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RESEARCH ARTICLE

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Intentions to report concussion symptoms in nonprofessional athletes: A fuzzy-trace theory approach

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Summary

Reducing concussion risks in athletes depends on self-reporting. Often, athletes decide whether to report concussions or continue playing and risk serious health consequences. Fuzzy-trace theory (FTT) predicts that reliance on gisty, categorical representations of risky decisions, not amounts of risk/reward, encourages risk avoidance and application of bottom-line values, or gist principles, thus promoting healthy decisions. Applying FTT, we test whether intentions to report are predicted by gist-based thinking about risks and values. High school and college students (N = 1,366) were assessed for concussion knowledge, social pressures to not report (by coaches/parents/teammates), categorical gist-based thinking, endorsement of gist principles expressing values, and intentions to report. As expected, the older group scored higher on gist measures. For young adults, categorical thinking, and gist principles predicted intentions, controlling for sex, knowledge, and social pressures. For adolescents, categorical thinking again predicted intentions. For both age groups, adding FTT's predictors accounted for significantly more variance than baseline models.

KEYWORDS

adolescence, athletes, concussions, risky decision making, sports psychology

1 | INTRODUCTION

Concussions have grown in importance as a public health issue over the past decade: The most recent statistics from Centers for Disease Control and Prevention (CDC) indicate that emergency room visits resulting from traumatic brain injuries (TBIs) increased dramatically over the last decade from 521.6 per 100,000 people in 2006 to 801.9 per 100,000 people (CDC, 2014). The number of sports-related concussions, a type of TBI, have been estimated as falling between 1.6 million and 3.8 million annually, but this number may be underestimated due to the many injuries that go unrecognized or underreported (Daneshvar, Nowinski, McKee, & Cantu, 2011). Reporting symptoms of concussion (e.g., to coaches) is crucial to avoid reinjury before the brain has had a chance to heal, which can worsen outcomes.

Although the media have focused on the effects of concussions on professional athletes, there is a growing literature examining the prevalence of concussions in the much-larger group of student athletes. The National Collegiate Athletic Association (NCAA) Injury Surveillance Program determined that reported concussions were widespread among 12 men's and 13 women's collegiate sports (Zuckerman et al., 2015). However, many athletes do not report that they are experiencing symptoms of concussions (Delaney, Lamfookon, Bloom, Al-Kashmiri, & Correa, 2015; Kroshus, Garnett, Hawrilenko, Baugh, & Calzo, 2015; McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004; Meier et al., 2015). For example, McCrea et al. found that, out of 229 high school football players who received a concussion in the football season, fewer than half (47.3%) reported the concussion (i.e., to a coach, athletic trainer, etc.). The most common reasons for not reporting was that the athlete did not think the concussion was serious enough and did not want to leave the game. Similarly, Kroshus et al. studied 328 collegiate athletes, of whom only 8.56% reported sustaining a concussion, and almost half of those concussed athletes indicated that they continued to play through their concussion. Last, when Delaney et al. asked 92 university-level varsity athletes who suffered concussions whether they sought medical attention in a game or practice, 72 of them (78.3%) reported not seeking such attention. The majority of these athletes cited "not feel[ing] the concussion was serious/severe and [feeling they] could still continue to play with little danger to [themselves]," as reasons for not seeking medical attention.

If an athlete fails to report a possible concussion, the athlete runs the risk of a second head injury within a short span of time, which has been associated with longer recovery, long-term impairment, and death (Bey & Ostick, 2009; Harmon et al., 2013; Iverson, Gaetz, Lovell, & Collins, 2004; Khurana & Kaye, 2012). Therefore, some studies examined effects of providing education about recognizing concussions and their potentially serious health consequences. However, the effects of greater knowledge about concussions have been mixed. Although some studies have found a positive effect of knowledge on reporting (Register-Mihalik et al., 2013a), others have found no effect of knowledge on intentions to report concussion symptoms or reporting behavior (Kroshus, Baugh, Daneshvar, Nowinski, & Cantu, 2015; Wallace, Covassin, & Beidler, 2017; Wallace, Covassin, Nogle, Gould, & Kovan, 2017).

Other studies have examined social pressure. Athletes who reported that they felt pressure from fans, coaches, parents, or teammates were even more likely to underreport concussion symptoms and play while injured than those who did not feel such pressure (Kroshus, Garnett, Hawrilenko, et al., 2015). However, few studies marshal established psychological theory in understanding and addressing underreporting. Of the few studies incorporating theory, most focus on the theory of reasoned action and planned behavior, social cognitive theories (see Fishbein, 2008), which incorporate psychosocial factors, such as social pressures that influence behavior through effects of descriptive and injunctive norms (e.g., my parents would approve of…; Kroshus, Baugh, Daneshvar, & Viswanath, 2014; Kroshus, Garnett, Hawrilenko, et al., 2015; Register-Mihalik et al., 2012; Register-Mihalik et al., 2013). In another study by Warmath and Winterstein (2019), reporting skill, namely, knowing the actions to take in reporting, was more important than having knowledge of concussions or concussion symptoms; athletes with higher reporting skill had increased intentions to report concussions. This study supports the applicability of self-efficacy to reporting intentions, a component of social cognitive theories. In addition, while prior research incorporated some constructs from classic theories such as perceived risks and rewards of reporting concussion symptoms (Foster, D'Lauro, & Johnson, 2019), there has also only been one study to date that has attempted to incorporate contemporary theories of judgment and decision making. Applying dual-process theory that distinguishes deliberative versus automatic thinking (Kahneman, 2011), Baugh, Meehan, Kroshus, McGuire, and Hatfield (2019) used the cognitive reflection test to determine whether thinking deliberatively (as opposed to automatically) encouraged concussion reporting. However, no relation with cognitive reflection was observed. Thus, prior theoretical models yield some significant effects, but they also leave substantial variance unexplained (Kroshus et al., 2014; Kroshus, Garnett, Hawrilenko, et al., 2015; Warmath & Winterstein, 2019).

Here, we take a decision making approach to concussion reporting that builds on prior work. Certainly returning to play while experiencing a concussion has been viewed as taking a risk. However, only one study has attempted to incorporate theories of risky decision making (i.e., derivatives of prospect theory or rational choice theory), and none has attempted to incorporate fuzzy-trace theory (FTT). FTT combines cognitive and social factors, in particular, mental representations of the gist of risk-taking and of social values, to predict willingness to report concussion symptoms.

Specifically, FTT, a dual-process theory of memory and decision making, posits that people process information in two ways, which affect decisions made using that information (Reyna & Brainerd, 2011). FTT distinguishes between verbatim representations of information, consisting of surface details, and gist representations, consisting of the bottom-line meaning of information. The latter is more developmentally advanced, and, consistent with this prediction, research has shown that reliance on gist representations increases with age and expertise (Garavito, Weldon, & Reyna, 2018; Reyna & Farley, 2006).

In particular, relative reliance on gist, as opposed to more precise verbatim representations, predicts developmental and individual differences in risky decision making, including adolescent risk-taking in various contexts (Defoe, Dubas, Figner, & van Aken, 2015; Mills, Reyna, & Estrada, 2008; White, Gummerum, & Hanoch, 2015; Wilhelms & Reyna, 2013). Prior to FTT, decisions about risk were classically analyzed as tradeoffs between risk and reward (or, between probabilities, and outcomes combined multiplicatively; see Tversky & Kahneman, 1986). According to FTT, adolescents, who rely on verbatim representations, see risk-taking in this way; their mental representations make finer distinctions than those relied on by adults, and, hence, they trade amount of risk for amount of reward. FTT does not claim that risk-taking adolescents are better quantitative thinkers than adults, but, rather, that they rely more on analysis of precise and literal representations.

Ironically, such analytical approaches to decision making promote risk-taking in common circumstances in which the rewards of risk-taking are high and the probability of negative outcomes (i.e., the risk) for a single instance of risk-taking is low. In other words, it is often the case, in individual risk-taking (e.g., deciding whether to engage in unprotected sex), that prospective rewards of a single act outweigh the risks when considered objectively, favoring risk-taking (Reyna & Farley, 2006). In contrast, adults generally rely on gist representations that do not reflect risk–reward tradeoffs but, rather, reflect categorical thinking, such as "It only takes once to get HIV" or "Even low risks add up to 100% if you keep on having unprotected sex," that promote risk aversion for rewards. Research has supported FTT's predictions and process model in both applied and laboratory contexts (e.g., Blalock & Reyna, 2016; see Garavito et al., 2018).

Thus, per FTT, individuals who rely more often on simple gist representations have been found to take fewer unnecessary and unhealthy risks (e.g., Mills et al., 2008; Reyna et al., 2011). Developmentally, precise trading off, relying on verbatim representations, gives way to categorical thinking about risks, which seems to reduce preferences for risk-taking (e.g., Defoe et al., 2015). Therefore, beyond effects of knowledge, and social pressure, we expect that young people who think more categorically will be less likely to risk the deleterious outcomes of concussions, increasing intentions to report. Items that assess categorical gist thinking for a range of risk-taking behaviors were adapted to study intentions to report concussions (e.g., Mills et al., 2008; Reyna, 2008; Reyna et al., 2011).

Additionally, gist representations of risky decisions elicit relevant bottom-line principles and values that support decisions to seek or avoid risk (e.g., "Some fun is better than no fun; No risk is better than some risk"). This cuing effect occurs because principles and values are stored in a gist form in long-term memory, so decision representations that are similarly gisty are better retrieval cues for those principles and values. Per FTT, categorical thinking, in addition to effects of knowledge, works together with endorsement of bottom-line values to reduce unhealthy risk-taking (e.g., Mills et al., 2008; Reyna & Mills, 2014).

Risk-reduction curricula that have incorporated FTT (e.g., encouraging categorical thinking about risk) provide further evidence of these causal mechanisms. That is, programs that apply this theory-based approach, which go beyond interventions that only augment knowledge, have produced increases in valid-concordant decision making and reductions in unhealthy risk-taking (Fraenkel et al., 2015; Reyna & Mills, 2014; Wolfe et al., 2015; for a recent review, see Blalock & Reyna, 2016). Thus, FTT merits consideration in the domain of sports-related risk-taking and concussions.

In this study, we apply FTT to understand risky decisions to underreport concussions by measuring multiple potential factors in such decisions. Naturally, one reason that young people might underreport concussions is lack of knowledge, despite widespread efforts to educate the public, especially athletes. Thus, we use a validated scale of concussion knowledge to account for variation in reporting (Rosenbaum & Arnett, 2010). Building on validated scales in other domains of risk-taking, two FTT-based scales were developed that tap into categorical thinking and endorsement of simple, bottom-line principles centered around the topic of sports and concussions, with a focus on football. We adapted the scales in this study from existing FTT-based scales that were developed for, and applied to, diverse risky behaviors ranging from unprotected sex to patient choice in medical care for arthritis (Fraenkel et al., 2012; Reyna et al., 2011; Reyna & Mills, 2014). For example, subjects in a prior study rated agreement with the statement "[i]t only takes once to get HIV" with respect to unprotected sex, whereas subjects in this study rated agreement with the statement "[i]t only takes once to become permanently brain damaged" with respect to playing contact sports (for validity and reliability evidence of the unprotected sex items, see Mills et al., 2008; Reyna & Mills, 2014).

Then, we conducted planned Analysis of variances (ANOVAs) to test group differences in the FTT predictors of intentions to report concussion symptoms: Adolescents (high school students) were expected to score lower in categorical thinking compared to college students (young adults). This is due to increasing reliance on gist-level processing as youth develop (Reyna, Wilhelms, McCormick, & Weldon, 2015). Age differences would also be expected in endorsement of gist principles to the degree that they reflected categorical thinking about risk (e.g., "Avoid risk" or "No risk is better than some risk"; Mills et al., 2008; Reyna & Mills, 2014). It is also important to compare athletes, former athletes, and non-athletes to test whether the groups differ from one another in factors that are predicted to influence intentions to report concussions. Concussions are not limited to athletes, and non-athlete populations have shown similar underreporting effects as athletes (Foster et al., 2019). However, differences in the perception of the risk of concussive injuries have been observed among athletes, former athletes, and non-athletes (Garavito, Reyna, & DeTello, 2018). Thus, it makes sense to examine these group differences, too. Multiple regressions were then conducted with all age and athlete subgroups to determine the association between these theory-based scales and intentions to report concussion symptoms, controlling for knowledge, and perceptions of social pressures to underreport concussion symptoms. Greater categorical thinking and stronger endorsement of simple gist principles should be associated with greater intentions to report concussions symptoms. That is, greater gist-based categorical thinking reduces trading the catastrophic risks associated with underreporting concussion symptoms for the reward of playing sports. In addition, greater endorsement of risk-averse gist-level principles, which are more readily accessed and applied when thinking categorically (i.e., on a "gistier" level), should also be associated with greater intentions to report concussions symptoms, even when controlling for additional sources of variance, such as knowledge, social pressures, and sex.

2 | METHOD

2.1 | Participants

Participants were recruited from across the United States in New York, New Jersey, Rhode Island, Minnesota, Massachusetts, and Colorado. High schools, colleges, and universities were contacted, and participants received either course credit (not available for high school students) or payment for completion of the study. Specifically, 21 high schools, and 10 colleges and universities were contacted. In the end, we were able to recruit athletes from seven high schools (2 in Colorado and 5 in New York) and five colleges and universities (1 in New York, 1 in Rhode Island, 1 in New Jersey, 1 in Minnesota, and 1 in Massachusetts). To recruit athletes, we contacted coaches, and athletic directors, who were able to give us access to recruit athletes directly (e.g., after practices).

College participants were 1,162 students who ranged in age from 18 to 24 years (M_{age} = 19.82, SD = 1.349). The majority (69.4%; 806 participants) was female. The most common racial identity was Caucasian (49.7%; 577 participants), followed by Asian (27.9%; 324 participants), Black/African American (13.4%; 156 participants), Mixed/Other (9.0%; 105 participants), and Native American (.1%; 1 participant. Hispanics made up 10.5% of the sample (122 participants). Non-athletes composed 53.8% of the sample (625 participants); former athletes, 26.9% (313 participants); and current athletes 19.3% (224 participants). The Institutional Review Board approved the study, and all subjects provided informed consent.

High school participants were 164 students. Participants ranged in age from 14–20 years (M_{age} = 16.16, SD = 1.390). About half (49.4%; 81 participants) was female. The most common racial identity was Caucasian (50.0%; 82 participants), followed by Black/African American (22.0%; 36 participants), Mixed/Other (14.6%; 24 participants), Asian (11.6%; 19 participants), and Native American (1.8%; 3 participants). Hispanics made up 31.1% of the sample (51 participants). Non-athletes composed 23.8% of the sample (39 participants); athletes, 64.6% (106 participants); and former athletes, 11.6% (19 participants). All high school subjects provided informed assent and we obtained parental consent for all minors.

3 | MEASURES

Participants completed an online survey about engagement in sports ("Are you currently a student athlete?" and responses were yes/no/used to be student athlete), demographics, how many times they had been diagnosed with a concussion in their life, and intentions to report ("In the future, I intend to report my symptoms if I…" paired with 22 symptoms; see below). The survey also included the following scales (see Table 1 for descriptive statistics):

3.1 | Rosenbaum concussion knowledge index

To measure how much a participant knew about concussions (i.e., symptoms and post-concussion recovery and care), the survey included the Concussion Knowledge Index (CKI) Student Version (RoCKAS-ST; Rosenbaum & Arnett, 2010). The CKI is a 25-item validated measure of concussion knowledge (Kuder–Richardson, $KR\text{-}20_{\text{High school}}$ = .430; $KR\text{-}20_{\text{College}}$ = .480), some of which are true/false (e.g., "In order to be diagnosed with a concussion, you have to be knocked out.") and others involve classifying psychological, emotional, or physical difficulties as symptoms of a concussion (e.g., "headaches") or distractors (e.g., "hives"). To address reliability, we re-ran analyses using a modified version of the scale with higher reliability ($KR\text{-}20_{\text{High school}}$ = .706; $KR\text{-}20_{\text{College}}$ = .700). Using this revised knowledge scale, our results remained qualitatively the same, though concussion knowledge became a significant predictor of intentions to report for high school athletes (see Data S1).

3.2 | Categorical thinking about concussions

Participants completed a 25-item scale (see Table A1 in Appendix) that assessed the tendency to think *categorically* regarding risks in sports (High school α = .844; College α = .883; e.g., "If you continue playing football while feeling symptoms of a concussion (getting your 'bell rung' or getting 'dinged'], risk adds up, and you will permanently damage your brain."). Participants indicated agreement with each statement on a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree."

3.3 | Gist principles of concussions

Participants completed a 17-item scale (see Table A2 in Appendix) to assess agreement with bottom-line values or principles that are relevant to making decisions about one's health while participating in sports ($\alpha_{\text{High school}}$ = .811; α_{College} = .826). They indicated their level of agreement on a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (e.g., "No risk is better than some risk.").

3.4 | Social pressures

Each athlete also completed four questions regarding pressure that fans, parents, teammates, or coaches may have exerted on the athlete to return to play after a head impact (Kroshus, Garnett, Hawrilenko, et al., 2015; e.g., "I have felt pressure from teammates to return to play after a head impact."). They responded using a 7-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree," and responses were averaged to reflect social pressures on athletes against reporting concussion symptoms (High school α = .905; College α = .892).

3.5 | Intentions to report concussion symptoms

Participants completed a 22-item scale to measure their intentions to report symptoms of a concussion (High school α = .979; College α = .980; Kroshus, Garnett, Hawrilenko, et al., 2015). The scale used each of the 22 symptoms included in the Sport Concussion Assessment Tool-5th edition (SCAT-5; e.g., "In the future, I intend to report my symptoms if I sustain an impact that causes me to have a headache"). Participants used a 7-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree."

4 | ANALYSES

For the first set of analyses, we ran planned ANOVAs to detect group differences predicted by FTT, as discussed previously. These 2 (age group: high school vs. college) × 3 (athlete group: non-athletes

TABLE 1 Descriptive statistics for high school and college samples

			M	SD	Theo. Min.	Theo. Max.	Obs. Min.	Obs. Max.
High school	Athlete	SP	2.335	1.390	1	7	1.000	7.000
		CK	19.340	2.263	0	25	11.000	25.000
		GP	2.212	0.557	0	4	1.000	3.824
		CT	2.458	0.512	0	4	1.320	3.720
		ITR	5.530	1.178	1	7	2.045	7.000
	Former athlete	SP	2.921	1.586	1	7	1.000	5.250
		CK	17.895	2.865	0	25	12.000	21.000
		GP	2.071	0.484	0	4	1.176	3.176
		CT	2.518	0.512	0	4	1.520	3.360
		ITR	4.797	1.553	1	7	1.000	7.000
	Non-athlete	CK	17.641	2.777	0	25	11.000	22.000
		GP	2.276	0.457	0	4	1.176	3.471
		CT	2.401	0.411	0	4	1.440	3.120
		ITR	5.135	1.337	1	7	1.000	7.000
College	Athlete	SP	2.306	1.403	1	7	1.000	6.000
		CK	20.041	2.284	0	25	12.000	24.000
		GP	2.378	0.436	0	4	0.765	3.765
		CT	2.579	0.461	0	4	1.400	3.840
		ITR	5.638	1.196	1	7	1.000	7.000
	Former athlete	SP	2.346	1.423	1	7	1.000	7.000
		CK	20.006	2.075	0	25	10.000	24.000
		GP	2.578	0.497	0	4	0.941	3.941
		CT	2.715	0.487	0	4	1.320	4.000
		ITR	5.945	0.910	1	7	3.000	7.000
	Non-athlete	CK	19.551	2.390	0	25	9.000	25.000
		GP	2.640	0.517	0	4	1.176	3.882
		CT	2.728	0.512	0	4	1.600	4.000
		ITR	5.778	1.087	1	7	1.000	7.000

Note: Theo. Min./Max. is the lowest possible minimum or highest possible maximum for the respective scale. Obs. Min./Max. is the observed minimum or maximum for the sample.
Abbreviations: CK, Concussion Knowledge; CT, Categorical Thinking; GP, Gist Principles; ITR, Intentions to Report; SP, Social Pressures.

vs. former athletes vs. athletes) ANOVAs were run for, categorical thinking, endorsement of gist principles, and reporting intentions, respectively. Due to these expected differences, separate hierarchical regression analyses were run for the college and high school samples. High school students, being younger, and having spent less time in sports, were much less likely to be former athletes. Consequently, we had too few high school non-athletes and former athletes to run our models distinguishing those two groups. However, the two groups were very similar to each other, likely due to the relatively little amount of athletic experience that high school former athletes have had because of their young age. Accordingly, the high school non-athlete, and former athlete groups were combined. In the hierarchical regressions, the first model served as the baseline model consisting of all variables we intended to control for: concussion knowledge, social pressures, and sex. As only athletes and former athletes can be asked about social pressures to return to play, this variable was omitted for non-athletes. The second model added the two FTT-based scales measuring categorical thinking and endorsement of gist principles. This model tested the association between these FTT measures (categorical thinking and gist principles endorsement) and intentions to report concussion symptoms while controlling for all other variables. An additional model, using only the FTT-based scales, was run for all groups to assess possible suppressor effects; there were no such effects, and all significant effects were replicated in this analysis (see Data S1).

5 | RESULTS

In the ANOVA for categorical thinking (Table 2, ANOVA 1), a main effect was observed for age group, with college-aged individuals exhibiting significantly more gist-based, categorical thinking

TABLE 2 Main effects and interactions for ANOVAs

	SS	*df*	MSE	F	Partial η^2
ANOVA with categorical thinking as dependent variable					
Age group	4.292	1	4.292	17.519**	0.013
Athlete group	0.622	2	0.311	1.269	0.002
Age group * athlete group	1.032	2	0.516	2.106	0.003
Error	323.357	1,320	0.245		
ANOVA with gist principles as dependent variable					
Age group	11.091	1	11.091	44.264**	0.032
Athlete group	2.628	2	1.314	5.244**	0.008
Age group * athlete group	2.104	2	1.052	4.199*	0.006
Error	330.736	1,320	0.251		
ANOVA with intentions to report as dependent variable					
Age group	37.195	1	37.195	31.231**	0.023
Athlete group	3.359	2	1.680	1.410	0.002
Age group * athlete group	18.314	2	9.157	7.689**	0.012
Error	1,572.091	1,320	1.191		

Note: $^{\dagger}p < .1$, $^{*}p < .05$, $^{**}p < .01$.
Abbreviations: ANOVA, Analysis of variance; MSE, Mean Square Error; SS, Sum of Squares.

(M = 2.674, SE = 0.016) compared to high school participants (M = 2.459, SE = 0.049), $p < .001$. The main effect for athlete group, as well as the athlete and age group interaction, was not significant, $p > .05$ (Figure 1a).

The ANOVA using endorsement of gist principles is reported in Table 2, ANOVA 2. Again, there was a significant main effect for age group, with college-aged participants showing higher endorsement of gist principles (M = 2.532, SE = 0.016) than high school participants (M = 2.186, SE = 0.049). A significant main effect was also seen for athlete group. Former athletes (M = 2.324, SE = 0.059) and athletes (M = 2.295, SE = 0.030) did not significantly differ in endorsement of gist principles, p = .657, but athletes had significantly lower levels of endorsement than non-athletes (M = 2.458, SE = 0.041), p = .001. Non-athletes and former athletes differed marginally, M_{Diff} = 0.134, SE = 0.072, p = .064. Last, there was a significant interaction between age group and athlete group such that differences between high school and college groups were larger for nonathletes and former athletes but converged for athletes (Figure 1b). High school athletes, former athletes, and non-athletes did not differ, $p > .1$. Within the college sample, endorsement of gist principles for non-athletes and former athletes did not differ, M_{Diff} = 0.059, SE = 0.033, p = .071, but both groups had significantly greater levels of endorsement compared to athletes, $p < .001$.

In the ANOVA on intentions to report, there was a significant main effect of age group (Table 2, ANOVA 3). College students had significantly higher intentions to report (M = 5.769, SE = 0.034) than high school students (M = 5.447, SE = 0.106), p = .004. The interaction between age group and athlete group was also significant (Figure 1c). Again, differences between high school, and college groups were larger for nonathletes and former athletes but converged for athletes.

To preview regression results, in both models for all age and athlete groups, categorical thinking was significantly, and positively associated with intentions to report concussion symptoms, even when controlling for other variables. Endorsement of gist principles was a significant, positive predictor in the college sample but not for the high school sample. Bivariate correlations were significant for both of these FTT-based predictors (Data S1). Pearson's r was approximately .5 for all athlete groups within each age group, dropping lower only for high school athletes to .42 (Figures S1–S5).

For college athletes, the regression showed that all control measures—concussion knowledge, social pressures, and sex—were significant predictors of intentions to report concussion symptoms (Table 3, Model 1). In the regression model for college students that added FTT predictors, the FTT measures were both significant, positive predictors of intentions to report concussion symptoms, even while controlling for the other predictors (Table 3, Model 2). The FTT measures explained an additional 20.8% of variance, significantly contributing beyond the baseline control model, $F(2, 214)$ = 33.522, $p < .001$.

The regression results for former college athletes were nearly identical to those for athletes. In the control model, greater concussion knowledge and lower social pressures were associated with higher intentions to report (Table 3, Model 3). In the second model adding FTT predictors, greater categorical thinking and greater endorsement of gist principles were associated with greater intentions to report concussion symptoms (Table 3, Model 4). Concussion knowledge and social pressures remained significant. For this group, FTT measures explained an additional 22.2% of variance, again significant, $F(2, 303)$ = 54.385, $p < .001$.

Similar results were obtained for college non-athletes. In the control model, greater concussion knowledge was significantly associated

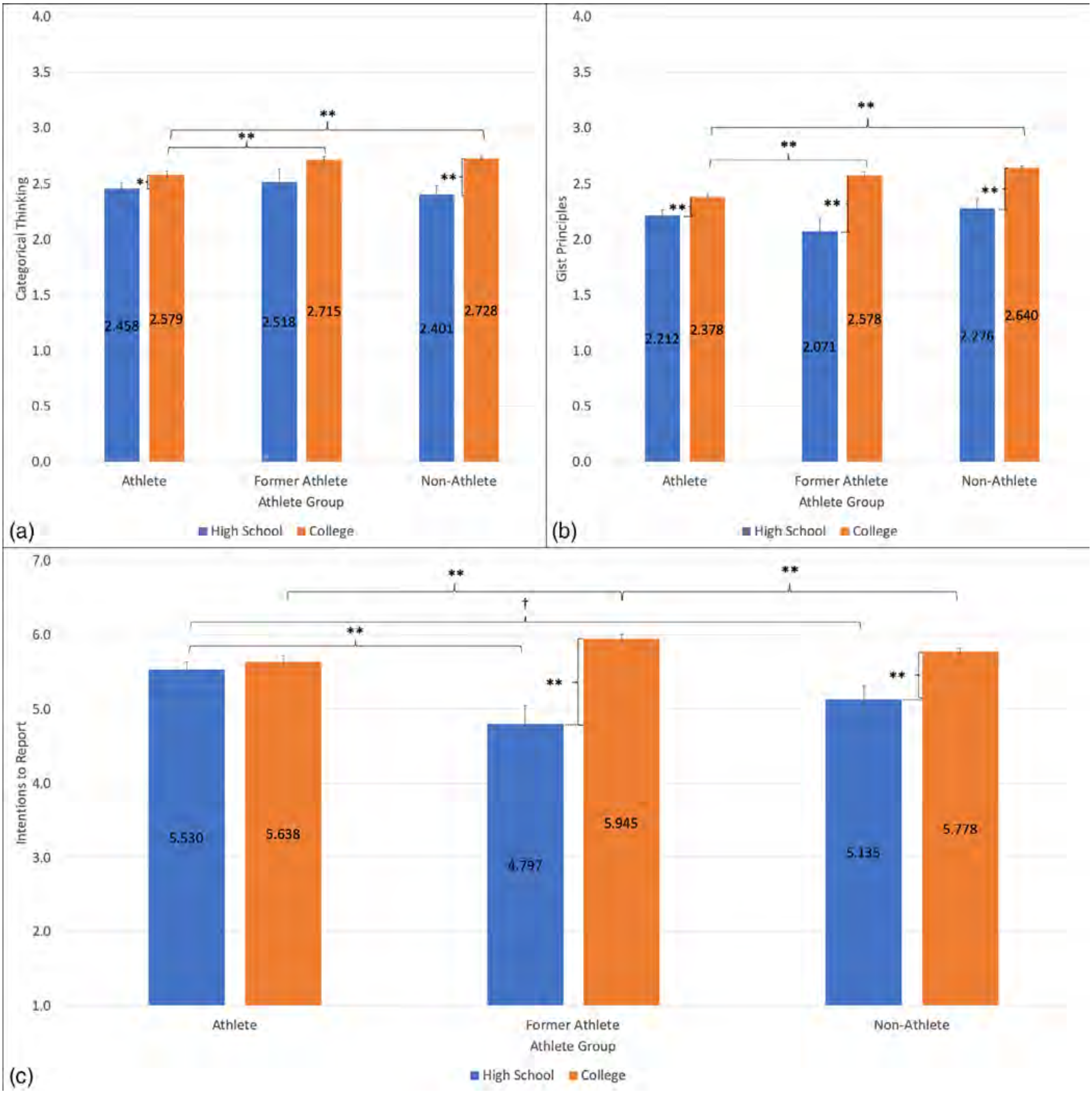

FIGURE 1 (a) Main effect of age group in categorical thinking (interaction with athlete group was nonsignificant). (b) Significant interaction between athlete group and age group in endorsement of gist principles. (c) Significant interaction between athlete group and age group in intentions to report. Asterisks indicate significant pairwise tests for differences in means, $^{\dagger}p < .1$, $^{*}p < .05$, $^{**}p < .01$. Error bars represent +/− 1 standard error [Colour figure can be viewed at wileyonlinelibrary.com]

with higher intentions to report concussion symptoms (Table 3, Model 5). In the second model adding FTT predictors, both greater categorical thinking, and greater endorsement of gist principles, were significantly, and positively associated with greater intentions to report, echoing results with the athlete and former athlete groups (Table 3, Model 6). Knowledge remained significant. FTT measures explained an additional 21.8% of variance, again significant, $F(2, 608) = 101.139$, $p < .001$.

For high school athletes, in the first model with control measures, social pressure was significantly associated with lower intentions to report, but no other predictors reached significance (Table 4, Model 1). In the second model adding FTT predictors, categorical thinking was significantly associated with greater intentions to report concussion symptoms. Unlike the college sample, however, endorsement of gist principles was not independently associated with intentions to report. The effect of social pressure remained significant in the second

TABLE 3 Hierarchical regressions for the college sample predicting intentions to report

	B	*SE*	β	t	VIF
Model 1: Control model for athletes (adj-R^2 = 0.117)					
(constant)	3.033	0.689		4.403**	
Sex	0.405	0.167	0.156	2.423*	1.033
Concussion knowledge	0.130	0.033	0.250	3.883**	1.025
Social pressures	−0.126	0.054	−0.148	−2.320*	1.013
Model 2: Full model for athletes (adj-R^2 = 0.322)					
(constant)	0.651	0.674		0.966	
Sex	0.275	0.148	0.106	1.860†	1.054
Concussion knowledge	0.064	0.031	0.122	2.075*	1.121
Social pressures	−0.044	0.049	−0.052	−0.905	1.059
Gist principles	0.684	0.201	0.237	3.408**	1.564
Categorical thinking	0.806	0.186	0.311	4.324**	1.669
Model 3: Control model for former athletes (adj-R^2 = 0.150)					
(constant)	3.714	0.482		7.707**	
Sex	0.176	0.102	0.091	1.723†	1.003
Concussion knowledge	0.123	0.023	0.282	5.328**	1.014
Social pressures	−0.148	0.033	−0.233	−4.419**	1.011
Model 4: Full model for former athletes (adj-R^2 = 0.370)					
(constant)	1.493	0.466		3.203**	
Sex	0.059	0.088	0.030	0.662	1.021
Concussion knowledge	0.101	0.020	0.230	4.997**	1.032
Social pressures	−0.077	0.030	−0.121	−2.600**	1.067
Gist principles	0.567	0.112	0.295	4.746**	1.893
Categorical thinking	0.446	0.115	0.242	3.891**	1.892
Model 5: Control model for non-athletes (adj-R^2 = 0.122)					
(constant)	2.673	0.344		7.756**	
Sex	−0.074	0.090	−0.031	−0.823	1.001
Concussion knowledge	0.161	0.017	0.353	9.311**	1.001
Model 6: Full model for non-athletes (adj-R^2 = 0.339)					
(constant)	1.238	0.327		3.911	
Sex	−0.122	0.078	−0.051	−1.563	1.004
Concussion knowledge	0.079	0.016	0.174	4.914**	1.157
Gist principles	0.510	0.111	0.226	4.580**	2.257
Categorical thinking	0.659	0.108	0.309	6.107**	2.377

Note: †$p < .1$, *$p < .05$, **$p < .01$.

model (Table 4, Model 2). No other predictors were significantly associated with intentions to report, including knowledge. The FTT measures, when added, explained an additional 19.1% of variability, significantly contributing, F(2, 100) = 14.753, $p < .001$.

The results of the regression with the combined high school former athlete and high school non-athlete groups mimicked those of the high school athletes (Table 4, Models 3 and 4). Concussion knowledge was significantly associated with greater intentions to report concussion symptoms. In the second model adding FTT predictors, categorical thinking was significantly associated with greater intentions to report concussion symptoms; endorsement of gist principles was marginally associated with intentions to report. Knowledge remained significant. The FTT measures explained an additional 21.3% of significant variability, F(2, 53) = 9.709, $p < .001$.

6 | DISCUSSION

As discussion surrounding the danger of concussions has grown, a body of research has tried to determine why athletes, despite the growing concern over health and safety, often fail to report concussion symptoms (Meier et al., 2015). This phenomenon exposes athletes to serious consequences, such as long-lasting cognitive damage or second-impact syndrome (Bey & Ostick, 2009; Harmon

TABLE 4 Hierarchical regressions for the high school sample predicting intentions to report

	B	*SE*	β	t	VIF
Model 1: Control model for athletes (adj-R^2 = 0.138)					
(constant)	4.599	0.989		4.650**	
Sex	0.379	0.223	0.154	1.699	1.005
Concussion knowledge	0.073	0.048	0.140	1.515	1.039
Social pressures	−0.261	0.078	−0.308	−3.336**	1.041
Model 2: Full model for athletes (adj-R^2 = 0.321)					
(constant)	2.203	0.990		2.227*	
Sex	0.250	0.200	0.102	1.249	1.023
Concussion knowledge	0.054	0.043	0.104	1.262	1.047
Social pressures	−0.166	0.072	−0.195	−2.288*	1.129
Gist principles	−0.077	0.294	−0.034	−0.261	2.666
Categorical thinking	1.115	0.304	0.485	3.674**	2.693
Model 3: Control model for non-athletes and former athletes (adj-R^2 = 0.176)					
(constant)	1.188	1.112		1.068	
Sex	−0.267	0.393	−0.082	−0.678	1.006
Concussion knowledge	0.228	0.061	0.451	3.738*	1.006
Model 4: Full model for non-athletes and former athletes (adj-R^2 = 0.374)					
(constant)	−1.164	1.117		−1.042	
Sex	−0.280	0.351	−0.086	−0.799	1.054
Concussion knowledge	0.120	0.060	0.238	2.023*	1.264
Gist principles	0.749	0.383	0.237	1.956†	1.338
Categorical thinking	1.108	0.419	0.351	2.648*	1.601

Note: †p < .1, *p < .05, **p < .01.

et al., 2013). However, the research on underreporting that applies psychological theories of decision making is scant, with most studies focusing on psychosocial factors (Kroshus et al., 2014; Kroshus, Garnett, Hawrilenko, et al., 2015). Further, no study to date has attempted to explain underreporting from the perspective of FTT. Here, we applied FTT, a psychological theory of risky decision making that emphasizes cognitive representations and social values, to the problem of underreporting of concussion symptoms (Garavito et al., 2018).

Overall, this study revealed significant FTT-based predictors—categorical thinking and endorsement of gist principles—of young people's intentions to report concussion symptoms. Thinking categorically about concussion risk consistently predicted reporting intentions across age and athlete groups. These results remained significant even when controlling for other variables such as concussion knowledge and social pressures, further supporting predictions. Knowledge about concussions mattered, too, and was greater in college than high school students, and in athletes compared to nonathletes for both age groups. The latter pattern resembles other kinds of risk-taking in that at-risk groups are sometimes more knowledgeable about risks; for example, sexually active (relative to inactive) adolescents are more knowledgeable about sexual risks (Reyna & Mills, 2014). As such a pattern suggests, however, knowledge does not fully explain intentions to reduce risk. Neither does social pressure from coaches, parents, and teammates—although it was also a significant predictor in this study, supporting prior research (Kroshus, Garnett, Hawrilenko, et al., 2015). Nevertheless, FTT-based predictors, especially categorical thinking, explained substantial unique variance beyond such factors.

Categorical thinking is a key construct in FTT, as thinking categorically is associated with developmentally advanced cognition (Garavito et al., 2018). Regarding concussion, it captures the meaningful insight that brain impairment differs qualitatively (i.e., categorically) from non-impairment and, thus, is arguably not a risk that should be traded off for the rewards of playing sports. FTT posits, and research has shown, that assessing risk and decisions in a categorical way (e.g., “It only takes once…”) is associated with a protective relationship between risk perception and risk-taking (e.g., Mills et al., 2008) confirmed in causal interventions (Reyna & Mills, 2014). This is noteworthy, as intuitive, categorical thinking, as opposed to precise deliberation, is considered flawed and primitive in other decision theories (Kahneman, 2011). Additionally, results from group comparisons showed that categorical gist thinking and endorsement of gist principles, in addition to intentions to report, were higher in the older college sample, supporting the idea that gist reliance is a developmentally advanced aspect of cognition.

When examining group differences, several trends emerged regarding athletes. First, being an athlete, former athlete, or non-athlete had no effect on categorical thinking. Second, overall, and for college students, athletes had lower endorsement of gist principles compared to nonathletes, though these differences were not significant for the high school sample. Third, college athletes did not have different intentions to report than non-athletes, though high school athletes had significantly higher intentions than non-athletes. Lastly, increases in endorsement of gist principles and intentions to report with age were attenuated for athletes, compared to other groups. However, *within* each athlete group, categorical thinking and, for the college sample, gist-principle endorsement accounted for individual differences in reporting intentions. Failure to obtain effects of gist-principle endorsement for high school students might relate to their lower levels of categorical thinking. That is, per FTT, categorical thinking allows people to apply their core values and principles to decisions, as opposed to balancing costs and benefits in a more verbatim manner (Garavito et al., 2018). FTT does not claim that risk aversion is always healthy. However, categorical aversion to concussion risks of playing a sport like football makes sense when consequences can be catastrophic (e.g., contracting HIV), as in other domains to which FTT has been applied (e.g., unprotected sex; Reyna & Mills, 2014).

One limitation of this study was that it focused on intentions to report concussion symptoms, not concussion reporting behavior itself. While it is important to note that intentions to report concussion symptoms have been found to be reliably associated with actual reporting behavior (Kroshus et al., 2015; Register-Mihalik et al., 2013), future studies examining the association of FTT measures and scales with reporting behavior would provide valuable insight. This future research could also provide additional insight into whether causal research manipulating FTT's psychological constructs in educational interventions, as done in other domains of risk-taking, would be worthwhile (Blalock & Reyna, 2016). Another concern was the finding that endorsement of gist principles was not a significant predictor of intentions to report in either group within our high school sample (although it was marginally significant in high school former/non-athletes). The two FTT-based predictors share some variance, as expected theoretically (Mills et al., 2008), although VIF scores did not reach a high enough level to suggest problematic multicollinearity (Hair Jr., Anderson, Tatham, & Black, 1995). Lastly, due to the relatively lower number of former athletes in the younger group, we were not able to completely replicate the analyses done in the college sample for the high school sample. In general, the high school sample was smaller than the college sample, particularly for former athletes; for this reason, we did not distinguish "former athletes" as a separate group for analyses with high school students. While this limitation is understandable given that high school students are much younger than college students and, therefore, have less time to become a part of, and then subsequently leave, athletic teams, we were not able to derive separate conclusions for this group. That being said, the combined high school former athlete and non-athlete group replicated results found with high school athletes. Nevertheless, future studies with high school and younger samples expanding on these results with larger numbers would be worthwhile.

As the health consequences of concussions have become better recognized, student athletic programs have begun shifting to a zero tolerance for head injuries. Although this policy addresses public health concerns, 100% testing of head impacts will increase false identification of concussions: false positives. From a societal perspective and from the perspective of the long-term health of the individual athlete, the impact of a false negative screening for concussion (athlete sustains concussion but is not appropriately identified) is much worse than the impact of a false-positive (athlete did not sustain concussion but is pulled from playing for further testing). However, there is a significant psychological impact of false positives from the athlete's perspective. That is, many athletes are being asked to undergo concussion testing and are benched from their position for a significant amount of time while undergoing concussion testing (often unable to return for several days or weeks) and found not to have suffered concussions. The impact of this benching can be an alteration in the ability of the athlete to participate in the sport during the rest of the season at their previously held position, (e.g., starting position vs. a benchwarmer). This can lead to reduction of opportunities for high school athletes for scholarships, reduction in college athletic participation in sports, and loss of consideration for professional opportunities. In addition, a false-positive screen for concussion may well reduce confidence and impair capacity to incorporate back into the team mode. Thus, the absence of the athlete from the team is often not a favorable outcome from the athlete's perspective as opposed to the program or society's perspective. Also, as false-positive results accumulate over time (a statistical inevitability), and without accurate understanding of the health implications, there may be a tendency over time to "look the other way" by coaches and school administrators due to a lack of trust in the process.

These predictable psychological impacts on athletes and staff place an even greater onus on communicating risk, which may be lessened if individuals understood the gist of their options more accurately. Our results, though correlational, are consistent with the hypothesis that inculcating gist thinking would be protective, as demonstrated causally in other domains of risk (e.g., Blalock & Reyna, 2016; Reyna & Mills, 2014). Conveying the categorical gist of risk does not mean exaggerating risk. Instead, risk communication should explain non-negligible categorical risks that can result in life-altering disability or death. For example, although one concussion will rarely lead to catastrophic consequences by itself, second-impact syndrome becomes a real possibility when athletes hide a concussion from their trainers and continue playing (Bey & Ostick, 2009; Boden, Tacchetti, Cantu, Knowles, & Mueller, 2007; Cina & Trelka, 2014; Halstead, Walter, Moffatt,, & Council on Sports Medicine and Fitness, 2018; Saunders & Harbaugh, 1984). Most people recover from a single serious concussion within a year, but multiple concussions can produce chronic physical and psychological symptoms (Guskiewicz et al., 2003; Kerr, Thomas, Simon, McCrea, & Guskiewicz, 2018; Losoi et al., 2016; Ponsford et al., 2000). Thus, the gist must capture the everyday qualitative reality of such impairments, the real possibility of a categorical shift in quality of life: the inability to be a student, perform meaningful work, or maintain relationships because of increased irritability and impulsiveness. As experts understand, the gist is that brain damage can change the course of a life and even who someone is.

In conclusion, our findings are consistent with a theoretical framework explaining how young people make decisions regarding concussion risks. Our results highlight the unique contribution of gist thinking about risk based on FTT and associated decision research, while also demonstrating the importance of other influences on athletes' decisions to report concussion symptoms (i.e., concussion knowledge, and social pressures). As FTT-based curricula have been tested, and shown promising results, in other areas of risk-taking in reducing unnecessary risk-taking and increasing value-concordant behaviors (Fraenkel et al., 2015; Reyna & Mills, 2014; Wolfe et al., 2015), studies evaluating such interventions may help further the understanding of FTT and concussion underreporting.

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CONFLICT OF INTERESTS

The authors have no conflicts of interest to disclose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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APPENDIX: FTT-BASED SCALES ON SPORTS AND CONCUSSIONS

TABLE A1 Categorical thinking about concussion items

Item
1. If you keep playing lots of football, risk adds up, and you will suffer serious brain damage.
2. In general, playing football is risk-free.*
3. Even low risks add up to 100% if you keep playing football.
4. If you keep playing football, risk does NOT accumulate.*
5. Low risks do NOT add up to 100% if you keep playing football.*
6. Playing football is NOT risk-free.
7. It is okay to risk injury from time to time.*
8. It only takes once to become permanently brain-damaged.
9. Bad things will happen to someone who plays football when there is a high risk of brain injury.
10. More time on the field is NOT better when it comes to playing football.
11. If you routinely play football while experiencing symptoms of a concussion (getting your “bell rung” or getting “dinged”), you will permanently damage your brain.
12. Playing football while experiencing symptoms of a concussion (getting your “bell rung” or getting “dinged”) can be okay; it depends on the amount of playing time.*
13. Every once in a while it is good to take a risk, even if it means risking brain damage.*
14. Playing football when a long-term injury is possible should be avoided at all costs.
15. Bad things will NOT happen when people play football.*
16. It's better to play football for less time than get a concussion (getting your “bell rung” or getting “dinged”).
17. Playing football to the point of getting brain damage should be avoided at all costs; you just never want to go there.
18. Even though the risk of brain damage as a result of playing football is low, it happens to someone.
19. It is NEVER okay to play football if you are experiencing symptoms of a possible concussion.
20. It is okay to play football if you are experiencing symptoms of a possible concussion (getting your “bell rung” or getting “dinged”).*
21. Playing football to the point of getting brain damage is worth it sometimes.*
22. Regarding playing football, there are minimal health risks.*
23. You will NOT face negative health consequences if you play football every day while experiencing effects of a possible concussion (getting your “bell rung” or getting “dinged”).*
24. If you continue playing football while feeling symptoms of a concussion (getting your “bell rung” or getting “dinged”), risk adds up, and you will permanently damage your brain.
25. If you continue playing football while feeling symptoms of a concussion (getting your “bell rung” or getting “dinged”), risk does NOT add up.*

Note: Asterisks represent a reverse-coded item. All items were answered on a 5-Point Scale ranging from *strongly disagree* to *strongly agree*. The prompt for these items was the following: “Please choose the response that best represents your position about playing contact sports.”

TABLE A2 Gist principles of concussion items

Item
1. I should avoid risk of concussion (“getting your bell rung” or “getting dinged”).
2. I have a responsibility to myself not to take risks.
3. I have a responsibility to my parents/family not to take risks.
4. Some risks are worth it.*
5. Less risk is better than more risk.
6. Fewer tackles are better for your health than more tackles in football
7. No tackles are better for your health than more tackles in football
8. No risk is better than some risk.
9. Less is better when it comes to time on the field in football.
10. More time on the field is always better than less time in football.*
11. Being healthy is more important than having fun when it comes to playing football.
12. Having fun is more important than being healthy when it comes to playing football.*
13. Playing lots of football on a regular basis can cause permanent brain damage.
14. Playing football every day CANNOT cause permanent brain damage.*
15. If you possibly have had a concussion (had your “bell rung” or gotten “dinged”), a moderate reduction of playing time in football is better than no reduction at all.
16. If you possibly have had a concussion (had your “bell rung” or gotten “dinged”), a large reduction of playing time in football is better than a moderate reduction of playing time in football.
17. If you possibly have had a concussion (had your “bell rung” or gotten “dinged”), a large reduction of playing time in football is not different from a small reduction of playing time in football.*

Note: Asterisks represent a reverse-coded item. All items were answered on a 5-Point Scale ranging from *strongly disagree* to *strongly agree*. The prompt for these items was the following: “The following statements reflect values or principles that may guide students' choices when playing contact sports. Please choose the response that best represents your position about your current behavior regarding contact sports.”