), which represent the model structure common to every confirmatory analysis. All eight outcomes were examined. Diagnostics included: (a) skewness and excess kurtosis of the Pearson residuals; (b) normal Q-Q plots of the residuals; (c) residuals versus fitted-values plots to assess homoscedasticity; and (d)

Q-Q plots of the participant-level and PSA-level random intercepts to evaluate normality of the random-effects structure.

Table M2

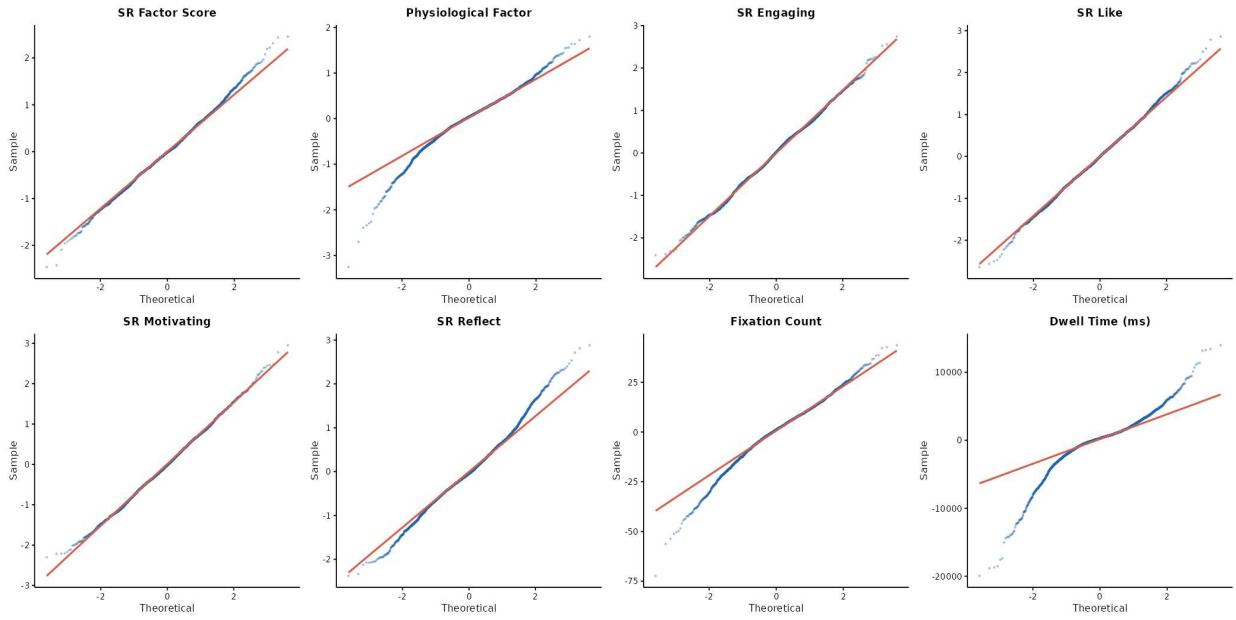
Distributional Properties of Pearson Residuals from A2 REML Models

Outcome	*N*	Skewness	Ex. Kurtosis	SW *W*	SW *p*
SR Factor Score	3,132	0.11	0.33	0.998	< .001
Physiological Factor	3,132	−0.64	2.18	0.971	< .001
SR Engaging	3,497	−0.02	−0.01	0.998	< .001
SR Like	3,490	0.06	0.26	0.999	.009
SR Motivating	3,497	0.08	−0.04	0.999	.044
SR Reflect	3,497	0.25	0.69	0.991	< .001
Fixation Count	3,059	−0.53	1.27	0.981	< .001
Dwell Time (ms)	3,060	−1.14	5.60	0.898	< .001

Note. SR = Self-report. *N* = number of non-missing Pearson residuals from the A2 REML model (GAD-7 main effect + six covariates, crossed random intercepts for participants and PSAs, 32-vivid PSA subset). Ex. Kurtosis = excess kurtosis (kurtosis − 3; normal distribution = 0). SW *W* and SW *p* = Shapiro-Wilk statistic and p-value computed on a random subsample of up to 5,000 residuals; at sample sizes of 3,000–3,500 the Shapiro-Wilk test will almost invariably reach significance regardless of distributional adequacy—skewness and excess kurtosis are the primary criteria. Acceptable thresholds: |skewness| < 2, |excess kurtosis| < 4 (West et al., 1995). All residual distributions (except for Dwell Time) satisfied both criteria.

Figure M2

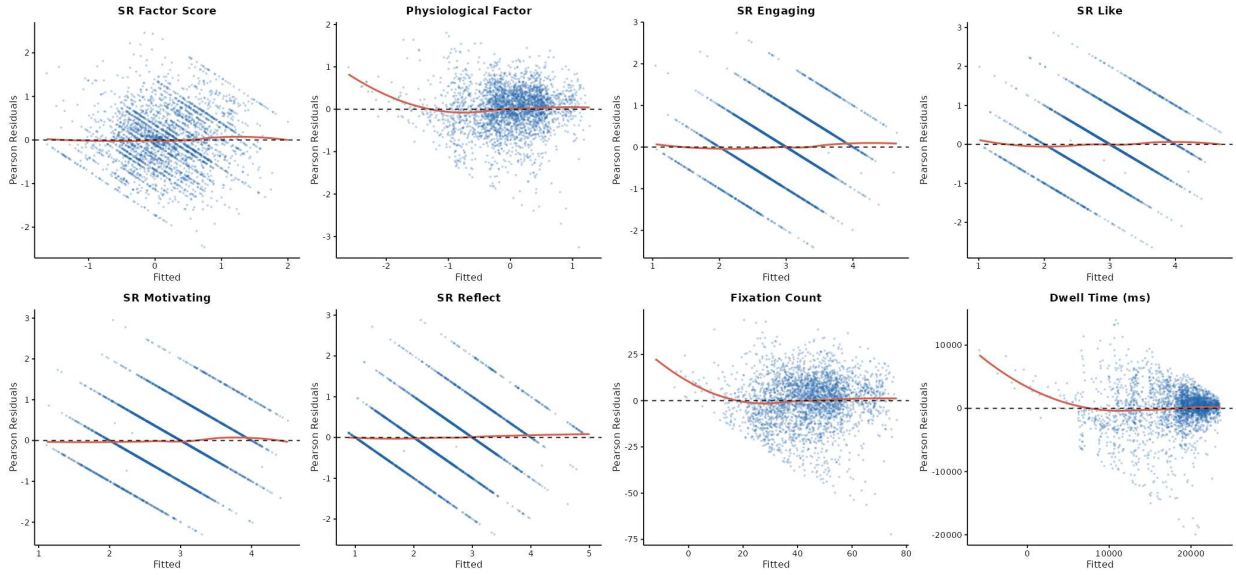
Normal Q-Q Plots of Pearson Residuals (A2 REML Models, All Eight Outcomes)



Note. Models were adjusted for age, sex, simple reaction time, Flanker interference, delay discounting, and BDEFS Self-Restraint. Points represent Pearson residuals (random subsample of up to 5,000 per outcome). The red diagonal line indicates theoretical normal quantiles. Approximate alignment with the line indicates normality. Moderate tail deviations for Dwell Time are consistent with the elevated excess kurtosis (5.60) reported in Table M2.

Figure M3

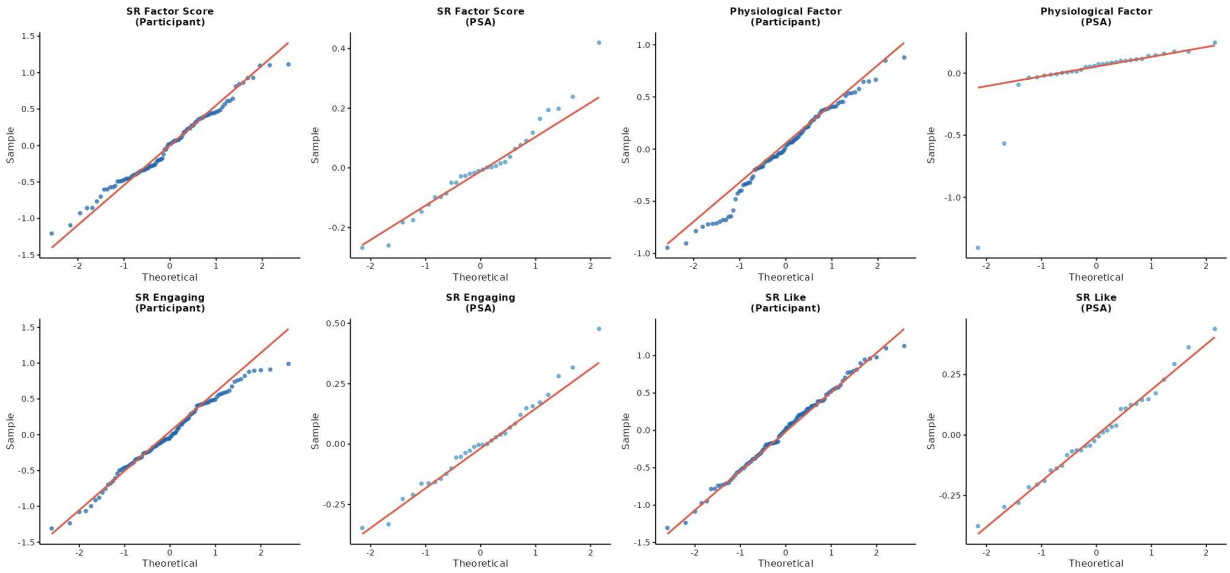
Pearson Residuals vs. Fitted Values (A2 REML Models, All Eight Outcomes)



Note. Models were adjusted for age, sex, simple reaction time, Flanker interference, delay discounting, and BDEFS Self-Restraint. Pearson residuals plotted against model-fitted values (random subsample of up to 4,000 observations per outcome). The red loess curve shows the local mean of the residuals; near-zero values across the range of fitted values indicate homoscedasticity. Minor deviations visible for Dwell Time and Fixation Count reflect the bounded nature of these distributions after data cleaning rather than a systematic model misspecification.

Figure M4

Normal Q-Q Plots of Random Effects (First Four Outcomes Shown)



Note. Models were adjusted for age, sex, simple reaction time, Flanker interference, delay discounting, and BDEFS Self-Restraint. Empirical quantiles of estimated random intercepts for participants (blue) and PSAs (teal) plotted against theoretical normal quantiles for the SR (Self-Report) Factor Score, Physiological Factor, SR Engaging, and SR Like outcomes. Points close to the diagonal indicate that the random-intercept distributions are approximately normal, satisfying the LME assumption regarding the random-effects structure.

Section 3: Summary

Taken together, the pre-model distributional checks (Section 1) and the post-fitting residual diagnostics (Section 2) generally support the conclusion that a linear mixed-effects framework with normally distributed errors was appropriate for the primary analyses. All outcomes (except Dwell Time) satisfied the conventional skewness and excess kurtosis thresholds both before model fitting and in the residuals of the fitted models. Dwell time showed heavier tails, but no clear evidence of systematic heteroscedasticity. Q-Q plots of the Pearson residuals (Figure M2) showed generally good alignment with the theoretical normal distribution, with more noticeable tail deviations for Dwell Time. Pearson residuals for Dwell Time showed elevated excess kurtosis (5.60), indicating heavier tails than the other outcomes and likely reflecting the bounded nature of the 25-second viewing paradigm. Importantly, GAD-7 did not significantly predict dwell time in any primary model; because heavier-tailed residuals are more likely to inflate Type I error than to create spurious null effects, these null results are unlikely to be artifacts of the residual non-normality. Residuals-versus-fitted plots (Figure M3) did not indicate strong systematic heteroscedasticity, although minor structure was visible for Dwell Time and Fixation Count. Random intercepts at both the participant and PSA levels were approximately normally distributed (Figure M4). No transformations of the primary outcome variables were retained; log-transformation was considered for Dwell Time but worsened the distribution. Log-transformation was applied to the delay-discounting covariate (ln[k] mean) as described in the main Methods section.

Glossary

Term	Definition
Attention maintenance models	Theories that emphasize not only the initial capture of attention by a stimulus but also the processes that sustain attention over time. In anxiety, it describes how anxious individuals tend to become stuck on threat-related cues: they rapidly detect potential dangers (hypervigilance/initial engagement) but have difficulty shifting attention away from them (impaired disengagement), resulting in prolonged monitoring of threat. This breakdown in top–down control over attention limits reorienting toward safety or efficacy information, magnifying perceived threat and helping to sustain anxious responding over time.
Attentional Control Theory	An extension of Processing Efficiency Theory proposing that anxiety primarily impairs the goal-directed, top-down functions of attentional control—particularly inhibition (the ability to suppress attention to task-irrelevant or distracting stimuli) and shifting (the ability to flexibly redirect attention between stimuli or tasks)—while leaving stimulus-driven, bottom-up attentional processes relatively intact. Because reduced inhibitory control makes it more difficult to disengage once attention has been captured, anxious individuals are particularly prone to prolonged processing of threat-related or emotionally salient stimuli.
Construal Level Theory	Theory proposing that psychological distance (the subjective sense of how near or far something feels from the self in time, space, social connection, or likelihood) systematically shapes how people mentally represent events or actions, ranging from concrete, detail-focused representations for proximal events to more abstract, high-level interpretations for distant events.

Term	Definition
Hyperbolic discounting	The tendency for individuals to disproportionately devalue outcomes as they move into the future, such that preferences become more short-sighted when decisions involve immediate versus delayed consequences.
Processing Efficiency Theory	Theory proposing that anxiety consumes working-memory resources that would otherwise be allocated to the task at hand, thereby reducing processing efficiency—the ratio of task performance to the cognitive effort or resources expended. According to this theory, anxious individuals can often achieve the same level of performance (effectiveness) as non-anxious individuals, but only by investing additional effort or compensatory strategies, such as more sustained or elaborate processing of relevant information.
Psychological reactance	A motivational state that emerges when individuals perceive that their freedom to think or behave in a particular way is being threatened or restricted by an external agent, such as a persuasive message or mandate. Reactance often manifests as resistance or oppositional behavior (e.g., dismissing or counterarguing a message).
The Extended Parallel Process Model	Theory describing how individuals respond to fear-evoking messages by integrating perceived threat (severity and susceptibility) with perceived efficacy (belief that the recommended response is effective and feasible for them). When both perceived threat and efficacy are high, people are more likely to engage in adaptive "danger control" responses (e.g., behavior change), whereas high threat paired with low efficacy can trigger defensive "fear control" responses (e.g., message avoidance or denial).