Final Progress Report for Research Projects Funded by Health Research Grants

Instructions: Please complete all of the items as instructed. Do not delete instructions. Do not leave any items blank; responses must be provided for all items. If your response to an item is "None", please specify "None" as your response. "Not applicable" is not an acceptable response for any of the items. There is no limit to the length of your response to any question. Responses should be single-spaced, no smaller than 12-point type. The report **must be completed using MS Word**. Submitted reports must be Word documents; they should not be converted to pdf format. Questions? Contact Health Research Program staff at 717-783-2548.

1. **Grantee Institution:** Temple University – Of The Commonwealth System of Higher Education

2. **Reporting Period (start and end date of grant award period):** 1/12010-12/31/2013

3. **Grant Contact Person (First Name, M.I., Last Name, Degrees):** Germaine A Calicat, MLA

4. **Grant Contact Person's Telephone Number:** 215.204.7655

5. **Grant SAP Number:** 4100050909

6. **Project Number and Title of Research Project:** Project 18 - Enhancing Effective Healthcare Decision Making with the Use of Brain Imaging Tools

7. **Start and End Date of Research Project:** 9/20/2011 – 12/31/2013

8. **Name of Principal Investigator for the Research Project:** Angelika Dimoka, Ph.D.

9. **Research Project Expenses**.

   9(A) Please provide the total amount of health research grant funds spent on this project for the entire duration of the grant, including indirect costs and any interest earned that was spent:

   $ 293,419.31

   9(B) Provide the last names (include first initial if multiple individuals with the same last name are listed) of **all** persons who worked on this research project and were supported with health research funds. Include position titles (Principal Investigator, Graduate Assistant, Post-doctoral Fellow, etc.), percent of effort on project and total health research funds expended for the position. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name, First Name	Position Title	% of Effort on Project	Cost
Vo, Khoi	Research Assistant	80	$31,000
Marston, David	Research Assistant	90	$28,000

9(C) Provide the names of **all** persons who worked on this research project, but who *were not* supported with health research funds. Include position titles (Research Assistant, Administrative Assistant, etc.) and percent of effort on project. For multiple year projects, if percent of effort varied from year to year, report in the % of Effort column the effort by year 1, 2, 3, etc. of the project (x% Yr 1; z% Yr 2-3).

Last Name, First Name	Position Title	% of Effort on Project
Venkatraman, Vinod	Assistant Professor	5
Yoon, Carolyn	Professor	1
Huang, Yianliu	Assistant Professor	4
Pavlou, Paul	Professor	3

9(D) Provide a list of **all** scientific equipment purchased as part of this research grant, a short description of the value (benefit) derived by the institution from this equipment, and the cost of the equipment.

Type of Scientific Equipment	Value Derived	Cost

10. Co-funding of Research Project during Health Research Grant Award Period. Did this research project receive funding from any other source during the project period when it was supported by the health research grant?

Yes_____ No____X____

If yes, please indicate the source and amount of other funds:

11. Leveraging of Additional Funds

11(A) As a result of the health research funds provided for this research project, were you able to apply for and/or obtain funding from other sources to continue or expand the research?

Yes_____ No____X____

If yes, please list the applications submitted (column A), the funding agency (National Institutes of Health—NIH, or other source in column B), the month and year when the application was submitted (column C), and the amount of funds requested (column D). If you have received a notice that the grant will be funded, please indicate the amount of funds to be awarded (column E). If the grant was not funded, insert "not funded" in column E.

Do not include funding from your own institution or from CURE (tobacco settlement funds). Do not include grants submitted prior to the start date of the grant as shown in Question 2. If you list grants submitted within 1-6 months of the start date of this grant, add a statement below the table indicating how the data/results from this project were used to secure that grant.

A. Title of research project on grant application	B. Funding agency (check those that apply)	C. Month and Year Submitted	D. Amount of funds requested:	E. Amount of funds to be awarded:
	☐NIH ☐ Other federal (specify:_____ _____) ☐ Nonfederal source (specify: _____)		$	$
	☐NIH ☐ Other federal (specify:_____ _____) ☐ Nonfederal source (specify: _____)		$	$

11(B) Are you planning to apply for additional funding in the future to continue or expand the research?

Yes___X____ No_____

If yes, please describe your plans:

Will apply for NIH R01 in Year 2015

12. **Future of Research Project.** What are the future plans for this research project?

Continue data analysis. Submit journal and conference articles. Apply for further funding to continue the project

13. **New Investigator Training and Development**. Did students participate in project supported internships or graduate or post-graduate training for at least one semester or one summer?

Yes_____ No__X_____

If yes, how many students? Please specify in the tables below:

	Undergraduate	Masters	Pre-doc	Post-doc
Male				
Female				
Unknown				
Total				

	Undergraduate	Masters	Pre-doc	Post-doc
Hispanic				
Non-Hispanic				
Unknown				
Total				

	Undergraduate	Masters	Pre-doc	Post-doc
White				
Black				
Asian				
Other				
Unknown				
Total				

14. **Recruitment of Out-of–State Researchers**. Did you bring researchers into Pennsylvania to carry out this research project?

Yes_____ No____X____

If yes, please list the name and degree of each researcher and his/her previous affiliation:

15. Impact on Research Capacity and Quality. Did the health research project enhance the quality and/or capacity of research at your institution?

Yes____X___ No_____

If yes, describe how improvements in infrastructure, the addition of new investigators, and other resources have led to more and better research.

Able to acquire two new research assistant that have led to significant more research.

16. Collaboration, business and community involvement.

16(A) Did the health research funds lead to collaboration with research partners outside of your institution (e.g., entire university, entire hospital system)?

Yes___X____ No_____

If yes, please describe the collaborations:

Drexel University, Collaboration with an assistant professor.

16(B) Did the research project result in commercial development of any research products?

Yes_____ No____X_____

If yes, please describe commercial development activities that resulted from the research project:

16(C) Did the research lead to new involvement with the community?

Yes_____ No___X_____

If yes, please describe involvement with community groups that resulted from the research project:

17. Progress in Achieving Research Goals, Objectives and Aims.
List the project goals, objectives and specific aims (as contained in the grant agreement). Summarize the progress made in achieving these goals, objectives and aims <u>for the period that the project was funded (i.e., from project start date through end date).</u> Indicate whether or not each goal/objective/aim was achieved; if something was not achieved, note the reasons why. Describe the methods used. If changes were made to the research

goals/objectives/aims, methods, design or timeline since the original grant application was submitted, please describe the changes. Provide detailed results of the project. Include evidence of the data that was generated and analyzed, and provide tables, graphs, and figures of the data. List published abstracts, poster presentations and scientific meeting presentations at the end of the summary of progress; peer-reviewed publications should be listed under item 20.

This response should be a DETAILED report of the methods and findings. It is not sufficient to state that the work was completed. Insufficient information may result in an unfavorable performance review, which may jeopardize future funding. If research findings are pending publication you must still include enough detail for the expert peer reviewers to evaluate the progress during the course of the project.

Health research grants funded under the Tobacco Settlement Act will be evaluated via a performance review by an expert panel of researchers and clinicians who will assess project work using this Final Progress Report, all project Annual Reports and the project's strategic plan. After the final performance review of each project is complete, approximately 12-16 months after the end of the grant, this Final Progress Report, as well as the Final Performance Review Report containing the comments of the expert review panel, and the grantee's written response to the Final Performance Review Report, will be posted on the CURE Web site.

There is no limit to the length of your response. Responses must be single-spaced below, no smaller than 12-point type. If you cut and paste text from a publication, be sure symbols print properly, e.g., the Greek symbol for alpha (α) and beta (ß) should not print as boxes (□) and include the appropriate citation(s). DO NOT DELETE THESE INSTRUCTIONS.

Background: Effective healthcare depends on the extent to which patients adhere to messages for a healthy lifestyle, follow their physicians' advice in the course of an illness, and seek preventive treatment. However, patients often ignore these messages and advice because they tend to underestimate the likelihood of a disease happening to them. This phenomenon is formally termed self-positivity bias, and it was shown to prevent patients from adhering to health communications and advice. This project used fMRI tools to enhance effective decision-making in a healthcare context, particularly for older adults, minorities, and the poor, by designing and testing decision aids that correspond to the brain's functionality to help patients reduce self-positivity bias.

fMRI tools can help identify the neural correlates of self-positivity bias (which areas of the brain are activated when self-positivity bias is triggered). They measure the brain activity induced by self-positivity bias, when subjects are asked to estimate their own versus other people's probability of contracting a certain disease. Based on the neural correlates of self-positivity bias across common diseases (i.e., AIDS, STDs, cancer) and analysis of their underlying neural origins drawn from the neuroscience literature, we designed decision aids and interventions that seek to overcome the negative effects of self-positivity bias and motivate people to pursue a

healthier lifestyle, seek preventive medical care, and adhere to medical advice by healthcare providers.

Specific Aims: This study had three specific aims: Specific Aim 1. The first objective was to identify the neural self-positivity bias perceptions across individuals in a behavioral study. Specific Aim 2. The second objective was to identify the neural correlates of self-positivity bias (which areas of the brain are activated when self-positivity bias is triggered) using fMRI tools, which allow the temporal and spatial measurement of brain activity. Specific Aim 3. The identification, analysis, and understanding of the neural origins of self-positivity bias across these common diseases was used as a basis for designing customized decision aids and interventions for each disease that specifically target the neural correlates of self-positivity bias. The first two aims were achieved as described below. For the third aim, we were not able to differentiate across the different interventions, so we collected subsequent data to learn more about the target diseases and the subjects' behavior on self positivity bias.

Progress Achieved - Specific Aim 1:

We surveyed 61 subjects on their perceptions about six diseases: AIDS, drinking problem, STDs, cancer, heart attack, and Hepatitis. Participants were asked to fill out an online survey where they indicated their perceptions about all of these diseases. Specifically, for each of these diseases, they first expressed how anxious, worried, tense, fearful, uptight, and scared they were when thinking about this specific disease (i.e., emotions toward the disease). They then indicated how serious they thought this disease was. They answered all of these questions on a set of 9-point semantic differential scales ranging from "1 = not at all" to "9 = very". The disease was then rated for *personal experience* where participants selected among following options: "1 = has not happened to anyone I know", "2 = has happened to acquaintances", "3 = has happened to friends or close relatives", "4 = has happened to me once", and "5 = has happened to me more than once". If more than one option applies then they were asked to select the one with the highest experience level. They also rated the *controllability* of the event by choosing one of the following options: "1 = there is nothing one can do that will change the likelihood that the event will take place", "2 = things one can do have a small effect on the chances that the event will occur", "3 = things one can do have a large effect", and "4 = the disease is completely controllable". Finally, participants estimated the probability of contracting this specific disease by entering a number between 0 and 100 for each of the three target persons including the self, their closest friend, and an average undergraduate student from the same university.

First, for each disease, a repeated-measure ANOVA was conducted with the type of target person as the independent variable and the risk estimation as the dependent variable. These analyses as well as the risk estimation means were displayed in Table A1. As can be seen, there was a significant main effect of target person for almost all the diseases except for the heart attack. Specifically, the disease-contracting risk estimation was always higher for an average undergraduate student from the same university than for oneself (self-positivity bias 1 or SPB1) and for one's closest friend (self-positivity bias 2 or SPB2) respectively. In addition, the risk estimation for one's closest friend was also higher than for oneself (self-positivity bias 3 or SPB3). All of these three types of self-positivity bias have been demonstrated a lot in the literature where the magnitude of SPB1is usually the greatest, followed by that of the SPB2 and

then SPB3. As shown in Table A1, both heart attack and hepatitis showed no or relatively small magnitude for these three types of self-positivity bias. Since we want to ensure that the diseases we selected had high enough self-positivity bias that can be captured in the fMRI study, we excluded both heart attack and hepatitis for the further examination and inclusion in the later behavioral and fMRI studies.

We next tried to select appropriate stimuli from the remaining four diseases (i.e., STDs, AIDS, cancer, and drinking problem) for our further studies to test our hypotheses that the brain mechanisms of the self-positivity bias depend on how people perceive each type of disease (i.e., cognitive or emotional). We first specifically examined in detail the effect of those perception factors (i.e., the emotions toward the disease, perceived disease seriousness, their personal experience, and the perceived controllability of the disease) on self-positivity bias. Since emotions toward the disease were measured by asking people how anxious, worried, tense, fearful, uptight, and scared they were when thinking about this specific disease and these six emotion measures demonstrated high internal consistency (Cronbach's $\alpha = .97$), they were averaged to form a composite emotion index for each disease. A composite self-positivity bias index was also generated by averaging SPB1, SPB2, and SPB3 for each disease.

How participants perceived each of these four diseases were presented in Figure A1. Participants had the least negative emotions toward drinking problem when compared with AIDS, STDs, and cancer (2.84 vs. 4.73 vs. 5.15 vs. 5.38, between drinking problem and the other three respectively, ps < .0001). AIDS was perceived as more serious than the other three, followed by STDs and cancer, and finally by drinking problem (AIDS vs. STDs vs. cancer vs. drinking problem: 8.50 vs. 7.43 vs. 7.40 vs. 6.28, between AIDS and the other three respectively, ps < .001; between STDs and cancer, $p > .90$; between drinking problem and STDs and cancer respectively, ps < .01). Next, among these four diseases, people have the greatest personal experience with drinking problem and the least experience with AIDS (drinking problem vs. AIDS vs. STDs vs. cancer: 2.75 vs. 1.10 vs. 2.07 vs. 2.40, between drinking problem and the other three respectively, ps < .02; between AIDS and the other three, ps < .001; between STDs and cancer, $p < .05$). Finally, cancer was perceived as the least controllable when compared with the other three (cancer vs. AIDS vs. STDs vs. drinking problem: 2.07 vs. 2.71 vs. 3.16 vs. 3.21, between cancer and the other three, ps < .003; between AIDS and STDs and drinking problem respectively, ps < .01; no difference between STDs and drinking problem).

Given that in comparison with the emotions toward the disease, both personal experience and perceived controllability are relatively "cognitive" factors, the risk estimation for drinking problem may be most likely cognitive-based (i.e., little negative emotions and great personal experience involved), the risk estimation for STDs and AIDS may be emotionally based (i.e., great negative emotions and little personal experience involved), and the risk estimation for cancer may be both cognitively and emotionally based (i.e., great negative emotions moderate personal experience, and the least perceived controllability involved).

In order to provide further support for our assumption regarding how each disease is perceived and how disease perception factors influence risk estimation and self-positivity bias, correlational analyses were conducted for each of these four diseases. First, for drinking problem, the only factor significantly correlated with the composite self-positivity bias was

personal experience (r = -0.35, p = .006). Furthermore, consistent with previous literature and our hypotheses 1 to 2 that self-relevant judgment leads to more mental responses (either emotional or cognitive depending on specific diseases) compared with other-relevant judgment, the simple correlations with the personal experience were .44 (p = .0004) for self risk estimation, .27 (p = .04) for the closest friend risk estimation, and -.01 (p > .90) for the estimation for an average undergraduate student. These results suggest that participants with more personal experience with drinking problem tend to make higher self risk estimation and comparable other-risk estimation when compared with those people with less personal experience, which results in reduced self-positivity bias.

None of the disease perception factors were significantly correlated with the self-positivity bias or specific risk estimation for AIDS (p > .18). For STDs, the only factor significantly correlated with the composite self-positivity bias for STDs was the negative emotions toward the disease (r = -0.29, p = .02). In addition, the simple correlations with the emotions were only significant for the self risk estimation but not for the other two (for the self-estimation: r = 0.24, p = .06; for the closest friend estimation and the estimation for an average student: p > .19), suggesting that the more negatively a person feels about STDs, the more likely she is going to increase the risk estimation for herself but not for others and thus reduce the self-positivity bias.

Finally, for cancer, both emotions toward the disease and the perceived disease controllability were not correlated with the composite self-positivity bias (for emotions: r = -0.20, p = .12; for controllability: r = 0.20, p = .12) and these two factors did NOT correlate with each other (p > .70). Specifically, similar to STDs, the correlations with the emotions were significant for the self risk and the closet friend estimations but not for the average student estimation (for the self-estimation: r = 0.27, p = .04; for the closest friend estimation: r = 0.33, p = .01; for the estimation for an average student: p > .42), Furthermore, the perceived controllability positively correlated with all the specific risk estimations for an average undergraduate student (for the self-estimation: r = 0.21, p = .10; for the closest friend estimation: r = 0.19, p = .14; and for the estimation for an average undergraduate: r = 0.36, p = .005). These results suggest that the more controllable a person thinks cancer is, the more likely she is going to make high self-risk estimation and even higher risk estimation for other people. Therefore, high controllability leads to higher self-positivity bias, as suggested by the literature.

TABLE A1: RISK ESTIMATION AND CORRESPONDING ANALYSES FOR EACH DISEASE AND TARGET PERSON

			Risk Estimation					
Event	***F* (2, 120)**	***p***	**Self**	**Closest Friend**	**Average Student**	**SPB1 ("average student-self")**	**SPB2 ("average student-closest friend")**	**SPB3 ("closest friend-self")**
AIDS	10.19	<.0001	6.61	12.30	19.52	12.91***	7.22*	5.69*
STDs	41.90	<.0001	16.40	29.35	44.62	28.22***	15.27***	12.95***
Drinking Problem	17.56	<.0001	23.26	34.38	46.56	23.30***	12.18**	11.12**
Cancer	9.47	<.01	23.03	28.53	34.53	11.50***	6.00*	5.50*
Heart Attack	2.07	*ns*	18.62	17.84	22.34	3.72	4.50*	-0.78
Hepatitis	3.59	<.05	10.72	13.34	18.64	7.92*	5.30	2.62

*Note. *p<.05. **p<.01. ***p< .001.*

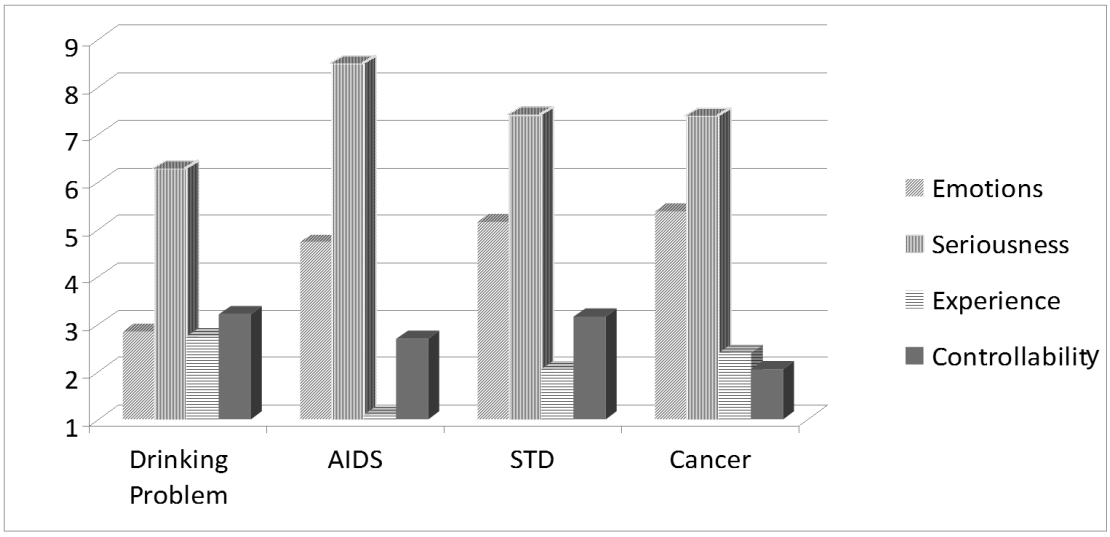


FIGURE A1: DISEASE PERCEPTION IN STUDY 1

Progress Achieved - Specific Aim 2:

Following the results revealed from the first aim, we identified that three diseases (STD, Drinking Problem, Cancer) showed the strongest self positivity bias. Similarly with the first aim of the study, we used three groups as the target, self, close friend and average student on the subject's peer group.

For the fMRI phase of this study, 19 subjects were scanned at Temple Hospital using a Siemens Magnetom Verio 3T scanner. Of the 19 subjects, 13 were females and 6 were males who were recruited from the Philadelphia region. Due to technical issues, 4 subjects were excluded due to incomplete data acquisition and another 5 subjects were excluded from the final analyses due to excessive movement (> 5mm) during image acquisition. Unfortunately, the movement in these 5

subjects occurs progressively throughout the entire scan, not just within one particular epoch. Thus, our preliminary analyses included data from 11 subjects.

During each scanning sessions, participants are asked to evaluate the probability of a target (Self, Close Friend, Average Student) developing or contracting a given disease (STD, Drinking Problem, Cancer). The questions that are asked are shown on table B1. Every participant answers these questions once for each disease (90 trials, 10 trials x 3 targets x 3 diseases). After each disease block (30 trials, 10 questions x 3 targets), depending on the testing condition ("Emotional" or "Cognitive"), participants are shown some texts related to STD, Drinking Problem, or Cancer. After participants see these different conditions, they again see the same questions as part 1 to make the same judgments for the 3 targets for that same disease.

Statistical Data Analysis

fMRI images are usually reported in terms of statistical activation maps that are obtained through statistical tests at each individual voxel level for each condition and subject. This tests if the time-series activation of each voxel is driven by the experimental condition relative to a baseline by testing the probability that the relative BOLD effect significantly differs from zero. The significance of any given voxel and its level of brain activation reveal the association with the experimental condition. Spatial maps were created using a parametric univariate analysis implemented using the General Linear Model (GLM) that fits a reference hemodynamic response function (hrf) which describes how the BOLD signal evolves over time in response to changes in brain activity. After the analysis was conducted at each individual voxel to minimize error, the value of each voxel was calculated as a statistical quantity (often expressed in T-values or Z-values), that is displayed in a statistical activation maps. The T-statistic [SPM(t)] was transformed to a normal distribution [SPM(z)]. SPM is a voxel-based approach that makes area-specific statistical inferences to experimental conditions. The reported SPMs were over-laid on the structural brain images to graphically display the areas of brain activation, as shown in the brain images throughout the paper (Figures B3-B9).

Design Matrix. In an fMRI implementation of GLM, a design matrix is used to define the experimental design and test hypotheses. For this study, the design matrix was generated using a canonical hemodynamic response function (hrf) using a box-car Finite Impulse Response (FIR) model. Thereafter, contrast images were generated by computing the difference between the parameter estimates of the two conditions in test. The design matrix contained the indicator variables (parametric covariates or regressors) that encoded the experimental tasks. Each regressor was modeled in terms of a function in the presence of other regressors, which all constituted the first columns of the design matrix. A series of terms were also included to remove low frequency variations in the brain signal due to noise artifacts. Several sources of variance were controlled for by regressing the nuisance variables.

These nuisance variables included: six parameter rigid body head motion (obtained from motion correction), the BOLD signal averaged over the whole-brain correlates with respiration-induced fMRI signal fluctuations, the BOLD signal averaged over regions centered bilaterally in the lateral ventricles, and bilateral regions centered in the deep cerebral white matter. The relative contribution of each of these columns was assessed using standard least squares, and inference

about these effects was made using standard T statistics. SPM8 was used to create the design matrix with GLM and identify statistically significant voxels by setting a corrected threshold based on the spatial extent using $t \geq 1.96$, a cluster probability of an uncorrected $\alpha=0.05$, and 30 voxels minimum size. Typically, $\alpha=0.001$, a more stringent condition, is used to identify statistically significant voxels. However, this is often done with a larger sample size than the sample size we have. Thus, due to the small sample size, we used the less stringent condition of $\alpha=0.05$ at the whole brain level.

Individual and Group Analysis: Data analysis was first conducted separately for each subject to obtain individual whole-brain activation maps (first-order analysis). The first-order analysis resulted in SPMs for each subject individually. The individual activations were then aggregated by combining the normalized brain activations of all individual subjects (second-order analysis) to generalize the results across all subjects. The first-order analysis modeled the sources of individual variation and data noise as confounds for the second-level analysis, which aggregated the levels of activation (con images) from the first-order analysis to infer whether the brain activations are comparable across all subjects.

The level of brain activation was first obtained by the value of the t-test at each individual voxel, which reflected the intensity of the BOLD signal. This was done since the absolute levels are much different across subjects because of inter-subject physiological variations, and thus not readily comparable. Besides, such inter-subject physiological differences, albeit non-systematic, are difficult to overcome due to the relatively small sample size. The first-order analysis assumed autocorrelated data, while the second-level analysis assumes a small number of independent and identically distributed (IID) data. Accordingly, the first-order analysis used fixed-effects, while the second-order analysis used random-effects. The aggregate of all brain activity was then captured with z-tests, which corresponded to the unit normal distribution that rendered the same p-values as the t-statistic, which was quantified with continuous measures (termed z-scores). This analysis resulted in a thresholded map with a continuous BOLD intensity level (measured with z-scores) at each voxel. Finally, the peak activation (measured using a z-value) in a given brain area was considered a proxy for the overall strength of all adjacent voxels in that brain area.

Whole-brain and ROI Analysis: We first performed whole-brain followed by region-of-interest (ROI) analysis. The ROI analysis was used to improve statistical power and test a priori hypotheses. First-order analyses based on changes in BOLD contrasts were performed with the General Linear Model (GLM) in SPM8. Two GLMs were created, each with six conditions, to look at the main effects of Target or Disease. A third GLM contains 9 interaction terms for Target x Disease. Results from the third GLM were used to create a full factorial model in SPM, which was used to confirm the results from GLM1 and GLM2.

We found a significant effect of Target, Disease, and Target x Disease for the self-reported measures that were obtained during the scan (Table B2). Holding Disease constant, there is a significant difference between Self and Other ($p < 0.001$), between Self and Close Friend ($p = 0.018$), and between Close Friend and Other ($p < 0.001$). These results confirm our behavioral data collected outside the scanner in a separate sample.

Note: Having had initial difficulties with data collection (with multiple technical issues concerning the scanner and testing computer), we were only able to perform a group analysis based on 11 of the 19 participant data sets. For a random effects model, this number is too low to provide enough power for statistical analyses at a more stringent alpha ($p < 0.001$ uncorrected). Thus, these results are preliminary and continuing research is required to increase power. Taking the results from GLM3 (9x9 condition), we ran a full factorial model on 11 participants. Figure B1 depicts activations at $p < 0.05$ at a cluster (k) = 30 for main effect of target. Figure B2 depicts activations at $p < 0.05$ (k = 30) for main effect of disease. There was no interaction effect (Figure B3) at $p < 0.05$ (k = 0). Overall, the full factorial model provides a good overview of the neural data. However, to have a better understanding of the activation on different levels of our main factors, we created second level models from GLM1 and GLM2 results.

GLM1 Model – Main Effect of Target (Self, Average Other, Close Friend)

Looking at the main effect for target, we were interested in seeing if there are different neural activations when participants are making judgments about the three diseases for self, close friend, or average other. In this model, we focused our efforts on Self > Average Other (Figure B4), Close Friend > Average Other (Figure B5), and Self > Close Friend (Figure B6). By focusing our analyses on these three, paired conditions, we are able to, in each condition, control for any common activation occurring during different cognitive processes. Surviving activation from each pair signifies greater neural activation in one condition versus the other. For example, in the Self > Average Other condition, we are interested in any additional neural activations when participants are making judgments for self instead of average other. More specifically, we are interested in whether or not there are differences in neural activation when there exists a self-positivity bias, such that a person believes he/she is less susceptible to negative life events such as contracting STD, developing a drinking problem, or developing cancer, compared to other people.

In the Self > Average Other condition as well as Close Friend > Average Other condition, there are significant activations in the mPFC, dmPFC, and bilateral middle frontal gyrus ($p < 0.05$, k = 30). Overall, there are more wide spread activations in visual attention regions in Close Friend > Average Other condition, which will require further exploration. In Self > Close Friend condition, there are no significantly different neural activity between Self and Close Friend conditions.

GLM2 Model – Main Effect of Disease (Drinking Problem, Cancer, STD)

Looking at the main effect for disease, the focus is now shifted to looking at neural activations when participants are making judgments about particular diseases across conditions of self, close friend, or average other. Similar to analyses performed for GLM1 results, we explored the differences between trials for one disease versus another. Our most robust activation ($p < 0.005$, k = 30) occurred in the Drinking > Cancer condition (Figure B7a). In particular, when participants are thinking about the likelihood of a “drinking problem” occurring to self, average other, or close friend, there is more neural activity in the bilateral basal ganglia (caudate & putamen). The left caudate activity is also significant in Drinking > STD condition (Figure B7b). These activations are similar to those found in experiments that studied the effects of alcohol as a motivational stimulus on neural responses in social drinkers and recovered alcoholics. In the STD > Cancer condition, there is significantly ($p < 0.05$, k = 30) more activity in emotional

control regions such as bilateral insula (Figure B8a) and right amygdala (Figure B8b). Similar amygdala activation is also significant in STD > Drinking condition (Figure B8c). For Cancer > STD condition, there is significantly more activity in the mPFC and dmPFC (Figure B9a). There is no significant result in the Cancer > Drinking Problem condition (Figure B9b) other than a small cluster in the superior temporal gyrus.

The fMRI scanner was a 3 Tesla, Siemens Magnetom Verio whole-body scanner with a standard CP head coil. Subjects were scanned with contiguous (no gap) 5 mm axial high-resolution T1-weighted structural slices (matrix size=512×512; TR=1600; TE=2.51ms; NEX=1; slice thickness=0.9mm), which were collected for spatial normalization procedures and overlay of functional data. Besides T1-weighted structural slices, T2-weighted structural slices were also collected, also for spatial normalization procedures. Precise localization based on standard anatomic markers (AC-PC Line) was used for all subjects. Functional scans were acquired with a gradient-echo planar free induction decay (EPI-FID) sequence (T2*weighted: 64×64 matrix; slice thickness = 5 mm; TR = 2s; and TE = 30 ms, slices=28) in the same plane as the structural images. Voxel size was 3.28 mm × 3.28 mm × 5 mm.

Data Processing: The data were processed and analyzed using SPM8 (Statistical Parametric Mapping, Wellcome Department of Cognitive Neurology, University College of London, UK), a toolbox for Matlab (The Mathworks). Before statistical analyses were applied to acquired images, they were pre-processed to remove any image artifacts and noise, increase signal-to-noise ratio, and allow comparisons across subjects' anatomically different brains. Pre-processing of fMRI data included: (a) slice timing correction, (b) realignment, (c) spatial co-registration, (d) segmentation, (e) normalization, and (f) smoothing.

Contrast maps were obtained through linear contrasts across all conditions. Group-level random effects analyses for main effects were accomplished by entering whole brain contrasts into one-sample *t* tests. For the second-order analysis, ROI analysis was used, which defined a specific area of interest in the brain within which to make local measurements. ROI analysis offers a more precise analysis by focusing on certain brain areas, thus not being affected by spurious activations in unrelated areas. ROI analysis limits corrections for multiple tests to a known set of voxels (small volume correction). For the ROI analysis, the WFU PickAtlas and MarsBar toolboxes were used with anatomical criteria using standard MNI coordinates and functional criteria based on brain activation patterns. A significance threshold based on spatial extent using a height of $t \geq 1.96$, and cluster probability of an uncorrected $p \leq 0.05$ was applied to the ROIs. All ROI's are defined by the population activation level achieved at the second level.

GLM1 focuses on Target. 3 regressors of Self, Average Student, and Close Friend were created, along with 3 regressors for responses, control condition (emotional or cognitive texts), and a nuisance regressor. All 6 regressors were modeled with a canonical hemodynamic response function (hrf). GLM2 focuses on Disease. 3 regressors of STD, Cancer, and Drinking Problem were created, along with 3 regressors for responses, control condition (emotional or cognitive texts), and a nuisance regressor. All 6 regressors were modeled with a canonical hemodynamic response function (hrf). GLM3 focuses on TargetxDisease. 9 interaction regressors (target x disease), along with 3 regressors for responses, control condition (emotional or cognitive texts), and a nuisance regressor. All 12 regressors were modeled with a canonical hemodynamic response function (hrf).

Table B1: Self Positivity bias measurement items

1. Estimate the probability [disease] will happen to [people]:
2. Estimate the probability of [people] getting [disease]:
3. Estimate the risk of [people] getting [disease]:
4. Rate the likelihood that [people] will develop [disease]:
5. Rate the probability that [people] will develop [disease]:
6. What are the chances [disease] will happen to [people]?
7. What is the chance of [people] getting [disease]?
8. What is the likelihood of [disease] occurring to [people]?
9. What is the probability of [people] getting [disease]?
10. What is the risk of [people] getting [disease]?

Table B2: Behavioral data collected during the fMRI study

Descriptive Statistics Behavioral

Condition	Mean	Stdev	N
self_drinking	1.837	1.449	208
self_cancer	4.721	2.158	208
self_std	1.928	1.171	208
other_drinking	5.885	1.399	208
other_cancer	4.380	1.940	208
other_std	5.125	1.721	208
cf_drinking	3.361	2.043	208
cf_cancer	3.543	2.019	208
cf_std	2.308	1.387	208

Figure B1: Full factorial model for main effect of target

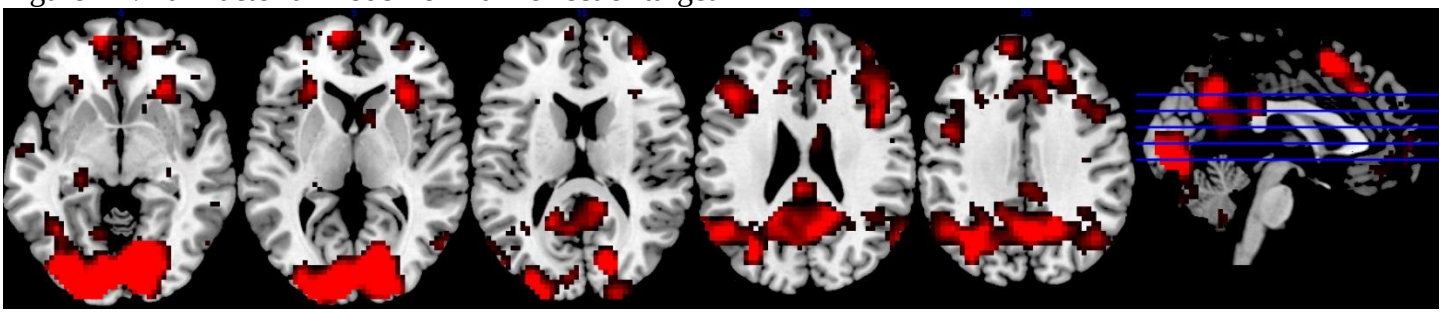


Figure B2: Full factorial model for main effect of disease

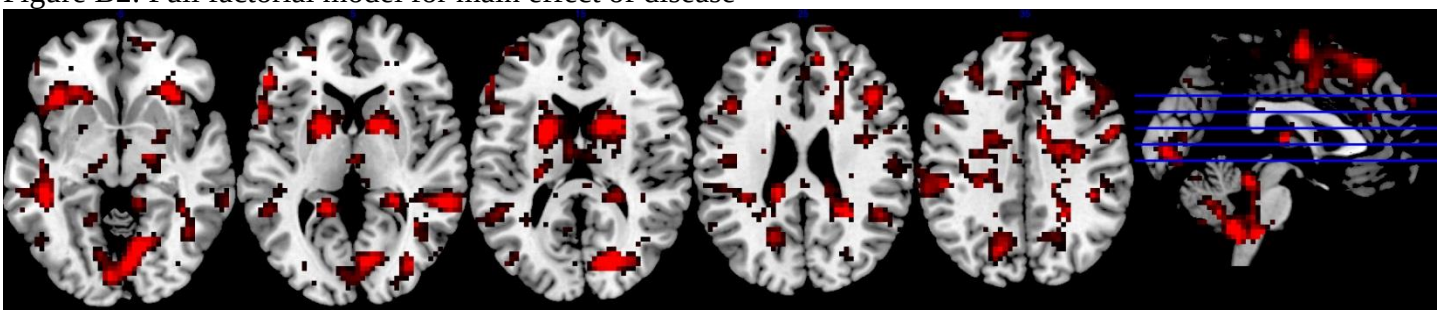


Figure B3: Full factorial model for interaction effect

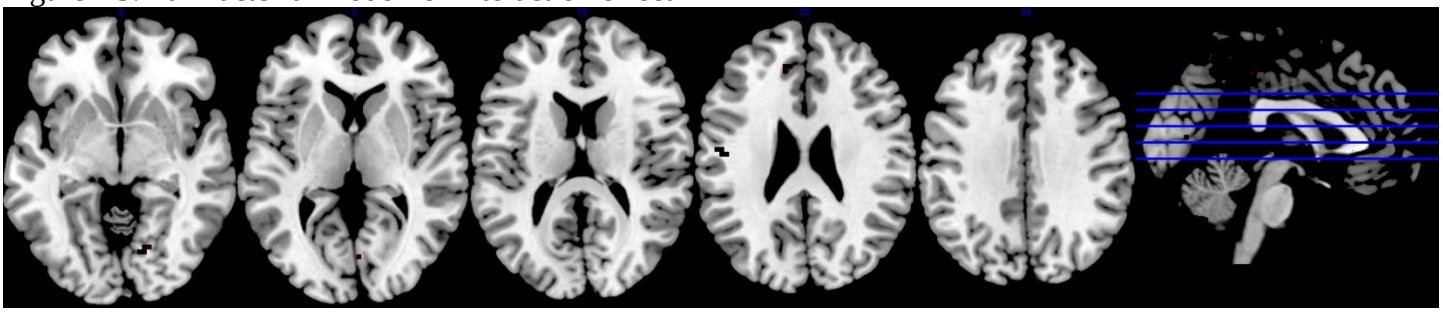


Figure B4 (Self > Average Other)

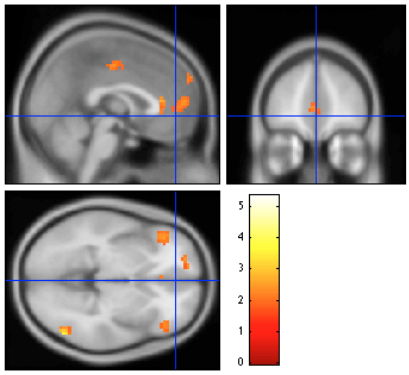


Figure B5 (Close Friend > Average Other)

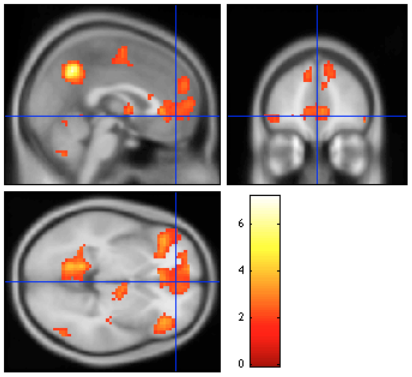


Figure B6 (Self > Close Friend)

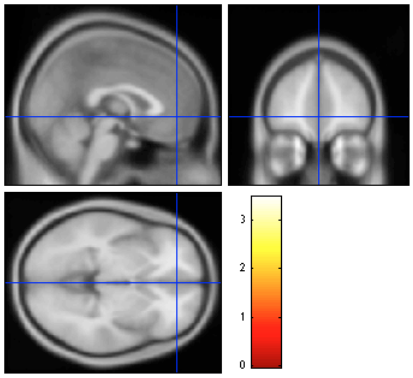


Figure B7a (Drinking Problem > Cancer)

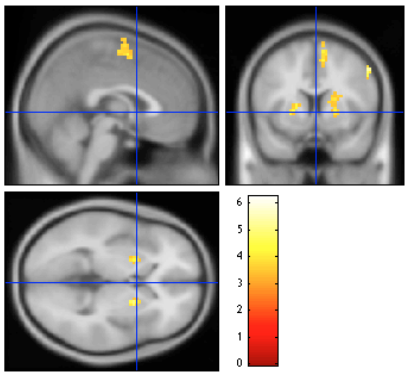


Figure B7b (Drinking Problem > Cancer)

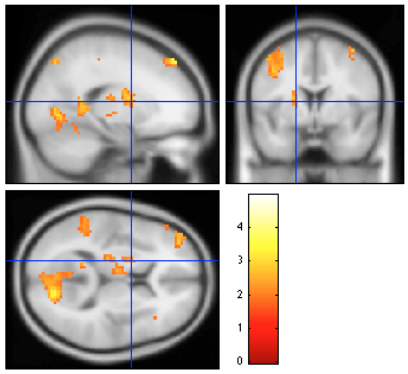


Figure B8a (STD > Cancer)

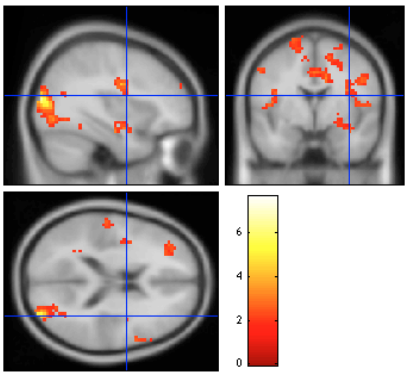


Figure B8b (STD > Cancer)

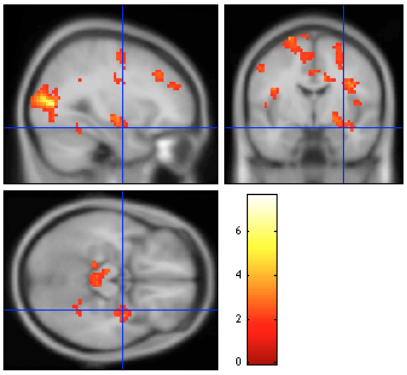


Figure B8c (STD > Drinking Problem)

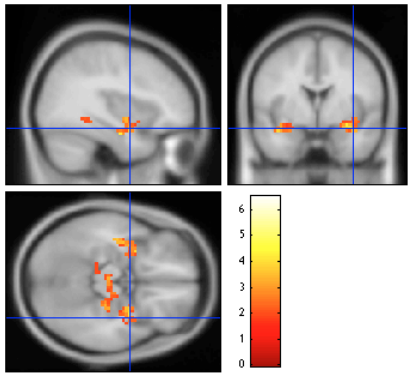


Figure B9a (Cancer > STD)

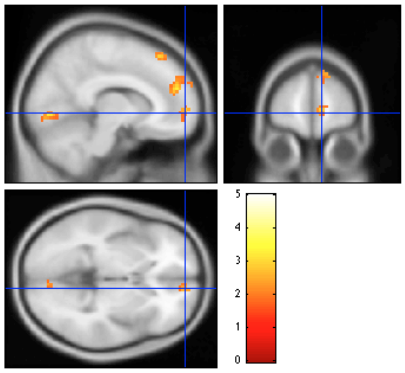
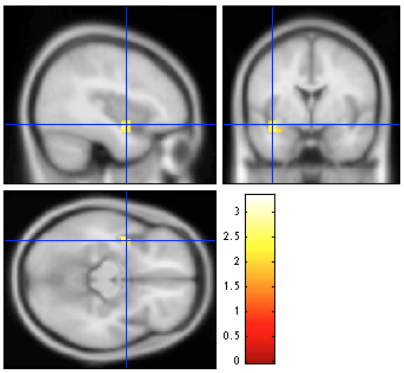


Figure B9b (Cancer > Drinking Problem)



Discussion

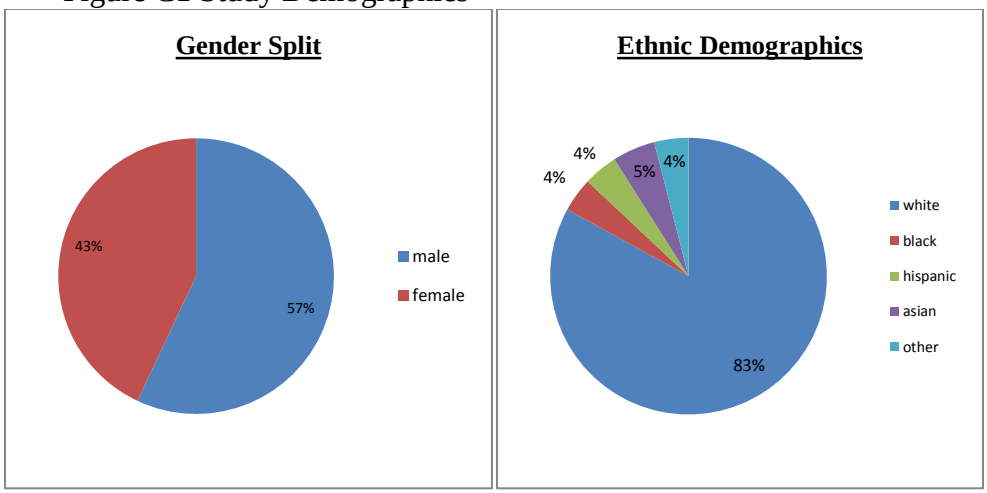
Using Neurosynth.org, we were able to perform a quick meta-analysis on 206 studies with the keyword "self", which contains studies that look at self-positivity bias. From these studies, we have identified regions of interests that could have higher activations when thinking about "self" such as the medial prefrontal cortex (mPFC) and dorsomedial prefrontal cortex (dmPFC). In other studies looking specifically at positivity biases, we have also identified the left and right inferior frontal gyri (IFG) and cerebellum as additional regions of interest (ROI).

Furthermore, the design included three targets (self, close friend, and average person). For each disease, participants were asked ten questions for each target. This repeated measure design did not allow for enough variance in what participants saw, and thus gave us less power than we had hoped for our analyses. Also the different interventions used did not induce any differences in the results. Moreover, participants were asked two questions per disease, instead of ten. Additional behavioral experiments are required to validate the necessity of the neural regions above and how they are involved in cognitive processing of self versus other.

Progress Achieved - Specific Aim 3:

For this part of the study, we explored the nature of the self-positivity bias and its implications for the domain of health marketing. 154 participants were recruited using Amazon Mechanical Turk. 15 were excluded from the data analysis process after failing an attention check placed in the experiment. Data from 139 participants were used in the data analyses. Of the participants, the average age was 37 (min: 20, max: 70, median: 33). Charts for gender and ethnic demographics are shown (Figure C1). For the experimental task used in the behavioral pilot study, participants were first asked to complete a demographics questionnaire. Next, participants had to provide information about the health profile of an average person in their peer group.

Figure C1 Study Demographics



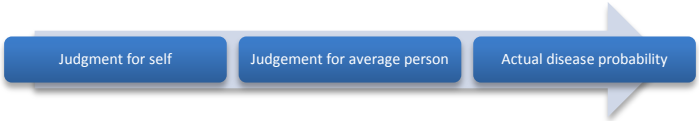
In the first block of the experiment, participants were presented with the same three diseases as the previous two parts of the project; STD, Cancer, and Drinking Problem. In each trial, subjects were presented with a disease and were asked either to estimate their likelihood of

developing/contracting the disease or to estimate the likelihood that an average person in their peer group would develop/contract that disease. Between the first and second block, participants completed the State-Trait Anxiety Inventory (STAI) and The Rosenberg self-esteem scale (RSES). In a second block, participants were asked to make the same judgments about the diseases they had previously seen, and were shown the actual probabilities again. To ensure that participants were reading the instructions and paying attention, the attention check was embedded in the second block.

In a third block, participants were asked to answer four questions for the three diseases. First, to measure perceived controllability of each disease, participants were asked to judge whether or not a person could control whether or not they developed/contracted a specific disease. Second, participants were asked to judge how serious or dangerous a disease is. Third, participants had to indicate, relative to other diseases seen, the desirability of developing/contracting a specific disease. Furthermore, as a test of memory, participants were asked to recall the actual probability of developing/contracting each disease. Finally, at the end of the experiment participants had to complete a lifestyle survey as well as the Life Orientation Test-Revised (LOT-R) questionnaire.

1. **Pre Phase**. Participants are asked to make estimations for **<u>3 diseases</u>** (STD, Lung Cancer, Drinking Problem). The actual probabilities for each disease, respectively, are: 1) 35% 2) 7% 3) 10%
   Questions for judgment trials: What is the likelihood that you will **<u>develop/contract</u>** [disease]?

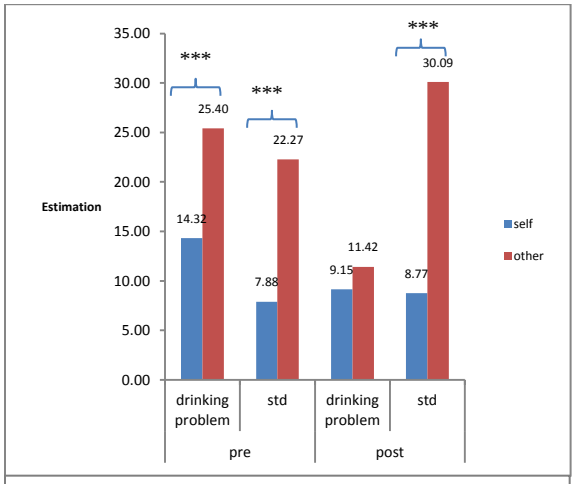
2. **Post Phase.** After making judgments for all 3 diseases and being exposed to the average probability of each disease, participants are asked to make the same judgment again for the same 3 diseases for self and other.



For the data analysis, data was organized and analyzed using SPSS. Preliminary analyses were carried out to see if the self-positivity bias was observed for each disease. If estimations for 'self' are significantly lower than estimations for 'other,' then it can be inferred that the self-positivity bias has been exhibited.

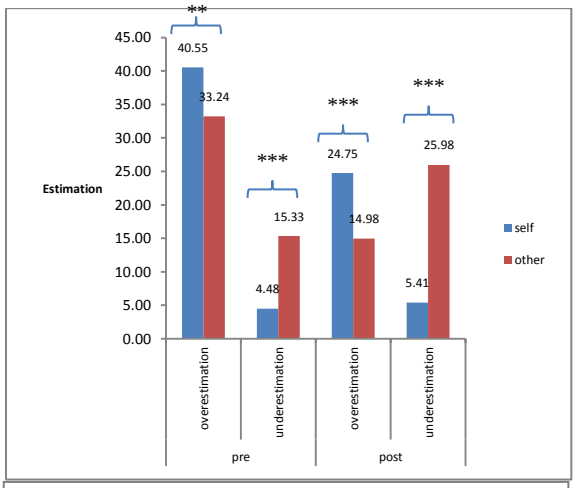
First, pre and post phase estimations for self and other were analyzed using the two analysis frameworks outlined above. ANOVAS were run in SPSS. From the preliminary analyses, participants exhibited the self-positivity bias for two of the three selected diseases (STD and Drinking Problem). Since participants did not show a significant self-positivity bias in estimations for lung cancer, this disease was excluded from the analyses (Figure C2a, and C2b). We also calculated if subjects overestimated (estimated higher than the actual percentage of contracting the disease) or underestimated (estimated lower than the actual percentage of contracting the disease).

Figure C2a) “Disease” variable Analyses Split



- Pre-estimations for drinking problem and STD were significantly higher for ‘other’ than for ‘self.’
- In the post condition, other-estimations were significantly higher than self-estimations for STD.

Figure C2b) “Over/Underestimation”



- For “overestimations” in both pre and post, self-estimations were significantly higher than estimations for other.
- Conversely, in cases classified as “underestimations,” other estimations were significantly higher than those for self.

Next, ANCOVAs for were carried out to analyze the moderating effect of the covariates in the study (controllability, seriousness, desirability, memory, LOT-R, Figure C3). The only covariates that seemed to have any effect on pre and post measures were: desirability and memory (Figure C4).

Figure C3. “Disease Variable” Analyses

Effect	F Value	Sig.
pre_post	0.04	0.851
pre_post*controllability	1.02	0.314
pre_post*seriousness	2.57	0.109
pre_post*desirability	7.08	0.008
pre_post*memory	3.92	0.048
pre_post*lotr	2.67	0.103
pre_post * Disease	14.38	0.000
pre_post * selfother	0.60	0.438
pre_post * Disease * selfother	42.43	0.000

Figure C4. “Overestimation/Underestimation” Analyses

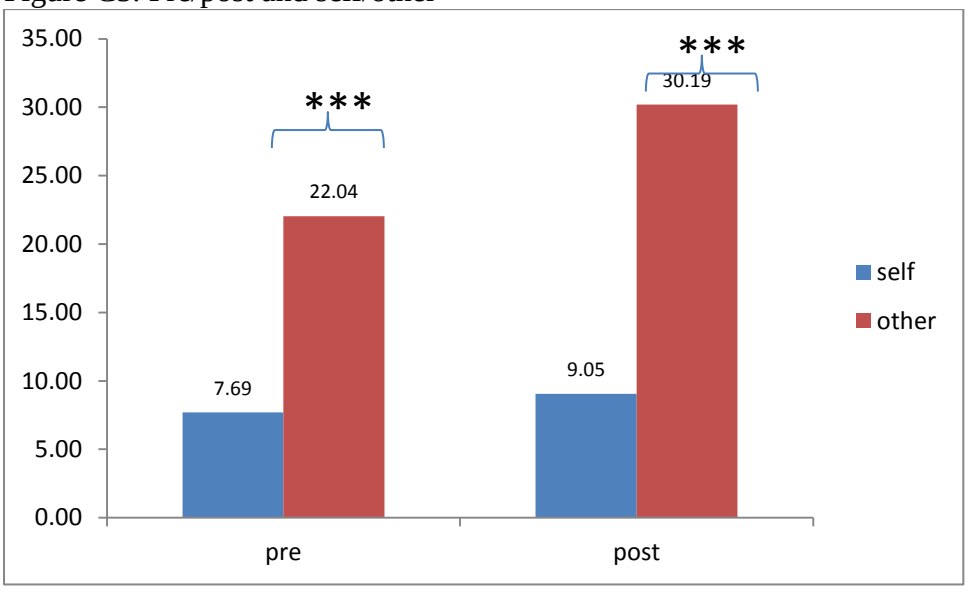
Effect	F Value	Sig.
pre_post	.49	.484
pre_post*controllability	1.69	.195
pre_post*seriousness	.98	.322
pre_post*desirability	1.87	.172
pre_post*memory	5.87	.016
pre_post*lotr	1.88	.171
pre_post * overestimation/underestimation	239.06	.000
pre_post * selfother	7.06	.008
pre_post *goodbad*selfother	25.10	.000

From the analyses done using the “overestimation/underestimation” framework, the only covariates that had a significant effect was memory.

<u>STD Results:</u>

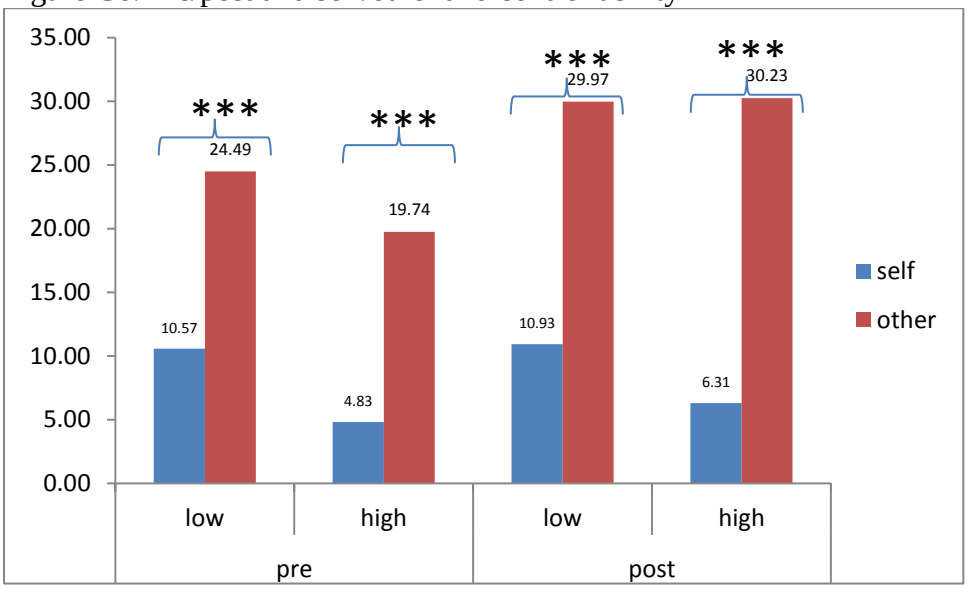
For these results the actual probability of the average person contracting an STD used was 36%. The results indicated that participants showed a self-positivity bias when making estimations for the STD category. Significance was seen in both the pre-condition and the post-condition (Figure C5).

Figure C5. Pre/post and self/other

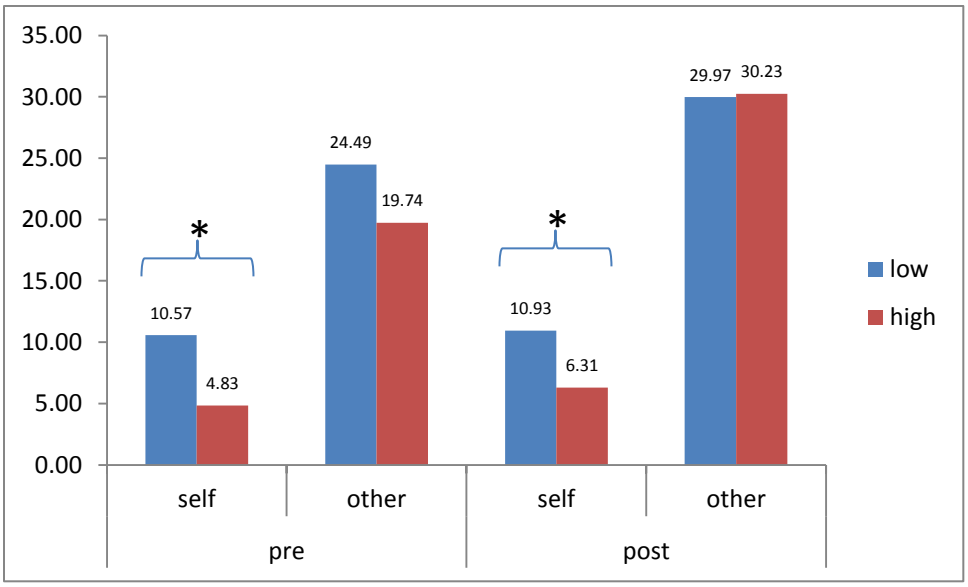


Self-estimations were significantly lower than other estimations for both diseases with high controllability ratings and those with low controllability ratings (Figure C6).

Figure C6. Pre/post and self/other and controllability

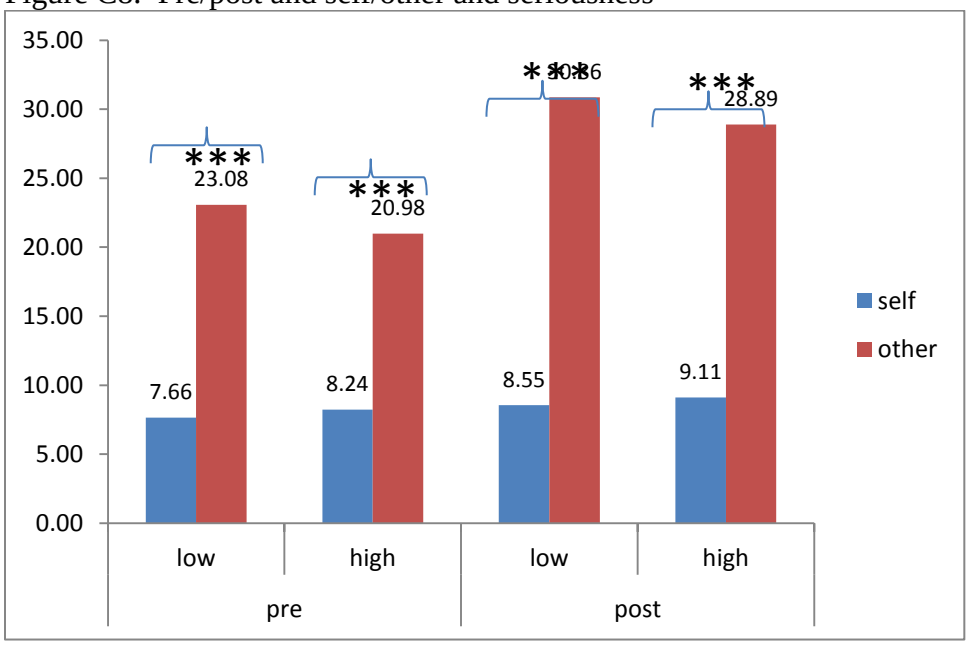


When taking a closer look at self-estimations, the results indicate that estimations were significantly lower for participants in the high controllability group, for both the pre and post conditions (Figure C7).



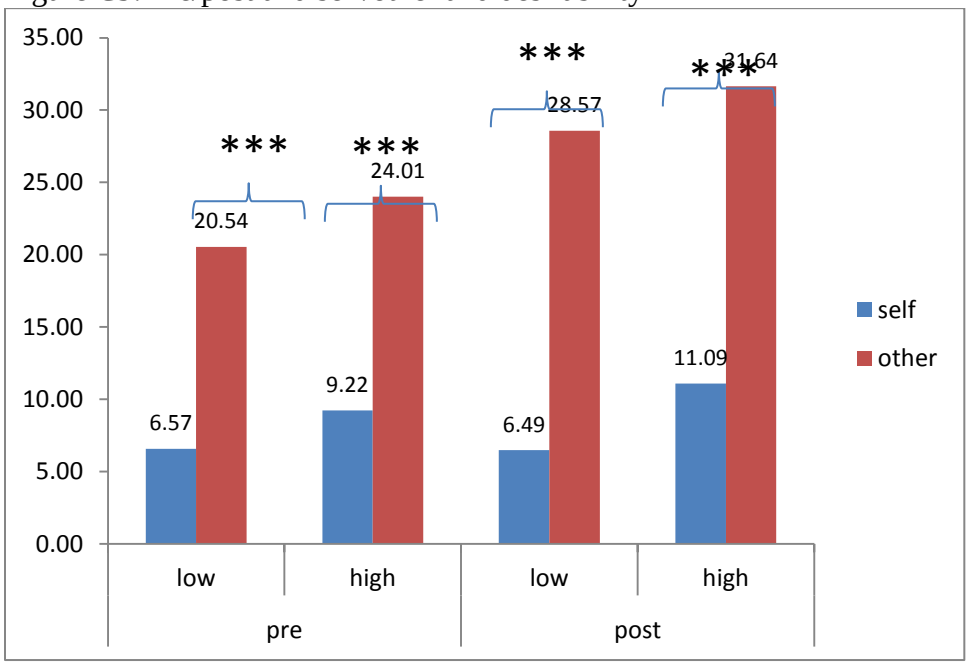
In both the pre and post conditions, self-estimations were significantly lower than other estimations for both diseases with a high seriousness classification and those with a low seriousness classification (Figure C8).

Figure C8. Pre/post and self/other and seriousness



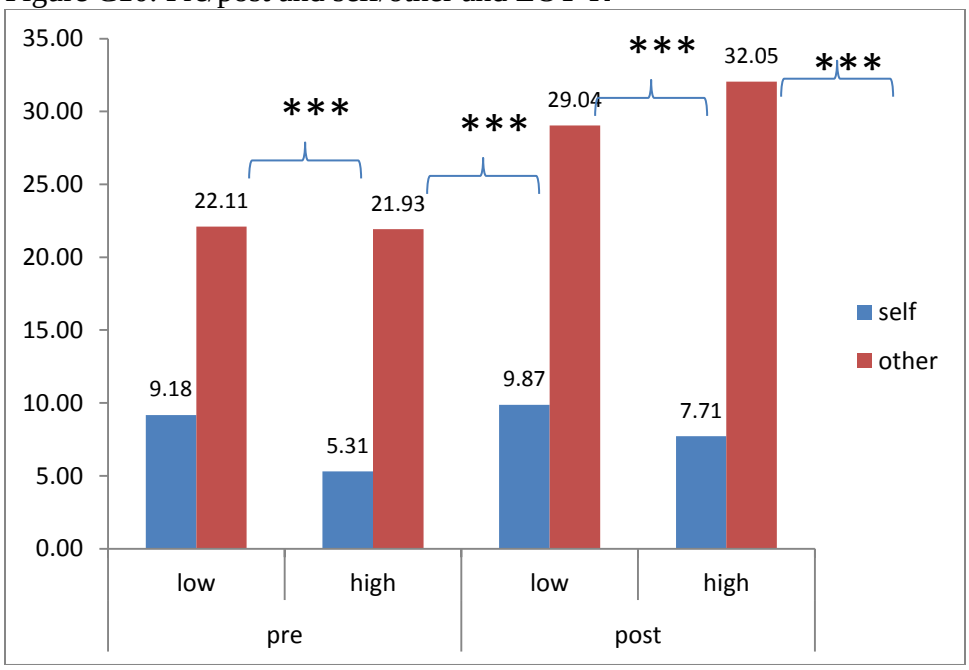
In both the pre and post conditions, self-estimations were significantly lower than other estimations for participants who gave a high desirability classification than those who gave a low desirability classification (Figure C9).

Figure C9. Pre/post and self/other and desirability



Participants were categorized as high and low optimists based on LOT-R scores. Both pre and post conditions, self-estimations were significantly lower than other estimations for STD with a high seriousness classification and those with a low seriousness classification (Figure C10).

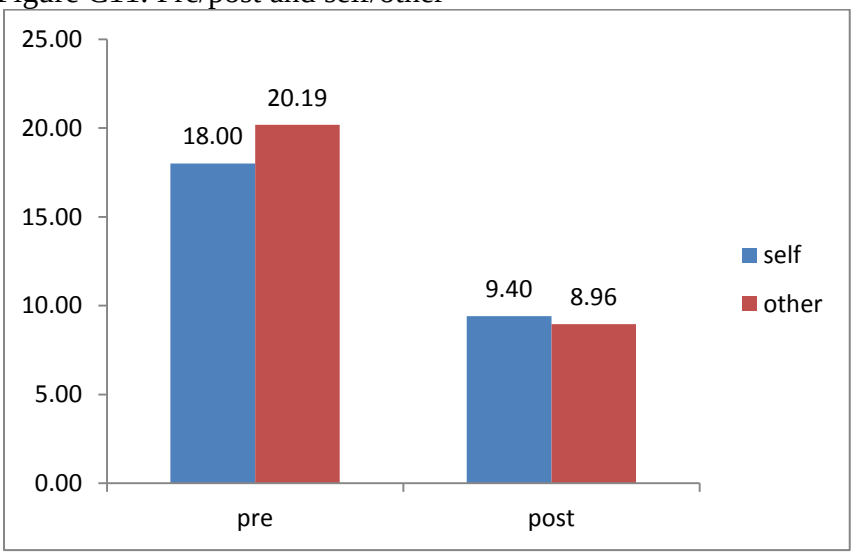
Figure C10. Pre/post and self/other and LOT-R



Lung Cancer Results:

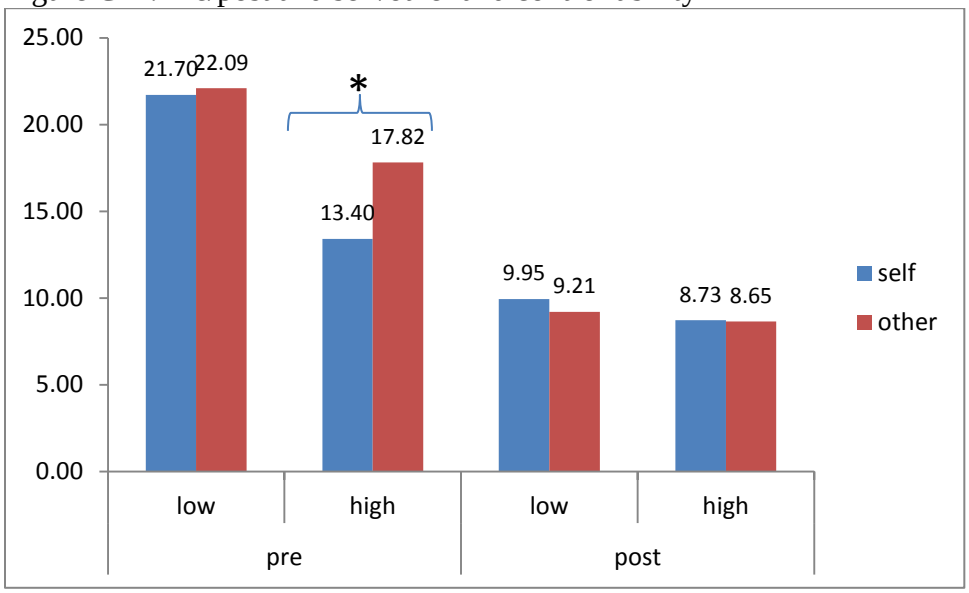
For these results the actual probability of the average person contracting lung cancer used was 7%. There was no significant difference between self and other estimations in either the pre or post condition for Lung Cancer (Figure C11).

Figure C11. Pre/post and self/other

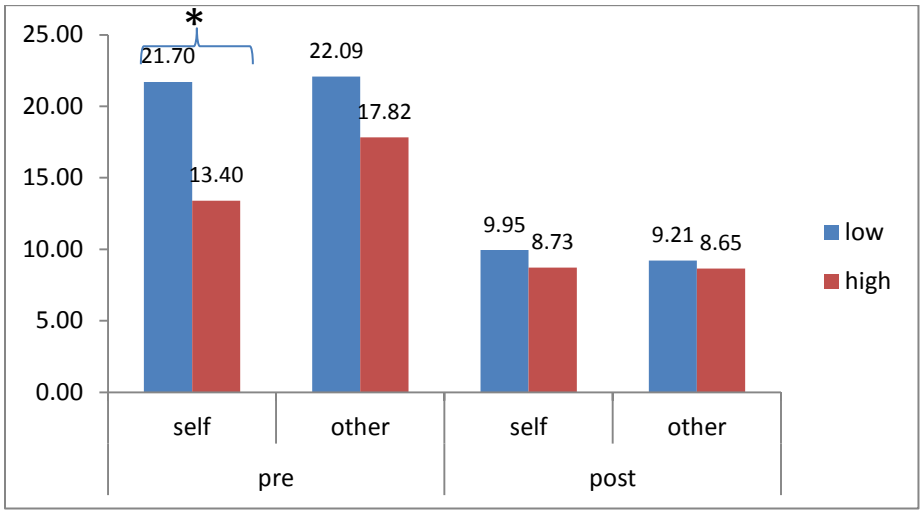


For lung cancer, in the pre-condition, only participants in the high controllability group showed a self-positivity bias (figure C12).

Figure C12. Pre/post and self/other and controllability

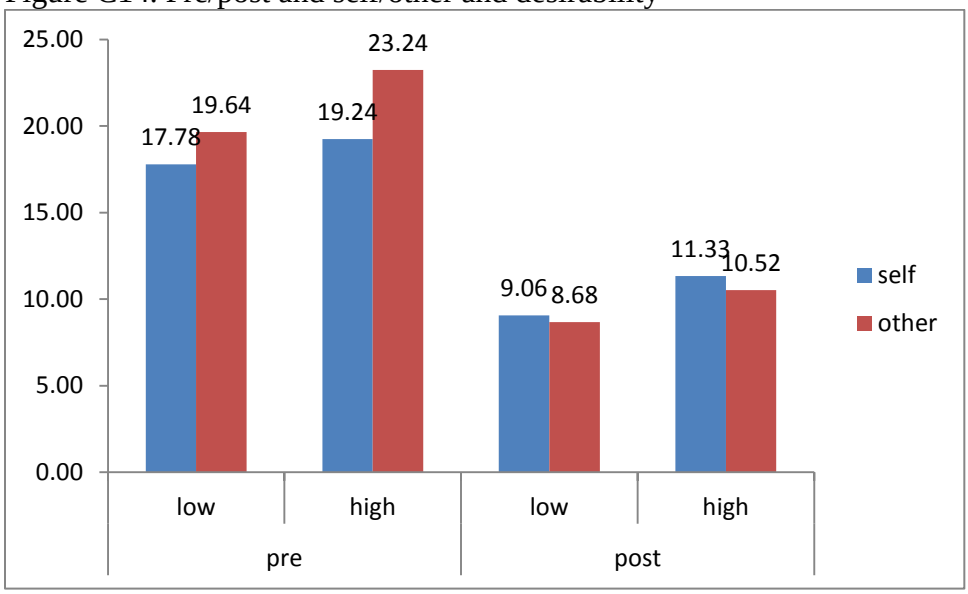


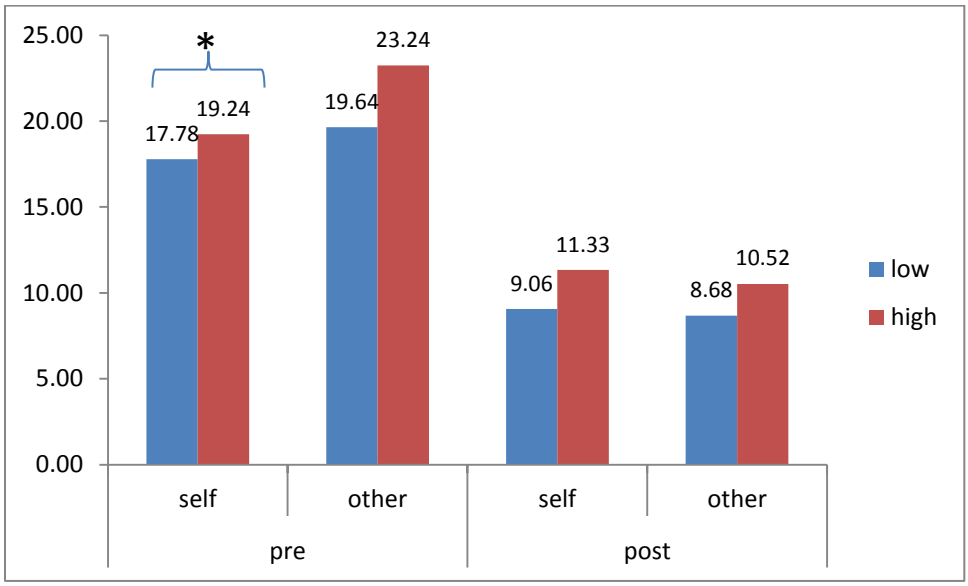
For lung cancer, there was a significant difference in pre estimations for self, with estimations being lower for participants in the high controllability group than those in the low controllability group (Figure C13).



There was a significant difference in pre estimations for self, with estimations being lower for participants in the high desirability group relative to those in the low desirability (Figure C14).

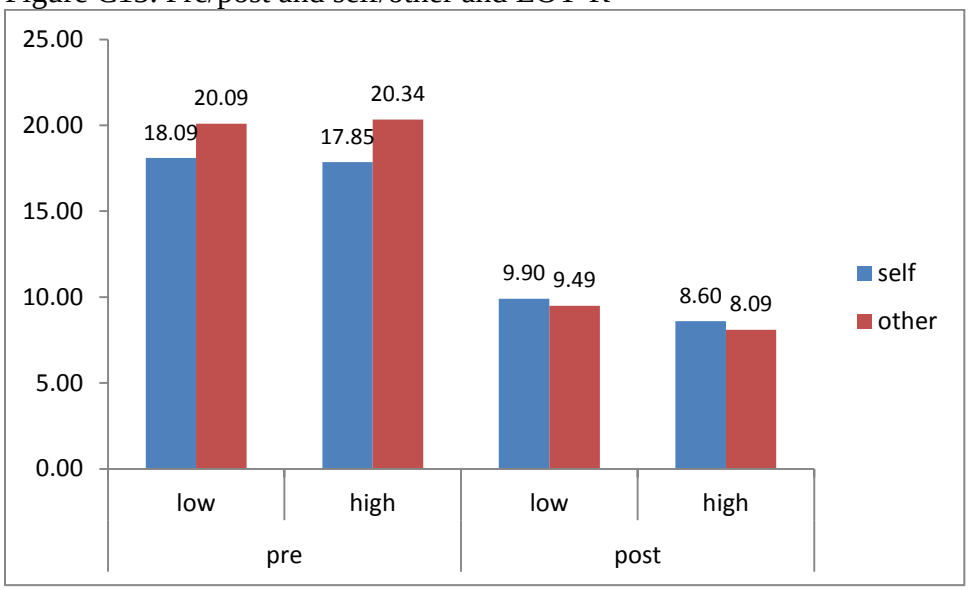
Figure C14. Pre/post and self/other and desirability

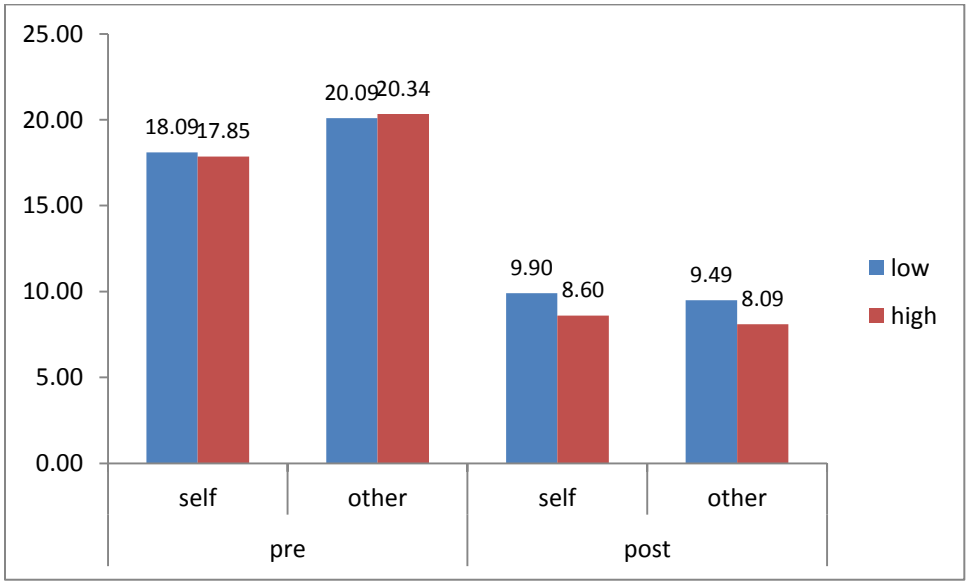




Participants were also categorized as high and low optimists based on LOT-R scores. In both the pre and post conditions, self-estimations were significantly lower than other estimations for lung cancer with a high seriousness classification and those with a low seriousness classification (Figure C15).

Figure C15. Pre/post and self/other and LOT-R

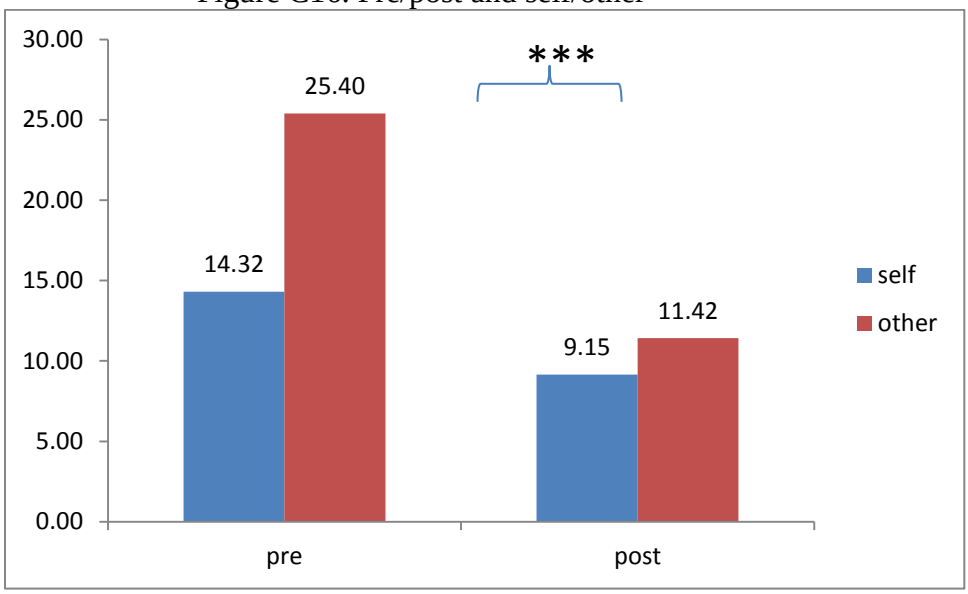




<u>Drinking Problem Results:</u>

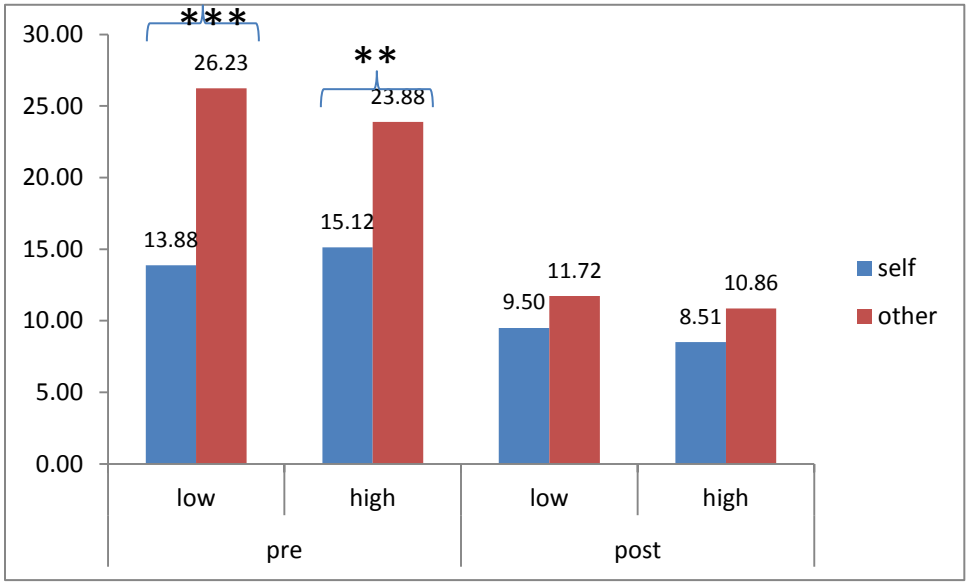
For the drinking problem results the actual probability of the average person having a drinking problem was 10%. The results indicated that participants showed a self-positivity bias when making estimations for the STD category. Significance was seen in both the pre-condition and the post-condition (Figure C16).

Figure C16. Pre/post and self/other



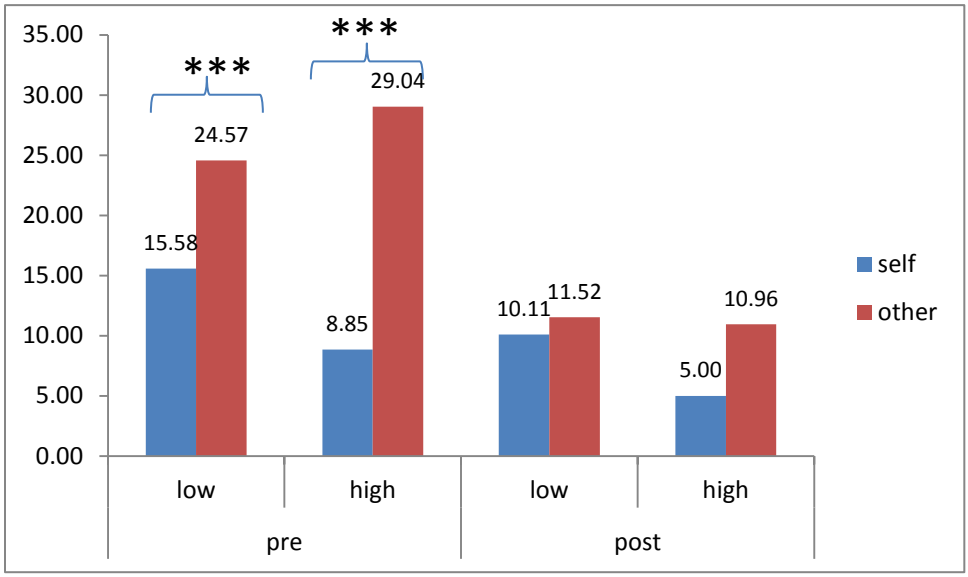
In the pre-condition, in both the high and low splits, self-risk estimations were significantly lower than other-estimations.

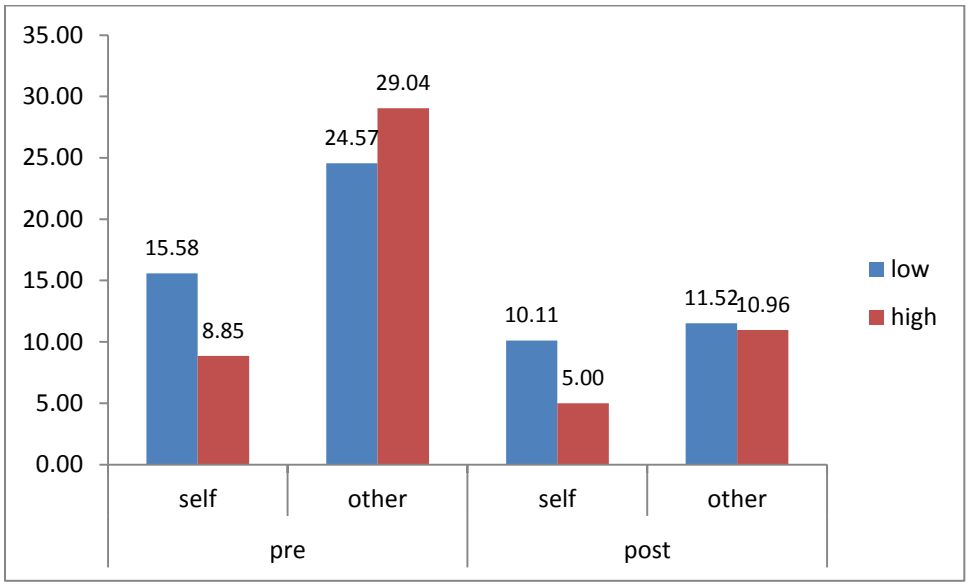
Figure C17. Pre/post and self/other and controllability



When looking at pre estimations for drinking problem, self-estimations were significantly lower than other-estimations for participants in both the high and low seriousness groups (Figure C18).

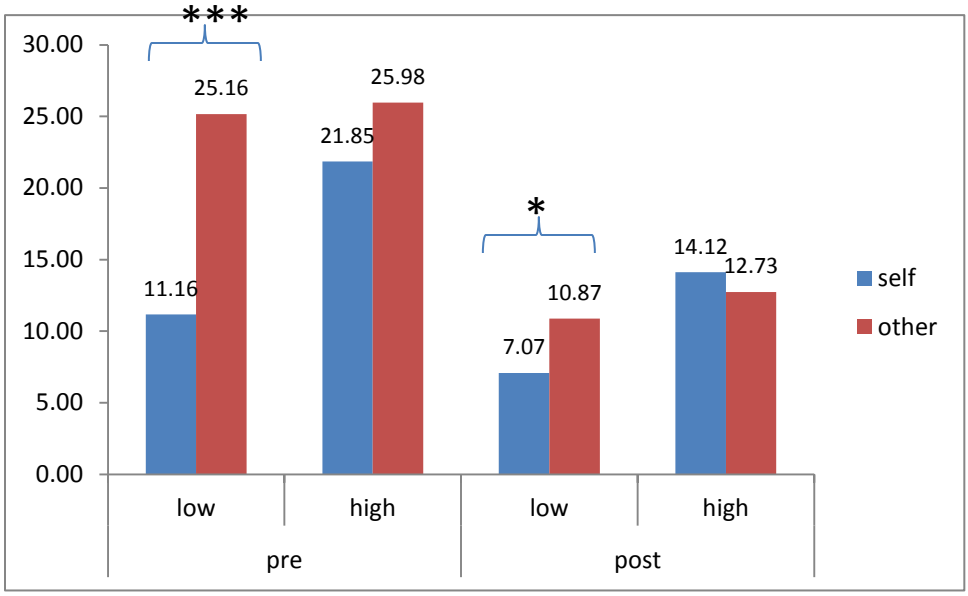
Figure C18. Pre/post and self/other and seriousness

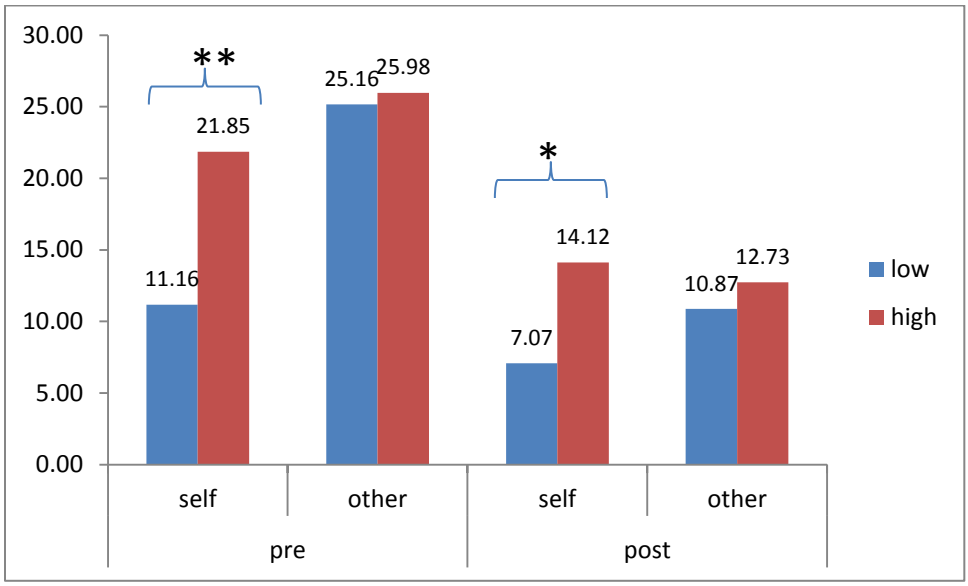




For drinking problem, in both the pre- and post-conditions, self-estimations were significantly lower than other-estimations only for participants who categorized drinking problem as having low desirability. (Figure C19).

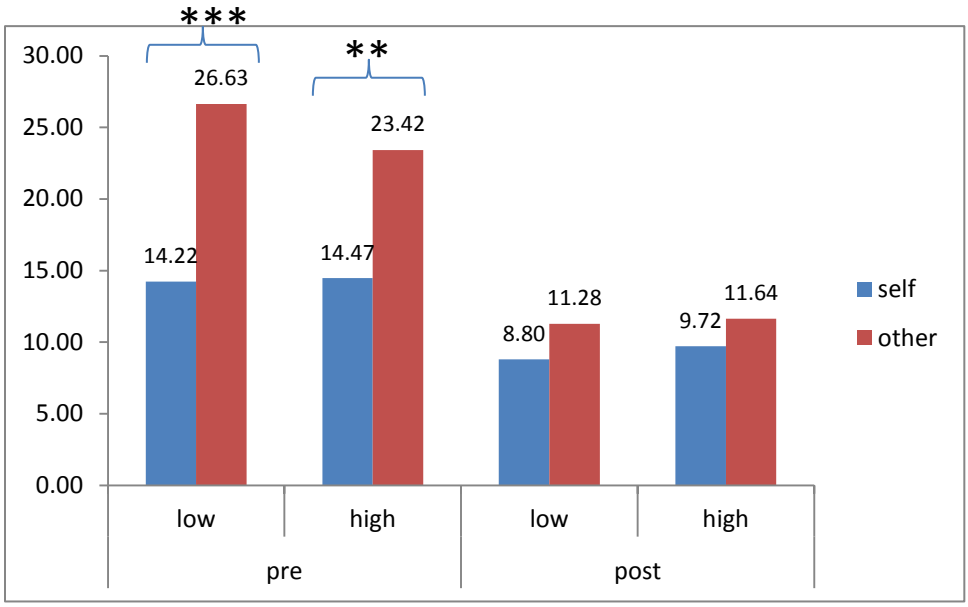
Figure C19. Pre/post and self/other and desirability

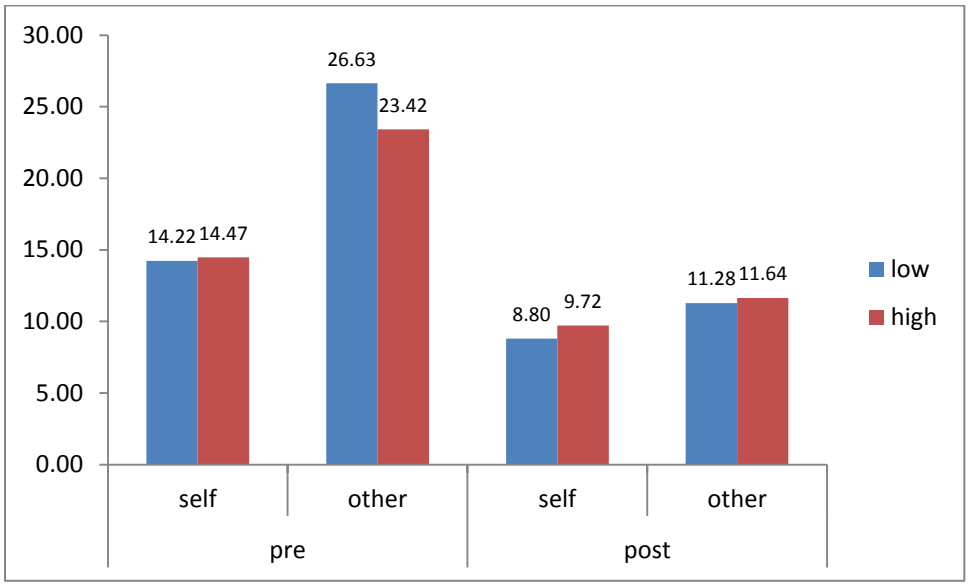




In the pre-condition, participants in the low and high optimism groups, gave significantly lower self-estimations than other-estimations (Figure C20).

Figure C20. Pre/post and self/other and LOT-R





LOT-R Questionnaire

Please be as honest and accurate as you can throughout. Try not to let your response to one statement influence your responses to other statements. There are no "correct" or "incorrect" answers. Answer according to your own feelings, rather than how you think "most people" would answer.

A = I agree a lot
B = I agree a little
C = I neither agree nor disagree
D = I DISagree a little
E = I DISagree a lot

1. In uncertain times, I usually expect the best.
[2. It's easy for me to relax.]
3. If something can go wrong for me, it will.
4. I'm always optimistic about my future.
[5. I enjoy my friends a lot.]
[6. It's important for me to keep busy.]
7. I hardly ever expect things to go my way.
[8. I don't get upset too easily.]
9. I rarely count on good things happening to me.
10. Overall, I expect more good things to happen to me than bad.

Discussion

In this part of the study, we were able to replicate previous findings that people update for only overestimation but not for underestimation cases. Also subjects updated estimations for others more than for themselves, especially for underestimation cases. We also found that covariates such as controllability, memory, seriousness, and desirability, LOT-R do not seem to be interacting with the updating process. These results apply to both STD and Drinking Problem, but not to Lung Cancer.

Comparing STD and Drinking Problem, it seems that people tend to underestimate the probability of STD contraction and overestimate the probability of developing a Drinking Problem. Thus, STD works like an “underestimation” case and Drinking Problem works like an "overestimation" case. After being presented with the actual probabilities, participants updated their estimations not enough for the "underestimation" case (STD) so the self-positivity bias was still observed in post measures for STD. Nonetheless, they updated their probabilities adequately (especially for others) for the "overestimation" case (drinking problem) so the self-positivity bias disappeared afterwards.

18. Extent of Clinical Activities Initiated and Completed. Items 18(A) and 18(B) should be completed for all research projects. If the project was restricted to secondary analysis of clinical data or data analysis of clinical research, then responses to 18(A) and 18(B) should be "No."

18(A) Did you initiate a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

_____Yes
__X__No

18(B) Did you complete a study that involved the testing of treatment, prevention or diagnostic procedures on human subjects?

_____Yes
_X___No

If "Yes" to either 18(A) or 18(B), items 18(C) – (F) must also be completed. (Do NOT complete 18(C-F) if 18(A) and 18(B) are both "No.")

18(C) How many hospital and health care professionals were involved in the research project?

_____Number of hospital and health care professionals involved in the research project

18(D) How many subjects were included in the study compared to targeted goals?

_____Number of subjects originally targeted to be included in the study
_____Number of subjects enrolled in the study

Note: Studies that fall dramatically short on recruitment are encouraged to provide the details of their recruitment efforts in Item 17, Progress in Achieving Research Goals, Objectives and Aims. For example, the number of eligible subjects approached, the number that refused to participate and the reasons for refusal. Without this information it is difficult to discern whether eligibility criteria were too restrictive or the study simply did not appeal to subjects.

18(E) How many subjects were enrolled in the study by gender, ethnicity and race?

Gender:
_____Males
_____Females
_____Unknown

Ethnicity:
_____Latinos or Hispanics
_____Not Latinos or Hispanics
_____Unknown

Race:
_____American Indian or Alaska Native
_____Asian
_____Blacks or African American
_____Native Hawaiian or Other Pacific Islander
_____White
_____Other, specify:_____
_____Unknown

18(F) Where was the research study conducted? (List the county where the research study was conducted. If the treatment, prevention and diagnostic tests were offered in more than one county, list all of the counties where the research study was conducted.)

19. Human Embryonic Stem Cell Research. Item 19(A) should be completed for all research projects. If the research project involved human embryonic stem cells, items 19(B) and 19(C) must also be completed.

19(A) Did this project involve, in any capacity, human embryonic stem cells?
_____Yes
__X__ No

19(B) Were these stem cell lines NIH-approved lines that were derived outside of Pennsylvania?
_____Yes
__X__ No

19(C) Please describe how this project involved human embryonic stem cells:

20. Articles Submitted to Peer-Reviewed Publications.

20(A) Identify all publications that resulted from the research performed during the funding period and that have been submitted to peer-reviewed publications. Do not list journal abstracts or presentations at professional meetings; abstract and meeting presentations should be listed at the end of item 17. **Include only those publications that acknowledge the Pennsylvania Department of Health as a funding source** (as required in the grant agreement). List the title of the journal article, the authors, the name of the peer-reviewed publication, the month and year when it was submitted, and the status of publication (submitted for publication, accepted for publication or published.). Submit an electronic copy of each publication or paper submitted for publication, listed in the table, in a PDF version 5.0.5 (or greater) format, 1,200 dpi. Filenames for each publication should include the number of the research project, the last name of the PI, and an abbreviated title of the publication. For example, if you submit two publications for Smith (PI for Project 01), one

publication for Zhang (PI for Project 03), and one publication for Bates (PI for Project 04), the filenames would be:

Project 01 – Smith – Three cases of isolated
Project 01 – Smith – Investigation of NEB1 deletions
Project 03 – Zhang – Molecular profiling of aromatase
Project 04 – Bates – Neonatal intensive care

If the publication is not available electronically, provide 5 paper copies of the publication.

Note: The grant agreement requires that recipients acknowledge the Pennsylvania Department of Health funding in all publications. Please ensure that all publications listed acknowledge the Department of Health funding. If a publication does not acknowledge the funding from the Commonwealth, do not list the publication.

Title of Journal Article:	Authors:	Name of Peer-reviewed Publication:	Month and Year Submitted:	Publication Status (check appropriate box below):
1.				☐Submitted ☐Accepted ☐Published
2.				☐Submitted ☐Accepted ☐Published

20(B) Based on this project, are you planning to submit articles to peer-reviewed publications in the future?

Yes___X____ No_____

If yes, please describe your plans:

We are drafting a manuscript for the Journal of Marketing Research.

21. Changes in Outcome, Impact and Effectiveness Attributable to the Research Project. Describe the outcome, impact, and effectiveness of the research project by summarizing its impact on the incidence of disease, death from disease, stage of disease at time of diagnosis, or other relevant measures of outcome, impact or effectiveness of the research project. If there were no changes, insert "None"; do not use "Not applicable." Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

NONE

22. Major Discoveries, New Drugs, and New Approaches for Prevention Diagnosis and Treatment. Describe major discoveries, new drugs, and new approaches for prevention,

diagnosis and treatment that are attributable to the completed research project. If there were no major discoveries, drugs or approaches, insert "None"; do not use "Not applicable." Responses must be single-spaced below, and no smaller than 12-point type. DO NOT DELETE THESE INSTRUCTIONS. There is no limit to the length of your response.

NONE

23. Inventions, Patents and Commercial Development Opportunities.

23(A) Were any inventions, which may be patentable or otherwise protectable under Title 35 of the United States Code, conceived or first actually reduced to practice in the performance of work under this health research grant? Yes_____ No____X_____

If "Yes" to 23(A), complete items a – g below for each invention. (Do NOT complete items a - g if 23(A) is "No.")

a. Title of Invention:

b. Name of Inventor(s):

c. Technical Description of Invention (describe nature, purpose, operation and physical, chemical, biological or electrical characteristics of the invention):

d. Was a patent filed for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No____

If yes, indicate date patent was filed:

e. Was a patent issued for the invention conceived or first actually reduced to practice in the performance of work under this health research grant?
Yes_____ No____
If yes, indicate number of patent, title and date issued:
Patent number:
Title of patent:
Date issued:

f. Were any licenses granted for the patent obtained as a result of work performed under this health research grant? Yes_____ No____

If yes, how many licenses were granted?_____

g. Were any commercial development activities taken to develop the invention into a commercial product or service for manufacture or sale? Yes___ No____

If yes, describe the commercial development activities:

23(B) Based on the results of this project, are you planning to file for any licenses or patents, or undertake any commercial development opportunities in the future?

Yes_____ No_____X_____

If yes, please describe your plans:

24. Key Investigator Qualifications. Briefly describe the education, research interests and experience and professional commitments of the Principal Investigator and all other key investigators. In place of narrative you may insert the NIH biosketch form here; however, please limit each biosketch to 1-2 pages. *For Nonformula grants only – include information for only those key investigators whose biosketches were not included in the original grant application.*

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She holds a PhD from the Viterbi School of Engineering (major in Neuroscience) with a minor from the Marshall School of Business at the University of Southern California.

Her research interests' lie within decision neuroscience with emphasis on functional neuroimaging in marketing (neuromarketing) and IS (NeuroIS), **electronic commerce, and modeling of information pathways in the brain**.

Her research appeared in the top journal in the field as well as in popular press such as Newsweek, CBS, and Semana.