



Future Directions in Peer Relations Research

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ABSTRACT

Peer relationships among youth have been examined as predictors of mental health outcomes for at least fifty years, revealing dozens of discrete peer constructs that each are associated with adjustment in childhood, adolescence, and later in adulthood. Future research may benefit by examining a range of new outcomes and psychological processes that have been discussed recently in related literatures. This paper reviews recent research on interpersonal determinants of physical health outcomes, and opportunities for greater examination of 1) peer influence processes toward health risk behaviors; 2) neural correlates of peer adversity; 3) adverse peer experiences that may affect physiological markers of stress response; and 4) immune system markers of peer adversity. Additional future directions include the study of differences in the forms and functions of peer interactions within the digital age.

In the 1960s and early 1970s, psychological scientists stumbled upon an interesting finding in the field now known as developmental psychopathology. For decades prior, theories regarding the putative causes of psychopathology and maladjustment focused primarily on mother-child interactions, with relatively little attention to other interpersonal relationships that may be formative in children's development (Hartup, 1970, 1979). Yet, a pair of follow-back studies offered compelling results that changed the way scientists have since understood interpersonal experiences among youth.

Each of these studies included a sample of adults who had experienced serious forms of maladjustment. Roff (1961) examined former child guidance clinic clients who subsequently entered the military. His research compared those who were honorably vs. dishonorably discharged, and relied on archival clinic records to examine what childhood factors might be associated significantly with later military outcomes. Cowen et al. (1973) examined a sample of young adults who had received psychiatric treatment as well as age-matched controls. School-records from grades 1–3, including a wide array of standardized assessments, were used to predict which youth would register for psychiatric treatment 11–13 years later. In both studies, unexpected results emerged. Despite controlling for factors such as children's intellectual ability, academic achievement, teacher-ratings, and child-reported anxiety, findings revealed that it was children's peer

relationships that seemed to be most relevant. Specifically, in both studies, findings revealed that children with poor peer experiences, including negative peer reputations, peer rejection, and peer conflict were significantly more likely to experience poor outcomes in adulthood than those with adaptive peer experiences years earlier (Cowen et al., 1973; Roff, 1961). In fact, in one of these studies, findings revealed that the association between peer experiences and later outcomes was stronger than the effects of all other factors that had been examined (Cowen et al., 1973).

Findings such as these likely were influential in a large body of research that emerged over the subsequent five decades. Today, a myriad of peer experiences that may be relevant for child and adolescent adjustment have been identified, with significant bodies of research examining social interactions in infancy (e.g., Hay et al., 2018; Vandell et al., 1980), early childhood play behavior (e.g., Gershman & Hayes, 1983; Howe & Leach, 2018), gender-typed roles reinforced among peers (e.g., Maccoby, 1999; Rose & Rudolph, 2006), child- and family-based determinants of children's peer reputations/status (e.g., Parke & Ladd, 1992), multiple forms (e.g., overt and relational) and functions (i.e., proactive, reactive) of peer aggression/bullying, and peer victimization (Casper & Card, 2017; Crick & Grotpeter, 1995; Olweus, 1993). In addition, research has examined friendship and friendship qualities (e.g., Bagwell & Schmidt, 2013; Bukowski et al., 1998), discrete types of youths' peer reputations (i.e., likability

and popularity; Asher & Coie, 1990; Cillessen & Rose, 2005; Cillessen et al., 2011), peer cliques (e.g., Ennett & Bauman, 2000; Lansford et al., 2009; Urberg et al., 1995), peer crowds (e.g., Brown et al., 1986), online peer experiences (e.g., Nesi et al., 2018a, 2018b), and processes of peer influence (e.g., Brechwald & Prinstein, 2011). In addition, emerging work has examined cultural and cross-cultural factors, such as gender, race/ethnicity, sexual/gender minority experiences, and geographic region/nationality, that each have been woefully underexplored, but surely are relevant for understanding youth's peer interactions and their implications for adjustment. Moreover, hundreds of prospective longitudinal studies have demonstrated that children's peer experiences are associated with a large range of psychological outcomes in childhood and adolescence, including externalizing symptoms (e.g., aggression, delinquency, oppositional behavior; Coie et al., 1995; Miller-Johnson et al., 2002; Ollendick et al., 1992), internalizing symptoms (e.g., depression, anxiety, suicide; Burks et al., 1995; Coie et al., 1992; Heilbron & Prinstein, 2010), school truancy, academic achievement, and a wide range of health risk behaviors (e.g., substance use; see Parker & Asher, 1987; Prinstein & Giletta, 2016, for reviews). Findings also have suggested that childhood peer experiences are associated with long-term outcomes in adulthood, including employment status, income, and psychological well-being (Almquist & Brannstrom, 2014).

Indeed, the peer relations research literature is vast, with "Peer Relations Preconferences" offered at the Society of Research on Child Development and the Society of Research on Adolescence, a seminal handbook summarizing the field now in its second edition (Bukowski et al., 2019), and an ever-growing number of students who are interested in studying youths' peer interactions. Investigators in a wide array of social science disciplines recognize peer processes as critical for understanding the contagion of ideas, values, and behavioral choices (e.g., Bayer et al., 2009; Dishion Andrews et al., 1995; McCord, 1992; Vigdor, 2008); policy makers have identified peer harassment as a national crisis within US school districts (Espelage, 2016); increasingly comprehensive assessments of peer interactions have become commonplace in clinical practice (e.g., Gresham & Elliott, 2019); and resources to assist educators with students who experience difficulties among peers have rapidly proliferated (e.g., Shapiro, 2008; Van Dijk, 2015).

Yet, there remain many relatively unexplored frontiers that deserve greater attention in the peer relations literature. In this "future directions" article, we discuss one that was selected based on the observation that for over fifty years, investigators' research largely has

reflected a basic assumption that adverse peer experiences may be most relevant to social, behavioral, and psychological outcomes. Recent research suggests that this assumption deserves further consideration.

In the past decade, several striking findings have revealed that social experiences also have remarkably powerful effects on our physical health (Cacioppo et al., 2015). Importantly, these findings are not applicable only to middle-aged or elderly individuals, but perhaps especially relevant to youth. In this paper, we briefly review recent research to suggest that our knowledge regarding youths' peer interactions may be applicable to host of health science fields that currently need experts in the study of child and adolescent peer interactions. Next, we offer a discussion of plausible psychological and biological processes that may elucidate why peer difficulties may increase morbidity and mortality. Last, we offer encouragement and resources to scholars who wish to enter the thriving and relatively young peer relations field by discussing additional future directions.

Youths' Peer Relations and Physical Health

It has long been known that social relationships have interesting, perhaps even powerful implications for physical health (Miller, 2011; Spiegel et al., 1989). Indeed, evolutionary theories suggests that humans' ability to successfully interact with peers may have been a critical characteristic that ensured our survival as a species. Unlike other hominid species that also existed, and comingled with *Homo Sapiens* about 60,000 years ago (e.g., Neanderthals, Denisovans, *Homo Floresiensis*), some anthropologists suggest that our species developed genetic mutations affecting the shape of the larynx and the complexity of brain regions associated with auditory comprehension (c.f., Berwick et al., 2013; Boyd et al., 2000; Dediu & Levinson, 2013). Together, these unique genetic advantages conferred the ability to develop the rudiments of language – a critical factor necessary to engage in social interaction. Specifically, with language *Homo Sapiens* developed cooperative behaviors (e.g., warning one another of predators, sharing tools for hunting, etc.) that ultimately associated group membership/acceptance with survival, and ostracism/rejection with imminent injury or death.

Empirical work suggests that that our ability to participate in successful social relationships remains curiously linked with our mortality, albeit perhaps for reasons that are different today than millennia ago. In more recent years, empirical data have supported this notion in several ways. For instance, about a decade

ago, Holt-Lunstad et al. (2010) meta-analyzed 148 studies, including over 308,000 individuals across the globe, to examine the extent to which people's involvement in, and quality of social relationships among friends, acquaintances, and romantic relationships was associated with morbidity and mortality. Results revealed that difficulties with social relationships indeed predicted early death, yielding remarkably large effect sizes of these markers of peer experiences on mortality (i.e., not including death by suicide) between 3 months to 58 years later. Few social relationships were associated with 20% increased odds of death, commensurate with the health risk effects of six or more alcoholic drinks a day. *Poor quality* relationships nearly doubled mortality risk, which is greater than the strength of the effect of twenty of more cigarettes a day on early mortality (Holt-Lunstad et al., 2010).

More recently, findings have suggested that the association between interpersonal and physical functioning may be relevant not only among adults, but perhaps especially for those experiencing social relationship difficulties in childhood and adolescence. Yang et al. (2016) published an analysis of data from four national databases to examine the association between social experiences and risk for physical illness. Data included nearly 14,000 individuals who had participated in either the National Longitudinal Study of Adolescent to Adult Health (followed 12 years later), the MIDUS study (Midlife in the United States; followed 9 years later), the Health and Retirement Study (HRS, followed biennially for 8 years), or the National Social Life, Health, and Aging Project (NSHAP, followed 5 years later). Within this combined dataset, investigators examined the number of, and level of perceived social support within participants' interpersonal relationships, which included relationships with family members and romantic partners, but predominantly focused on interactions with friends and other peers. Associations within each of five age groups then were examined with three health-related outcomes, including hypertension, obesity and C-reactive protein (i.e., a marker of low-grade inflammation that forecasts cardiovascular events). Findings revealed significant associations among all age groups suggesting that fewer and lower quality interpersonal relationships were associated prospectively with increased odds of negative health-related outcomes. Interestingly, however, results suggested that the second highest odds ratios (i.e., following the elderly) were revealed among adolescents, who were between 20-40% more likely to experience future health difficulties if they had experienced poor social relationships. Moreover, these effects were curiously strong; investigators reported that effect sizes for poor childhood peer relations on later health outcomes were comparable

to the effects of physical inactivity on inflammation risk or the effects of diabetes on later hypertension (Yang et al., 2016).

Findings generally are consistent with results across a variety of related literatures. For instance, one study showed that youths' difficulties within their peer group were associated with increased risks of metabolic syndrome and even cardiovascular disease in adulthood, about 20 years later (Caspi et al., 2006; Gustafsson et al., 2012). Conversely, another study revealed that adolescents' positive relationship quality with friends predicts lower metabolic risk in early adulthood (Ehrlich et al., 2015). Overall, research has documented that children's and adolescents' relationships may curiously be powerful predictors of physical health outcomes. However, this link is not yet well understood.

In this paper, four specific research areas that are especially relevant to clinical child and adolescent psychology are reviewed to elucidate how peer experiences may affect youths' physical health. These include 1) peer influence processes toward health risk behaviors, 2) neural correlates associated with peer adversity 3) the manner in which adverse peer experiences may affect physiological stress-responses, and 4) potential links between peer adversity and the immune system functioning.

Peer Influence and Health Risk Behaviors

Adolescents' engagement in health risk behaviors poses known risks for both behavioral and health outcomes. For instance, early engagement in substance use has been associated with long-term risks for substance abuse/dependence in adulthood (Chassin et al., 2002; Greenberg, 1992). Similarly, adolescents' sexual risk behavior has been associated with a greater likelihood of teenage pregnancy, sexually transmitted infections, as well as cervical cancer later in life (Greenberg, 1992). The manner in which peer experiences may lead to engagement in health risk behaviors, therefore, likely is relevant for understanding the association between childhood peer experiences and health morbidity and mortality years later.

Investigators who examine peer relationships have long been interested in the association between peer experiences and an increased risk for health risk behaviors. Prior longitudinal work has suggested that children who are rejected by peers, and perhaps especially those who are also aggressive (i.e., rejected-aggressives; Haselager et al., 2002) are at much greater long-term risk for use of alcohol, nicotine, marijuana (Prinstein & La Greca, 2004), in addition to an array of externalizing symptoms that are known to be associated with long-

term risky behavior (Coie et al., 1995). Among older children and adolescents, high levels of popular reputations also are associated with aggression (Cillessen & Rose, 2005; Prinstein & Cillessen, 2003), and risk behavior, including substance use (Prinstein et al., 2011). It has also been well-established that the link between peer status and health risk behavior may be largely explained by rejected youths' affiliation with risk-taking peers (Dishion, Capaldi, et al., 1995), creating a context ripe for deviant peer socialization (Kandel, 1978). However, understanding the scope of potential peer socialization effects, who may be particularly influential, or which adolescents may be most susceptible to negative peer influences have been largely unexplored. Each of these ideas is discussed in more detail below.

First, with regard to the scope of potential peer influence effects, it is notable, and perhaps lamentable that most prior research examining the tendency of youth to affiliate with peers who have similar attitudes or behavioral proclivities (i.e., selection effects) and the effects of peers' attitudes or behavior on youth's own behavioral trajectories (i.e., socialization effects) has been restricted to a handful of outcomes. Prior work has suggested repeatedly and powerfully that peers socialize one another toward increased substance use (e.g., Larsen et al., 2010), delinquent behavior (e.g., Vitaro et al., 1997), academic values/achievement (e.g., Véronneau & Dishion, 2010), and also depressive symptoms (e.g., Hogue & Steinberg, 1995; Prinstein, 2007). Yet, it may be useful to dedicate greater attention to other health risk behaviors that additionally are of interest to psychologists, and may also explain greater risks for physical health outcomes. For instance, most sexual behavior occurs in the context of interpersonal interactions (i.e., with a same-aged partner), yet relatively few studies have examined peer socialization effects toward sexual behavior debut, the number of adolescents' sexual partners (Billy & Udry, 1985; Choukas-Bradley et al., 2014), attitudes toward sexual behaviors, or safe-sex practices, despite research suggesting that adolescents frequently communicate with peers regarding each of these topics (Widman et al., 2014).

Adolescents and their peers frequently discuss their body shape and behaviors meant to alter body size; in fact, eating is one of the most common activities adolescents engage in with peers (Salk & Engeln-Maddox, 2012), offering a context ripe for detailed discussions regarding weight-related behaviors. It is surprising, therefore, that so few studies have examined peer socialization effects for dieting, exercise, "fat-talk" (Nichter & Vuckovic, 1994), as well as maladaptive weight-related behaviors, such as bingeing, restriction, etc.

(see Bruening et al., 2012; Rancourt et al., 2014; Story et al., 2002).

Recent research suggests that the majority of adolescents' social interactions now occur via electronic-forums (i.e., using texting, direct message features within a range of apps, or in the context of social media posts), yet remarkably few studies have examined socialization processes that may occur online (Nesi et al., 2017). This too offers an important direction for contemporary research.

Second, note that the vast majority of prior research has examined the effects of adolescents' closest friends as potentially influential agents toward health risk behaviors. Yet, adolescents today may have greater access to sources of influence than ever before, and few of these other types of peer relationships have been examined as potentially influential. Research suggests that peer socialization effects may occur following exposure to romantic partners' (Simon et al., 2008) or popular peers' (Helms et al., 2014) behaviors, and perhaps even through interactions with enemies (i.e., through processes of anti-conformity), or online-only friends (Lenhart, 2015). More research similarly is needed to understand how youth reconcile potentially conflicting social pressures from all of the socializing agents in their lives, including peers, media influences, and adults. The examination of youths' ability to perceive, and judicate among multiple forms of influence has been studied remarkably rarely, yet may reveal social-cognitive or moral reasoning processes that could be leveraged in preventive interventions to reduce deleterious peer influence.

A third understudied topic that could inform preventive interventions is a focus on understanding why some adolescents may be especially susceptible to their peers' engagement in risk behaviors, while other teens are remarkably resilient. It currently is unknown whether susceptibility is a stable trait among individuals, a time-varying characteristic (Albert et al., 2013; Steinberg & Monahan, 2007), or a context-dependent state with substantial intra-individual variability. This is an unfortunate omission in prior work. Given that efforts to dissuade adolescents from befriending risk-taking peers are unwelcomed by teens, and that descriptive/injunctive norms interventions among youth (i.e., attempting to adjust teens' misperceptions regarding the frequency of, or attitudes underlying, their peers' risk behaviors) have had limited efficacy with youth (Prentice, 2008), there is a strong need to better understand what individual difference factors might be promoted to reduce adolescents' conformity.

Although few studies have examined peer influence susceptibility per se, many studies have examined moderators of peer influence effects, often conceptualized and examined as factors that statistically moderate the association between adolescents' friends' behavior, and adolescents' own behavior (see Brechwald & Prinstein, 2011 for a review). Interestingly, many moderators identified in prior work, including family dysfunction, social anxiety, low self-esteem, or genetic markers (i.e., COMT genotype) also have strong main effects on adolescents' health risk behavior engagement, making it difficult to determine whether these moderators are changing the strength of socialization effects, or simply conferring synergistic impact with peers' behavior as compounding risk factors for maladaptive outcomes. In contrast, peer influence susceptibility represents a discrete notion altogether that might indeed be predicted by previously studied "moderators," yet likely reflects a unique psychological construct. Research has not elucidated what developmental factors may lead to greater peer influence susceptibility (but see Allen et al., 2011; Widman et al., 2016), or whether susceptibility might be modified, yet emerging results have revealed interesting findings.

For instance, prior work has yielded a variety of approaches to measuring peer influence susceptibility, offering important data for future research. Self-report measures, such as the Resistance to Peer Influence scale (Steinberg & Monahan, 2007) or items embedded within measures of sociotropy (e.g., Bieling et al., 2000), offer one opportunity to examine susceptibility, capturing individuals' meta-cognitive ability to recognize and report their own perception of conformity to peers. Performance-based measures offer a second approach, allowing investigators to determine how much youth might change their opinions when 1) confronted with a peer confederate (Allen et al., 2006), 2) following exposure to prosocial or risky norms ostensibly communicated by grademates (e.g., Prinstein et al., 2011), 3) following exposure to unfamiliar peers online (Gommans et al., 2017), or 4) when they believe that no, few, or many of their friends have endorsed engagement in risky substance use (Duell et al., [under review](#)). In support of predictive validity, amassing research is demonstrating that in some cases, these measures of peer influence significantly moderate the association between exposure to peers' behavior and youths' own behavior (e.g., Choukas-Bradley et al., 2014; DiGuseppi et al., 2018; Duell et al., [under review](#)). Using instruments such as these, research is needed to examine which adolescents are most susceptible, to better understand developmental precursors to susceptibility, and to study the emotional or contextual

conditions that are associated with heightened versus suppressed susceptibility.

Recent neuroscience findings also offer an exciting contribution to the study of peer influence susceptibility. Based on dual-process models suggesting asynchronous neural development during adolescence between limbic brain regions associated with social rewards/punishment (e.g., ventral striatum) and prefrontal regions associated with inhibitory control (Somerville et al., 2010), several researchers have suggested that neural markers of susceptibility may be found within the motivational relevance network or by examining connectivity among neural networks (Do et al., [in press](#)). Emerging research suggests this is a fruitful line of inquiry, and an important direction for future research. For instance, recent work has revealed that individual differences in ACC or ventral striatum activation following presentation of socially rewarding stimuli is significantly associated with greater conformity among adults in a confederate-based paradigm within the lab (e.g., Nook & Zaki, 2015), and with adolescents' actual risk-behavior among adolescents who report high levels of their friends' engagement in risk-behaviors (Telzer et al., [in press](#)). Continued examination of neural markers of peer influence susceptibility is an exciting future direction and may have implications for prevention efforts as well. Identifying which brain networks are most strongly implicated in peer conformity, and how individual differences in neural activity may be associated with variability in peer influence susceptibility could elucidate what psychological processes (e.g., emotional salience, inhibitory control, mentalizing) should be targeted to help youth build greater resistance to implicit peer pressures.

Overall, it is notable that peer influence has been cited as one of the most powerful psychological risk factors for adolescents' engagement in dangerous, illegal, and maladaptive risk-taking behavior (Brechwald & Prinstein, 2011), with significant implications for both physical and behavioral health. However, no preventive interventions with demonstrated efficacy among youth are available to reduce peer socialization processes, suggesting an important target for future research.

Peer Adversity and Neural Responses

Mounting evidence from neuroscience research intriguingly suggests that adverse peer experiences may be associated with previously unknown, yet direct and potentially powerful effects on central nervous system responses. This line of research has potentially game-changing implications, suggesting that youths' relationships with peers may be uniquely associated with

a cascade of biological, social, and psychological processes that have long been intimated within the literature, but now may be supported with emerging data from a variety of disciplines.

For instance, consistent with evolutionary theories discussed above, prior research has reported vestigial signals suggesting that social exclusion may trigger a powerful neural warning. Data suggesting unexpected neural activity following social rejection was most prominently revealed in an fMRI study by Eisenberger et al. (2003). In this study, young adults were asked to play “Cyberball,” a task presented to participants ostensibly to examine synchronous neural activity between the participant and two other ball-tossing “players,” but actually designed to examine neural responses when two computer-simulated confederates suddenly stopped passing the ball to the study participant. Results suggested that as compared to periods of social inclusion, the experience of social exclusion was associated with activation in two neural regions that previously had been associated with the experience of physical pain. One of these regions was the dorsal anterior cingulate cortex (dACC), which is associated with affective (rather than sensory) distress, but especially may reflect a neural “alarm,” signaling incongruity between stimuli and humans’ fundamental goals. Eisenberger et al. (2003) argue that the dACC is closely associated with the motivation to avoid, or act in opposition to these stimuli. Findings also revealed activation in the right ventral prefrontal cortex, a region associated with regulation of physically painful stimuli. Findings were remarkable for two reasons. First, results revealing an overlap between neural responses to physical pain, and to what investigators referred to as “social pain” were unexpected, suggesting that our biological sensitivity to our social relationships goes perhaps “deeper” than previously realized. Second, findings at least preliminarily revealed that our species is remarkably attuned to how well we get along with peers, and may be sub-cortically (i.e., implicitly) and powerfully motivated toward peer acceptance, and away from peer rejection.

Subsequent research largely has supported the overlap between physical and “social pain” biological systems, revealing several common neural and peripheral responses to both physical injury and social exclusion/rejection (e.g., see Eisenberger, 2015; Rotge et al., 2015, for reviews). Findings also have revealed overlap in physical vs. social pain sensitivity (Bernstein & Claypool, 2012; Eisenberger et al., 2006), and have suggested that common physical pain-relief substances (e.g., endogenous opioids, morphine, acetaminophen) reduce social pain as well (e.g., Dewall et al., 2010;

Machin & Dunbar, 2011). Findings also have revealed social-psychological correlates of neural social pain responses. For instance, both childhood peer rejection and decreased interaction with friends in adolescence are associated with greater neural social pain responses (Masten et al., 2012; Will et al., 2016), suggesting individual differences in neural responses to social pain that may guide future research.

To date, the majority of research on neural markers of social rejection, and on the study of social pain correlates has been conducted among adults, and in cross-sectional designs. However, the study of neurobiological correlates to social rejection among youth is rapidly flourishing (see Asscheman et al., 2019; De Water et al., 2017; McIver et al., 2018; Rudolph et al., 2016; Schriber & Guyer, 2016), offering an exciting opportunity to synthesize research on peer relations constructs with social developmental neuroscience. For instance, future research may benefit by examining how neural responses to social rejection may be differentially associated with an array of discrete aversive peer experiences, such as peer rejection, low popularity, peer victimization, friendlessness, low friendship quality, or perhaps even vicarious effects based on affiliation with others who have experienced peer stress (Slavich & Cole, 2013). Research also may benefit from further work examining peer experiences that may buffer neural responses to social pain (e.g., friendship affiliation or quality; Masten et al., 2010), and how these may differ by gender or culture. Further examination of developmental variation in social pain may reflect unique periods of heightened social pain responses, perhaps in early adolescence (Somerville, 2013), unique individual trajectories, or changes in neural connectivity between social pain regions (i.e., dACC, AI, rvPFC) and other brain regions associated with engagement in risk-behavior (see Falk et al., 2014; Peake et al., 2013; Telzer et al., 2018). Finally, research that examines neural responses to peer adversity in combination with peripheral responses, such as physiological stress responses and especially immune system responses, is particularly needed to clearly elucidate the potential relevance of these neural networks for physical health. For example, initial evidence exists suggesting that greater neural responses to social rejection, including responses in the social pain regions (dACC, AI), are associated with greater endocrine and sympathetic nervous system responses (Eisenberger & Cole, 2012), as well as more pronounced inflammatory responses (Muscatell et al., 2015; Slavich et al., 2010), that, as discussed below, may be directly involved in the development of health problems. In short, the peer relations field likely has much to offer as research on neural

responses to youth's social experiences proliferates, and this may be an especially exciting (and fundable!) direction for continued work understanding the importance of youths' experiences with peers.

Peer Adversity and Physiological Stress Responses

Youth who struggle to form and maintain positive relationships with their peers often face intense and repeated stressors. Many of these negative experiences, such as peer rejection and victimization, tend to be uncontrollable and thus directly threaten youths' social self and sense of belonging, perhaps especially in adolescence when sensitivity to peers is heightened (Nelson et al., 2016). Notably, uncontrollable and socially-threatening stressors are known to be particularly powerful in affecting physiological responses (Dickerson & Kemeny, 2004). Thus, it seems highly plausible that negative peer experiences may influence physiological response systems. Within the past decade, researchers have begun to examine specific peer experiences that may be associated with the development of maladaptive physiological stress responses, driven by the hypothesis that these may represent key mechanisms to understand the health consequences of adverse peer relationships. Excellent reviews of this nascent literature have been offered by Murray-Close (2012a, 2012b) and more recently Rudolph and colleagues (Rudolph et al., *in press*), suggesting that peer victimization, peer aggression, and peer status each may be associated with youths' stress-responses (e.g., within the autonomic nervous system, hypothalamic-pituitary-adrenal (HPA) axis, and the hypothalamic-pituitary-gonadal (HPG) system).

Perhaps most well-studied in this area are associations between peer experiences and responses of the HPA axis, with a focus on both *diurnal* cortisol patterns and cortisol *reactivity* to acute stress. In this regard, a number of studies have examined peer victimization, given the particularly adverse nature of this experience, revealing that youth exposed to a history of peer victimization mostly show blunted diurnal cortisol levels (e.g., Jiang et al., 2018; Knack et al., 2011; Vaillancourt et al., 2008; although see Brendgen et al., 2017) as well as blunted cortisol responses to acute stressors (Kliewer, 2016; Ouellet-Morin et al., 2011a; Ouellet-Morin et al., 2011b; although see Chen et al., 2018) as compared to their non-victimized peers. Other types of peer relationships have also received attention, as well as the interplay between different peer experiences. Calhoun et al. (2014), for example, not only revealed that frequent experiences with relational

victimization were associated with adolescent girls' blunted HPA reactivity following an *in vivo* social stressor, but also that high levels of negative friendship quality were associated with slower HPA recovery. Additionally, work by Peters et al. (2011) examined the association between fourth grade youths' peer relationships and diurnal cortisol patterns. Similar to reviews discussed above, Peters et al. (2011) explored interactions between youths' overall peer affiliation, marked by levels of social exclusion, as well as levels of youths' relationship quality with a close friend. Findings interestingly revealed that youth with low levels of peer affiliation who also had poor quality relationships – notably, the same social profile as those with the highest increased odds of early death (Holt-Lunstad et al., 2010) – had flatter cortisol profiles across the day (i.e., lower morning cortisol levels) than did youth with better peer relationships (see also Adams et al., 2011; Vaillancourt et al., 2008). Finally, a few studies have focused on autonomic nervous system responses, by assessing either cardiac and electrodermal activity (e.g., pre-ejection period) or salivary markers (e.g., alpha-amylase) of sympathetic and parasympathetic nervous system functioning, offering preliminary promising results (for a review, see Rudolph et al., *in press*). Altogether these findings suggest that peer experiences may be relevant for understanding youths' developing physiological stress response systems, and deserve further consideration among peer relations researchers.

Yet, further research is warranted to better elucidate whether dysregulated physiological responses represent possible pathways through which peer experiences pose risks for health outcomes. Several issues deserve greater attention. First and foremost, longitudinal research sorely is needed. With a few exceptions (e.g., Vaillancourt et al., 2011), existing work rarely has examined physiological responses repeatedly over time, thus precluding conclusions about the extent to which peer experiences can change trajectories of stress-response markers. In this regard, studies are also needed to directly test physiological stress responses as plausible mechanisms of biological embedding (see Rudolph et al., *in press*).

Second, important considerations should be taken into account when examining the effects of physiological stress response systems on health outcomes. Although dysregulated physiological responses (e.g., flatter diurnal cortisol patterns; see Adam et al., 2017) have been linked to both mental and physical health, consistent and strong evidence supporting the hypothesis that physiological responses may contribute to the development of poor physical health outcomes is

lacking. At best, these physiological stress response systems have an indirect effect on health outcomes by inducing/channeling downstream changes in other systems (e.g., immune, metabolism) and by regulating gene expression activity. Thus, focusing exclusively on single biomarkers of physiological functioning (e.g., cortisol levels), may limit the opportunity to identify key processes (e.g., glucocorticoid signaling) that have more direct implications for health outcomes (see Ehrlich, Miller, & Chen, 2016). Therefore, while we urge greater research attention toward the study of associations between youths' peer relations and physiological stress response systems, it will be crucial to adopt a multi-system approach to better understand when and how physiological responses may modify relevant downstream activities at the molecular level (e.g., intracellular inflammatory responses; Kuhlman et al., 2017).

Finally, it should be noted that not all existing studies have revealed that prior peer experiences are associated with maladaptive physiological functioning; findings have been mixed (c.f., Kliewer, 2006; Kliewer et al., 2012; Knack et al., 2011; Ouellet-Morin, Danese, et al., 2011a; Ouellet-Morin, Odgers, et al., 2011b; Rudolph et al., 2011). This may be welcome news to clinical child and adolescent psychologists, particularly those who may be disheartened by a recent increased emphasis on biological models for understanding human behavior (Teachman et al., 2019), because results suggest that there may be several additional factors that work in conjunction with peer experiences to affect patterns of physiological functioning. Future research thus may benefit by addressing not *whether* peer experiences affect stress-responses, but *under what conditions* these effects are most likely to occur. For instance, in prior work peer relations researchers dedicated substantial effort toward understanding how children's encoding of social cues, cue interpretations, goal clarification, response construction, selection, and enactment may be implicated in youth's aggressive behavior (e.g., Crick & Dodge, 1994; Lemerise & Arsenio, 2000) and addressed in problem-solving skills interventions to reduce disruptive behavior (Lochman & Wells, 2004). Similar frameworks might be used to understand under what circumstances peer experiences might affect physiological stress-responses. It is likely that stressful experiences among peers are deleterious to developing physiological systems only when youth encode and interpret social stimuli as stressful, for instance. Of course, this is relevant not only to the study of physiological stress response, but also to a wide array of other biological, neural, and epigenetic stress responses that have been studied rather

infrequently within the peer literature (see section below on immune system functioning). In addition, modern technological advances may allow for the assessment of many of these social-cognitive processes with greater scientific rigor, such as the use of eye-tracking devices to examine cue encoding (Bangee et al., 2014), or the use of electronically-mediated communication (e.g., texts, social media posts) to capture cue interpretations or response enactments.

The resurrection of research on social information processing to understand when youth may be at risk for maladaptive stress responses also may have implications for prevention and intervention efforts. If results suggest that social-cognitive processes significantly moderate the association between adverse peer experiences and maladaptive physiological stress-responses, it would follow that universal cognitive-behavioral skills training may be indicated not only to prevent behavioral, but potentially also physical health conditions.

Peer Adversity and Immune System Functioning

Research also has recently revealed that adverse peer experiences may be associated with immune system processes that likely have important implications for physical health as well as psychological symptoms. Of course, it has long been known that physical injuries or infections trigger the innate immune system, signaling immune cells (e.g., macrophages) to begin an inflammatory response. This process is fundamental to allow our species to withstand physical threats and therefore is crucial for an individual's survival.

Health psychologists examining psychoneuroimmunology have demonstrated that social environmental factors also can regulate inflammatory responses, even in the absence of physical injuries. One body of research has revealed that exposure to *acute* social stressors results in temporary increases in inflammation. For instance, a recent meta-analysis of experimental studies demonstrates that laboratory (social) stressors induce moderate to strong increases in multiple circulating pro-inflammatory cytokines (e.g., interleukin [IL]1- β , IL-6) between 40 and 120 minutes after exposure (Marsland et al., 2017). Similar, and related to neural responses to social exclusion discussed above, it has been posited that these inflammatory responses may reflect a social self-preservation system that humans may have evolved due to the survival values of social relationships (Dickerson et al., 2004; Gruenewald et al., 2007), and likely occur following the activation of physiological systems (i.e., sympathetic nervous system and HPA-axis) discussed above. Thus,

there is strong theoretical and empirical work suggesting that acute negative peer interactions (e.g., friends' conflict, peer rejection), may be potent regulators of inflammatory responses; yet to date this remains a largely underdeveloped area of research.

Another body of work has focused on the effects of *chronic*, rather than acute, stress. Specifically, several studies revealed that individuals exposed to repeated and enduring stressors (e.g., early life adversity) have sustained levels of inflammation, as indicated by markers of systemic low-grade inflammation (e.g., C-reactive protein – CRP; see Baumeister et al., 2016; Rohleder, 2019). These latter findings are particularly relevant as they indicate that repeated adversity may in fact result in more stable and persistent changes in the immune system functioning, which likely have more direct and profound consequences for health. Accordingly, recent theoretical frameworks (e.g., neuroimmune network hypothesis; Hostinar et al., 2018; Nusslock & Miller, 2016) posit that exposure to chronic stress may sensitize immune system responses, leading to an increased tendency to mount inflammatory responses in face of subsequent threats. This may result in a prolonged state of elevated inflammation, also referred to as pro-inflammatory phenotype (Miller et al., 2011), which may explain how adversity gets biologically embedded.

Drawing on this work, a handful of studies have begun to explore the extent to which peer adversity may affect the immune system functioning. For instance, using longitudinal data from the Great Smoky Mountains Study, Copeland et al. (2014) reported that children exposed to bullying victimization showed stronger increases in low-grade inflammation (i.e., CRP) over time as compared to their nonbullied peers. In another study, the effects of childhood bullying victimization on CRP persisted into adulthood, across a time span of more than 30 years (Takizawa et al., 2015). Finally, research suggests that peer victimization may sensitize immune system responses to subsequent social stressors, as indexed by increased production of pro-inflammatory cytokines (i.e., IL-1 β , IL-6) in response to an acute laboratory stressor (Giletta et al., 2018). Preliminary evidence suggests similar effects may be evident for additional forms of peer adversity as well (e.g., low peer preference, poor conflict resolution among peers) and for additional markers of inflammation (e.g., Allen et al., 2018; De Bruine et al., 2019; Ehrlich, Miller, Rohleder, et al., 2016; Fuligni et al., 2009); yet this field is only in its early infancy.

In recent years, exciting findings from the new field of “human social genomics” – which examines how

social factors regulate the activity of the human genome (Cole, 2014) – further highlight the relevance of immune system processes to understand the link between social experiences and health. Pioneering this field, Slavich and Cole (2013) explicate how physiological responses to life stress, and perhaps especially to social rejection-related experiences (Murphy et al., 2015), can have intra-cellular implications, leading to transcriptional changes in specific gene sets that shape health and behavior (Cole, 2019). Specifically, Slavich and Cole (2013) propose a Conserved Transcriptional Response to Adversity (CTRA) in which exposure to social stress downregulates the expression of genes involved in anti-viral immunity and upregulates the expression of genes involved in pro-inflammatory activity. Following from the evolutionary theories discussed above, results regarding inflammation are consistent with the notion that once ostracized from others, *Homo Sapiens*' risk for physical injury may have increased significantly, with survival being most likely for those who were able to quickly heal and ward off infections; meanwhile, viral immunity was less necessary if removed from the presence of other humans (i.e., who carry transferrable viruses; Slavich & Cole, 2013). Interestingly, although neither of these molecular responses may be necessary today to ensure survival following social rejection, significant evidence suggests that this social rejection-related shifting of transcriptional resources toward an increased inflammatory and reduced anti-viral state remains observable in recent research and may help shed light on how peer social rejection ultimately affects human health and behavior (Slavich, *in press*).

Indeed, the relevance of these immune system processes lies in the fact that they likely have important implications for the development of a wide array of both physical as well as mental health outcomes, many of which have been previously related to peer adversity. Of course, elevated chronic inflammation may be involved in the occurrence of several chronic cardiovascular, neoplastic (cancer) and neurodegenerative diseases (Finch, 2010) and may therefore provide a biologically plausible pathway linking peer relationships with a more pervasive set of wellness outcomes than has been explored in prior work (Allen et al., 2015; Almquist, 2009; Almquist & Brannstrom, 2014). Yet, inflammation is not only relevant for physical health outcomes, many of which may clearly manifest only in adulthood, several years after exposure to peer adversity. Mounting evidence suggests that, in the shorter term, elevated inflammation may have substantial repercussions on cognitive functioning and social behavior, which may be critical to understand health problems later in life. Notably, the

cognitive, social and behavioral consequences of inflammation may be of particular relevance to clinical child and adolescent psychology investigators, given that many of these social and cognitive processes have been extensively examined in the context of youth peer experiences. For example, animal and human research suggest that elevated levels of inflammation can increase threat perception and increase social withdrawal (Bollen et al., 2017; Eisenberger et al., 2017). For instance, in experimental studies participants exposed to a dose of endotoxin (triggering inflammation) showed increased sensitivity to negative social situations (e.g., social rejection) and enhanced self-reported social withdrawal, as compared to participants exposed to placebo (see Eisenberger et al., 2017). Other work revealed that elevated inflammatory markers are associated with poorer executive functioning and self-regulation abilities (Hostinar et al., 2018; Shields et al., 2017), as well as with behavioral manifestations of those cognitive processes, including elevated body mass index, eating disorders and other mental health outcomes (e.g., Dalton et al., 2018; Hotamisligil, 2006; Mac Giollabhui et al., 2019; Miller, 2020).

In the context of mental health, much work has recently focused on examining the link between inflammation and depression. Theory and research suggest that elevated inflammation and inflammatory responses to social stress may be associated with increased risk for depression, as well as several somatic complaints that frequently co-occur with depression, such as asthma, arthritis, and chronic pain (e.g., Dooley et al., 2018; Kiecolt-Glaser et al., 2015; Valkanova et al., 2013). In this regard, Slavich and Irwin (2014) articulate how social stress activates a multi-level social signal transduction pathway that links social stress with increased physiologic and inflammatory activity. Consistent with this Social Signal Transduction Theory of Depression, some recent research has revealed that inflammatory markers (Moriarty et al., 2019) and pro-inflammatory cytokine responses to social stress each are associated with increases in adolescents' depressive symptoms (Slavich et al., 2020). Although it should be acknowledged that the association between inflammation and depression is complex, and likely is bidirectional in nature, this line of research certainly warrants further investigations to elucidate the conditions under which inflammation may increase the risk for depression (Miller & Raison, 2016). Overall, findings such as those reviewed above offer numerous exciting opportunities for peer relations research, including the examination of specific peer interactions that may be especially associated with markers of immune system

functioning, including the CTRA profile, transactional models to examine how inflammatory responses may affect youths' subsequent social information processing within the peer milieu and vice versa, or perhaps even intergenerational epigenetic effects of peer status and stress exposure. As discussed above, longitudinal research is needed and future work would dramatically benefit from integrating theories and theoretical frameworks from the peer relations literature (e.g., Crick & Dodge, 1994; Lemerise & Arsenio, 2000). Additionally, a particularly exciting research direction may involve the simultaneous examination of neural and immune system responses. This research, for example, will be fundamental to underscore how peripheral responses to peer adversity at the level of the immune system may alter and interact with neural responses (e.g., reward and threat circuitries; see neuroimmune network hypothesis; Hostinar et al., 2018; Nusslock & Miller, 2016), thus allowing a better understanding of the processes that may lead to the development of health problems. In sum, recent research from psychoneuroimmunology offers a number of new exciting avenues for peer relations research, many of which have now increased feasibility thank to methodological advances that allow to reliably assess immune system markers (e.g., using minimally invasive procedures, such as dried blood spots; McDade, 2014).

Peer relations researchers are needed to help inform, guide, and enhance the study of immune system and more broadly biological, responses to social stress. Unfortunately, research in psychological science often occurs within siloed sub-disciplines, precluding the collaborations necessary to allow for rapid advances that reflect current expertise in all scientific domains. It may be useful for scholars who examine peer relationships to seek partnerships with investigators in areas outside of clinical and developmental psychology, to allow for greater cross-pollination of ideas and increased use of knowledge from the peer relations literature in the examination of questions that could benefit from a more sophisticated understanding of youths' peer interactions. Notably, the study of physical health outcomes offers numerous funding opportunities among institutes interested in specific medical ailments, as well as aging more broadly. In a world in which mental health stigma unfortunately remains high (Martinez & Hinshaw, 2016), the ability to demonstrate the physical consequences of youths' social functioning and stress exposure offers new talking points for advocacy and policy work that could be aimed toward peer competence curricula and increased psychological services for those experiencing peer adversity.

Additional Future Directions

This paper focused on four specific areas of research that are ripe for additional work and may help address emerging questions regarding the association between adverse peer experiences and youths' physical health outcomes. Of course, there are many additional frontiers that also would benefit from greater research attention to help understand the nature and impact of youths' peer relationships. Several of these are briefly listed here with hopes that they may motivate young scholars to dedicate their careers to this worthy and important area of psychological study.

In fact, in some ways, young scholars may be uniquely well-suited to become peer relations investigators, given that as compared to research on other clinical child and adolescent psychology processes, it seems that recent changes in peer interactions have been especially dramatic. Early career investigators, as compared to more senior scholars, likely have more recent personal experience that may be useful to help understand contemporary peer interactions.

For instance, as noted above, it is especially concerning that so little research has examined multicultural factors that are relevant to child and adolescent peer interactions, yet emerging data suggests that this is an absolutely critical direction for future work (e.g., Espinoza et al., 2018). To date, our understanding of popularity, forms of peer aggression/victimization, and friendship qualities and benefits, for instance, have largely reflected the majority culture in North American communities. Growing research has offered important perspectives on these topics from other global regions, which is critical (e.g., French et al., 2016; Schwartz et al., 2009). In addition, more work is needed to understand the experiences of members from racial/ethnic and sexual/gender minority groups. Importantly, this may suggest interesting forms of functions of peer interactions that reflect cultural differences, or may result from the experience of minority stress. Young scholars who have been raised in an increasingly diverse society may have unique insights that would enrich our understanding of child and adolescent peer experiences, and allow prior research to be reconsidered within a multicultural framework.

Early career scholars also have been at the forefront of emerging research on electronically-mediated communication between peers (i.e., via text, or on social media and gaming platforms) which has become far more frequent than the types of peer interactions that have been studied to date. Interestingly, research suggests that adolescents' experiences with technology do not merely reflect the peer relationships that are

occurring offline, but create unique social goals, interactions, and expectations that simply were not possible a decade ago (Nesi et al., 2018a, 2018b). Accordingly, research on technology use is yielding an exciting array of new peer relations constructs (e.g., digital status seeking, digital stress, etc. see Nesi & Prinstein, 2019; Slavich, *in press*; Steele et al., *in press*) that have no offline parallel, and promise to reframe discussions about peer relationships in exciting ways. Indeed, given the remarkably high proportion of youth that use devices to communicate with peers, and the extraordinary frequencies in which they do so (Lenhart, 2015; Rideout, 2016), the peer relations field may be at a crossroads; it may soon be impossible to understand contemporary peer relationships without a focus on online interactions. The peer relations field is uniquely well-suited to lead this area of scholarly pursuit, and the public is especially excited to learn about findings to help navigate the brave new world adolescents live in.

It also may be useful to consider how the era of electronically-mediated peer interactions may have altered the culture of youths' social relationships more broadly, affecting the goals, functions, and expectations of peer interactions occurring both on- and offline. This may have several implications for future research. Perhaps most dramatically, it has long been assumed that local peers provided a context essential for development – a training ground to experiment with new social roles, emerging identities, and social skills, and a milieu in which social rewards and punishments from peers provided ongoing feedback to guide this development (Bandura, 1973; Sullivan, 1953). The online world now offers youth a new context in which those developmental needs may be met, perhaps dramatically altering the ways in which researchers consider the role of peers. In many cases, youths' online interactions are with local peers, and may extend the context of relationships that occur across both online and offline contexts. However, youth increasingly engage in frequent interactions with others who not locally available, and often interact with content provided by “peers” who may not be age-mates or in nearby locations; often this content is highly curated, or even falsified. How do peers affect development in a world where adolescents have an alternate context to experiment and grow within?

The concept of peer status also may have new meanings and functions in the digital era.

Youth now live in a society where markers of peer status have been quantified and made salient on a world-wide scale, among both youth and adults. Are youth today consequently more invested in their peer

status than generations ago? Or alternatively, perhaps popularity among local peers is less relevant for the current generation of children and adolescents given the compensatory functions that online status may offer.

Last, for a generation of youth who grew up knowing of no world before social media, the concept of friendship also may be markedly different than the construct that has been examined in years prior. Today's youth may no longer regard in-person companionship as a determinant of friendship closeness; in fact, many adolescents report they are close friends with peers they have never met in person (Lenhart, 2015), or perhaps only play video games through virtual platforms. Today's youth also may have unique expectations for the provision of support and affirmation within friendships; unlike years ago, youth expect unfettered access to their friends at all hours, and demand public displays of affection and validation shortly after they text a bid for support, or a communicate vulnerability within a post. Social media profiles also may offer opportunities for youth to express their affection toward friends perhaps more frequently than in years past, and through the use of private profiles (e.g., "Finsta") adolescents' emotional expression also now takes different forms (i.e., relying on facial expression or songs to convey emotional distress). Even social goals for offline interactions have adapted, with in-person interaction now serving as opportunities to create images that can be posted online to broadcast peer experiences among a few to many others who were not present.

In short, future research on electronically-mediated communication among peers may benefit by examining not only what happens online, but also how online experiences, and the new culture that has given rise to/been influenced by them may have affected peer interactions more globally (see review by Prinstein et al., 2020). It will be important and exciting to determine whether technology may have fundamentally changed youths' expectations of, assumptions for, and uses of relationships in their lives. Indeed, this may represent a turning point for the peer relations field that could be led by new investigators in the field!

In sum, peer relationships are as important as ever for understanding psychological development. Beginning in daycare within the first months of life, through the school-aged years, and into adolescence using omnipresent, multimodal forms of communication, youth are raised primarily among peers. In the world of science, the study of peer relationships is relatively young, and perhaps suddenly increasingly relevant as wide range of scientific disciplines discover

that social relationships are critical to mental health, our physical health, and our fundamental identity. It's a great time to study peer relationships, and an especially exciting topic for young scholars who are interested in understanding what makes us human.

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