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Trans Fatty Acid Intake and Emotion Regulation

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Abstract

Background—We examined whether there is a relationship between trans fatty acid (TFA) intakes and emotion regulation, mediated by positive or negative affect.

Methods—Archival data on 1699 men and 3293 women were used to measure TFA intake at baseline, positive and negative affect and emotion regulation at follow up.

Results—Higher TFA intake related to subsequent difficulties with emotional awareness ($p=.045$), clarity ($p=0.012$) and regulation strategies ($p=.009$). Affect mediated these relationships. Lower TFA intake associated with increased positive and decreased negative affect which, in turn, associated with improved emotion regulation.

Conclusions—TFA intakes may be associated with subsequent ability to regulate emotions.

Keywords

Emotion regulation; emotion regulation; trans fatty acids; positive affect; negative affect

Background

Dietary intake patterns in the United States and other developed countries are often collectively referred to as the Western diet. This diet is characterized by high intake of energy dense foods and beverages, saturated fatty acids, trans fatty acids (TFAs), refined/simple carbohydrates and processed foods. The Western diet, coupled with abundant food-related media cues, ease of access to these foods, and a sedentary lifestyle, as well as TFA intakes in particular, have significantly contributed to the obesity epidemic (Kanoski, 2012;

Thompson et al., 2011). In 2003, TFA intakes were 4.6g/person/day, though intake has decreased to 1.3g/person/day as of 2010 (Doell et al., 2012). TFAs form during the process of hydrogenation, whereby previously protective vegetable oils are modified into a solid form. Further, Cordain and colleagues (2005) explain that TFAs increase serum levels of low density lipoprotein (LDL) cholesterol, thereby increasing risk of cardiovascular diseases. In addition, TFAs have pro-inflammatory effects that may result in oxidative stress in the hypothalamus, and interfering with signaling pathways that regulate hunger, fullness and other metabolic processes (Velloso, 2009).

TFA may influence psychological health. An observational study by Golomb and colleagues (2012) prospectively measured depression, aggression and TFA intakes in 945 adults. Results demonstrated a significant link between increased TFA intakes and aggression and depression. Another area of interest is the connection between TFA intakes and affect. In a recent observational study, Ford and colleagues (2013) found intake of TFAs to be linked with negative affect. In the present study we extended these results to study the connection between TFA consumption and emotion regulation skills.

Many pathological conditions described in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) involve difficulties with regulation of emotions, including depressive and anxiety disorders and eating disorders (Gross, 2002). Gratz and Roemer (2004) proposed the Difficulties in Emotion Regulation Scale (DERS) as a measure of emotion regulation difficulties to determine which aspects of regulation are most problematic. Studies have shown differences in DERS according to gender and negative affect with males demonstrating worse emotion regulation than females and negative affect relating to worse emotion regulation (Lafrance-Robinson et al., 2013). Emotion regulation domains and affective states have been shown in some studies to differ by gender and ethnicity (Christensen and Brookes, 2006; Lafrance-Robinson et al., 2013; Nolen-Hoeksema, 2012; Bardwell and Dimsdale, 2001; Gratz and Roemer, 2004). The present study looked at the effect of TFA consumption on later emotion regulation difficulties, and the potential mediating role of positive and negative affect, controlling for gender and ethnicity.

Methods

Participants—Archival data from the Adventist Health Study II (AHS-2) (Butler et al., 2008), and from the first two waves of a sub-study of the AHS-II, the Biopsychosocial Religion and Health Study (BRHS) (Lee et al., 2009) were used for this investigation. In 2002–2006, as part of AHS-2 a 52 page questionnaire on diet, lifestyle and health was completed by approximately 97,000 Seventh-day Adventists. Of a random sample of 21,000 AHS-2 participants, 10,988 completed the 2006–07 BRHS survey on religion and health in 2006–2007 and 6,508 of the same individuals also completed a second 2010–11 BRHS survey. Based on likely error in recording or self-report, the following were excluded from the 6,508 participants: (a) daily energy intake under 500 kcals ($n=5$) or over 4500 kcals ($n=41$); (b) BMI under 15 or over 60 ($n=39$); (c) ethnicity other than Black or White ($n=8$) and (d) missing data on one or more study variables ($n=1423$). A total of 4992 remained for analysis. Excluded participants were analyzed along with those who remained in the study for comparative purposes using Pearson's Chi Square for categorical and mean comparisons

for continuous variables. The percentage of females and males, respectively, in the original sample was 72.6% and 27.4%, whereas the percentages remaining in the final sample were 66% and 34% ($p=.000$). Initially, White participants constituted 48.2% of the original sample, but made up 73.6% of the final sample, and the percentage of Black participants went from 33.7% to 26.4% ($p=.000$). Excluded participants were generally less educated than those included in the final sample ($p=.000$), and had a significantly higher BMI relative to included study participants (27.2 kg/m² vs. 26.7 kg/m²) ($p=.005$). Finally, the average age of excluded participants was older (65.4 years) than those included (61.3 years, $p=.000$).

The Loma Linda University Institutional Review Board granted expedited approval and consent was implied by return of survey materials. Participant's personal information was stored separately from survey responses in a secure database.

Measures

Dietary measurements—Dietary data was collected using a food frequency questionnaire (FFQ) from the 2002–6 AHS-2 survey. Participants were asked to identify how frequently they consumed food and beverage items on a 9-point scale: never or rarely, 1 to 3 times monthly, once per week, 2 to 4 times weekly, 5 to 6 times weekly, once per day, 2 to 3 times daily, 4 to 5 times daily, and 6 or more times daily. Additionally, participants indicated the amount of each dietary item consumed on a three point scale: standard serving size, half the standard size or less, or one and one half the standard serving or more based on photos depicting these portions. The top five TFA contributors from AHS-2 FFQ were margarine, doughnuts, popcorn, French fries and cookies. The NDS-R 2008 database (The Nutrition Coordinating Center), manufacturer records and the Caribbean Food and Nutrition Institute were used to calculate daily kilocalorie intake based upon FFQ responses. The residual method was used to control for kilocalorie intake when calculating TFA intake (Willett, 2009).

Measurements of affect and emotion regulation—The mailed 2006–7 BRHS survey contained the 10-item Positive and Negative Affect Schedule (PANAS) (Mackinnon et al., 1999) to assess affect over the past year using a 5-point Likert scale (*very slightly or not at all to extremely*) to generate both positive and negative affect mean scores. Tests for internal consistency in our data yielded Cronbach's alphas of 0.85 for positive affect and 0.87 for negative affect.

Emotion Regulation—Gratz and Roemer (2004) developed the Difficulties in Emotion Regulation Scale (DERS) for use as a comprehensive measure of emotion regulation. The authors define emotion regulation as presence of the following: “having awareness, acceptance and understanding of emotions, ability to control impulse behavior and to behave in accordance with goals when experiencing negative emotions, and ability to use situationally appropriate emotional regulation strategies flexibly to modulate responses” (p. 42–43). Absence of any of the criteria suggests emotional regulation difficulties. The second wave of BRHS (2010–2011) surveys assessed three Difficulty with Emotional Regulation Subscales: emotional awareness (6 items), emotional clarity (5 items) and emotion regulation strategies (8 items). While the original DERS encompasses six domains, only the

three were selected for use in BRHS by investigators to decrease survey length and respondent burden. Higher scores for each subscale indicate greater difficulty with emotion regulation, and a mean score were calculated for each subscale. Some items, denoted by '(r)', indicate reverse scoring.

- a. *Emotional awareness* Questions pertaining to awareness were as follows: (a) I am attentive to my feelings (r); (b) I care about what I am feeling (r); (c) I pay attention to how I feel (r); (d) When I'm upset, I acknowledge my emotions (r); (e) When I'm upset, I take the time to figure out what I'm really feeling (r); (f) When I'm upset, I believe that my feelings are valid and important (r).
- b. *Emotional clarity* Questions pertaining to emotional clarity were as follows: (a) I am clear about my feelings (r); (b) I am confused about how I feel; (c) I have difficulty making sense out of my feelings; (d) I have no idea how I am feeling; (e) I know exactly how I am feeling (r).
- c. *Emotion regulation strategies* Questions pertaining to emotion regulation strategies were as follows: (a) When I'm upset, I know that I can find a way to eventually feel better (r); (b) When I'm upset, I start to feel very bad about myself; (c) When I'm upset, it takes me a long time to feel better; (d) When I'm upset, my emotions feel overwhelming; (e) When I'm upset, I believe I will remain that way for a long time; (f) When I'm upset, I believe I will end up feeling very depressed; (g) When I'm upset, I believe that there is nothing I can do to make myself feel better; (h) When I'm upset, I believe that wallowing in it is all I can do.

Subjects self-reported their emotion regulation difficulties on a 5-point scale, with the following equally weighted response options: *almost never* (0–10%), *sometimes* (11–35%), *about half of the time* (36–65%), *most of the time* (66–90%), *almost always* (91–100%). Cronbach's alphas were 0.81, 0.70 and 0.74, respectively, for awareness, clarity and strategy subscales.

Statistical analyses

For all scales, mean scores were calculated with available items if no more than one item was omitted. Control variables were selected based upon variables identified in similar studies as potential confounders (Sofi et al., 2008) including age, gender, ethnicity, self-reported BMI, education and exercise frequency assessed in the AHS-2 survey in 2002–6. Exercise was measured by self-report on an 8-point Likert scale (*never to six or more times per week*) regarding frequency of vigorous exercise. A Bonferroni correction was specified for the pairwise comparisons in table 1 to account for multiple tests. The role of positive and negative affect in the TFA and DERS subscale score relationships was assessed using Hayes (2012) Process SPSS macros to test for moderation effects. Individual as well as combined effect sizes were generated for positive and negative affect, and 95% confidence intervals were calculated by using a 1000 sample, bias-adjusted bootstrap technique. SPSS version 21.0 was used for data analyses. For all tests, a significance level of 0.05 was used.

Results

Mean and percentages for study variables are shown by gender and ethnic group in table 1. Whites in this sample were older than Blacks, and Black females had the highest BMI. More than 75% of every group had achieved at least an associate degree or had some college experience, with males being the most educated. White males had the highest frequency of physical activity, followed by Black males, then by females.

Pillai's Trace test for significance on the continuous variables indicated that groups overall were different, $t=0.163$, $F=28.665$, $df=30$ ($p=.000$). Analysis of variance (ANOVA) indicated that there were significant differences among the four groups for all study variables (age, BMI, exercise, affect, DERS scores and TFA intake) with $p=.000$. Pearson's Chi Square showed that groups were significantly different in terms of highest education level completed with $p=.000$. Blacks had higher positive affect scores than Whites. Females had higher negative affect scores than males. White males had more difficulty with emotional awareness than White females and Blacks with Blacks (both male and female) having the least amount of difficulty. Whites had more difficulty with emotional clarity than Blacks. White females had more difficulty with emotion regulation strategies than Black females or White males. White females had higher intakes of TFAs than Blacks.

As predicted, higher intakes of TFA's were positively correlated with difficulties with emotional awareness, clarity and strategies (table 2). Also, higher TFA intakes were positively correlated to negative affect and negatively correlated to positive affect. Further, higher TFA intakes were associated with higher BMI, less education and less frequent exercise.

Table 3 shows the results of regressing each 2011–2012 emotion regulation variable on the 2002–2006 TFA intake and control variables. Results are shown with and without control for affect measured in 2006–2007. TFA intake predicted difficulties with emotional awareness ($p=.045$), clarity ($p=.012$), and emotion regulation strategies ($p=.009$). When affect scores were added to the model, lower positive and higher negative affect predicted difficulties with all three later DERS subscale scores and the associations of TFA intake with the later DERS subscale scores were no longer statistically significant. This suggests a mediating influence of affect in the relationship between TFA intake and difficulties with emotion regulation across three skill domains.

Ethnicity and TFA intakes and gender and TFA intakes were entered into the regression as interaction terms, and the product of the ethnicity and gender dummy variables as well as TFA intakes; all were non-significant. Because these interactions were not significant, gender and ethnicity differences are not further reported.

Mediation Analyses

Results from the regression analysis prompted further testing to examine the mediating influence of positive and negative affect. Table 4 shows the results of using Hayes' Process SPSS macros for this purpose. Results indicated that TFA had no direct association with difficulty in emotional regulation once controlling for the mediating effect of positive and

negative affect, but that positive and negative affect mediate the relationship between TFA intake and the three emotional regulation domains.

Discussion

Results of the present study demonstrated a relationship between TFA intake and all three emotion regulation domains and implicate positive and negative affect as mediating this relationship. Results were consistent with recent findings, such as those of Sanchez-Villegas and colleagues (2011), in which TFA intake was directly correlated with increased risk of depression. These authors suggest that this relationship is mediated by the increase in proinflammatory cytokines that occur following intake of TFAs and subsequent endothelial damage; future research should test this hypothesis further.

Not surprisingly we found a direct relationship between higher TFA intake and higher BMI, lower levels of exercise and less education (table 2). Further, we found that females fared better in terms of awareness of emotions which is consistent with Gratz and Roemer (2004). However, subsequent analyses did not show differences between men and women regarding associations of TFA intake and emotional regulation. Thus, even though there are gender and ethnic differences relating to emotions and emotion regulation such as worse emotion regulation in males (Lafrance-Robinson et al., 2013), the relationships between these variables are similar across gender and ethnic groups examined here (Christensen and Brookes, 2006; Lafrance-Robinson et al., 2013; Nolen-Hoeksema, 2012; Bardwell and Dimsdale, 2001; Bardwell and Dimsdale, 2001; Gratz and Roemer, 2004).

There are study limitations that should be acknowledged. First, due to the observational nature of this study, causation cannot be assumed. There was a selection bias in those included in the study sample due to self-selection or inability to complete the complex questionnaires including fewer Blacks, less educated, older, and those with higher BMIs. This selection bias means that these data may not generalize to these other groups. Also, a significantly greater percentage of participants in the final sample (74.4% vs. 85%) had a calorie intake within 500 kcals to 4500 kcals daily, suggesting that excluded participants were more likely to have a calorie intake suggestive of error in reporting or recording, or abnormal intake patterns ($p=.000$). Responses for the present study variables were given by self-report, which may limit validity, as subjects may be trying to look good or aiming to please investigators, or may lack the detailed awareness required to answer such questions. While the FFQ is considered a well validated tool for assessment of dietary intake patterns, subjects are prone to under-reporting intake, particularly of foods regarded as unhealthy. This is of particular importance in the present study, given our emphasis on TFA intake (Henriquez et al., 2009; Ortiz et al., 2009; Willett, 2009). With FFQ's, some variables are powerfully correlated for partially spurious reasons, and we did not adjust for other dietary constituents to which TFA's are potentially correlated. Also, as of January 1, 2006, the FDA required Nutrition Facts labels to list the grams per serving of TFA's, which subsequently resulted in heightened awareness on behalf of consumers of the ill effect of TFA consumption, and efforts by manufacturers to decrease reliance on TFA's in food production (Eckel et al., 2007). TFA intakes in the present study were collected from 2002–2006, and

it's possible that intakes have decreased among study participants since labeling legislation was introduced in 2006.

To our knowledge, this is one of the only longitudinal studies to examine the relationship between trans fatty acid intake with emotional regulation skill domains, while considering the mediating influence of positive and negative affect. Difficulties with emotion regulation characterize and often predict onset of a number of common psychiatric conditions, and have been linked to poor health outcomes (Kardemes et al., 2011; Kinnunen et al., 2005; Werner and Gross, 2010). Results of the present study demonstrate that increased intake of TFA's were related to increased difficulties with awareness of emotions, clarity of emotions, and reported utilization of emotion regulation strategies. Further, positive and negative affect serve as mediators in this relationship. Rather than looking solely at single nutrients, future studies could assess the relationship between dietary patterns and additional domains of emotion regulation within sample populations. Also, future research should attempt to further explicate the directionality of these effects with experimental designs.

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Descriptive characteristics and Pairwise Comparisons of N= 4992 participants by ethnicity and gender (mean and standard deviation or percentages are given)

Table 1

	Female		Male		<i>p</i> value ^a (<i>df</i>)
	Black	White	Black	White	
Age, years	19.7% n=981	46.3% n=2312	6.7% n=335	27.3% n=1364	
Body mass index, kg/m ²	57.7 _b (11.6)	62.1 _a (12.4)	59.3 _b (11.6)	63.0 _a (12.5)	0.000 (3)
Education	28.4 _b (6.1)	26.5 _a (6.1)	26.9 _a (4.5)	26.2 _a (4.6)	0.000 (3)
Grade school/Some high school	4.6% _a	3.5% _a	4.5% _a	2.6% _a	0.000 (12)
High school or trade school diploma	13.6% _{a,b}	17.2% _a	12.2% _{a,b}	13.0% _b	
Associate's degree/Some college	35.6% _a	36.6% _a	25.1% _b	23.8% _b	
Bachelor's degree	22.7% _b	28.0% _a	25.1% _{a,b}	23.0% _b	
Master's or doctoral degree	23.5% _b	14.7% _a	33.1% _c	37.6% _c	
Exercise Frequency	4.03 _a (2.14)	4.09 _a (2.27)	4.37 _{a,b} (2.17)	4.43 _b (2.17)	0.000 (3)
Affect Score					
Positive affect	3.73 _b (0.71)	3.48 _a (0.67)	3.80 _b (0.67)	3.48 _a (0.65)	0.000 (3)
Negative affect	1.77 _a (0.72)	1.77 _a (0.72)	1.53 _b (0.55)	1.57 _b (0.60)	0.000 (3)
Difficulties with Emotion Regulation Subscales					
Awareness	1.97 _b (0.84)	2.23 _a (0.83)	2.08 _b (0.82)	2.44 _c (0.85)	0.000 (3)
Clarity	1.58 _b (0.61)	1.66 _a (0.61)	1.51 _b (0.57)	1.65 _a (0.63)	0.000 (3)
Strategies	1.91 _b (0.49)	1.96 _a (0.48)	1.90 _{a,b} (0.46)	1.89 _b (0.45)	0.000 (3)
Trans Fatty Acid Intake ^b	2.58 _b (0.18)	2.60 _a (0.16)	2.57 _b (0.16)	2.59 _{a,b} (0.14)	0.000 (3)

Notes: Values in the same row not sharing the same subscript are significantly different ($p < .05$) in the two-sided test of equality for column means. Cells without a subscript are not included in the test. Tests are adjusted for all pairwise comparisons within a row using the Bonferroni correction.

^a ANOVA was used for continuous variables assuming equal variance in groups; Pearson's Chi Square was used for the categorical variable education.

^b Trans Fatty Acid Intake was measured in grams per day

Table 2

Pearson Correlation Coefficient of Trans Fatty Acid Intake with Study Variables with 95% Confidence Intervals Based on a 1000 Sample Bias Corrected Bootstrap (N = 4992)

	<i>R</i>	<u>95% Confidence Interval</u>		<i>p</i> (2-tailed)
		Lower	Upper	
Age, years	−0.02	−0.046	0.014	0.251
Body mass index, kg/m ²	0.16	0.133	0.184	0.000
Education	−0.12	−0.141	−0.083	0.000
Exercise Frequency	−0.17	−0.200	−0.144	0.000
Affect Score				
Positive affect score	−0.13	−0.153	−0.099	0.000
Negative affect score	0.09	0.061	0.127	0.000
Difficulty with Emotional Regulation				
Awareness	0.05	0.024	0.084	0.000
Clarity	0.06	0.030	0.090	0.000
Strategies	0.06	0.027	0.092	0.000

Table 3
Association of Emotion Regulation^a with Earlier Trans Fatty Acid Intake with and without Controls for Affect

	Model 1 ^a (without Affect)			Model 2 (with Affect)		
	B	95% CI	p	B	95% CI	p
Difficulty with Awareness						
Age, years	0.002	[0.000, 0.004]	0.025	0.003	[0.001, 0.005]	0.001
Body mass index, kg/m ²	0.002	[-0.002, 0.006]	0.373	-0.001	[-0.005, 0.003]	0.559
Gender ^b	0.214	[0.164, 0.264]	0.000	0.219	[0.171, 0.267]	0.000
Education	-0.051	[-0.72, -0.029]	0.000	-0.029	[-0.050, -0.009]	0.006
Exercise Frequency	-0.026	[-0.037, -0.015]	0.000	-0.011	[-0.022, -0.001]	0.032
Ethnicity ^c	-0.274	[-0.328, -0.221]	0.000	-0.177	[-0.229, -0.124]	0.000
Positive affect				-0.344	[-0.379, -0.309]	0.000
Negative affect				0.089	[0.055, 0.124]	0.000
Trans Fatty Acid Intake	0.155	[0.003, 0.306]	0.045	0.018	[-0.128, 0.163]	0.813
Difficulty with Clarity						
Age, years	-0.002	[-0.003, 0.000]	0.014	0.001	[-0.001, 0.002]	0.333
Body mass index, kg/m ²	0.004	[0.000, 0.007]	0.026	0.002	[-0.001, 0.005]	0.274
Gender	0.007	[-0.030, 0.043]	0.718	0.040	[0.005, 0.074]	0.024
Education	-0.036	[-0.052, -0.020]	0.000	-0.016	[-0.030, -0.001]	0.037
Exercise Frequency	-0.010	[-0.018, -0.002]	0.010	0.001	[-0.007, 0.008]	0.845
Ethnicity	-0.105	[-0.145, -0.066]	0.000	-0.042	[-0.079, -0.004]	0.030
Positive affect				-0.191	[-0.216, -0.166]	0.000
Negative affect				0.227	[0.202, 0.251]	0.000
Trans Fatty Acid Intake	0.142	[0.031, 0.253]	0.012	0.015	[-0.089, 0.119]	0.779
Difficulty with Strategies						
Age, years	-0.005	[-0.006, -0.004]	0.000	-0.003	[-0.004, -0.002]	0.000
Body mass index, kg/m ²	0.003	[0.001, 0.006]	0.006	0.003	[0.000, 0.005]	0.024
Gender	-0.037	[-0.065, -0.009]	0.010	0.000	[-0.026, 0.027]	0.986
Education	-0.019	[-0.031, -0.007]	0.002	-0.005	[-0.017, 0.006]	0.363
Exercise Frequency	-0.006	[-0.013, 0.000]	0.035	0.000	[-0.006, 0.005]	0.921
Ethnicity	-0.062	[-0.092, -0.032]	0.000	-0.032	[-0.061, -0.004]	0.027

	Model 1 ^a (without Affect)			Model 2 (with Affect)		
	B	95% CI	p	B	95% CI	p
Positive affect				−0.063	[−0.083, −0.044]	0.000
Negative affect				0.231	[0.212, 0.250]	0.000
Trans Fatty Acid Intake	0.113	[0.028, 0.198]	0.009	0.026	[−0.054, 0.106]	0.521

^a Emotion regulation subscales scores regressed upon trans fatty acid intake

^b Gender was coded 1=female and 2=male

^c Ethnicity was coded as 1=White and 2=Black

Table 4

Test for Mediating Effects of Positive and Negative Affect Scores on Relationship between Trans Fatty Acid Intake and Emotion Regulation ^a (N=4992)

	<i>Effect^b</i>	95% CI	SE	t	p
Direct Effects of Trans Fatty Acid Intake on DERS Subscale Scores ^c					
Awareness	0.0176	[-0.1277, 0.1629]	0.0741	0.2371	0.8126
Clarity	0.0149	[-0.0891, 0.1188]	0.0530	0.2803	0.7793
Strategies	0.0262	[-0.0537, 0.1060]	0.0407	0.6421	0.5208
Indirect Effects of Trans Fatty Acid Intake on DERS Subscale Scores					
Awareness					
Total	0.1372	[0.0900, 0.1952]	0.0264		
Positive Affect	0.1117	[0.0673, 0.1642]	0.0240		
Negative Affect	0.0255	[0.0122, 0.0466]	0.0083		
Clarity					
Total	0.1270	[0.0826, 0.1753]	0.0236		
Positive Affect	0.0621	[0.0368, 0.0897]	0.0136		
Negative Affect	0.0649	[0.0330, 0.1001]	0.0165		
Strategies					
Total	0.0867	[0.0509, 0.1209]	0.001		
Positive Affect	0.0206	[0.0109, 0.0336]	0.001		
Negative Affect	0.0661	[0.364, 0.986]	0.001		

^a Hayes (2012) Process SPSS macros performed with 95% confidence intervals based on a 1000 sample bias-corrected bootstrap.

^b Effects are change in difficulty with emotion for a 1 unit change in the trans fatty acid (TFA) intake through the corresponding path. For example consider the indirect association of TFA on awareness, a 1 unit increase in TFA intake is associated with a .1117 increase in difficulty with awareness by the indirect path through positive affect.

^c Once positive and negative affect are controlled.