Prev Sci (2017) 18:1006–1016
DOI 10.1007/s11121-017-0836-7

A Biopsychological Model of Anti-drug PSA Processing: Developing Effective Persuasive Messages

Zachary P. Hohman[1,2] · **Justin Robert Keene**[1] · **Breanna N. Harris**[1] · **Elizabeth M. Niedbala**[1] · **Collin K. Berke**[3]

Published online: 26 August 2017

Abstract For the current study, we developed and tested a biopsychological model to combine research on psychological tension, the Limited Capacity Model of Motivated Mediated Message Processing, and the endocrine system to predict and understand how people process anti-drug PSAs. We predicted that co-presentation of pleasant and unpleasant information, vs. solely pleasant or unpleasant, will trigger evaluative tension about the target behavior in persuasive messages and result in a biological response (increase in cortisol, alpha amylase, and heart rate). In experiment 1, we assessed the impact of co-presentation of pleasant and unpleasant information in persuasive messages on evaluative tension (conceptualized as attitude ambivalence), in experiment 2, we explored the impact of co-presentation on endocrine system responses (salivary cortisol and alpha amylase), and in experiment 3, we assessed the impact of co-presentation on heart rate. Across all experiments, we demonstrated that co-presentation of pleasant and unpleasant information, vs. solely pleasant or unpleasant, in persuasive communications leads to increases in attitude ambivalence, salivary cortisol, salivary alpha amylase, and heart rate. Taken together, the results support the initial paths of our biopsychological model of persuasive message processing and indicate that including both pleasant and unpleasant information in a message impacts the viewer. We predict that increases in evaluative tension and biological responses will aid in memory and cognitive processing of the message. However, future research is needed to test that hypothesis.

Keywords Public service announcement · Evaluative tension · Cortisol · Alpha amylase · Limited Capacity Model of Motivated Mediated Message Processing

Currently, drug use is on the rise, which reverses a decade of decline (SAMHSA 2014; Hasin et al. 2015). Co-occurring with the reverse in this usage trend is a drop in young people's disapproval of drug use and lowered perceptions of risk (Hughes et al. 2016). The overall picture is unsettling: Young people now view drugs as easy to obtain, normative, and harmless (SAMHSA 2014). These perceptions are dangerous because drug use by young individuals is linked to a host adverse consequences, such as developmental/cognitive problems (Hart et al. 2001), low self-esteem (Shrier et al. 2001), low academic achievement (Bryant and Zimmerman 2002), and increased school dropouts (Bryant and Zimmerman 2002), to name just a few. Clearly, the recent uptick in and approval of drug use are issues that need to be addressed.

Drug use is a longstanding problem for local, state, and federal agencies. Attempts by these agencies to reduce marijuana use include the Drug Abuse Resistance Education program (DARE: since 1983) and the National Youth Anti-Drug Media Campaign (NYAMC: since 1998). Both campaigns were deployed on a national level but were not effective. Alarmingly, some evaluations of DARE show program participants had significantly *higher* rates of illicit substance use than non-participants (Werch and Owen 2002), while others found that the program had no impact on drug use (Clayton et al. 1996). Similarly, NYAMC's anti-drug messages produced unintended negative consequences: Viewing the

✉ Zachary P. Hohman
zachary.hohman@ttu.edu

[1] Texas Tech University, Lubbock, TX, USA

[2] Department of Psychological Sciences, Texas Tech University, MS 2051, Lubbock, TX 79409, USA

[3] University of Nebraska-Lincoln, Lincoln, NE, USA

messages led to weaker anti-drug norms, greater reactance, and a belief that others used drugs (Hornik 2006; Magura 2012). These nationally deployed campaigns were, at best, ineffective and, at worst, increased drug use, thus creating a critical national need for effective drug prevention messages.

Crafting a message that is effective at reducing drug use is critical (Palmgreen and Donohew 2003). Yet, it is still unclear which aspects of a message are most important in its effectiveness (Harrington et al. 2014). A limiting factor and critical barrier of standard prevention approaches is that they do not consider the structure of a message, including what information is presented, how it is presented, and when it appears, nor do they consider how that structure interacts with the viewer, both psychologically and biologically. Moreover, there is little integration across fields to determine how to incorporate findings from different research areas. Specifically, current approaches do not consider how the message framework interacts with the viewer across the psychological and biological systems. The contribution of the proposed research is an interdisciplinary, theory-driven framework for the creation of effective anti-drug prevention messages.

We propose a novel biopsychological model to determine how persuasive message presentation and composition impact psychological and biological response in the viewer and message effectiveness. Our model is an interdisciplinary integration of research on evaluative tension, the Limited Capacity Model of Motivated Mediated Message Processing (LC4MP, Lang 2006), and the endocrine stress systems. Our central hypothesis is messages that display both pleasant *and* unpleasant information, as opposed to just pleasant *or* unpleasant, will trigger evaluative tension (psychological measure), endocrine system activation, and increases in heart rate (biological measures). Ultimately, we predict that appropriately placed content about social norms can be used to alleviate message-induced evaluative tension and to help shape drug-use attitudes and behaviors, and that the biological responses will aid in memory of presented social normative information (see Fig. 1 for the full model). The goal of the current study is to test the initial paths and provide proof of concept for our framework. For our study here, we specifically address drug use (prescription drug abuse), but our model can be used by prevention researchers to address a host of health-related behaviors, e.g., healthy eating, alcohol use, and suicide prevention. Additionally, we envision our model to have great utility, as our framework could be used to craft prevention messages that target at-risk non-users, or target current users.

Evaluative Tension

People often hold both negative and positive evaluations of an object, and holding these simultaneous evaluations can produce psychological discomfort (Newby-Clark et al. 2002). For example, if people believe they will have more friends by using marijuana but also fear the negative consequences of use, they will experience discomfort. This discomfort results in a state of evaluative tension (Hass et al. 1992). To reduce the tension, people pay close attention to information in the environment that will help them resolve the conflict (Briñol et al. 2006; Clark et al. 2008). For example, people high in evaluative tension elaborate a persuasive message more intensely and are more persuaded by strong messages (Maio et al. 1996). Also, people high in evaluative tension look for and use social norm information to resolve the tension (Hodson et al. 2001). Thus, people seek information in the social context to reduce evaluative tension.

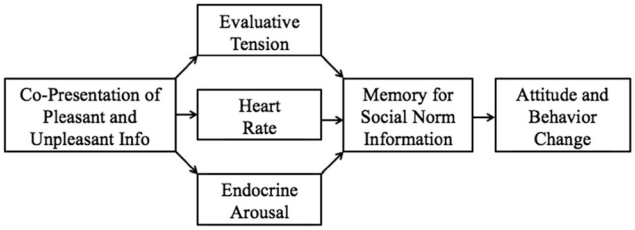

Fig. 1 Biopsychological model of PSA processing

Accordingly, we have shown that evaluative tension motivates people to adhere to social norms to reduce the tension (Hohman et al. 2016; Hohman et al. 2014). We aim to capitalize on these previous findings to make more effective PSAs. To do this, we must first understand how people process PSAs and understand what aspects of messages can be manipulated to invoke evaluative tension.

LC4MP

The LC4MP is a theoretical perspective that combines a dimensional theory of emotion (Bradley et al. 2001), a dual motivational systems model (Cacioppo and Gardner 1999), and a limited capacity information processing model to explain how people process messages. At the core of this model are two systems: the appetitive and aversive (Lang et al. 1997). The appetitive system responds automatically to pleasant stimuli and is the driving force behind approach behavior. The aversive system responds automatically to potential threats in the environment, both through fast-acting automatic defensive behaviors and by motivating complex behaviors like caution, fight, and flight. The motivational systems can activate in three patterns: reciprocal (only one system activates at a time), co-activation (both systems activate simultaneously or closely over time), and uncoupled (the activation patterns are uncorrelated; Cacioppo and Berntson 1994). Co-activation can be achieved by presenting pleasant and unpleasant information in rapid succession or simultaneously. Messages that elicit co-activation, compared to those that only activate one motivational system, receive greater resource allocation, measured by changes in tonic heart rate, and are also remembered

better by the participant (Keene and Lang 2012). Thus, heart rate is an indirect measure of how much people are processing (and remembering) a message.

Here, we predict messages that present positive and negative information will elicit co-activation (engagement of both appetitive and aversive systems) and will induce evaluative tension. We know that co-activation leads to changes in heart rate and seems to increase memory for a message (Keene and Lang 2012); however, other biological bases of co-activation have not been explored, though they are vital for understanding how people process messages. We propose that two specific endocrine systems increase following co-activation.

Endocrine System

In response to arousing events, both pleasant and unpleasant, two major endocrine systems activate—the sympathoadrenomedullary system (SAM) and the hypothalamic-pituitary-adrenal (HPA) axis (Reeder and Kramer 2005). The degree of activation in these systems is related to the level of arousal, and the SAM is more sensitive and faster-acting than the HPA axis (Sapolsky et al. 2000; van Stegeren et al. 2008). The SAM responds with a release of catecholamines, norepinephrine, and epinephrine, which are responsible for "flight or fight" responses: increased alertness, dilated pupils, racing heart, and increased breathing (Cannon 1929). The HPA axis response results in an increase in the hormone cortisol, and SAM responses lead to an increase in salivary alpha amylase. SAM and HPA hormone elevation can have synergistic effects on memory (Smeets et al. 2008), and both can enhance information gathering, cognitive processing, memory, and learning (Joëls et al. 2006; Lupien et al. 2005). Given similarities in the theoretical underpinnings of the LC4MP and the functions of the SAM and HPA axis, we propose these two endocrine systems are at least partial mediators of the previously demonstrated memory enhancing effects of co-activation (Keene and Lang 2012). Thus, we predict that presenting pleasant and unpleasant information in a message will elicit responses in both the SAM and HPA axis.

Current Study

We predict that when messages co-present both pleasant and unpleasant information, people experience evaluative tension and a biological response (increase heart rate, SAM, and HPA axis response). The purpose of the current study was to test these hypotheses across three experiments. The first experiment tests if co-presentation leads to evaluative tension, the second experiment tests if co-presentation leads to activation in the SAM and HPA axis, and experiment three tests if co-presentation leads to increases in heart rate. Co-presentation in a message can be achieved in one of the three possible ways (Keene and Lang 2012)—pleasant and unpleasant information can be presented simultaneously (e.g., talking about unpleasant consequences of drug use while playing pleasant music), the message can start with pleasant information and switch to unpleasant, or the message can start with unpleasant information and switch to pleasant. Regardless of co-presentation method, we predict that all co-presentation conditions, vs. solely pleasant or unpleasant, lead to evaluative tension and a biological system response.

Pilot Study

We selected PSAs targeting reduction of prescription drug abuse. Our goal was to find one message for each of five presentation conditions: pleasant information only (pleasant), unpleasant information only (unpleasant), simultaneously presenting pleasant and unpleasant information (simultaneous), a message that switches from presenting pleasant to unpleasant information (pleasant-to-unpleasant), and a message that switches from presenting unpleasant to pleasant information (unpleasant-to-pleasant). The videos with both pleasant and unpleasant information were predicted to elicit co-activation (the three ways to achieve co-activation), whereas the univalent (only pleasant, only unpleasant) were predicated to activate only one system. We found previously produced anti-prescription drug abuse PSAs from several drug prevention organizations (e.g., Partnership for a Drug Free America, http://www.drugfree.org/videos/). We pre-tested 50 ads using Continuous Response Measurement (Biocca et al. 1994). Participants (N = 60) were split into three groups. Group 1 rated all clips for pleasantness over time, group 2 for unpleasantness over time, and group 3 for arousal over time. We examined the emotional trajectory of each ad and then conducted a trend analysis to verify each trajectory using recommendations of Keene and Lang (2016) and Keene (2014). We then selected the strongest message for each of the five conditions.

Overall we had five, 30-s messages, (1) only pleasant (Bear Trap PSA, https://www.youtube.com/watch?v=wa0rq3jks1o, $M_{arousal}$ = 4.34, SD = 2.88), (2) only unpleasant (Aaron, https://www.youtube.com/watch?v=-h88t3lCuOk, $M_{arousal}$ = 3.72, SD = 2.51), (3) simultaneous presentation of pleasant and unpleasant information (Prescription Drugs—PSA [Owsley County Alliance], https://www.youtube.com/watch?v=JnFyaov-RXM, $M_{arousal}$ = 3.78, SD = 2.26), (4) pleasant-to-unpleasant (Partnership for a Drug Free Canada TV commercial, https://www.youtube.com/watch?v=7VAuDhkUFng, $M_{arousal}$ = 3.20, SD = 2.62), and (5) unpleasant-to-pleasant (Palm Partners Commercial—Prescription Drug Abuse, https://www.youtube.com/watch?v=XLgrEhcsYhU, $M_{arousal}$ = 3.49, SD = 2.64). These five videos were used in all

experiments. The institutional review board approved all procedures for all experiments and the pilot. All participants were recruited from undergraduate participant pools at a Southwest university.

Experiment 1

We hypothesized that people will experience an increase in evaluative tension when both pleasant and unpleasant information is presented together vs. singly in a message. To operationalize evaluative tension in this study, we used attitude ambivalence. Ambivalence is the simultaneous experience of pleasant and unpleasant attitudes toward an object, and past research demonstrates that attitude ambivalence is a form of evaluative tension (Priester and Petty 2001). For this study, we randomly assigned participants to watch one of the five PSAs and then measured their attitude ambivalence. We chose to use a post-test only design, rather than assess changes in ambivalence, because of the time between measures (about 30–45 s). Due to people's desire for cognitive consistency, it is unlikely that they would have changed their self-reported level of ambivalence, even if they were feeling more ambivalent (Dillman 2011).

Method

Participants One hundred and fifty-five male and 174 female participants (N = 329, M_{age} = 19.16, SD = 2.71) completed experiment 1. The ethnic breakdown was African-American (11.7%), Asian (2.5%), Caucasian (61.5%), Hispanic (17.8%), or others (6.5%).

Procedures and Materials Participants came into the lab and were seated in a cubical with a computer and headphones. Participants put the headphones on and then were randomly assigned to watch one of the five messages. After watching the message, participants answered questions to measure their attitude ambivalence using the felt ambivalence measure (Priester and Petty 1996). Felt ambivalence measures the extent to which people feel evaluative tension. To measure felt ambivalence, participants answered three questions (adapted from Priester and Petty 1996, "Please identify the amount of *conflict/mixed feelings/indecision* you feel when you think about abusing prescription medication"). To create a single felt ambivalence measure, we took the average of the three items, α = 0.60.

Results

A one-way, message condition ANOVA on felt ambivalence, with time of day and sex entered as covariates, revealed a significant main effect, $F(4, 318) = 13.03$, $p < 0.001$, $\eta_p^2 = 0.143$. Participants experienced the greatest level of felt ambivalence in the simultaneous (M = 5.45, SD = 1.93) and pleasant-unpleasant (M = 5.57, SD = 1.99) conditions, followed by unpleasant-pleasant (M = 4.57, SD = 2.20) and pleasant (M = 4.04, SD = 1.80) conditions; the lowest level of felt ambivalence was the unpleasant condition (M = 3.64, SD = 1.85). Comparing all conditions (using a Fisher's LSD with Bonferroni adjustment, which we used in the analyses for all experiments), the simultaneous condition significantly differed from pleasant ($p < 0.001$) and unpleasant conditions ($p < 0.001$) and unpleasant-pleasant condition (non-significant marginal trend, p = 0.078); simultaneous and pleasant-unpleasant conditions did not differ ($p > 0.999$). The pleasant-unpleasant condition was significantly greater than the pleasant condition ($p < 0.001$), the unpleasant condition ($p < 0.001$), and the unpleasant-pleasant condition ($p = 0.039$). For the unpleasant-pleasant condition, there was a non-significant marginal trend suggesting ambivalence was greater than in the unpleasant condition (p = 0.081); however, there was no significant difference between the unpleasant-pleasant condition and the pleasant condition ($p > 0.999$). Finally, there was no difference between the pleasant and unpleasant conditions ($p > 0.999$).

Experiment 2

We hypothesized that people will experience activation in the SAM and HPA axis when pleasant and unpleasant information is presented together, vs. singly, in a message. For this study, we employed a pre/post-test design where we measured participants' baseline SAM and HPA axis activation, randomly assigned participants to watch one of the five PSAs, and then measured post-PSA SAM and HPA axis activation. We chose to employ a pre-post design for the endocrine study because the within person analysis increased our power, which was needed due to sample size considerations and the cost of analyzing hormone data.

Method

Participants Ninety-three individuals (39 males, 54 females), aged 17 to 28 years (M = 19.40, SD = 1.41), participated in the study. The ethnic breakdown was African-American (9.7%), Asian (4.3%), Caucasian (47.3%), Hispanic (31.2%), or others (7.5%). On the day of the study, we asked the participants to refrain from activities that affect salivary cortisol and salivary alpha amylase (sAA) levels (e.g., smoking, drinking caffeine).

Procedures and Materials To control for the circadian rhythm of cortisol, data were collected between 10 A.M. and 2 P.M. To start, participants rinsed their mouths with water, waited 10 min, then provided their first saliva samples via the

passive drool method (Granger et al. 2007). Next, participants viewed one of the five videos, following the same procedures as experiment 1. After watching the video, participants provided two additional saliva samples for sAA (8 min later) and cortisol (20 min later) analysis (Engert et al. 2011). While waiting to provide the saliva samples, participants played solitaire on an iPad to make sure participants did nothing else arousing. Time needed to collect 1 ml of saliva was recorded for the sAA sample.

Salivary Hormone Analysis Baseline and post-video salivary samples were assayed in duplicate for concentration of cortisol and for sAA using commercially available enzyme immunoassay (cortisol: 1-3002) and kinetic enzyme assay kits (sAA: 1-1902; Salimetrics, Carlsbad, CA) following the manufacturer's instructions. Samples from the same individual were always run in the same assay plate. For both assays, sample duplicate coefficient of variation (CV) values were all under 10%. For cortisol, high and low controls were run in each assay plate, intra- and inter-assay CVs were 2.5 and 7.7% (high), and 6.2 and 8.3% (low). For sAA, kit-provided high and low controls were run with each plate and were within the acceptable range provided by Salimetrics. Cortisol concentration is reported as micrograms of hormone per deciliter of saliva (μg/dl). sAA data are reported as average amylase output (U/min), adjusted for salivary flow rate (for discussion see, Rohleder et al. 2006). Cortisol and amylase activity data were natural-log-transformed to improve normality as sample distribution was positively skewed; back-transformed data are presented.

Results

Cortisol To evaluate changes in cortisol from pre- to post-message, we conducted a repeated measures ANCOVA with pre/post natural logged cortisol as the repeated factor, message condition as the independent variable, and time of day and participant sex as covariates. Results uncovered a significant cortisol × message interaction, $F(4, 86) = 5.14$, $p = 0.001$, $\eta^2 = 0.193$, see Fig. 2. Looking at the cortisol change for each message, we found a significant increase for the simultaneous condition ($M_{pre} = 0.229$ vs. $M_{post} = 0.266$), $F(1, 86) = 4.13$,

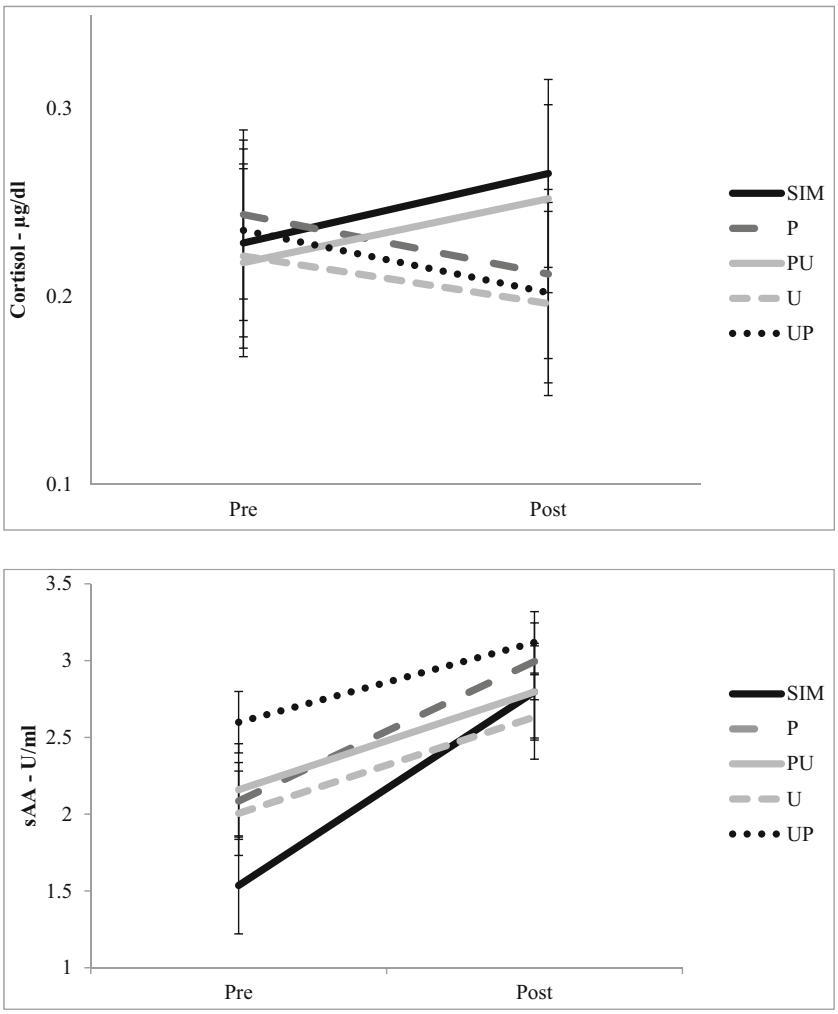

Fig. 2 Experiment 2, change in cortisol and sAA from pre- to post-message. Notes. Error bars represent 95% confidence intervals

$p = 0.045$, $\eta^2 = 0.046$, and the pleasant to unpleasant condition ($M_{pre} = 0.218$ vs. $M_{post} = 0.252$), $F(1, 86) = 4.31$, $p = 0.041$, $\eta^2 = 0.048$. For the unpleasant to pleasant condition ($M_{pre} = 0.235$ vs. $M_{post} = 0.202$), $F(1, 86) = 6.20$, $p = 0.015$, $\eta^2 = 0.067$, and the pleasant condition ($M_{pre} = 0.244$ vs. $M_{post} = 0.212$), $F(1, 86) = 5.44$, $p = 0.022$, $\eta^2 = 0.060$, there was a significant decrease. For the unpleasant condition, there was a non-significant marginal trend that suggests a decrease ($M_{pre} = 0.222$ vs. $M_{post} = 0.196$), $F(1, 86) = 3.56$, $p = 0.062$, $\eta^2 = 0.040$.

sAA To evaluate changes in sAA from pre- to post-message, we conducted a repeated measures ANCOVA with pre/post natural logged flow-corrected sAA using time of day and participant sex as covariates. Results uncovered a significant sAA × message interaction, $F(4, 86) = 2.71$, $p = 0.036$, $\eta^2 = 0.112$, see Fig. 2. Looking at the change in sAA from pre to post for each message, we found an increase in sAA for all conditions: simultaneous condition ($M_{pre} = 1.54$ vs. $M_{post} = 2.80$), $F(1, 86) = 42.77$, $p < 0.001$, $\eta^2 = 0.332$; pleasant condition ($M_{pre} = 2.09$ vs. $M_{post} = 2.99$), $F(1, 86) = 34.38$, $p < 0.001$, $\eta^2 = 0.286$; pleasant to unpleasant ($M_{pre} = 2.16$ vs. $M_{post} = 2.80$), $F(1, 86) = 12.31$, $p = 0.001$, $\eta^2 = 0.125$; unpleasant condition ($M_{pre} = 2.00$ vs. $M_{post} = 2.63$), $F(1, 86) = 14.08$, $p < 0.001$, $\eta^2 = 0.141$; unpleasant to pleasant condition ($M_{pre} = 2.60$ vs. $M_{post} = 3.12$), $F(1, 86) = 10.67$, $p = 0.002$, $\eta^2 = 0.110$.

Experiment 3

We predicted that people will experience an increase in heart rate following co-presentation vs. singularly presented information. The design was a 5 (message) × 30 (time) factorial design with change in heart rate over the course of each message as the within subject variable. For this experiment, each participant watched all five videos. The fully within-subjects allowed for the comparison of participant reactions across all five conditions, and it allowed for greater statistical power with a smaller sample (see Potter and Bolls 2012). We could not use a full within person design for experiment 2 because of the time course required to detect post-PSA changes in sAA (8 min) and cortisol (20 min).

Method

Participants Sixty-three students (15 males, 48 females), aged 18 to 28 ($M = 21.16$, $SD = 2.40$), participated in the study. The ethnic breakdown was African-American (9.5%), Asian (1.6%), Caucasian (66.7%), Hispanic (19.0%), or others (3.2%).

Procedure Participants watched all five videos and were randomly assigned to one of the two viewing orders. To start the study, participants were seated in a reclining chair 4 ft away from a 55-in. television. All visual stimuli were presented on the television (using MediaLab), and all audio stimuli were presented through headphones. Once a participant was seated in the chair, two Ag/AgCl electrodes were attached to his/her non-dominant arm and one electrode was attached to the dominant arm. Participants then viewed all five messages.

Heart Rate Recording Physiological responding was recorded using a BioPac Systems Inc. MP150, and data collection was controlled via the BioPac Systems AcqKnowledge 4.4 software. MediaLab triggered the physiological recording at the onset and offset of the stimuli. Heart rate was measured following the standard method in the field, described in Lang et al. (2007). Heart rate data was calculated per second, giving each participant 30 data points per video, and change scores were created for each time point using the average of the 5 s prior to onset as the baseline. Change scores are advantageous when reporting heart rate data in BPM per second because it normalizes the data and avoids any of the confounds of individual variance in resting heart rate (Keene et al. 2017).

Results

To evaluate changes in heart rate as a function of message condition, a 5 (message) × 30 (time) repeated measures ANOVA was conducted, controlling for sex. Due to the auto-correlated nature of physiological data, the Greenhouse-Geisser correction was used. There were significant main effects for the message condition, $F(3.695, 166.275) = 5.392$, $p = 0.001$, $\eta^2_p = 0.107$, and for time, $F(9.037, 406.652) = 7.056$, $p < 0.001$, $\eta^2_p = 0.136$. In addition, there was a significant interaction of message condition and time, $F(17.008, 765.358) = 2.793$, $p < 0.001$, $\eta^2_p = 0.058$, see Fig. 3. Due to the large number of possible pairwise comparisons, only those post hoc tests (to look for cardiac accelerations) relevant to our predictions will be described below.

The two messages that elicited the greatest ambivalence and increases in cortisol/sAA in experiments 1 and 2—simultaneous and pleasant to unpleasant—exhibited periods of significant cardiac acceleration over time, see Fig. 4. Specifically, the simultaneous message resulted in cardiac acceleration starting at second 12 ($M = -5.48$, $SE = 1.04$) and ending at second 17 ($M = -0.89$, $SE = 0.93$). A post hoc t test of these two time points showed that this acceleration was significant, $t(90) = 3.30$, $p < 0.01$. This response coincides with the time-period when the moderately arousing pleasant and unpleasant information were co-presented. In addition, the message that started pleasant and ended unpleasant resulted in a significant acceleration after the message switched from pleasant to unpleasant (at the 17-s mark). Of note, there is approximately a 6 s time lag in cardiac response to structural features such as emotional change (Potter and Bolls 2012). Specifically, the

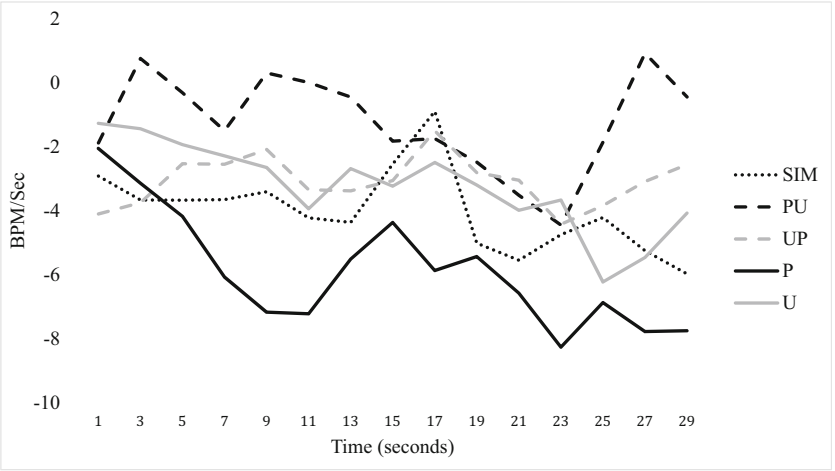

Fig. 3 Experiment 3, change in heart rate from baseline for each message. Notes. Data averaged over 2 s to smooth the data for presentation purposes

results show an acceleration starting at second 23 ($M = -4.84$, $SE = 0.94$) and ending at second 27 ($M = 1.12$, $SE = 0.92$). A post hoc t test of these two time points showed that this acceleration was significant, $t(90) = 4.52$, $p < 0.001$. This switch from pleasant to unpleasant activation has been shown to result in a period of co-activation (Keene and Lang 2016). In contrast, the other three conditions did not result in any statistically significant (ps > 0.14) or sustained accelerations of the same magnitude (> 4.5 BPM/s).

Discussion

The goal of this study was to test the initial paths of our biopsychological model of anti-drug PSA processing. Specially, we tested if including both pleasant and unpleasant information, vs. solely pleasant or unpleasant, would lead to an increase in evaluative tension and biological responses. We also examined if the way in which pleasant and unpleasant information was presented (simultaneous, pleasant-to-

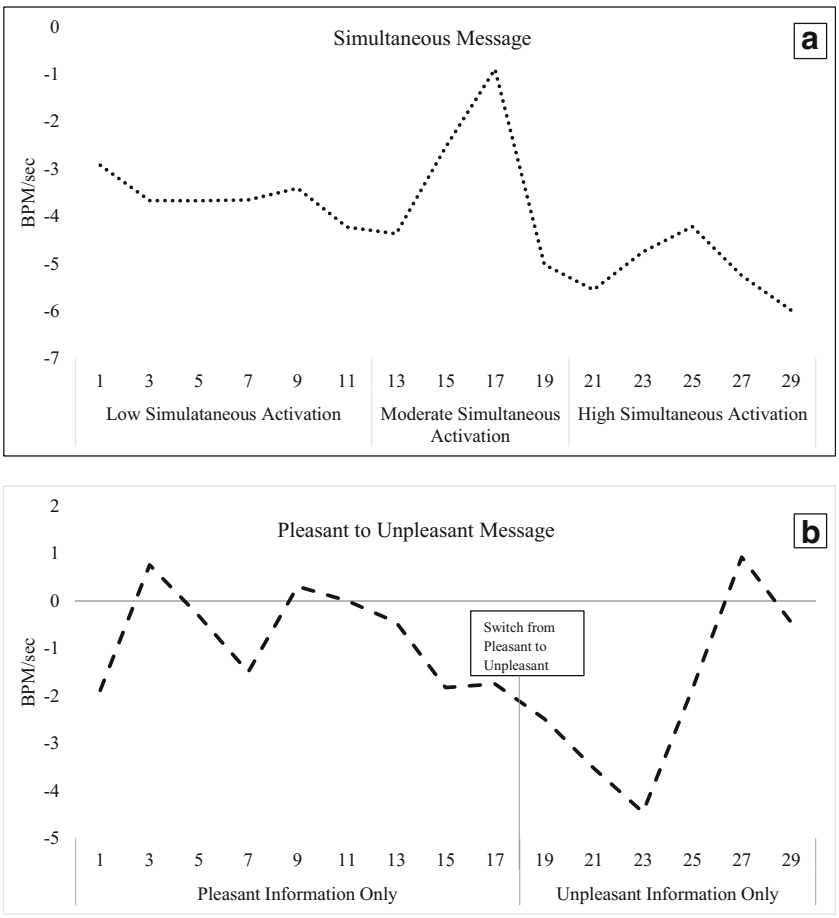

Fig. 4 Change in heart rate for the **a** simultaneous and **b** pleasant to unpleasant messages. Notes. Data averaged over 2 s to smooth the data for presentation purposes

unpleasant, unpleasant-to-pleasant) impacted these endpoints. We predicted that all forms of co-presentation would increase evaluative tension, salivary cortisol, salivary alpha amylase, and heart rate. Experiment 1 demonstrates that when both pleasant and unpleasant information are presented simultaneously or when messages switch from pleasant to unpleasant, people experience evaluative tension (here: attitude ambivalence), supporting the first path of the model. Experiment 2 demonstrates that these same two conditions lead to an increase in cortisol and sAA, supporting the second path of the model. Experiment 3 demonstrates that co-presentation leads people to experience an increase in cardiac acceleration at the point of simultaneous presentation or when the message switches from pleasant to unpleasant. Taken together, the results support the initial paths of our biopsychological model.

In our model, we argue that co-presentation of information in a message will lead to evaluative tension and biological responses. However, in this study, only the simultaneous and pleasant-unpleasant messages had the predicted impact on all measured variables. The unpleasant to pleasant message did not increase ambivalence, cortisol, or heart rate (but it did increase sAA). It is possible that because unpleasant information is naturally uncomfortable for the viewer (Lang 2006), providing pleasant information makes the viewer feel better and subsequently does not lead to our predicted responses. Or it is possible that the message we chose for the unpleasant to pleasant condition was not as strong (arousing) as the simultaneous or pleasant to unpleasant conditions and the perceived differences among these groups is due to the strength of the messages. However, our continuous response measurement data suggests that arousal levels across the three messages were very similar (simultaneous $M_{arousal} = 3.78$; pleasant to unpleasant $M_{arousal} = 3.20$; unpleasant to pleasant $M_{arousal} = 3.49$). Future research needs to examine other messages within each of these conditions and see how switching from unpleasant to pleasant impacts evaluative tension, cortisol, and heart rate.

In experiment 2, we found that all five videos increased sAA. However, simultaneous presentation of pleasant and unpleasant information showed the greatest sAA rise. For cortisol, only two of the videos, simultaneous and pleasant-to-unpleasant, showed an increase. Differential response of the SAM and HPA axis fits with previous literature. Viewing neutral or negative photos elevated sAA but not cortisol, whereas a more pronounced stressor (cold pressor test) elevated cortisol and sAA (van Stegeren et al. 2008). These results mirror our findings that the negative-only video increase sAA, but not cortisol, and may help explain why we did not see cortisol increases in the negative-to-positive video condition. Interestingly, we found significant elevation of both hormones following simultaneous and pleasant-to-unpleasant videos. The exact reasoning for these results is unknown and warrants further study.

In the model, we predict that co-presentation in a message will lead to evaluative tension. In this study, we conceptualized evaluative tension as attitude ambivalence, because ambivalence is when one holds both pleasant and unpleasant beliefs about something. However, there are other conceptualizations of evaluative tension (e.g., cognitive dissonance, mixed emotions) we could have used in this study and could play a role in our model. Future research should explore how other forms of evaluative tension are influenced by co-presentation in a persuasive message.

Limitations

A limitation of the current study is that we used only one message per condition. Therefore, it is possible that the results of the experiments could be due to something about these specific messages, rather than just the inclusion of pleasant and unpleasant information. We did, however, pre-test over 50 messages to determine which messages best fit each of our experimental conditions, so we are confident that the results are due to the combination of pleasant and unpleasant information, and not some other random aspect of the message. Nonetheless, future research using different messages, and more than one message per condition, is needed to rule out message specific effects.

Another limitation in this study is the sample size for experiments 2 and 3. Due to the cost of endocrine analysis and electrodes for heart rate collection, we could not collect large sample sizes for those experiments. However, observed power in each of those studies was very high (both studies had an observed power of 0.99), so we do not believe power is an issue in these experiments. An additional issue with the sample is that it was predominately Caucasian, non-Hispanic, and collected from two different college participant pools. We chose college students because this group is most at-risk for prescription drug abuse (Garnier-Dykstra et al. 2012), making them an ideal population to test our model using prescription drug abuse PSAs. Future research needs to test the model using a more diverse sample collected from different populations. Also, future research should test the model in a single, large-scale study that tests all model paths, rather than testing individual paths from multiple experiments. Please note that collecting endocrine and physiology data at the same time requires the use of a between-subjects design and increases sample size demands and costs.

We used pre-existing messages in the current study. Ideally, we would have carefully crafted our messages using the model for each experimental condition. Unfortunately, the cost of creating anti-drug video messages is prohibitive. Future research should create messages specifically designed with this model in mind to provide a pure test of the model. Finally, the felt attitude ambivalence scale for experiment 1 had a somewhat low Cronbach alpha (0.60). This alpha was within the range of research using the felt ambivalence scale (Armitage and Arden 2007; Priester and Petty 1996). However, future research should employ different measures of felt

ambivalence to make sure that the low reliability did not impact the results in this study.

Implications

Now that the underlying pillars of the model have been tested, future research needs to examine the full model. Overall, our model suggests that when messages co-present pleasant and unpleasant information, people will experience evaluative tension and have a biological response. We predict the increased evaluative tension will lead people to search for information in the message to reduce conflict and that the biological responses will increase memory for the information presented. By providing social norms after co-presentation, we hypothesize that people will use norms to guide behavior and reduce ambivalence. Therefore, we ultimately predict that providing social norms after co-presentation (when people are experiencing increased cortisol, sAA, and heart rate) will lead to (a) reduced evaluative tension, (b) change in attitudes toward the social norm, (c) better memory for the normative information, (d) change in behavioral intentions toward the social norm, and (e) change in behavior to be in line with the norm. The model allows us to make predictions about when and where information should be placed within messages and the kind of information (e.g., pleasant and/or unpleasant, social norms) that should be included. Determining not only *what*, but *where* information should be placed in a message has the potential to inform researchers on how to create effective prevention messages addressing many different problematic lifestyle issues. We developed the model to be flexible, so that it could be used to target a host of health behaviors and for diverse populations, including both users and non-users. One important question for prevention researchers interested in using our model to create messages revolves around what should the pleasant information included in a message look like. Research on the LC4MP suggests that pleasant information has its greatest impact when it is in auditory format (Keene and Lang 2016), which would suggest that pleasant music while simultaneously talking about unpleasant information or showing unpleasant images would be a good method for co-activating the two motivational systems.

Conclusion

Overall, we use a novel and interdisciplinary model to show that co-presenting pleasant and unpleasant information in a message, specifically in a simultaneous or pleasant-to-unpleasant manner, leads to ambivalence, increased heart rate, and increases in cortisol and sAA. We predict that increases in the psychological systems should lead the viewer to search for information that reduces negative feelings and that increases in biological systems should enhance attention to, and memory for, those messages; however, future research is needed to test that idea.

Funding Funding for this research was supplied by start-up funds provided to the first and second authors.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

Research Involving Human Participants All procedures performed in studies involving human participants were in accordance with the ethical standards of the Human Subjects division of the Institutional Review Board and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All research was performed with approval from the Texas Tech University's Institutional Review Board, and the Texas Tech University Institutional Biosafety Committee.

Informed Consent Informed consent was obtained from all participants included in the research.

References

Armitage, C. J., & Arden, M. A. (2007). Felt and potential ambivalence across the stages of change. *Journal of Health Psychology, 12*, 149–158. https://doi.org/10.1177/1359105307071749.

Biocca, F., David, P., & West, M. (1994). Continuous response measurement (CRM). A computerized tool for research on the cognitive processing of communication messages. In A. Lang (Ed.), *Measuring psychological responses to media messages* (pp. 15–64). Mahwah, NJ: Lawrence Erlbaum Associates, Inc..

Bradley, M. M., Codispoti, M., Cuthbert, B. N., & Lang, P. J. (2001). Emotion and motivation I: Defensive and appetitive reactions in picture processing. *Emotion, 1*, 276–298.

Briñol, P., Petty, R. E., & Wheeler, S. C. (2006). Discrepancies between explicit and implicit self-concepts: Consequences for information processing. *Journal of Personality and Social Psychology, 91*, 154–170. https://doi.org/10.1037/0022-3514.91.1.154.

Bryant, A. L., & Zimmerman, M. A. (2002). Examining the effects of academic beliefs and behaviors on changes in substance use among urban adolescents. *Journal of Educational Psychology, 94*, 621–637. https://doi.org/10.1037/0022-0663.94.3.621.

Cacioppo, J. T., & Berntson, G. G. (1994). Relationship between attitudes and evaluative space: A critical review, with emphasis on the separability of positive and negative substrates. *Psychological Bulletin, 115*, 401–423. https://doi.org/10.1037/0033-2909.115.3.401.

Cacioppo, J. T., & Gardner, W. L. (1999). Emotion. *Annual Reviews: Psychology, 50*, 191–214.

Cannon, W. B. (1929). *Bodily changes in pain, hunger, fear, and range*. New York: Appleton.

Clark, J. K., Wegener, D. T., & Fabrigar, L. R. (2008). Attitudinal ambivalence and message-based persuasion: Motivated processing of proattitudinal information and avoidance of counterattitudinal information. *Personality and Social Psychology Bulletin, 34*, 565–577. https://doi.org/10.1177/0146167207312527.

Clayton, R. R., Cattarello, A. M., & Johnstone, B. M. (1996). The effectiveness of drug abuse resistance education (project DARE): 5-year follow-up results. *Preventive Medicine, 25*, 307–318. https://doi.org/10.1006/pmed.1996.0061.

Dillman, D. A. (2011). *Mail and Internet surveys: The tailored design method—2007 update with new Internet, visual, and mixed-mode guide*. New York, NY: John Wiley & Sons.

Engert, V., Vogel, S., Efanov, S. I., Duchesne, A., Corbo, V., Ali, N., & Pruessner, J. C. (2011). Investigation into the cross-correlation of

salivary cortisol and alpha-amylase responses to psychological stress. *Psychoneuroendocrinology, 36*, 1294–1302. https://doi.org/10.1016/j.psyneuen.2011.02.018.

Garnier-Dykstra, L. M., Caldeira, K. M., Vincent, K. B., O'Grady, K. E., & Arria, A. M. (2012). Nonmedical use of prescription stimulants during college: Four-year trends in exposure opportunity, use, motives, and sources. *Journal of American College Health, 60*, 226–236.

Granger, D. A., Kivlighan, K. T., Fortunato, C., Harmon, A. G., Hibel, L. C., Schwartz, E. B., & Whembolua, G. L. (2007). Integration of salivary biomarkers into developmental and behaviorally-oriented research: Problems and solutions for collecting specimens. *Physiology & Behavior, 92*, 583–590. https://doi.org/10.1016/j.physbeh.2007.05.004.

Harrington, N. G., Palmgreen, P. C., & Donohew, L. (2014). Programmatic research to increase the effectiveness of health communication campaigns. *Journal of Health Communication, 19*, 1472–1480. https://doi.org/10.1080/10810730.2014.954082.

Hart, C. L., Van Gorp, W., Haney, M., Foltin, R. W., & Fischman, M. W. (2001). Effects of acute smoked marijuana on complex cognitive performance. *Neuropsychopharmacology, 25*, 757–765. https://doi.org/10.1016/s0893-133x(01)00273-1.

Hasin, D. S., Saha, T. D., Kerridge, B. T., Goldstein, R. B., Chou, S. P., Zhang, H., et al. (2015). Prevalence of marijuana use disorders in the United States between 2001-2002 and 2012-2013. *Journal of American Medical Association: Psychiatry, 72*, 1235–1242.

Hass, R. G., Katz, I., Rizzo, N., Bailey, J., & Moore, L. (1992). When racial ambivalence evokes negative affect, using a disguised measure of mood. *Personality and Social Psychology Bulletin, 18*, 786–797. https://doi.org/10.1177/0146167292186015.

Hodson, G., Maio, G. R., & Esses, V. M. (2001). The role of attitudinal ambivalence in susceptibility to consensus information. *Basic and Applied Social Psychology, 23*, 197–205. https://doi.org/10.1207/153248301750433678.

Hohman, Z. P., Crano, W. D., Siegel, J. T., & Alvaro, E. (2014). Attitude ambivalence, friend norms, and adolescent drug use. *Prevention Science, 15*, 65–74.

Hohman, Z. P., Crano, W. D., & Niedbala, E. M. (2016). Attitude ambivalence, social norms, and behavioral intentions: Developing effective antitobacco persuasive communications. *Psychology of Addictive Behavior, 30*, 209–219. https://doi.org/10.1037/adb0000126.

Hornik, R. (2006). Personal influence and the effects of the national youth anti-drug media campaign. *The Annals of the American Academy of Political and Social Science, 608*, 282–300. https://doi.org/10.1177/0002716206291972.

Hughes, A., Lipari, R.N., & Williams, M.R. (2016). Marijuana use and perceived risk of harm from marijuana use varies within and across states. The CBHSQ Report: July 26, 2016. Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration, Rockville, MD.

Joëls, M., Pu, Z., Wiegert, O., Oitzl, M. S., & Krugers, H. J. (2006). Learning under stress: How does it work? *Trends in Cognitive Science, 10*, 152–158. https://doi.org/10.1016/j.tics.2006.02.002.

Keene, J. R. (2014). *Coactivation in the motivational systems and motivational inhibition: Processing and emotional judgments of pictures and framed anti-drug messages*. Bloomington, IN: Indiana University.

Keene, J. R., & Lang, A. (2012). Positively negative: An overtime examination of reactions to coactive messages. *Psychophysiology, 49*(S1), S73. https://doi.org/10.1111/j.1469-8986.2012.01440.x.

Keene, J. R., & Lang, A. (2016). Dynamic motivated processing of emotional trajectories in public service announcements. *Communication Monographs., 83*, 468–485.

Keene, J. R., Clayton, R., Berke, C. K., Loof, T., & Bolls, P. D. (2017). On the use of beats-per-minute and inter-beat interval in the analysis of cardiac responses to mediated messages. *Communication Research Reports*. **Advanced online publication**. https://doi.org/10.1080/08824096.2017.1334640.

Lang, A. (2006). Using the limited capacity model of motivated mediated message processing to design effective cancer communication messages. *Journal of Communication, 56*, S57–S80. https://doi.org/10.1111/j.1460-2466.2006.00283.x.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). Motivated attention: Affect, activation, and action. In P. J. Lang, R. F. Simons, & M. T. Balaban (Eds.), *Attention and orienting: Sensory and motivational processes* (pp. 97–135). Hillsdale, NJ: Erlbaum.

Lang, A., Bradley, S. D., Sparks Jr., J. V., & Lee, S. (2007). The motivation activation measure (MAM): How well does MAM predict individual differences in physiological indicators of appetitive and aversive activation? *Communication Methods and Measures, 1*, 113–136. https://doi.org/10.1080/19312450701399370.

Lupien, S. J., Fiocco, A., Wan, N., Maheu, F., Lord, C., Schramek, T., & Tu, M. T. (2005). Stress hormones and human memory function across the lifespan. *Psychoneuroendocrinology, 30*, 225–242. https://doi.org/10.1016/j.psyneuen.2004.08.003.

Magura, S. (2012). Failure of intervention or failure of evaluation: A meta-evaluation of the National Youth Anti-Drug Media Campaign Evaluation. *Substance Use & Misuse, 47*, 1414–1420. https://doi.org/10.3109/10826084.2012.705706.

Maio, G. R., Bell, D. W., & Esses, V. M. (1996). Ambivalence and persuasion: The processing of messages about immigrant groups. *Journal of Experimental Social Psychology, 32*, 513–536. https://doi.org/10.1006/jesp.1996.0023.

Newby-Clark, I. R., McGregor, I., & Zanna, M. P. (2002). Thinking and caring about cognitive inconsistency: When and for whom does attitudinal ambivalence feel uncomfortable? *Journal of Personality and Social Psychology, 82*, 157–166.

Palmgreen, P., & Donohew, L. (2003). Effective mass media strategies for drug abuse prevention campaigns. In Z. Sloboda & W. J. Bukoski (Eds.), *Handbook of drug abuse prevention: Theory, science and practice* (pp. 27–43). New York, NY: Kluwer/Plenum.

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

Priester, J. R., & Petty, R. E. (1996). The gradual threshold model of ambivalence: Relating the positive and negative bases of attitudes to subjective ambivalence. *Journal of Personality and Social Psychology, 71*, 431–449. https://doi.org/10.1037/0022-3514.71.3.431.

Priester, J. R., & Petty, R. E. (2001). Extending the bases of subjective attitude ambivalence: Interpersonal and intrapersonal antecedents of evaluative tension. *Journal of Personality and Social Psychology, 80*, 19–34. https://doi.org/10.1037//0022-3514.80.1.19.

Reeder, D. M., & Kramer, K. M. (2005). Stress in free-ranging mammals: Integrating physiology, ecology, and natural history. *Journal of Mammalogy, 86*, 225–235.

Rohleder, N., Wolf, J. M., Maldonado, E. F., & Kirschbaum, C. (2006). The psychosocial stress-induced increase in salivary alpha-amylase is independent of saliva flow rate. *Psychophysiology, 43*, 645–652. https://doi.org/10.1111/j.1469-8986.2006.00457.x.

Sapolsky, R. M., Romero, L. M., & Munck, A. U. (2000). How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. *Endocrinology Reviews, 21*, 55–89. https://doi.org/10.1210/edrv.21.1.0389.

Shrier, L. A., Harris, S. K., Sternberg, M., & Beardslee, W. R. (2001). Associations of depression, self-esteem, and substance use with sexual risk among adolescents. *Preventive Medicine, 33*, 179–189. https://doi.org/10.1006/pmed.2001.0869.

Smeets, T., Otgaar, H., Candel, I., & Wolf, O. T. (2008). True or false? Memory is differentially affected by stress-induced cortisol

elevations and sympathetic activity at consolidation and retrieval. *Psychoneuroendocrinology, 33*, 1378–1386.

Substance Abuse and Mental Health Services Administration. (2014). Results from the 2013 National Survey on Drug Use and Health: National findings (NSDUH Series H-34, DHHS Publication No. SMA 14–4863). Rockville, MD: Substance Abuse and Mental Health Services Administration.

van Stegeren, A. H., Wolf, O. T., & Kindt, M. (2008). Salivary alpha amylase and cortisol responses to different stress tasks: Impact of sex. *International Journal of Psychophysiology, 69*, 33–40. https://doi.org/10.1016/j.ijpsycho.2008.02.008.

Werch, C. E., & Owen, D. M. (2002). Iatrogenic effects of alcohol and drug prevention programs. *Journal of Studies on Alcohol, 63*, 581–590. 10.15288/jsa.2002.63.581.