Ajayi, P. T., Garavito, D. M. N., & Reyna, V. F. (2021). Socioeconomic status and concussion reporting: The distinct and mediating roles of gist processing, knowledge, and attitudes. *Journal of Behavioral Decision Making*, *34*(5), 639 -656. https://doi.org/10.1002/bdm.2235



Received: 23 June 2020 | Revised: 28 January 2021 | Accepted: 28 January 2021

DOI: 10.1002/bdm.2235

RESEARCH ARTICLE

WILEY

# Socioeconomic status and concussion reporting: The distinct and mediating roles of gist processing, knowledge, and attitudes

**Peter T. Ajayi** | **David M.N. Garavito** | **Valerie F. Reyna**

Department of Human Development, Human Neuroscience Institute, Cornell University, Ithaca, New York, USA

**Correspondence**
David Garavito, Department of Human Development, Cornell University, Ithaca, NY 14853, USA.
Email: dmg345@cornell.edu

**Funding information**
Office of Engagement Initiatives at Cornell University; National Institute of Food and Agriculture, Grant/Award Number: NYC-321407; National Institute of Nursing Research, Grant/Award Numbers: R01NR014368, R21NR016905

## Abstract

Improving health outcomes for concussed athletes and others requires self-reporting symptoms; not reporting risks second-impact syndrome and death. However, concussions in adolescents and young adults are often underreported. We treat reporting as a risky decision, extending predictions of fuzzy-trace theory (FTT). We hypothesize that low SES indirectly interferes with the development of cognitive skills that reduce unhealthy risky decision making. Specifically, we expect that SES may be related to intentions to report a concussion because low SES delays development of cognitive gist processing that reduces risk-taking. Adolescents in high-school and young adults in college ($n$ = 1211) answered questions about concussion knowledge, concussion attitudes, and cognitive scales based on FTT: categorical thinking and endorsement of gist principles about risk. Overall, for each of the two age groups, and for athletes as well as nonathletes, SES was associated with reporting intentions, and this association was mediated by the three psychological predictors we tested: gist processing, concussion knowledge, and concussion attitudes. Results are consistent with lower SES reducing opportunities for normative cognitive development, the latter characterized by developmental increases in gist processing about risk. Hence, consistent with hypotheses, gist processing, concussion knowledge, and healthier attitudes about concussions were each associated with greater intentions to report concussions. Although educational initiatives currently focus on rote knowledge and healthy attitudes, future interventions to reduce concussion underreporting could benefit from explaining the gist of risk, especially to low SES youth, adapting successful FTT-based risk-reduction curricula from other domains.

KEYWORDS
concussions, fuzzy-trace theory, gist, risky decision making, socioeconomic status

## 1 | INTRODUCTION

Traumatic brain injuries (TBIs) have grown in importance as a health issue in the United States. TBIs contribute to permanent disability and injury-related deaths (McLendon et al., 2016; Mez et al., 2017). An estimated 2.5 million Americans sustain a TBI each year (Frieden et al., 2014). Emergency department visits for concussions, a type of TBI, increased annually among children and adolescents until

Peter T. Ajayi is now at Division of Intramural Research, National Heart, Lung, and Blood Institute.

  

2012–2018, mainly due to contact sports (Waltzman et al., 2020; see also Broglio & Puetz, 2008; Gerberich et al., 1983; Howell et al., 2013; Kurča et al., 2006). Confirmed diagnoses of reported concussions are high, but this is the tip of the iceberg: although reporting of concussions may have increased due to wider recognition of their consequences, many concussions remain unreported (Meier et al., 2015).

An untreated concussion has important implications for the developing brain and may cause deficiencies in cognitive processes and behavior (Covassin & Elbin, 2010; Giza & Hovda, 2014; Khurana & Kaye, 2012). In fact, a concussion can have long-term consequences, including symptoms similar to Alzheimer's disease, Parkinson's disease, and amyotrophic lateral sclerosis (Faden & Loane, 2015; Gardner & Yaffe, 2015; Jafari et al., 2013). Reporting concussion symptoms immediately improves brain recovery (e.g., by removing athletes from play) and is necessary to reduce consequences such as second-impact syndrome, poor quality of life, and early death (Anderson et al., 2011; Thomas et al., 2011). Given the deleterious effects associated with an unreported concussion, it is necessary to elucidate the factors influencing reporting behaviors especially considering that many healthcare professionals rely heavily on self-reported symptoms for a clear diagnosis and appropriate treatment.

The prevalence of concussion underreporting is surprising considering its short- and long-term health effects (Khurana & Kaye, 2012; Webbe & Barth, 2003). Because reporting improves concussion outcomes, researchers have attempted to pinpoint underlying reasons for underreporting. One may reasonably suspect that increasing concussion knowledge reduces the likelihood that a person underreports due to the awareness of negative consequences. While some studies have found no relationship between concussion knowledge and intentions to report or self-reported nonreporting (Chinn & Porter, 2016; Kroshus, Baugh, et al., 2015; Kroshus, Garnett, et al., 2015), other studies, often using different or more reliable measures of concussion knowledge, have found a significant relationship (Donnell et al., 2018; Garavito et al., 2020; Register-Mihalik et al., 2018). Thus, because null effects are indeterminate, on balance, knowledge appears to be related to underreporting. However, although relevant knowledge is generally needed to determine specific symptoms associated with a concussion, it might not be sufficient to change concussion reporting or intentions to report.

In addition to knowledge, studies have focused on the theories of reasoned action and planned behavior, that is, on psychosocial aspects of intentions to report concussions (Kroshus et al., 2014; Register-Mihalik, Linnan, et al., 2013). However, using these theories as a conceptual framework leaves a fair amount of the variance unexplained in concussion reporting (Register-Mihalik, Linnan, et al., 2013). In this study, we incorporate fuzzy-trace theory (FTT) to capture important unexplained variance in concussion reporting.

## 2 | FUZZY-TRACE THEORY

FTT posits that decision making is based on two types of representations of information, which are encoded and retrieved separately: the bottom-line meaning or "gist" and precise representations of superficial details or "verbatim," and each supports analogous reasoning (Reyna, 2012; Reyna & Brainerd, 2011; Wilhelms & Reyna, 2013). Gist processing is the more developmentally advanced form of reasoning that reflects education, culture, beliefs, and other life experiences (Reyna & Farley, 2006). Increasing reliance on gist, as opposed to verbatim, processing generally predicts healthier intentions and behaviors (Blalock & Reyna, 2016).

Decisions about risk have classically been analyzed as tradeoffs between risk and reward (see Rahimi-Golkhandan et al., 2017). According to FTT, verbatim processing supports trading degrees of risk for degrees of reward because finer distinctions are processed as contrasted with simple qualitative meaning represented in gist. Although adolescents and adults process both gist and verbatim representations, adolescents are more likely to rely on finer distinctions when making decisions, whereas adults are more likely to rely on gist processing. An example that highlights the developmental shift in processing is being confronted with the risk of becoming infecting with the human immunosuppression virus (HIV) from a single act of unprotected sex. Considering that the risk of HIV is low in this situation, adolescents may perceive that the benefits outweigh the risks of unprotected sex. Crucially, adolescents are often aware of the risk but trade off risk against potential rewards (Reyna & Farley, 2006). In contrast, adults rely on a categorical gist representation of risk: it only takes once to get HIV. The developmental shift described above does not mean that adolescents are superior quantitative thinkers. Instead, compared with adults, adolescents are more likely to rely on precise details, to trade degrees of risk for degrees of reward, rather than respond categorically (Kwak et al., 2015).

Prior research has supported the idea that increased reliance on meaningful gist processing, and not more precise verbatim processing, is protective against maladaptive risk taking (Mills et al., 2008; Rivers et al., 2008; White et al., 2015; Wilhelms & Reyna, 2013). Accordingly, FTT suggests that verbatim processes are likely to reduce concussion-reporting intentions and subsequent behavior, whereas gist processes are likely to have the opposite effect. Aligned with the HIV example, the risk of severe brain damage or death from an unreported concussion is low but catastrophic. Thus, concussion reporting should be encouraged by thinking of these consequences categorically, as opposed to degrees of potential harm that trade off against the rewards of playing sports. In addition, risks become categorical with repeated exposure to risks; although one exposure to unprotected sex has a low risk of pregnancy, those risks add up quickly and become a virtual certainty in about a year for most young people (see Reyna & Mills, 2014). Once one can "get the gist" that low risks add up and become a categorical inevitability with repetition, unhealthy risk-taking can be reduced or avoided (Reyna et al., 2015).

Gist representations also curtail unhealthy risk-taking by allowing decision makers to more easily access their values that promote health (e.g., Fujita & Han, 2009). Per FTT, core values are represented as vague or fuzzy long-term memories, such as "Getting an incurable disease is bad" or "Avoid risk of brain damage." Categorical representations of risk serve as cues to retrieve gisty representations of values or principles in long-term memory, which supports their application in risky decision making. The combined contributions of knowledge of risks, categorical thinking about risk, and retrieval (and application) of healthy values facilitate developmentally advanced gist-based intuition that reduces unnecessary risk-taking (Mills et al., 2008; Reyna & Mills, 2014).

In summary, FTT predicts that with the accumulation of knowledge, insight, and life experiences during development, people become more inclined to base their decisions on simple gist representations and principles as opposed to more precise mental representations (Reyna et al., 2011; Reyna et al., 2014; Reyna & Farley, 2006). Categorical gist representations of decision options and healthy gist principles fit together like a lock and key with respect to memory retrieval (gist representations cue relevant gist principles), which safeguards against unhealthy risk taking. Gist representations have been shown to endure over time, to be easier to mentally manipulate and to be less subject to interference (e.g., from high arousal or emotion)—all of which should help decision-makers make healthy decisions (Reyna & Brainerd, 2011).

## 3 | WHY SOCIOECONOMIC STATUS MATTERS

SES refers to differences in education, income, and occupation that have ramifications for healthy growth and development. As currently operationalized, education and income are more strongly linked to health in the United States compared with occupation (Adler & Rehkopf, 2008). Higher SES individuals have been shown to generally be better able to protect their health (Link & Phelan, 1995). Early cognitive and learning stimulation that typically accompany higher SES environments influence brain development, which in turn shapes higher cognitive functions (Bradley & Corwyn, 2002; see also Johnson et al., 2016 for a review). For example, parents who are well-off (e.g., higher economic resources and education) are better able to provide their children with cognitively stimulating experiences (e.g., music lessons, tutoring, and access to quality schools) that often lead to positive long-term outcomes (Guo & Harris, 2000). Longitudinal studies suggest that income gains early in life predict improved cognitive functioning later on (Grasset et al., 2019; Raffington et al., 2018). Similar conclusions have been found with education (Eilertsen et al., 2016; Gottfried et al., 2003). Conversely, being socioeconomically disadvantaged may affect developmental trajectories of reasoning abilities, particularly due to environmental stressors (Evans & Kim, 2013; McEwen, 2017).

The stress response system is interconnected with decision-making processes (Weller et al., 2014). Specifically, stress impairs learning and memory (Lindau et al., 2016; Sandi & Pinelo-Nava, 2007). Greater numbers of traumatic and other stressful life events coincide with lower SES (Hatch & Dohrenwend, 2007), and there is mounting evidence that the cumulative effects of stress and traumatic events have negative implications for health and cognitive processes across the lifespan, particularly causing delays in healthy development (Kim et al., 2018). SES is also associated with unhealthy behaviors (Pampel et al., 2010). The behavioral correlates of low SES, which is linked to stress and, thus, developmental delays, have important implications for decisions that young athletes make about their own health.

After moderate and severe TBI, adolescents from lower-SES families develop more behavioral and social problems than their advantaged counterparts (Zuckerman et al., 2017). Adjusting for relevant factors, SES was found to be a significant predictor of poor cognitive outcome at 3 months post-concussion injury (Rabinowitz et al., 2015). Identifying factors that promote reporting intentions is important to limit the harmful effects of an unreported concussion, especially in low SES individuals. A few studies have suggested SES differences in concussion knowledge and the decision to report a concussion injury (Wallace et al., 2017). However, there is meager research on SES as it relates to concussion reporting (since submission, two new studies reported SES differences in concussion knowledge or attitudes: Chandran et al., 2020; Salmon et al., 2020). The processes by which SES exerts its well-attested effects are not adequately understood (Bradley & Corwyn, 2002). Although SES is a useful predictor of health, it is unlikely to have a direct effect but, rather, it serves as a proxy for other direct determinants (Evans & Kim, 2010; Luby et al., 2013; Pampel et al., 2010). There are limited studies on how SES is associated with proximal factors of concussion reporting. Thus, considering the deleterious effects of low SES and the widespread problem of concussions, it is important to elucidate the direct and indirect associations between SES and the willingness to report concussive symptoms.

## 4 | THEORETICAL LINKS BETWEEN SES AND CONCUSSION REPORTING INTENTIONS: HYPOTHESIZED MEDIATORS

Lower cognitive and educational level are potential risk factors for concussion occurrence (Teasdale & Frøsig, 2013). When compared with adolescents with higher SES backgrounds, lower SES adolescents were less likely to know what to do if they suspected a concussion (Donnell et al., 2018). Given the evidence that SES and knowledge about concussions are associated (knowledge about what to do when it happens), a relationship between SES and reporting intentions could plausibly be expected in adolescents and young adults. However, what about higher SES might lead to an increased willingness to report concussion symptoms?

Differences in concussion knowledge are one possible explanation for the link between SES and reporting intentions (despite some null results, discussed above). Annual household income and level of education have been found to positively predict concussion knowledge and access to educational programs on concussions (Cusimano et al., 2017; Donnell et al., 2018). Furthermore, although the literature has been inconsistent, overall, there is evidence for a relationship between knowledge on underreporting intentions and behaviors (Garavito et al., 2020; Register-Mihalik et al., 2018). For example, Donnell et al. (2018) found that those who reported receiving concussion education were three times as likely to self-report intentions to report future concussions. This yields the first hypothesis (H1): Participants from higher SES backgrounds will tend to know more basic facts about concussions and knowing these facts will be associated with higher intentions to report future concussion symptoms.

Previous work dealing with sexually transmitted diseases suggests that SES is associated with safer attitudes, which in turn are associated with greater protective behaviors (Baker et al., 2011). In the context of concussions, a few studies have suggested a relationship between higher SES and safer concussion attitudes (Donnell et al., 2018; Lin et al., 2015), which is linked to greater reporting intentions (Kroshus et al., 2014; Register-Mihalik, Linnan, et al., 2013). Therefore, safer attitudes about concussions may provide another explanation as to how SES is related to reporting intentions. Thus, the second hypothesis (H2) is that participants from higher SES backgrounds will have safer attitudes about concussions and that having these attitudes will be associated with higher intentions to report future concussion symptoms.

As discussed, gist processing is generally an advanced form of risk reasoning that predicts safer intentions and behaviors in various health contexts (for a review see Blalock & Reyna, 2016). FTT does not inevitably predict risk avoidance but, rather, predicts that gist thinking reduces unhealthy decisions by capturing the essence of decision options and by helping people access their healthy values. According to FTT, adequate opportunity for enriching experiences facilitates developmentally advanced cognition—gist reasoning has been hypothesized not to be a function of age but of enriching experiences (Reyna et al., 2011; Reyna et al., 2014; Reyna & Farley, 2006). If cognitively enriching experiences are limited, then development of advanced reasoning will, theoretically, lag. Additionally, as mentioned earlier, there is growing evidence that low SES exacerbates stress. This stress delays cognitive development, particularly in areas such as decision making and memory (Kowalski & Vaught, 2003; McEwen, 2017), and would thus delay the developmental shift towards reliance on cognitively advanced gist processing (Reyna et al., 2015). Through a collection of interacting mechanisms to include among others, cognitive stimulation and stress, those from lower-SES environments may find it difficult to engage in healthy gist-based thinking. Findings from the work of Gamino and collaborators suggest that when compared with students with higher SES, lower SES students have lower gist reasoning (Gamino et al., 2014). Thus, the third hypothesis (H3) is that participants from higher SES backgrounds will show greater reliance on gist processing, which will in turn be associated with higher intentions to report future concussion symptoms. However, it is important to emphasize that our hypothesis is not that people from low SES environments are unable to use gist processing; we are instead predicting that, overall, people from low-SES environments will use gist processing to a lesser degree compared with their high-SES counterparts.

In addition, general intelligence is often related to SES such that lower parental education and fewer financial resources lead to lower cognitive stimulation, which results in lower IQ scores (Hackman et al., 2010; von Stumm & Plomin, 2015) and associated worse health outcomes (Eilertsen et al., 2016; Gottfredson, 2004; Rindermann et al., 2010; Singh-Manoux et al., 2005; Stelzl et al., 1995) (see also Mani et al., 2013). Numeracy has also been related to risk decision making (Blalock & Reyna, 2016; Låg et al., 2014; Reyna et al., 2009; Sinayev & Peters, 2015). Therefore, we also controlled for intelligence and numeracy in additional analyses. Taken together the prior evidence, three candidate mediators—concussion knowledge, concussion attitudes, and gist processing—are expected to explain the association between SES and concussion reporting intentions. Mediators are not thought to be mutually exclusive; however, analyzing mediators simultaneously affords the ability to compare their indirect effects and thereby relative contributions to the SES-reporting association (Hayes, 2018). It should be noted that race/ethnicity and SES are correlated in the United States (Kaufman & Cooper, 2001; Williams et al., 2010, 2016). Given the complex relations between these two constructs, we statistically controlled for race/ethnicity in the mediation analysis to determine unique contributions of SES. Although the likelihood of sustaining a concussion is high in sports, a concussion is possible outside of a sports context (Taylor et al., 2017). Additionally, the work of Foster and collaborators supports the hypothesis that both athletes and nonathletes develop cultures of concussion non-disclosure (Foster et al., 2019). Therefore, the present study included both athletes and nonathletes to provide a more inclusive perspective on the barriers and facilitators of concussion reporting. Finally, particularly for non-athletes, examining how participants assess the risk associated with, and process information regarding, concussion-prone sports has implications for public policy.

## 5 | METHOD

### 5.1 | Participants

Participants were recruited from across the United States in 16 states: Colorado, Connecticut, Illinois, Florida, Georgia, Maryland, Massachusetts, Minnesota, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, and Texas. Over 40 high schools and universities were contacted. To recruit athletes, we contacted coaches and athletic directors, who were able to give us access to recruit athletes directly (e.g., after practices). On average, about one quarter to one half of the teams we were given access to completed the study.

Participants were 1211 students (1079 college undergraduates and 132 high schoolers) from various states across the United States. Participants took part in the study for course credit (not available for high school students), monetary compensation, or on a volunteer basis. The mean age of college undergraduates was 19.79 (*SD* = 1.314) and for high schoolers 16.11 (*SD* = 1.357). The percentage of females was 69.1% in the college sample and 47.7% in the high school sample, and a sizeable number considered themselves athletes (46.3% and 79.5%, respectively). Among college undergraduates, the most common racial identity was Caucasian (50.4%), followed by

Asian (27.3%), Black/African American (13.1%), and Mixed/Other (9.1%). Hispanics made up 10.5%. Among high schoolers, the most common racial identity was Caucasian (50.0%), followed by Black/African American (22.7%), Mixed/Other (17.5%), and Asian (9.8%). Hispanics made up 30.3%. Participants who had received (or were receiving) a free/reduced lunch was, overall, $n$ = 276, 22.8%; college $n$ = 188, 17.4%; high school $n$ = 88, 66.7%). The Institutional Review Board of Cornell University approved the study. Participants under 18 years of age provided informed assent (and experimenters also obtained parental consent) whereas those 18 years of age or older provided informed consent.

## 5.2 | Measures

### 5.2.1 | Gist: categorical thinking

The Categorical Thinking scale assessed an individual's tendency to think categorically about risk. FTT postulates that more categorical thinking (e.g., comparing "some" risk to "no risk") as opposed to weighing objective values of risks and benefits will be associated with healthier decisions (Blalock & Reyna, 2016; Reyna et al., 2011). This scale consists of 25 items (e.g., "Playing football to the point of getting brain damage should be avoided at all costs; you just never want to go there") which participants rated on a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree" (see Table 1 for scoring and Supporting Information for items). Averaged higher scores indicate the greater tendency to think categorically about concussions. Items were drawn from research on concussion (Garavito et al., 2020) and adapted from other domains of risky decision making (e.g., Mills et al., 2008; Reyna, 2008; Reyna et al., 2011; Reyna & Mills, 2014).

### 5.2.2 | Gist principles

The Gist Principles scale consisted of 17 items that applied to simple, bottom-line values and principles about avoiding risks relevant to playing sports. For example, "I should avoid risk of concussions

**TABLE 1** Descriptive statistics and reliabilities of the major study variables

| | | | | | Score | | |
|---|---|---|---|---|---|---|---|
| Sample | Variable | M | SD | α | Theoretical | Observed | Skew |
| Overall ($n$ = 1211) | SES | 0.000 | 0.849 | 0.612 | N/A | −2.880–0.484 | −1.745 |
| | PE | 3.711 | 0.693 | N/A | 1–4 | 1.000–4.000 | −2.517 |
| | GPR | 0.000 | 1.000 | 0.916 | N/A | −3.154–2.819 | 0.177 |
| | CT | 2.682 | 0.501 | 0.881 | 0–4 | 1.320–4.000 | 0.144 |
| | GP | 2.549 | 0.517 | 0.829 | 0–4 | 0.760–3.880 | 0.087 |
| | CK | 16.881 | 2.213 | 0.685[a] | 0–19 | 4.000–19.000 | −1.850 |
| | CA | 58.625 | 7.791 | 0.831 | 15–75 | 36.000–75.000 | −0.220 |
| | ITR | 5.773 | 1.086 | 0.980 | 1–7 | 1.000–7.000 | −0.966 |
| College ($n$ = 1079) | SES | 0.000 | 0.835 | 0.567 | N/A | −3.40–0.41 | −2.188 |
| | PE | 3.785 | 0.603 | N/A | 1–4 | 1.000–4.000 | −3.069 |
| | GPR | 0.000 | 1.000 | 0.916 | N/A | −3.280–2.808 | 0.162 |
| | CT | 2.706 | 0.496 | 0.883 | 0–4 | 1.320–4.000 | 0.112 |
| | GP | 2.584 | 0.504 | 0.825 | 0–4 | 0.760–3.880 | 0.084 |
| | CK | 16.982 | 2.166 | 0.686[a] | 0–19 | 4.000–19.000 | −1.984 |
| | CA | 58.873 | 7.672 | 0.827 | 15–75 | 39.000–75.000 | −0.222 |
| | ITR | 5.807 | 1.065 | 0.980 | 1–7 | 1.000–7.000 | −0.993 |
| High school ($n$ = 132) | SES | 0.000 | 0.804 | 0.452 | N/A | −1.39–1.15 | 0.024 |
| | PE | 3.106 | 1.013 | N/A | 1–4 | 1.000–4.000 | −0.752 |
| | GPR | 0.000 | 1.000 | 0.897 | N/A | −2.016–2.960 | 0.578 |
| | CT | 2.483 | 0.501 | 0.851 | 0–4 | 1.440–3.720 | 0.518 |
| | GP | 2.259 | 0.528 | 0.806 | 0–4 | 1.180–3.820 | 0.463 |
| | CK | 16.053 | 2.419 | 0.650[a] | 0–19 | 8.000–19.000 | −1.144 |
| | CA | 56.599 | 8.465 | 0.848 | 15–75 | 36.000–75.000 | −0.092 |
| | ITR | 5.498 | 1.218 | 0.979 | 1–7 | 1.000–7.000 | −0.711 |

*Note*: CA, concussion attitudes; CK, concussion knowledge; CT, categorical thinking; GP, gist principles; GPR, gist processing; ITR, intentions to report concussion symptoms; PE, parental education; SES, socioeconomic status.
[a]Kuder-Richardson 20 (KR-20).

('getting your bell rung' or 'getting dinged')." The scale captures values that people retrieve and then apply to the representation of risky options to make decisions. The 5-point Likert response scale ranged from "Strongly Disagree" to "Strongly Agree" for each item (see Table 1 for scoring and Supporting Information for items; items were drawn from the sources indicated above). Averaged higher scores indicate greater endorsement of risk-avoidant values related to concussions.

#### 5.2.3 | Concussion reporting behavioral intentions

Symptom reporting intentions were assessed by querying intentions to report for each of the 22 symptoms listed in the Sport Concussion Assessment Tool-5th edition (Kroshus, Garnett, et al., 2015; McCrory et al., 2017). An example of an item from this scale is as follows: "In the future, I intend to report my symptoms if I sustain an impact that causes me to feel pressure in my head." Response options were provided on the 7-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree." Scoring can be found in Table 1. Higher averaged scores reflect higher intentions to report concussion symptoms.

#### 5.2.4 | Concussion knowledge

Rosenbaum and Arnett's (2010) Concussion Knowledge Index (CKI) was used to assess how much participants knew about concussion symptoms and post-concussion recovery. The validated 25-item scale contained three sections. The first section included 15 true/false items and assessed knowledge of the causes and consequences of a concussion (e.g., "There is a possibility of death if a second concussion occurs before the first one has healed"). The second section used three applied true/false items to assess knowledge of the causes and consequences of a concussion (e.g., "While playing in a game, Player Q and Player X collide with each other and each suffers a concussion. Player Q has never had a concussion in the past. Player X has had 4 concussions in the past. It is likely that Player Q's concussion will affect his long-term health and well-being"). The last section included a checklist in which participants needed to check off if they believed a symptom was likely to occur after suffering a concussion (e.g., "Think about someone who has had a concussion. Check off the following signs and symptoms that you believe someone may be likely to experience AFTER a concussion"). Items from the three subscales that were incorrectly answered received 0 points and those correctly answered received 1 point. Scores for each item were added such that higher scores were indicative of higher levels of concussion knowledge.

The original version of the CKI showed low reliability (*KR-20* = .445); accordingly, a modified version of the scale with higher reliability was used for all analyses. Items that lowered reliability of the CKI were removed. Our revised CKI had 19 of the 25 items and higher reliability (*KR-20* = .690); items used on the revised scale are presented in Appendix A.

#### 5.2.5 | Concussion attitudes

Rosenbaum and Arnett's (2010) Concussion Attitudes Index was used to assess participant's concussion attitudes. The scales assessed agreement/disagreement with a variety of concussion practices and policies implemented in sports. The validated 15-item scale contained two sections. The first section contained five items that were basic opinion items (e.g., "I feel that coaches need to be extremely cautious when determining whether an athlete should return to play"). The second section contained 10 items that were applied opinion items (e.g., "Athlete H suffered a concussion and he has a game in two hours. He is still experiencing symptoms of concussion. However, Athlete H knows that if he tells his coach about the symptoms, his coach will keep him out of the game. I feel that Athlete H should tell his coach about the symptoms"). Responses were rated on the 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree." Scoring can be found in Table 1. Higher scores represent agreement with recommended practices concerning concussions.

#### 5.2.6 | Athletic status

Self-reported athletic status was assessed with the item: "Are you a student-athlete?" Participants recorded their responses with the following options: "Yes," "No," and "I am not a student-athlete currently, but I used to be one." For a subset of analyses, those who identified themselves as currently or formerly a student-athlete were classified as an "athlete" (scored as 1) and those otherwise were classified as a "nonathlete" (scored as 0).

#### 5.2.7 | SES indices

Participants reported if they have ever received free/reduced lunch and the educational attainment of their parent(s) for a measurement of socioeconomic status. The Child Nutrition Programs run by the federal government offers free or reduced meals in schools throughout the United States if a household falls below an income threshold (Mirtcheva & Powell, 2009). As the federal income poverty guidelines are adjusted based on household size, eligibility for free or reduced lunch is also adjusted. Receiving free/reduced lunch (0 = yes; 1 = no, so that higher SES is scored as higher) can be a useful and reliable proxy for household income, which is not only likely to be unknown by adolescents but could be misreported (Ensminger et al., 2000; Moore et al., 2000; Nicholson et al., 2014). The educational attainment of parent(s) was reported in four categories: 1 = less than high school, 2 = completed high school or equivalent, 3 = some college after high school, and 4 = 4-year degree or more. Parental education was computed as the highest level of education from either parent. Aligned with prior research, a composite indicator of SES was created by averaging the standardized values (*z* scores) of the two indices—free/reduced lunch status and parental education—for each individual (Gianaros et al., 2007; Swartz et al., 2017). Characteristics for the raw scores for parental education and SES measure can be found in Table 1.

### 5.3 | Analytical plan

All measures were correlated with each other to determine significant associations. To limit multicollinearity and confirm that the categorical thinking and gist principles measures group together in theoretically sensible ways per FTT, we then performed a principal component analysis with orthogonal rotation (varimax) using the full sample (both high school and college subsamples). Only the two gist measures—categorical thinking and gist principles—were entered into the analysis, and the two gist measures loaded highly on one factor for the overall, college, and high school samples tested (see Supporting Information). The extracted gist factor score for each participant—gist processing—was used in the mediation analysis. Perceived risks and benefits were also included in additional bivariate correlations (see Supporting Information).

Also, demographic variables were included as covariates in subsequent analyses: sex, race/ethnicity (see below), and age in overall analyses. An independent-groups *t* test was used to examine differences in SES scores between race/ethnicity groups to confirm its inclusion as a covariate. Based on the frequencies of self-reported demographics, race/ethnicity was coded as 0 for White Non-Hispanic and 1 for non-White and/or Hispanic. Prior empirical work suggests that athletes are more willing to expose themselves to a high probability of concussion risk compared with nonathletes (Garavito et al., 2019). Further, the work of Geisner and collaborators has shown associations between athletic involvement and increased incidence of risky health-related behaviors (Geisner et al., 2012). Given these findings, mediation models were run separately for athletes and nonathletes in addition to the overall sample. The SPSS macro program developed by Preacher and Hayes (Hayes, 2018) was then used to test the significance of indirect effects through the three-candidate mediators. Briefly, the indirect effect assesses the extent to which the total effect of the predictor on the outcome variable is significantly reduced when adding potential mediators to the model (Hayes, 2018). We tested mediators simultaneously by calculating 95% confidence intervals (CIs) with 5000 resamples. An effect is significant when the CI does not include zero. Compared to other statistical methods, indirect effects that are completely standardized allow for comparison across situations using different metrics for independent and dependent variables (Preacher & Kelley, 2011). We report complete standardized indirect effects in addition to standardized regression coefficients.

## 6 | RESULTS

### 6.1 | Zero-order correlations and between-groups *t* tests

As predicted, parental education and free/reduced lunch variables were found to correlate significantly with each other in the overall ($r$ = .441, $p$ < .001), college ($r$ = .395, $p$ < .001), and high school samples ($r$ = .292, $p$ < .001). As expected, in the overall sample, non-Whites/Hispanics had significantly lower SES composite scores ($M$ = −.20, $SD$ = .97) than White non-Hispanics ($M$ = .26, $SD$ = .56); $t$(1121.073) = 10.412, $p$ < .001. Similar differences were found in the college, $t$(873.893) = 9.916, $p$ < .001, and high school, $t$(130) = 3.638, $p$ < .001, samples.

### 6.2 | Relationships between gist scales: principal component analysis with orthogonal rotation

As per FTT, categorical thinking and gist principles scales loaded onto a single component with an eigenvalue greater than 1 for the overall, high school, and college samples. With factor loadings greater than .9 for the two measures, the extracted factor explained roughly 85% of the total variance in all three samples. The theoretically predicted grouping (gist processing) emerged from the principal component analysis, but the result that gist measures share variance makes sense theoretically and generally agrees with prior empirical evidence (Mills et al., 2008). Higher scores on gist processing indicate the ability to draw on less precise mental representations and to apply simple gist values that encourage healthy decision making. The Cronbach's alpha for all items used to create the two gist measures was very high suggesting that the extracted factor has high reliability (see Table 1).

### 6.3 | Model results: relationships between SES, mediators, and concussion reporting intentions for overall, college, and high school samples

Figure 1 shows the estimates of the unadjusted and adjusted total and indirect effects between SES and intentions among overall, college, and high school participants, respectively, including the three hypothesized mediating variables. Higher SES was associated with increases in the likelihood of having higher intentions in all three samples (total effect). When including covariates, the total effect of SES remained significant for the overall and high school groups but dropped slightly for the college group becoming nonsignificant. To understand the mediating roles of concussion knowledge, concussion attitudes, and gist processing, we first examined the distal links in H1, H2, and H3: for the overall sample, higher SES was significantly associated with greater knowledge, safer attitudes, and more gist processing (panel a). Similar results were seen in the college sample (panel c). Among high schoolers, SES did not significantly predict gist processing; however, the relationships between SES and the other two mediators were significant (panel e). The same mediators were significant when including covariates (panels b, d, and f).

Next, proximal links of the H1, H2, and H3 were examined. All three mediators predicted intentions for the overall and college samples. Although gist processing and attitudes were also significant for high schoolers, knowledge was insignificant though identical in magnitude (.11 for panels a, c, and e). When including covariates, this nonsignificant relationship between concussion knowledge and intentions

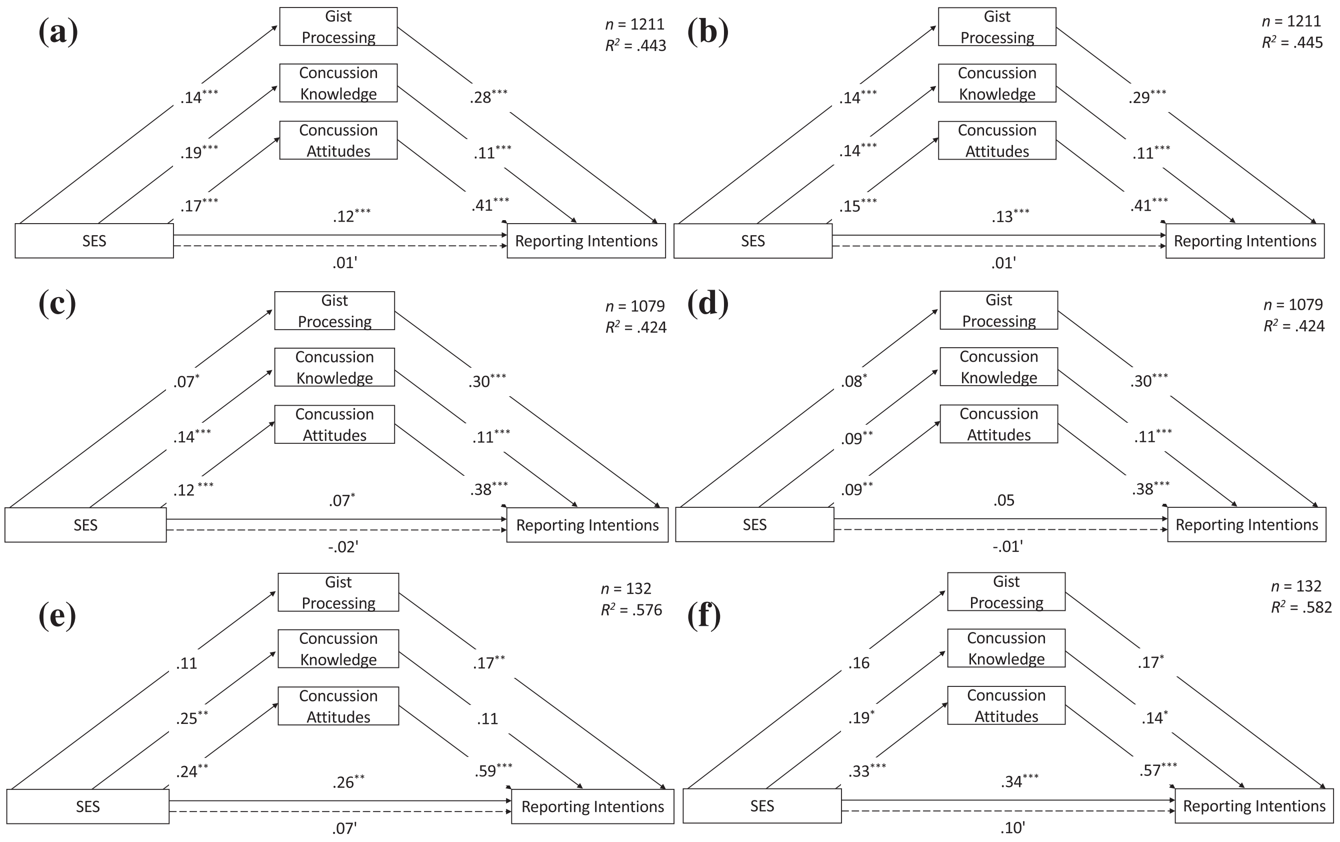


**FIGURE 1** Panels show mediation models with those on the left being unadjusted and those on the right being adjusted. We tested three groups: (a, b) overall; (c, d) those in college; and (e, f) high schoolers. The solid line between SES and reporting intentions represents the total association. The dotted line represents the direct association. R2 is the total amount of variance accounted for by the model. Race/ethnicity and sex were included as covariates in panels b, d, and f. Age (years) was included as a covariate in panel b. **p* < .05; ***p* < .01; ****p* < .001

became significant for high schoolers (panel f). Again, relationships were similar when covariates were included (panels b, d, and f).

## 6.4 | Model results: relationships between SES, mediators, and concussion reporting intentions for overall athletes, college athletes, and high school athletes

For all athlete groups, models are presented in Figure 2. The total effect (between SES and intentions) was significant for athletes overall and high school athletes but not college athletes (panels a, c, and e). Relationships were generally similar controlling for covariates, though some effects became nonsignificant (panels b, d, and f). Of note, the total effect among athletes in high school was relatively high. For athletes overall, all of the distal and proximal relationships were significant with and without controlling for covariates (panels a and b). When athletes were broken down into further subgroups, some relationships became nonsignificant. However, the magnitudes of nonsignificant coefficients were similar across college and high school samples (compare panels c to e and d to f).

## 6.5 | Model results: relationships between SES, mediators, and concussion reporting intentions for overall nonathletes and college nonathletes

Analyses for nonathletes were conducted to determine whether results were similar to those of athletes. Given the small sample size for high school nonathletes, separate models were not created for this subgroup (Fritz & MacKinnon, 2007). Thus, Figure 3 shows the model estimates for overall nonathletes and college nonathletes. A significant total effect was seen in the overall nonathlete sample (panel a) but not for college nonathletes (panel c). Among nonathletes overall, the relationship between SES and intentions to report was mediated by knowledge, attitudes, and gist processing regardless of the inclusion of covariates (the latter, panels b and d). Thus, hypotheses H1, H2, and H3 were supported.

For the subgroup of college nonathletes, all links in the pathways for knowledge and attitudes (distal and proximal) were significant (Figure 3c,d). However, SES was not significantly associated with gist processing. However, gist processing was still a significant proximal predictor of a nonathlete's intentions to report. Results did not change when covariates were included.

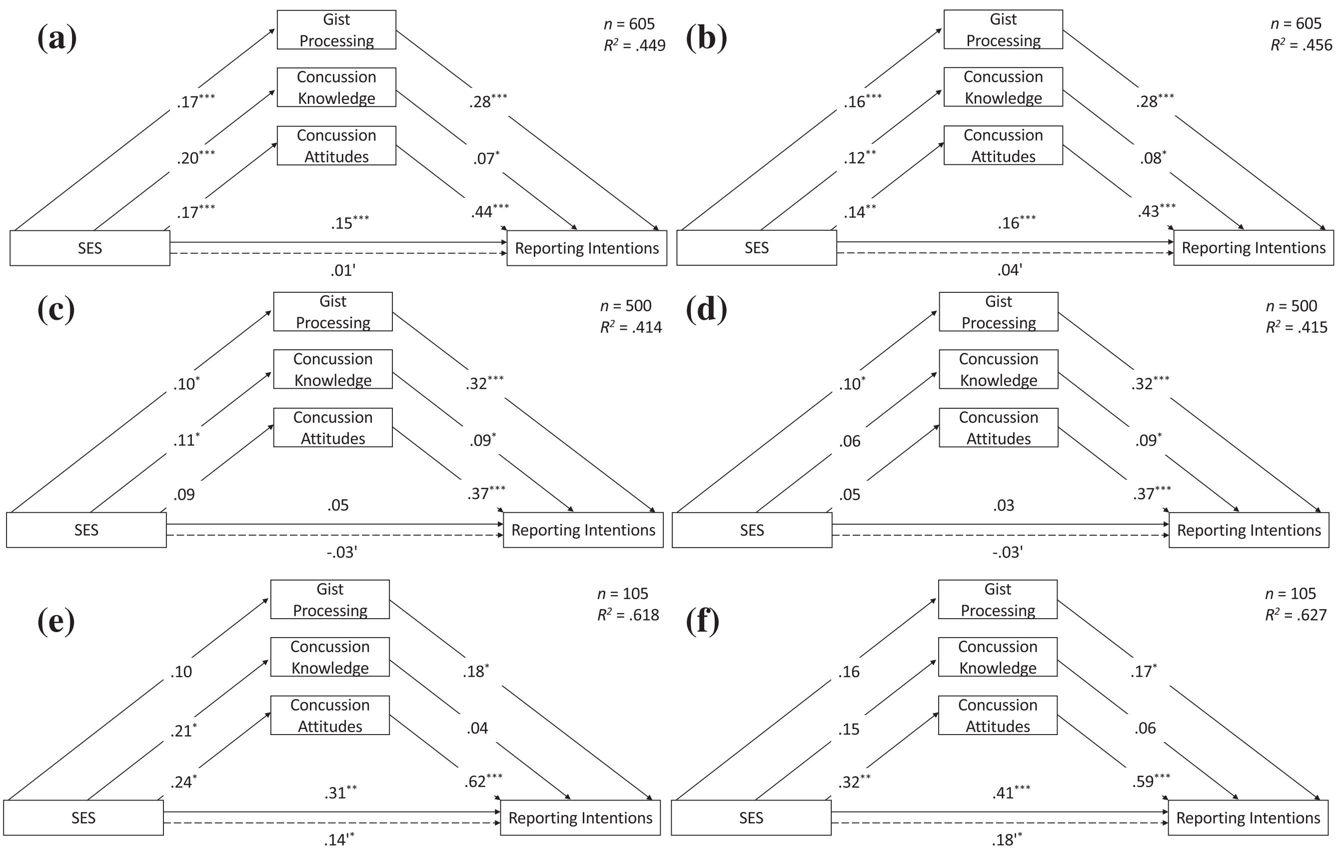


**FIGURE 2** Panels show mediation models with those on the left being unadjusted and those on the right being adjusted. We tested three groups: (a, b) overall athletes; (c, d) college athletes; and (e, f) high school athletes. The solid line between SES and reporting intentions represents the total association. The dotted line represents the direct association. $R^2$ is the total amount of variance accounted for by the model. Race/ethnicity and sex were included as covariates in panels b, d, and f. Age (years) was included as a covariate in panel b. **p* < .05; ***p* < .01; ****p* < .001

### 6.6 | Additional analyses

Standardized indirect effects for all models, with and without covariates, are displayed in Table 2. The results with the standardized indirect effects demonstrate similar significant results as displayed in Figures 1–3, described in detail above, with only two exceptions: without controlling for covariates, concussion knowledge did not significantly mediate the effect of SES on intentions to report for athletes overall nor for college athletes. When controlling for covariates, however, the indirect effect of knowledge reached significance in both athletes and college athletes. All other effects mirrored those described above.

In an overall analysis of the entire sample, all indirect pathways between SES and intentions to report remained significant controlling for an additional cognitive factor consisting of intelligence (as measured by the Ravens Progressive Matrices; Arthur & Day, 1994) and numeracy (as measured by the Objective Numeracy scale; Peters et al., 2006). The path between SES and gist processing remained significant in athletes (.09), as did the path from gist processing to intentions (.36), but the path from SES to gist processing was not significant in nonathletes (.03) although the gist processing to intentions path was significant (.28). However, the direct path between SES and intentions to report was not significant in these analyses once this additional cognitive factor was included; hence, these results are not reported in further detail.

In supplemental analyses on perceived risks and benefits of sports, there were no significant correlations between perceived benefits and gist processing (or its components), all *p*s > .05 (see Supporting Information). SES was significantly correlated with perceived benefits only for high school athletes, $r = .20$, $p < .05$, but disconfirmed the hypothesis that low SES students perceived greater benefits from athletic participation. In fact, there were generally no significant correlations except one result showed the opposite: higher SES students perceived greater benefits of participating in sports.

## 7 | DISCUSSION

We developed and tested a model of direct and indirect influences that links SES, psychological mediators, and concussion-reporting intentions. Overall, for each of the two age groups (adolescents in

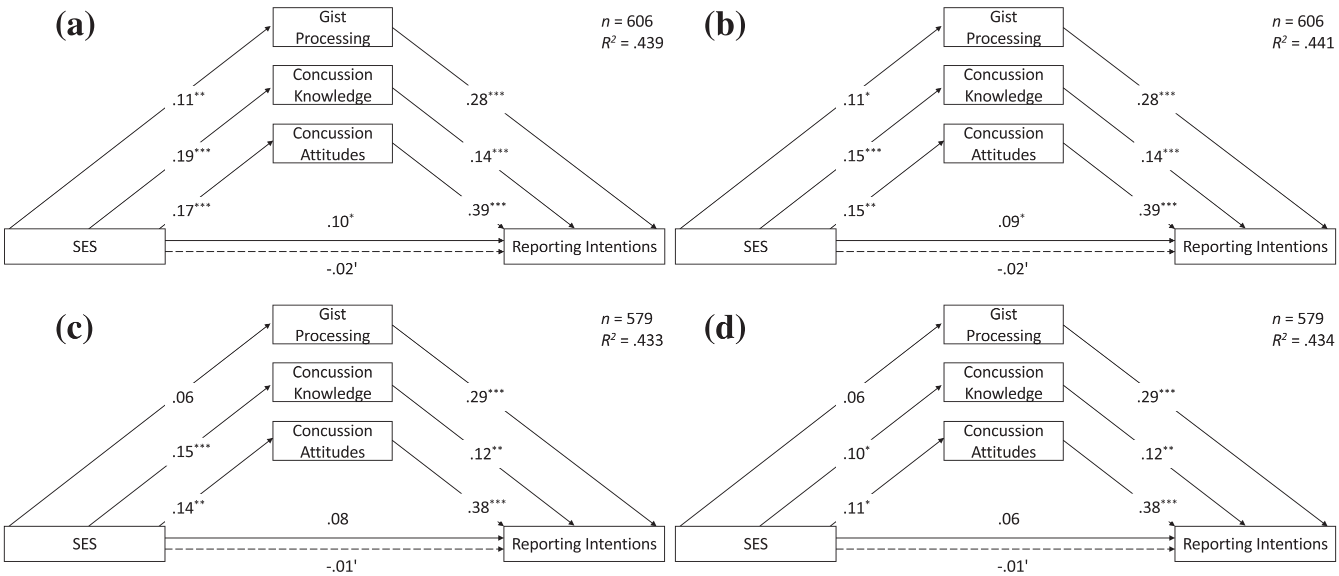


**FIGURE 3** Panels show mediation models with those on the left being unadjusted and those on the right being adjusted. We tested two groups: (a, b) overall nonathletes and (c, d) college nonathletes. The number of high school nonathletes was not sufficient to test the models. The solid line between SES and reporting intentions represents the total association. The dotted line represents the direct association. $R^2$ is the total amount of variance accounted for by the model. Race/ethnicity and sex were included as covariates in panels b and d. Age (years) was included as a covariate in panel b. **p* < .05; ***p* < .01; ****p* < .001

high school and young adults in college), and for athletes as well as nonathletes, SES was associated with reporting intentions, and this association was fully mediated by the three psychological predictors we tested: gist processing, concussion knowledge, and concussion attitudes. Furthermore, all of the distal and proximal pathways in the model were significant in these groups (Figures 1a,c, 2a, and 3a) with the exception of the high-school students whose qualitative findings, nevertheless, were similar to those of the other groups. These results were similar with and without controlling for covariates. In particular, the overall results shown in Figure 1b were robust controlling for sex, race/ethnicity, and age.

To our knowledge, this is the first study positing and demonstrating a link between SES and reporting intentions. We hypothesized this connection because of putative effects of SES on cognitive development, namely, on gist processing. Specifically, we conceptualized not reporting concussions as a risky decision, on analogy with other risky decisions made by adolescents and young adults (e.g., Reyna et al., 2015). Based on FTT, categorical gist processing and gist principles of risk avoidance are predicted to develop with experience from childhood through adulthood and to promote healthy decision making. Low SES, we hypothesized, offers fewer opportunities for enriching experiences, on the one hand, and greater exposure to stressors, on the other hand, delaying cognitive development (Amso & Lynn, 2017; Kowalski & Vaught, 2003; McEwen, 2017). Consistent with this hypothesis, Gamino et al. (2014) have documented SES differences in gist processing. Therefore, we expected that SES operating through gist processing, such as the categorical insight that a concussion can produce life-altering brain damage, would be associated with higher reporting intentions.

We also expected that concussion knowledge and attitudes would have positive relationships with reporting intentions that were distinct from those of gist processing, which were found. These predictions were based on the relevant literature on FTT, which has found that attitudes, knowledge, and gist processing, while not unrelated, are distinct theoretically (e.g., Cho, You, & Choi, 2018; Reyna, 2020). Regarding proximal relationships with intentions, as per prior work, concussion knowledge and concussion attitudes predicted reporting intentions in expected directions (Kroshus et al., 2014; Register-Mihalik, Guskiewicz, et al., 2013). Regarding distal relationships between SES and knowledge, our findings again echo prior work (Cusimano et al., 2017; Donnell et al., 2018), but we extend the finding across age groups. With respect to the link between SES and concussion attitudes, our findings are consistent with prior research (Donnell et al., 2018; Lin et al., 2015) and with those in other domains, such as risk attitudes toward sexually transmitted diseases and increased likelihood of protective behaviors (Baker et al., 2011; Donnell et al., 2018; Register-Mihalik, Guskiewicz, et al., 2013). A strength of this work is the integration of these variables in a theoretically motivated model.

We should underline that not all pathways in the models were significant when groups were further disaggregated into subgroups, such as college athletes or college nonathletes, and for the smaller sample of high school students and high school athletes. However, results were robust controlling for age in years for the overall analysis (Figure 1b), for athletes overall (Figure 2b), and for nonathletes overall (Figure 3b). Therefore, considering the results as a whole, there is evidence for the hypothesized distal and proximal relationships across age from adolescence to young adulthood and in both athletes and

**TABLE 2** Completely standardized indirect effects of SES on concussion reporting intentions

| Sample | Covariates | Mediator | β | *SE* | 95% CI *LL* | 95% CI *UL* |
|---|---|---|---|---|---|---|
| Overall (*n* = 1211) | No | GPR | .040* | .009 | .024 | .058 |
| | | CK | .020* | .006 | .010 | .033 |
| | | CA | .068* | .014 | .042 | .095 |
| | Yes | GPR | .039* | .009 | .022 | .057 |
| | | CK | .016* | .005 | .007 | .027 |
| | | CA | .062* | .014 | .035 | .090 |
| College (*n* = 1079) | No | GPR | .022* | .009 | .004 | .041 |
| | | CK | .015* | .005 | .006 | .027 |
| | | CA | .045* | .013 | .021 | .071 |
| | Yes | GPR | .023* | .010 | .004 | .043 |
| | | CK | .010* | .005 | .002 | .020 |
| | | CA | .034* | .013 | .009 | .059 |
| High school (*n* = 132) | No | GPR | .019 | .016 | −.007 | .056 |
| | | CK | .028 | .021 | −.008 | .074 |
| | | CA | .145* | .049 | .050 | .242 |
| | Yes | GPR | .027 | .018 | −.001 | .070 |
| | | CK | .027 | .020 | −.004 | .072 |
| | | CA | .189* | .054 | .083 | .296 |
| Athlete (*n* = 605) | No | GPR | .049* | .012 | .027 | .074 |
| | | CK | .014 | .008 | .000 | .030 |
| | | CA | .073* | .021 | .032 | .117 |
| | Yes | GPR | .046* | .013 | .023 | .073 |
| | | CK | .010* | .006 | .001 | .023 |
| | | CA | .061* | .023 | .019 | .108 |
| College athlete (*n* = 505) | No | GPR | .032* | .014 | .007 | .059 |
| | | CK | .010 | .007 | .000 | .025 |
| | | CA | .032 | .018 | −.003 | .069 |
| | Yes | GPR | .031* | .014 | .004 | .059 |
| | | CK | .006 | .006 | −.003 | .018 |
| | | CA | .017 | .018 | −.019 | .054 |
| High school athlete (*n* = 105) | No | GPR | .018 | .017 | −.012 | .056 |
| | | CK | .007 | .014 | −.017 | .041 |
| | | CA | .146* | .059 | .027 | .263 |
| | Yes | GPR | .028 | .020 | −.003 | .072 |
| | | CK | .009 | .015 | −.010 | .048 |
| | | CA | .190* | .062 | .067 | .312 |
| Nonathlete (*n* = 606) | No | GPR | .030* | .012 | .007 | .054 |
| | | CK | .026* | .010 | .010 | .048 |
| | | CA | .064* | .017 | .033 | .101 |
| | Yes | GPR | .031* | .013 | .008 | .059 |
| | | CK | .022* | .009 | .007 | .042 |
| | | CA | .056* | .017 | .024 | .093 |
| College nonathlete (*n* = 579) | No | GPR | .018 | .012 | −.006 | .043 |
| | | CK | .018* | .008 | .005 | .036 |
| | | CA | .053* | .016 | .023 | .087 |

(Continues)

**TABLE 2** (Continued)

| Sample | Covariates | Mediator | β | *SE* | 95% CI *LL* | 95% CI *UL* |
|---|---|---|---|---|---|---|
| | Yes | GPR | .019 | .014 | −.007 | .047 |
| | | CK | .012* | .007 | .001 | .028 |
| | | CA | .041* | .017 | .010 | .076 |

Abbreviations: CA, concussion attitudes; CI, confidence interval; CK, concussion knowledge; GPR, gist processing; *LL*, lower limit; *UL*, upper limit.
*Note*: *SE* and 95% CI were estimated using bootstrapping with $n = 5000$ resamples. Race/ethnicity, sex, and age (years) were included as covariates for the overall, nonathlete, and athlete subsamples (if specified). Age was not a covariate for either high school, high school athlete, and college subsamples.
*$p < .05$.

nonathletes. In fact, bivariate correlations showed a significant positive relationship between age and gist processing in the overall sample (see Supporting Information). Additionally, previous work using these FTT measures have found developmental differences supporting a cognitive developmental interpretation of these measures (Garavito et al., 2020). However, although we hypothesize that both age and SES are related to variables that affect the development of gist processing (e.g., exposure to enriching experiences), we did not find that a developmental trend was observed for high SES but not for low SES participants, as might be expected from some versions of our hypothesis. However, we should clarify that our hypothesized developmental differences could be manifested: (a) early in development but then be carried over through adolescence and young adulthood (producing significant differences for each age group, as we observed); (b) as cognitive underdevelopment among those low in SES but normative development for those high in SES in both adolescence and young adulthood (also consistent with our observations); (c) as both cognitive enrichment among those higher in SES and underdevelopment among those lower in SES manifested in both adolescence and young adulthood (again consistent with our observations). Note that development does not have to be flat for any group under any hypothesis because we do not claim that SES is the only factor that affects cognitive development, which means that our hypotheses are consistent with a variety of monotonic patterns (some of which we have spelled out). We also do not claim that underdevelopment is an immutable trait; underdevelopment could be reversible at any stage of life. Our results support the conclusion that, overall, people from low SES environments use developmentally advanced gist processing to a lesser degree compared with those from high-SES environments. Although these results support the hypothesis of a developmental delay, we are not claiming that there is an inability to use gist processing in those from low SES environments. Future studies examining the interaction between SES and developmental trends in gist processing across a wider age range and SES range would be worthwhile to test alternative hypotheses about the nature of developmental changes. The impact of SES on gist processing might change as people age. Nevertheless, the evidence presented in this study is consistent with the hypothesis that gist processing, knowledge, and attitudes reflect influences of SES, which in turn influence intentions to report concussions across groups. Demonstrating the generality of findings for athletes and nonathletes is important because not all concussions occur in the context of sports (Faul et al., 2010; Haarbauer-Krupa et al., 2018; Taylor et al., 2017), though the risk of repetitive brain injury is relatively high in contact sports.

We should also point out that the size of the total effect linking SES and intentions to report was generally small, which makes sense given the broad effects of SES and the presence of many other factors in an individual's life; the largest relationships were observed for high school students (Figure 1e,f) and high school athletes (Figure 2e,f). Indeed, coefficients reflecting proximal effects related to psychological predictors were often larger than those reflecting distal effects related to SES. Among other factors, individuals may experience direct pressure not to report concussions, thereby decreasing intentions (see Garavito et al., 2020).

It is important to note that we are not claiming that other aspects of SES do not influence a person's intentions to report concussion symptoms. This balance may be particularly important when individuals (especially adolescents) are relying more on more precise (toward verbatim) processing, which encourages trading off risks and benefits (Reyna & Farley, 2006).

An additional limitation of this study is a cross-sectional and correlational design, ultimately precluding causal inferences (Agler & Boeck, 2017). Although gist processing (as well as knowledge and attitudes) have been shown to affect self-reported risk taking in other domains using experimental designs (e.g., Blalock & Reyna, 2016; Reyna & Mills, 2014), such a causal link has not been established for concussions. Gist processing would be expected to be helpful even in the common context of high arousal accompanying playing sports (Chinn & Porter, 2016; Kroshus, Garnett, et al., 2015) because such thinking is resistant to effects of emotion and stress (Rivers et al., 2008). The concept of gist processing might also apply to thinking such as "No pain, no gain" or "You have to do what it takes to be a champion" or "The Team, the Team, the Team!"—although some of these might refer more to gist representations of values rather than to categorical thinking per se. Nevertheless, in the athletics world, these kinds of categories—as opposed to detailed cost–benefit analyses—might be causing some athletes to underreport. That is, although prior research has suggested that thinking about unhealthy risks progresses from more precise to more gist-based, reducing unhealthy risk-taking, some gist representations might promote risk-taking. For example, prior research indicated that, in the context of sexually transmitted infections, people inappropriately generalized the wrong gist about condoms' effectiveness against fluid-borne disease to diseases that are transferred skin-to-skin (Reyna & Adam, 2003).

Another limitation of the present work is the relatively limited range of SES; the high school sample was more diverse in SES than the college sample, although both encompassed a range of backgrounds, including students from disadvantaged backgrounds receiving full financial aid. Compared with the full range of SES conditions in the United States, however, there were fewer participants classified as low SES in the present study. Consequently, this may have reduced our power to detect significant effects that we may have otherwise seen in subgroups. In addition, behavioral intentions, rather than actual behavior, was used as the outcome variable. However, as in many behavioral domains, intentions to report concussions tend to predict reporting behavior (Kroshus, Baugh, et al., 2015).

In summary, our results are well-aligned with research showing links among SES, cognitive functioning, and health outcomes (Adler & Rehkopf, 2008; Duncan & Magnuson, 2012; Raizada & Kishiyama, 2010). To our knowledge, the current study is the first to detail an association between SES and concussion reporting intentions, approaching the latter as a risky decision. Building on FTT and prior research on concussion reporting, findings are consistent with the hypotheses that concussion knowledge, concussion attitudes, and gist processing are distinct and explain how being socioeconomically disadvantaged compromises reporting intentions. Although SES is related to knowledge, knowledge is not sufficient in explaining the link between SES and intention; the effects of SES go beyond educational opportunities to accumulate health facts, though such knowledge is important. Gist processing matters for health not because of specific knowledge or attitudes alone, but rather because it is a way of thinking about risk that promotes healthy decisions. Our findings add explanatory and theoretically motivated mechanisms to a large literature demonstrating how those higher in SES are on a developmental pathway that promotes favorable health outcomes.

## ACKNOWLEDGEMENTS

Support was provided by a grant from Engaged Cornell and the Office of Engagement Initiatives at Cornell University. We gratefully acknowledge support in part by grants from the National Institutes of Health (National Institute of Nursing Research R21NR016905 and R01NR014368) and the National Institute of Food and Agriculture (NYC-321407).

## CONFLICT OF INTEREST

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.

## ORCID

*Peter T. Ajayi* https://orcid.org/0000-0002-2378-5758
*David M.N. Garavito* https://orcid.org/0000-0003-4903-9486
*Valerie F. Reyna* https://orcid.org/0000-0003-2851-5797

## REFERENCES

Adler, N. E., & Rehkopf, D. H. (2008). U.S. disparities in health: Descriptions, causes, and mechanisms. *Annual Review of Public Health*, *29*(1), 235–252. https://doi.org/10.1146/annurev.publhealth.29.020907.090852

Agler, R., & Boeck, P. D. (2017). On the interpretation and use of mediation: Multiple perspectives on mediation analysis. *Frontiers in Psychology*, *8*(1984), 1–11. https://doi.org/10.3389/fpsyg.2017.01984

Amso, D., & Lynn, A. (2017). Distinctive mechanisms of adversity and socioeconomic inequality in child development: A review and recommendations for evidence-based policy. *Policy Insights from the Behavioral and Brain Sciences*, *4*(2), 139–146. https://doi.org/10.1177/2372732217721933

Anderson, V., Brown, S., Newitt, H., & Hoile, H. (2011). Long-term outcome from childhood traumatic brain injury: Intellectual ability, personality, and quality of life. *Neuropsychology*, *25*(2), 176–184. https://doi.org/10.1037/a0021217

Arthur, W., & Day, D. V. (1994). Development of a short form for the Raven Advanced Progressive Matrices Test. *Educational and Psychological Measurement*, *54*(2), 394–403. https://doi.org/10.1177/0013164494054002013

Baker, D. P., Leon, J., & Collins, J. M. (2011). Facts, attitudes, and health reasoning about HIV and AIDS: Explaining the education effect on condom use among adults in sub-Saharan Africa. *AIDS and Behavior*, *15*(7), 1319–1327. https://doi.org/10.1007/s10461-010-9717-9

Blalock, S. J., & Reyna, V. F. (2016). Using fuzzy-trace theory to understand and improve health judgments, decisions, and behaviors: A literature review. *Health Psychology*, *35*(8), 781–792. https://doi.org/10.1037/hea0000384

Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual Review of Psychology*, *53*, 371–399. https://doi.org/10.1146/annurev.psych.53.100901.135233

Broglio, S. P., & Puetz, T. W. (2008). The effect of sport concussion on neurocognitive function, self-report symptoms and postural control: A meta-analysis. *Sports Medicine*, *38*(1), 53–67. https://doi.org/10.2165/00007256-200838010-00005

Chandran, A., Nedimyer, A. K., Kerr, Z. Y., O'Neal, C., Mensch, J., & Yeargin, S. W. (2020). Concussion knowledge, attitudes, and self-reporting intentions in youth athletes. *Journal of Athletic Training*, *55*(10), 1027–1034. https://doi.org/10.4085/1062-6050-232-19

Chinn, N. R., & Porter, P. (2016). Concussion reporting behaviours of community college student-athletes and limits of transferring concussion knowledge during the stress of competition. *BMJ Open Sport & Exercise Medicine*, *2*(1), 1–8. https://doi.org/10.1136/bmjsem-2016-000118

Cho, Y. H., You, M., & Choi, H. (2018). Gist-based design of graphics to reduce caffeine consumption among adolescents. *Health Education Journal*, *77*(7), 778–790. https://doi.org/10.1177/0017896918765024

Covassin, T., & Elbin, R. J. (2010). The cognitive effects and decrements following concussion. *Open Access Journal of Sports Medicine*, 55–61. https://doi.org/10.2147/oajsm.s6919

Cusimano, M. D., Zhang, S., Topolovec-Vranic, J., Hutchison, M. G., & Jing, R. (2017). Factors affecting the concussion knowledge of athletes, parents, coaches, and medical professionals. *SAGE Open Medicine*, *5*, 1–9. https://doi.org/10.1177/2050312117694794

Donnell, Z., Hoffman, R., Sarmiento, K., & Hays, C. (2018). Concussion attitudes, behaviors, and education among youth ages 12–17: Results from the 2014 YouthStyles survey. *Journal of Safety Research*, *64*, 163–169. https://doi.org/10.1016/j.jsr.2017.12.001

Duncan, G. J., & Magnuson, K. (2012). Socioeconomic status and cognitive functioning: Moving from correlation to causation. *Wiley Interdisciplinary Reviews: Cognitive Science*, *3*, 377–386. https://doi.org/10.1002/wcs.1176

Eilertsen, T., Thorsen, A. L., Holm, S. E. H., Bøe, T., Sørensen, L., & Lundervold, A. J. (2016). Parental socioeconomic status and child intellectual functioning in a Norwegian sample. *Scandinavian Journal of Psychology*, *57*(5), 399–405. https://doi.org/10.1111/sjop.12324

Ensminger, M. E., Forrest, C. B., Riley, A. W., Kang, M., Green, B. F., Starfield, B., & Ryan, S. A. (2000). The validity of measures of socioeconomic status of adolescents. *Journal of Adolescent Research*, *15*(3), 392–419. https://doi.org/10.1177/0743558400153005

Evans, G. W., & Kim, P. (2010). Multiple risk exposure as a potential explanatory mechanism for the socioeconomic status-health gradient. In *Annals of the New York Academy of Sciences* (Vol. 1186) (pp. 174–189). Blackwell Publishing Inc. https://doi.org/10.1111/j.1749-6632.2009.05336.x

Evans, G. W., & Kim, P. (2013). Childhood poverty, chronic stress, self-regulation, and coping. *Child Development Perspectives*, *7*(1), 43–48. https://doi.org/10.1111/cdep.12013

Faden, A. I., & Loane, D. J. (2015). Chronic neurodegeneration after traumatic brain injury: Alzheimer disease, chronic traumatic encephalopathy, or persistent neuroinflammation? *Neurotherapeutics*, *12*, 143–150. https://doi.org/10.1007/s13311-014-0319-5

Faul, M., Xu, L., Wald, M. M., & Coronado, V. G. (2010). *Traumatic brain injury in the United States: Emergency department visits, hospitalizations and deaths 2002–2006*. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. https://www.cdc.gov/traumaticbraininjury/tbi_ed.html

Foster, C. A., D'Lauro, C., & Johnson, B. R. (2019). Pilots and athletes: Different concerns, similar concussion non-disclosure. *PLoS One*, *14*(5), 1–19. https://doi.org/10.1371/journal.pone.0215030

Frieden, T. R., Houry, D., & Baldwin, G. (2014). Report to congress on traumatic brain injury in the United States: Epidemiology and rehabilitation. In *National Center for Injury Prevention and Control*. Division of Unintentional Injury Prevention. https://www.cdc.gov/traumaticbraininjury/pubs/congress_epi_rehab.html

Fritz, M. S., & MacKinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychological Science*, *18*(3), 233–239. https://doi.org/10.1111/j.1467-9280.2007.01882.x

Fujita, K., & Han, H. A. (2009). Moving beyond deliberative control of impulses: The effect of construal levels on evaluative associations in self-control conflicts. *Psychological Science*, *20*(7), 799–804. https://doi.org/10.1111/j.1467-9280.2009.02372.x

Gamino, J. F., Motes, M. M., Riddle, R., Reid Lyon, G., Spence, J. S., & Chapman, S. B. (2014). Enhancing inferential abilities in adolescence: New hope for students in poverty. *Frontiers in Human Neuroscience*, *8*(924), 1–12. https://doi.org/10.3389/fnhum.2014.00924

Garavito, D. M. N., Reyna, V. F., & DeTello, J. E. (2019). A concussion by any other name: Differences in willingness to risk brain injury by label and level of participation in high-school and college sports. *Applied Cognitive Psychology*, *33*(4), 646–654. https://doi.org/10.1002/acp.3481

Garavito, D. M. N., Reyna, V. F., DeTello, J. E., Landow, B. R., Tarpinian, L. M. (2020). Intentions to report concussion symptoms in nonprofessional athletes: A fuzzy-trace theory approach [Manuscript submitted for publication].

Gardner, R. C., & Yaffe, K. (2015). Epidemiology of mild traumatic brain injury and neurodegenerative disease. *Molecular and Cellular Neuroscience*, *66*, 75–80. https://doi.org/10.1016/j.mcn.2015.03.001

Geisner, I. M., Grossbard, J., Tollison, S., & Larimer, M. E. (2012). Differences between athletes and non-athletes in risk and health behaviors in graduating high school seniors. *Journal of Child and Adolescent Substance Abuse*, *21*, 156–166. https://doi.org/10.1080/1067828X.2012.662433

Gerberich, S. G., Priest, J. D., Boen, J. R., Straub, C. P., & Maxwell, R. E. (1983). Concussion incidences and severity in secondary school varsity football players. *American Journal of Public Health*, *73*(12), 1370–1375. https://doi.org/10.2105/AJPH.73.12.1370

Gianaros, P. J., Horenstein, J. A., Cohen, S., Matthews, K. A., Brown, S. M., Flory, J. D., Critchley, H. D., Manuck, S. B., & Hariri, A. R. (2007). Perigenual anterior cingulate morphology covaries with perceived social standing. *Social Cognitive and Affective Neuroscience*, *2*(3), 161–173. https://doi.org/10.1093/scan/nsm013

Giza, C. C., & Hovda, D. A. (2014). The new neurometabolic cascade of concussion. *Neurosurgery*, *75*(4), S24–S33. https://doi.org/10.1227/NEU.0000000000000505

Gottfredson, L. S. (2004). Intelligence: Is it the epidemiologists' elusive "fundamental cause" of social class inequalities in health? *Journal of Personality and Social Psychology*, *86*(1), 174–199. https://doi.org/10.1037/0022-3514.86.1.174

Gottfried, A. W., Gottfried, A. E., Bathurst, K., Guerin, D. W., & Parramore, M. M. (2003). Socioeconomic status in children's development and family environment: Infancy through adolescence. In M. H. Bornstein & R. H. Bradley (Eds.), *Monographs in parenting series. Socioeconomic status, parenting, and child development* (pp. 189–207). Lawrence Erlbaum Associates Publishers.

Grasset, L., Glymour, M. M., Elfassy, T., Swift, S. L., Yaffe, K., Singh-Manoux, A., & Zeki Al Hazzouri, A. (2019). Relation between 20-year income volatility and brain health in midlife. *Neurology*, *93*(20), e1890–e1899. https://doi.org/10.1212/WNL.0000000000008463

Guo, G., & Harris, K. M. (2000). The mechanisms mediating the effects of poverty on children's intellectual development. *Demography*, *37*(4), 431–447. https://doi.org/10.1353/dem.2000.0005

Haarbauer-Krupa, J., Arbogast, K. B., Metzger, K. B., Greenspan, A. I., Kessler, R., Curry, A. E., … Master, C. L. (2018). Variations in mechanisms of injury for children with concussion. *Journal of Pediatrics*, *197*, 241–248.e1. https://doi.org/10.1016/j.jpeds.2018.01.075

Hackman, D. A., Farah, M. J., & Meaney, M. J. (2010). Socioeconomic status and the brain: Mechanistic insights from human and animal research. *Nature Reviews. Neuroscience*, *11*(9), 651–659. https://doi.org/10.1038/nrn2897

Hatch, S. L., & Dohrenwend, B. P. (2007). Distribution of traumatic and other stressful life events by race/ethnicity, gender, SES and age: A review of the research. *American Journal of Community Psychology*, *40*, 313–332. https://doi.org/10.1007/s10464-007-9134-z

Hayes, A. F. (2018). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach* (2nd ed.). Guilford Press.

Howell, D., Osternig, L., Van Donkelaar, P., Mayr, U., & Chou, L.-S. (2013). Effects of concussion on attention and executive function in adolescents. *Medicine and Science in Sports and Exercise*, *45*(6), 1030–1037. https://doi.org/10.1249/MSS.0b013e3182814595

Jafari, S., Etminan, M., Aminzadeh, F., & Samii, A. (2013). Head injury and risk of Parkinson disease: A systematic review and meta-analysis. *Movement Disorders*, *28*(9), 1222–1229. https://doi.org/10.1002/mds.25458

Johnson, S. B., Riis, J. L., & Noble, K. G. (2016). State of the art review: Poverty and the developing brain. *Pediatrics*, *137*(4), e20153075. https://doi.org/10.1542/peds.2015-3075

Kaufman, J. S., & Cooper, R. S. (2001). Commentary: Considerations for use of racial/ethnic classification in etiologic research. *American Journal of Epidemiology*, *154*(4), 291–298. https://doi.org/10.1093/aje/154.4.291

Khurana, V. G., & Kaye, A. H. (2012). An overview of concussion in sport. *Journal of Clinical Neuroscience*, *19*(1), 1–11. https://doi.org/10.1016/j.jocn.2011.08.002

Kim, P., Evans, G. W., Chen, E., Miller, G., & Seeman, T. (2018). How socioeconomic disadvantages get under the skin and into the brain to influence health development across the lifespan. In N. Halfon, C. B. Forrest, R. M. Lerner, & E. M. Faustman (Eds.), *Handbook of Life Course Health Development* (pp. 463–497). Springer International Publishing. https://doi.org/10.1007/978-3-319-47143-3_19

Kowalski, K. M., & Vaught, C. (2003). Judgment and decision making under stress: An overview for emergency managers. *International Journal of Emergency Management*, *1*(3), 278–289. https://doi.org/10.1504/IJEM.2003.003297

Kroshus, E., Baugh, C. M., Daneshvar, D. H., Nowinski, C. J., & Cantu, R. C. (2015). Concussion reporting intention: A valuable metric for predicting reporting behavior and evaluating concussion education. *Clinical Journal of Sport Medicine*, *25*(3), 243–247. https://doi.org/10.1097/JSM.0000000000000137

Kroshus, E., Baugh, C. M., Daneshvar, D. H., & Viswanath, K. (2014). Understanding concussion reporting using a model based on the theory of planned behavior. *Journal of Adolescent Health*, *54*(3), 269–274.e2. https://doi.org/10.1016/j.jadohealth.2013.11.011

Kroshus, E., Garnett, B., Hawrilenko, M., Baugh, C. M., & Calzo, J. P. (2015). Concussion under-reporting and pressure from coaches, teammates, fans, and parents. *Social Science and Medicine*, *134*, 66–75. https://doi.org/10.1016/j.socscimed.2015.04.011

Kurča, E., Sivák, Š., & Kučera, P. (2006). Impaired cognitive functions in mild traumatic brain injury patients with normal and pathologic magnetic resonance imaging. *Neuroradiology*, *48*(9), 661–669. https://doi.org/10.1007/s00234-006-0109-9

Kwak, Y., Payne, J. W., Cohen, A. L., & Huettel, S. A. (2015). The rational adolescent: Strategic information processing during decision making revealed by eye tracking. *Cognitive Development*, *36*, 20–30. https://doi.org/10.1016/j.cogdev.2015.08.001

Låg, T., Bauger, L., Lindberg, M., & Friborg, O. (2014). The role of numeracy and intelligence in health-risk estimation and medical data interpretation. *Journal of Behavioral Decision Making*, *27*, 95–108. https://doi.org/10.1002/bdm

Lin, A. C., Salzman, G. A., Bachman, S. L., Burke, R. V., Zaslow, T., Piasek, C. Z., … Upperman, J. S. (2015). Assessment of parental knowledge and attitudes toward pediatric sports-related concussions. *Sports Health*, *7*(2), 124–129. https://doi.org/10.1177/1941738115571570

Lindau, M., Almkvist, O., & Mohammed, A. H. (2016). Effects of stress on learning and memory. In *Stress: Concepts, cognition, emotion, and behavior* (pp. 153–160). https://doi.org/10.1016/B978-0-12-800951-2.00018-2

Link, B. G., & Phelan, J. (1995). Social conditions as fundamental causes of disease. *Journal of Health and Social Behavior*, *35*, 80–94. https://doi.org/10.2307/2626958

Luby, J., Belden, A., Botteron, K., Marrus, N., Harms, M. P., Babb, C., Nishino, T., & Barch, D. (2013). The effects of poverty on childhood brain development: The mediating effect of caregiving and stressful life events. *JAMA Pediatrics*, *167*(12), 1135–1142. https://doi.org/10.1001/jamapediatrics.2013.3139

Mani, A., Mullainathan, S., Shafir, E., & Zhao, J. (2013). Poverty impedes cognitive function. *Science*, *341*(6149), 976–980. https://doi.org/10.1126/science.1238041

McCrory, P., Meeuwisse, W., Dvořák, J., Aubry, M., Bailes, J., Broglio, S., Cantu, R. C., Cassidy, D., Echemendia, R. J., Castellani, R. J., Davis, G. A., Ellenbogen, R., Emery, C., Engerbretsen, L., Feddermann-Demont, N., Giza, C. C., Guskiewicz, K. M., Herring, S., Iverson, G. L., … Vos, P. E. (2017). Consensus statement on concussion in sport—The 5th international conference on concussion in sport held in Berlin, October 2016. *British Journal of Sports Medicine*, *51*(11), 838–847. https://doi.org/10.1136/bjsports-2017-097699

McEwen, B. S. (2017). Neurobiological and systemic effects of chronic stress. *Chronic Stress*, *1*, 1–11. https://doi.org/10.1177/2470547017692328

McLendon, L. A., Kralik, S. F., Grayson, P. A., & Golomb, M. R. (2016). The controversial second impact syndrome: A review of the literature. *Pediatric Neurology*, *62*, 9–17. https://doi.org/10.1016/j.pediatrneurol.2016.03.009

Meier, T. B., Brummel, B. J., Singh, R., Nerio, C. J., Polanski, D. W., & Bellgowan, P. S. F. (2015). The underreporting of self-reported symptoms following sports-related concussion. *Journal of Science and Medicine in Sport*, *18*(5), 507–511. https://doi.org/10.1016/j.jsams.2014.07.008

Mez, J., Daneshvar, D. H., Kiernan, P. T., Abdolmohammadi, B., Alvarez, V. E., Huber, B. R., Alosco, M. L., Solomon, T. M., Nowinski, C. J., McHale, L., Cormier, K. A., Kubilus, C. A., Martin, B. M., Murphy, L., Baugh, C. M., Montenigro, P. H., Chaisson, C. E., Tripodis, Y., Kowall, N. W., … McKee, A. C. (2017). Clinicopathological evaluation of chronic traumatic encephalopathy in players of American football. *JAMA*, *318*(4), 360–370. https://doi.org/10.1001/jama.2017.8334

Mills, B., Reyna, V. F., & Estrada, S. (2008). Explaining contradictory relationship between risk perception and risk taking. *Psychological Science*, *19*(5), 429–433. https://doi.org/10.1111/j.1467-9280.2008.02104.x

Mirtcheva, D. M., & Powell, L. M. (2009). Participation in the National School Lunch Program: Importance of school-level and neighborhood contextual factors. *Journal of School Health*, *79*(10), 485–494. https://doi.org/10.1111/j.1746-1561.2009.00438.x

Moore, J. C., Stinson, L. L., & Welniak, E. J. (2000). Income measurement error in surveys: A review. *Journal of Official Statistics*, *16*(4), 331–361.

Nicholson, L. M., Slater, S. J., Chriqui, J. F., & Chaloupka, F. (2014). Validating adolescent socioeconomic status: Comparing school free or reduced price lunch with community measures. *Spatial Demography*, *2*(1), 55–65. https://doi.org/10.1007/bf03354904

Pampel, F. C., Krueger, P. M., & Denney, J. T. (2010). Socioeconomic disparities in health behaviors. *Annual Review of Sociology*, *36*, 349–370. https://doi.org/10.1146/annurev.soc.012809.102529

Peters, E., Västfjäll, D., Slovic, P., Mertz, C. K., Mazzocco, K., & Dickert, S. (2006). Numeracy and decision making. *Psychological Science*, *17*(5), 407–413. https://doi.org/10.1111/j.1467-9280.2006.01720.x

Preacher, K. J., & Kelley, K. (2011). Effect size measures for mediation models: Quantitative strategies for communicating indirect effects. *Psychological Methods*, *16*(2), 93–115. https://doi.org/10.1037/a0022658

Rabinowitz, A. R., Li, X., Mccauley, S. R., Wilde, E. A., Barnes, A., Hanten, G., … Levin, H. S. (2015). Prevalence and predictors of poor recovery from mild traumatic brain injury. *Journal of Neurotrauma*, *32*, 1488–1496. https://doi.org/10.1089/neu.2014.3555

Raffington, L., Prindle, J. J., & Shing, Y. L. (2018). Income gains predict cognitive functioning longitudinally throughout later childhood in poor children. *Developmental Psychology*, *54*(7), 1232–1243. https://doi.org/10.1037/dev0000529

Rahimi-Golkhandan, S., Garavito, D. M. N., Reyna-Brainerd, B. B., & Reyna, V. F. (2017). A fuzzy-trace theory of risk and time preferences in decision making: Integrating cognition and motivation. In J. Stevens (Ed.), *Nebraska symposium on motivation*. University of Nebraska Press.

Raizada, R. D. S., & Kishiyama, M. M. (2010). Effects of socioeconomic status on brain development, and how cognitive neuroscience may contribute to leveling the playing field. *Frontiers in Human Neuroscience*, *4*(3), 1–11. https://doi.org/10.3389/neuro.09.003.2010

Register-Mihalik, J. K., Cameronc, K. L., Kaya, M. C., Kerr, Z. Y., Peck, K. Y., Houston, M. N., Linnan, L. A., Hennink-Kaminski, H., Gildner, P., Svoboda, S. J., & Marshall, S. W. (2018). Determinants of intention to disclose concussion symptoms in a population of U.S. military cadets. *Journal of Science and Medicine in Sport*, *22*(5), 509–515. https://doi.org/10.1016/j.jsams.2018.11.003

Register-Mihalik, J. K., Guskiewicz, K. M., McLeod, T. C. V., Linnan, L. A., Mueller, F. O., & Marshall, S. W. (2013). Knowledge, attitude, and concussion-reporting behaviors among high school athletes: A preliminary study. *Journal of Athletic Training*, *48*(5), 645–653. https://doi.org/10.4085/1062-6050-48.3.20

Register-Mihalik, J. K., Linnan, L. A., Marshall, S. W., McLeod, T. C. V., Mueller, F. O., & Guskiewicz, K. M. (2013). Using theory to understand high school aged athletes' intentions to report sport-related concussion: Implications for concussion education initiatives.

*Brain Injury*, *27*(7–8), 878–886. https://doi.org/10.3109/02699052.2013.775508

Reyna, V. F. (2008). A theory of medical decision making and health: Fuzzy trace theory. *Medical Decision Making*, *28*(6), 850–865. https://doi.org/10.1177/0272989x08327066

Reyna, V. F. (2012). A new intuitionism: Meaning, memory, and development in fuzzy-trace theory. *Judgment and Decision Making*, *7*(3), 332–359.

Reyna, V. F. (2020). A scientific theory of gist communication and misinformation resistance, with implications for health, education, and policy. *Proceedings of the National Academy of Sciences*, 201912441. https://doi.org/10.1073/pnas.1912441117

Reyna, V. F., & Adam, M. B. (2003). Fuzzy-trace theory, risk communication, and product labeling in sexually transmitted diseases. *Risk Analysis*, *23*, 325–342. https://doi.org/10.1111/1539-6924.00332

Reyna, V. F., & Brainerd, C. J. (2011). Dual processes in decision making and developmental neuroscience: A fuzzy-trace model. *Developmental Review*, *31*(2–3), 180–206. https://doi.org/10.1016/j.dr.2011.07.004

Reyna, V. F., Chick, C. F., Corbin, J. C., & Hsia, A. N. (2014). Developmental reversals in risky decision making: Intelligence agents show larger decision biases than college students. *Psychological Science*, *25*(1), 76–84. https://doi.org/10.1177/0956797613497022

Reyna, V. F., Estrada, S. M., DeMarinis, J. A., Myers, R. M., Stanisz, J. M., & Mills, B. A. (2011). Neurobiological and memory models of risky decision making in adolescents versus young adults. *Journal of Experimental Psychology: Learning Memory and Cognition*, *37*(5), 1125–1142. https://doi.org/10.1037/a0023943

Reyna, V. F., & Farley, F. (2006). Risk and rationality in adolescent decision making: Implications for theory, practice, and public policy. *Psychological Science in the Public Interest*, *7*(1), 1–44. https://doi.org/10.1111/j.1529-1006.2006.00026.x

Reyna, V. F., & Mills, B. A. (2014). Theoretically motivated interventions for reducing sexual risk taking in adolescence: A randomized controlled experiment applying fuzzy-trace theory. *Journal of Experimental Psychology: General*, *143*(4), 1627–1648. https://doi.org/10.1037/a0036717

Reyna, V. F., Nelson, W. L., Han, P. K., & Dieckmann, N. F. (2009). How numeracy influences risk comprehension and medical decision making. *Psychological Bulletin*, *135*(6), 943–973. https://doi.org/10.1037/a0017327

Reyna, V. F., Wilhelms, E. A., Mccormick, M. J., & Weldon, R. B. (2015). Development of risky decision making: Fuzzy-trace theory and neurobiological perspectives. *Child Development Perspectives*, *9*(2), 122–127. https://doi.org/10.1111/cdep.12117

Rindermann, H., Flores-Mendoza, C., & Mansur-Alves, M. (2010). Reciprocal effects between fluid and crystallized intelligence and their dependence on parents' socioeconomic status and education. *Learning and Individual Differences*, *20*(5), 544–548. https://doi.org/10.1016/j.lindif.2010.07.002

Rivers, S. E., Reyna, V. F., & Mills, B. (2008). Risk taking under the influence: A fuzzy-trace theory of emotion in adolescence. *Developmental Review*, *28*(1), 107–144. https://doi.org/10.1016/j.dr.2007.11.002

Rosenbaum, A. M., & Arnett, P. A. (2010). The development of a survey to examine knowledge about and attitudes toward concussion in high-school students. *Journal of Clinical and Experimental Neuropsychology*, *32*(1), 44–55. https://doi.org/10.1080/13803390902806535

Salmon, D. M., Romanchuk, J., Sullivan, S. J., Walters, S., Clacy, A., Register-Mihalik, J. K., Ker, Z. Y., Whatman, C., & Keung, S. (2020). Concussion knowledge, attitude and reporting intention in rugby coaches and high school rugby players. *International Journal of Sports Science and Coaching*, *16*, 54–69. https://doi.org/10.1177/1747954120961200

Sandi, C., & Pinelo-Nava, M. T. (2007). Stress and memory: Behavioral effects and neurobiological mechanisms. *Neural Plasticity*, *2007*, 1–20. https://doi.org/10.1155/2007/78970

Sinayev, A., & Peters, E. (2015). Cognitive reflection vs. calculation in decision making. *Frontiers in Psychology*, *6*(532), 1–16. https://doi.org/10.3389/fpsyg.2015.00532

Singh-Manoux, A., Ferrie, J. E., Lynch, J. W., & Marmot, M. (2005). The role of cognitive ability (intelligence) in explaining the association between socioeconomic position and health: Evidence from the Whitehall II prospective cohort study. *American Journal of Epidemiology*, *161*(9), 831–839. https://doi.org/10.1093/aje/kwi109

Stelzl, I., Merz, F., Ehlers, T., & Remer, H. (1995). The effect of schooling on the development of fluid and cristallized intelligence: A quasi-experimental study. *Intelligence*, *21*(3), 279–296. https://doi.org/10.1016/0160-2896(95)90018-7

Swartz, J. R., Hariri, A. R., & Williamson, D. E. (2017). An epigenetic mechanism links socioeconomic status to changes in depression-related brain function in high-risk adolescents Johnna. *Molecular Psychiatry*, *22*(2), 209–214. https://doi.org/10.1038/mp.2016.82

Taylor, C. A., Bell, J. M., Breiding, M. J., & Xu, L. (2017). Traumatic brain injury—Related emergency department visits, hospitalizations, and deaths—United States, 2007 and 2013. *MMWR. Surveillance Summaries*, *66*(9), 1–16. https://doi.org/10.15585/mmwr.ss6609a1

Teasdale, T. W., & Froøsig, A. J. (2013). Cognitive ability and educational level in relation to concussion: A population study of young men. *BMJ Open*, *3*(3), 1–6. https://doi.org/10.1136/bmjopen-2012-002321

Thomas, M., Haas, T. S., Doerer, J. J., Hodges, J. S., Aicher, B. O., Garberich, R. F., … Maron, B. J. (2011). Epidemiology of sudden death in young, competitive athletes due to blunt trauma. *Pediatrics*, *128*(1), e1–e8. https://doi.org/10.1542/peds.2010-2743

von Stumm, S., & Plomin, R. (2015). Socioeconomic status and the growth of intelligence from infancy through adolescence. *Intelligence*, *48*, 30–36. https://doi.org/10.1016/j.intell.2014.10.002

Wallace, J., Covassin, T., Nogle, S., Gould, D., & Kovan, J. (2017). Concussion knowledge and reporting behavior differences between high school athletes at urban and suburban high schools. *Journal of School Health*, *87*(9), 665–674. https://doi.org/10.1111/josh.12543

Waltzman, D., Womack, L. S., Thomas, K. E., & Sarmiento, K. (2020). Trends in emergency department visits for contact sports–related traumatic brain injuries among children—United States, 2001–2018. *Morbidity and Mortality Weekly Report*, *69*, 870–874. https://doi.org/10.15585/mmwr.mm6927a4

Webbe, F. M., & Barth, J. T. (2003). Short-term and long-term outcome of athletic closed head injuries. *Clinics in Sports Medicine*, *22*, 577–592. https://doi.org/10.1016/S0278-5919(02)00103-5

Weller, J. A., Buchanan, T. W., Shackleford, C., Morganstern, A., Hartman, J. J., Yuska, J., & Denburg, N. L. (2014). Diurnal cortisol rhythm is associated with increased risky decision-making in older adults. *Psychology and Aging*, *29*(2), 271–283. https://doi.org/10.1037/a0036623

White, C. M., Gummerum, M., & Hanoch, Y. (2015). Adolescents' and young adults' online risk taking: The role of gist and verbatim representations. *Risk Analysis*, *35*(8), 1407–1422. https://doi.org/10.1111/risa.12369

Wilhelms, E. A., & Reyna, V. F. (2013). Fuzzy trace theory and medical decisions by minors: Differences in reasoning between adolescents and adults. *Journal of Medicine and Philosophy*, *38*(3), 268–282. https://doi.org/10.1093/jmp/jht018

Williams, D. R., Mohammed, S. A., Leavell, J., & Collins, C. (2010). Race, socioeconomic status, and health: Complexities, ongoing challenges, and research opportunities. *Annals of the New York Academy of Sciences*, *1186*, 69–101. https://doi.org/10.1111/j.1749-6632.2009.05339.x

Williams, D. R., Priest, N., & Anderson, N. (2016). Understanding associations between race, socioeconomic status and health: Patterns and prospects. *Health Psychology*, *35*(4), 407–411. https://doi.org/10.1037/hea0000242

Zuckerman, S. L., Zalneraitis, B. H., Totten, D. J., Rubel, K. E., Kuhn, A. W., Yengo-Kahn, A. M., Bonfield, C. M., Sills, A. K., & Solomon, G. S. (2017). Socioeconomic status and outcomes after sport-related concussion: A preliminary investigation. *Journal of Neurosurgery: Pediatrics*, *19*(6), 652–661. https://doi.org/10.3171/2017.1.PEDS16611

## AUTHOR BIOGRAPHIES

**Peter Ajayi** is a post-baccalaureate researcher at the National Institutes of Health. His research interests primarily lie in socioeconomic inequality and cognitive theory, with his main focus on judgment and decision making. He aspires to integrate his research findings with patient care in medicine.

**David Garavito** is a doctoral student at Cornell University who studies cognitive theory and its application in various contexts across the lifespan. He also conducts research in the fields of law and neuroscience. His recent work has focused on the legal, psychological, and neurocognitive implications of concussive and subconcussive injuries.

**Valerie Reyna** is the Director of the Human Neuroscience Institute and Co-Director of the Center for Behavioral Economics and Decision Research at Cornell University; she is a developer of fuzzy-trace theory. Her recent work has focused on numeracy, medical decision making, risk communication, risk taking, neurocognition, and neurobiological development.

## SUPPORTING INFORMATION

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

**How to cite this article:** Ajayi, P. T., Garavito, D. M. N., & Reyna, V. F. (2021). Socioeconomic status and concussion reporting: The distinct and mediating roles of gist processing, knowledge, and attitudes. *Journal of Behavioral Decision Making*, *34*(5), 639–656. https://doi.org/10.1002/bdm.2235

## APPENDIX A.

| Concussion knowledge items | |
|---|---|
| 1 | In order to be diagnosed with a concussion, you have to be knocked out. |
| 2 | A concussion can only occur if there is a direct hit to the head. |
| 3 | Being knocked unconscious always causes permanent damage to the brain. |
| 4 | Symptoms of a concussion can last several weeks. |
| 5 | Sometimes a second concussion can help a person remember things that were forgotten after the first concussion. |
| 6 | If you receive one concussion and you have never had a concussion before, you will become less intelligent. |
| 7 | Concussions can sometimes lead to emotional disruptions. |
| 8 | There is rarely a risk to long-term health and well-being from multiple concussions. |
| 9 | It is likely that player Q's concussion will affect his long-term health and well-being. |
| 10 | It is likely that player X's concussion will affect his long-term health and well-being. |
| 11 | Even though player F is still experiencing the effects of the concussion, her performance will be the same as it would be had she not suffered a concussion. |
| 12 | Headache |
| 13 | Sensitivity to light |
| 14 | Difficulty remembering |
| 15 | Drowsiness |
| 16 | Feeling in a “fog” |
| 17 | Feeling slowed down |
| 18 | Difficulty concentrating |
| 19 | Dizziness |

*Note*: Items are from Rosenbaum and Arnett's (2010) Concussion Knowledge scale. The last section included a list of symptoms (12–19 above) that respondents checked off as follows: “Think about someone who has had a concussion. Check off the following signs and symptoms that you believe someone may be likely to experience AFTER a concussion.” (p. 55).