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Adolescent Sexual Decision Making and Sex Education:

Using developmental neuroscience to guide new directions for policy and practice

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Abstract: While school-based sex education is one of the key program and policy solutions to improve adolescent sexual health outcomes, new efforts are needed to strengthen its overall impact. The cognitive, hormonal, emotional, and physical changes that accompany the onset of puberty and occur throughout the teenage years play a significant role in aspects of adolescent sexual risk taking. Thus, one approach to advancing current understanding of these complex issues is to leverage emerging knowledge in developmental affective neuroscience over the past 15 years, which suggests some potentially promising innovations that may inform new educational directions to improve adolescent sexual health. Exploring the conceptual and empirical advances in understanding adolescent brain development through the lens of the conceptualization, implementation, and evaluation of sex education, this article provides new perspectives that encourage the testing of innovative approaches to sex education policy and practice.

Key Words: sex education, adolescent health, policy, neuroscience, Fuzzy-trace Theory

Introduction

Policy makers, public health professionals, educators and parents have engaged in an unending quest to understand and explain adolescent risk-taking behavior in an effort to provide appropriate scaffolding to improve adolescent sexual decision making. The current sexual health status of U.S. adolescents provides compelling reasons why improved interventions are needed. Despite recent decreases, the U.S. teen pregnancy rate continues to be one of the highest in the developed world (Guttmacher Institute, 2013a). While adolescents, aged 15–24 years, represent 25% of the sexually active population, they account for nearly 50% of the 18.9 million newly diagnosed sexually transmitted infection (STI) cases each year (Guttmacher Institute, 2013a). In 2008, almost 17% of the newly diagnosed HIV/AIDS cases in the U.S. were among youth between the ages of 13–24 years old (Guttmacher Institute, 2013a), signaling that many were exposed to the virus far earlier in their adolescence.

While school-based sex education remains an important tool to help improve adolescent health outcomes, new efforts are needed to improve its overall impacts. A primary reason that school-based sex education falls short stems from the fact that the current theoretical foundation of many curricula asserts that sexual decision making is primarily a rational, deliberative process. Far from being only a rational process, a number of affective (emotional and motivational) factors also influence adolescent sexual decision-making. The cognitive, hormonal, emotional, and physical changes that accompany the onset of puberty and occur throughout the teenage years play a significant role in aspects of adolescent sexual risk taking. Thus, one approach to advancing current understanding of these complex issues is to leverage emerging knowledge in developmental affective neuroscience over the past 15 years, which suggests some potentially promising innovations that may inform new educational directions to improve adolescent sexual health.

An extensive body of evidence from the fields of biology, psychology, sociology, public health, and education has helped to shape current sex education policies and practices and the

development of the National Sexuality Education Standards suggests a continued commitment to education policies and practices supported by science (Future of Sex Education Initiative, 2012). Despite this body of evidence, ideological factors serve as a significant impetus for policies related to school-based sex education (Bleakley, Hennessy, & Fishbein, 2006). While neuroscience alone cannot change this policy trend, it is important to understand what neuroscience can contribute to developing best practices. Emerging brain development research and neuroscience suggest that changes in rational, affective, and social processing play a critical role in influencing adolescent behavior (Crone & Dahl, 2012; Steinberg, 2005). The goal of this article is to explore ways to use emerging neuroscience research in adolescent decision making to inform sex education policies and behavioral interventions. While the current understanding of developmental neuroscience may be too formative at this time to directly translate into policy and practice, conceptual and empirical advances in understanding adolescent brain development may provide new perspectives that encourage the testing of innovative approaches to sex education, which, in turn, may lead to more effective behavioral interventions.

Using Evidence to Drive Sex Education Policy and Practice

Since the 1970's, one of the primary policy responses to address adolescent pregnancy and sexually transmitted infection (STI) rates, including HIV, has been school-based sex education programs (Guttmacher Institute, 2013b). Both abstinence only and comprehensive school-based sex education aims to provide young people with knowledge and skills and the opportunity to form attitudes and beliefs, with the end goal of improving adolescent sexual and reproductive health. While abstinence only education teaches about the "physical and emotional harm of casual teen sexual activity and strongly discourages such activity" (Martin, Rector, & Pardue, 2004, p. xv), comprehensive sex education aims to delay the initiation of sexual intercourse, improve sexual decision-making, and increase the use of condoms and other forms of contraception at the time of sexual debut, subsequently helping young people avoid adverse

health outcomes, including unintended pregnancy, STIs, and HIV. While few education programs include these components, when expanded to include the broader tenants of sexuality education, sex education also can also focus on positive sexual development, including the experience of healthy, safe, pleasurable sexual experiences (World Health Organization, 2010). Thus, truly comprehensive sexuality education expands to incorporate topics related to sexual development, interpersonal relationships, body image, intimacy, and gender roles (Goldfarb & Constantine, 2011; SIECUS, 2012).

Today, 33 states and the District of Columbia have policies mandating school-based HIV education, which include information about HIV infection and prevention, and 22 states and the District of Columbia mandate sex education (Guttmacher Institute, 2013b). In these policies, there has been strong support for use of best practice sex education curricula based firmly in health behavior theory (Brindis, Sattley, & Mamo, 2005; Kirby & Laris, 2009). Social learning theory (Rotter, 1954), social cognitive theory (Bandura, 1991), and self-efficacy theory (Bandura, 1977), provide the theoretical foundation for the majority of evidence-based adolescent sex education programs (Kirby, Laris, & Rolleri, 2007). Other significant theories that have informed effective current sex education efforts include the theory of reasoned action (Fishbein, 1979); the health belief model (Rosenstock, 1974); the theory of planned behavior (Ajzen, 1985); and the information-motivation-behavioral skills model (Fisher & Fisher, 1992; Kirby et al., 2007). Following a traditional educational model, these theories are all based in the assumption that adolescent sexual behavior results from an intentional, deliberative process in which the individual weighs the pros and cons of a decision, considers external influences, develops a behavioral plan, and follows through on the selected action (Gibbons, Houlihan, & Gerrard, 2009). In alignment with traditional education theory, these theories predict that providing adolescents with information, skills, self-efficacy, and opportunities to plan ahead, will improve their capacity to make informed sexual decisions.

Recent research has pushed policy makers, educators and practitioners to look beyond the abstinence and risk dichotomy to explore the social, economic, political, environmental, familial, and cultural factors that influence adolescent sexual decision making (Schalet, 2011). In recognition of the breadth of factors influencing adolescent sexual behavior and in an attempt to improve the impact of sex education, the 2012 National Sexuality Education Standards and newer rights based approaches have expanded the theoretical foundation to include social cognitive theory (Bandura, 1991), the social ecological model (Sallis, Owen, & Fisher, 2008), and other theories related to gender, power and human rights (Rogow et al., 2013).

Building Evidence

Over the past 20 years, there has been an extensive effort and considerable scholarly and practice-focused literature dedicated to determining the effectiveness of sex education (Devaney, Johnson, Maynard, & Trenholm, 2002; DiCenso, Guyatt, Willan, & Griffith, 2002; Jemmott III, Jemmott, & Fong, 2010; Kirby, 2008; The Administration for Children and Families Department of Health and Human Services, 2007). A number of in-depth studies have explored the impact of various approaches to sex education. Reflecting the theoretical underpinnings of many sex education curricula, the most widely documented impacts of sex education are changes in adolescents' sexual knowledge, attitudes and behavioral intentions (Kirby et al., 2007; Kohler, Manhart, & Lafferty, 2008). Given the overall complexity of the dynamics impacting adolescent sexual and reproductive health behaviors, these changes in knowledge have not been shown to directly translate into changes in adolescent sexual behavior or sexual health outcomes (Kirby, 2008). While some research has suggested that some effective, skills-based sex education may help delay the onset of sexual activity (Jemmott III et al., 2010) and increase use of contraception at first intercourse (Lindberg & Maddow-Zimet, 2012; Mueller, Gavin, & Kulkarni, 2008), other research has demonstrated that overall sex education has limited effect on these behaviors (DiCenso et al., 2002; Kirby et al., 2007). Studies examining teen pregnancy rates have yielded mixed results, with some studies showing no effect from

health education (Cavazos-Rehg et al., 2012; DiCenso et al., 2002; Kirby et al., 2007), while others showing promising reductions (Kohler et al., 2008).

Although researchers have made great strides in identifying the common characteristics of effective sex education programs, they continue to face challenges (Kirby & Laris, 2009; Kirby et al., 2007; Suellentrop, 2011). Programs that have proven successful in positively impacting sexual health outcomes often have the exact same characteristics and components as programs found to have no effect (Gavin, Catalano, David-Ferdon, Gloppen, & Markham, 2010). Evaluations of many existing interventions, even those deemed as best practices, have failed to establish a causal link between factors influenced by sex education and sexual decision-making, behavior, or health outcomes (Constantine, 2012). Overall, current sex education efforts *alone* have not contributed to profound reductions in adolescent pregnancy or STI rates or increases in age of first coitus (DiCenso et al., 2002; Hauser, 2004; Kirby et al., 2007; Kohler et al., 2008) and even for interventions that have had some impact, it is unclear what mechanisms or program components led to the behavior change (Kirby et al., 2007).

Expanded programs that are more culturally relevant and include discussion of gender roles have been found to result in more positive behavioral outcomes than social cognitive theory-based sex education (Bell, Terzian, & Moore, 2012). Broad, developmentally-based, longitudinal, comprehensive interventions, such as the Children's Aid Society (Philliber, Kaye, Herrling, & West, 2002) and the Abecedarian Project (Campbell, Ramey, Pungello, Sparling, & Miller-Johnson, 2002), have yielded promising impacts on adolescent sexual health outcomes as compared to more traditional sex education approaches, which often stress the provision of information (Gavin et al., 2010; Kirby, 2002). More limited service learning interventions that include voluntary community service with a structured opportunity for reflection on the service experience (e.g., Teen Outreach Program (Allen & Philliber, 2001)) have also shown some of the impacts of these more comprehensive programs. These multi-faceted, skill-building based approaches adopt a youth development framework providing both supports and services,

building upon existing youth strengths and assets (Brindis, 2006). Experts have proposed that the positive outcomes achieved are linked to longer lasting programs that support building meaningful relationships with caring adults, increased self-efficacy, focus on helping others, increased future orientation, and increased time in supervised, engaging activities (Gavin et al., 2010; Kirby, 2002).

Given the current state of sex education and the desire to improve the sexual health status of American youth, a key goal is to investigate ways to further improve sex education—in a way that leads to meaningful behavior change. Despite continued efforts to increase the adoption of evidence-based practices to inform sex education programs nationally, little progress has been made to assure that our nation’s youth have the ability to gain the types of knowledge and skills they need to navigate their adolescence successfully. These findings highlight the need to explore new ways to improve policy and practice.

One exciting opportunity for innovation points to rapid advances in understanding adolescent brain development—particularly the insights regarding pubertal changes in affective and social influences on cognitive processes—that may inform the theoretical underpinnings of school-based sex education. In addition, integrating innovative neuroscience methods to evaluate and refine sex education may improve and strengthen programs, increasing the likelihood of better short and longer-term outcomes.

Adolescent brain development and implications for sexual decision making

Adolescence is a period of incredible transformation during which adolescents experience a number of cognitive, hormonal, and physical changes that influence their sexual decision making. Adolescence begins with the hormonal and physiological changes associated with puberty and ends with a social transition to adulthood. The hormonal shift at the onset of puberty not only affects physical maturation, but also influences the brain – activating changes in emotions, goals, and motivations (Crone & Dahl, 2012). Recent developments in neuroscience have highlighted that the interactions between the maturation of cognitive,

affective, and social processing during adolescence appear to play a key role in understanding and addressing key aspects of adolescent risk-taking behavior (Crone & Dahl, 2012). The period of adolescence spotlights the importance of neural plasticity, a process through which thinking and learning transform the brain's physical structure and functional organization (Galván, 2010). Experiencing new attractions, motivations, and desires for experiences, sexual decision making (among a number of risk-taking behaviors) becomes complex for adolescents to navigate.

There are multiple layers involved in adolescent sexual decision making. While adolescents demonstrate similar cognitive capacity to adults, extensive research has shown that specifically in affectively charged contexts, adolescents take greater risks than adults due to simultaneous development of social and emotional processing systems (Chein, Albert, O'Brien, Uckert, & Steinberg, 2011; Steinberg, Cauffman, Woolard, Graham, & Banich, 2009; Van Duijvenvoorde & Crone, 2013). This developmental trajectory contributes to our understanding as to why adolescents have remarkably higher rates of unintended pregnancy and STI infection than adults. While 49% of pregnancies to U.S. women are unintended, 82% of pregnancies among adolescents, ages 15-19 years old, are unintended (Finer & Zolna, 2011). Similarly, the rate of chlamydia infection among 15-19 year old females is 2.5 times that of females 25-29 years old, and 6 times that of females 30-34 years old (Centers for Disease Control and Prevention, 2012). Most adolescents have adult-like capacity to make cognitively based decisions related to planning for sex or the skills necessary to seek treatment before or following sex, but they need better supports to make decisions when they find themselves making decisions in highly affectively charged, peer influenced sexual situations.

As a result, sex education based on a rational decision making model has a limited chance of success for premeditated sexual decisions and almost no chance for success for impulsive or spontaneous sexual decisions, which normally occur in highly affective states. Understanding the complexity of the interaction of the development of the neural systems and

how they influence adolescent sexual decision-making provides a foundation for improving school-based sex education. While a comprehensive review of adolescent neuroscience is beyond the scope of this paper, the following section highlights some of the key developmental changes that influence sexual decision-making and which in turn, need to be considered in the development of new sex education programs.

Cognitive Development

During adolescence, young people gain increasing cognitive capacity, which facilitates their ability to assume more adult-like roles and responsibilities. In recent years, neuroimaging has facilitated a more comprehensive understanding of the development of complex neural circuits that accompanies the important cognitive changes (Steinberg, 2005). The maturation of the lateral prefrontal cortex and the parietal cortex, both integral to managing impulse control, play the primary roles in adolescent cognitive development (Casey, Jones, & Hare, 2008). Maturation of the prefrontal regions affects basic cognitive control functions, including working memory, task switching, self-inhibition, and complex cognitive control functions, such as performance monitoring, feedback learning, and relational reasoning (Crone & Dahl, 2012). The prefrontal regions are also involved in individuals' assessments of other people (Pfeifer et al., 2013). While adolescents have increased prefrontal activation than children when completing cognitive control tasks, the difference in activation between adolescents and adults suggests different coordinated recruitment of similarly structurally mature regions (Smith, Chein, & Steinberg, 2013).

Differential activation of key frontal regions (right inferior frontal gyrus (rIGF) and insula) has also been linked to increased impulsivity in general and specifically to increased sexual risk taking (Goldenberg, Telzer, Lieberman, Fuligni, & Galván, 2013). Overall, in comparison to adults, adolescents exhibit decreased activation of the insula and rIGF during during a laboratory impulse control task (Go No-Go) (Goldenberg et al., 2013). Similarly, during the Go No-Go task, adolescents who took greater sexual risks by using less reliable contraception

during intercourse were less likely to recruit the insula and rIGF than less risk inclined peers (Goldenberg et al., 2013). This observed difference in prefrontal activation among adolescents who engage in greater sexual risk taking may suggest individual differences in engagement and attention and/or it may point to a key developmental process (Goldenberg et al., 2013).

While it would appear that the increase in cognitive control functions would lead to decreased risk-taking and improved sexual decision-making throughout adolescence, other factors also interact with this process. One key challenge results from the fact that sexual decision making that leads to the most health protective outcomes may actually conflict with an adolescent's rational goals of maintaining relationship intimacy and gaining social status (Reyna & Farley, 2006). By mid-adolescence, young people have similar cognitive capacities as do adults and understand risks associated with sexual activity, but they lack specific experience in affective evaluation and regulation related to sex, sexuality, and sexual behavior to employ when making decisions (Dahl, 2004; Steinberg, 2005). Even when adolescents employ careful rational processing in sexual decision-making, they may not always derive the most health protective outcome. Due to their inexperience, when adolescents employ cognition during decision-making, they may put greater weight on the *benefits* of engaging in sexual behavior, than on the *risks* associated with the behavior, resulting in adverse outcomes (Rivers, Reyna, & Mills, 2008).

Memory and prior experience

Upon encountering a new decision-making opportunity, an individual must rely on prior experience with related decisions and integrate new information from this novel experience. As people gain experience with making a decision, one's dependence on verbatim memory of the decision's context, process, and consequences decreases and one's dependence on generalized, rapid, "gist" based decision-making increases (Reyna & Farley, 2006; Rivers et al., 2008). In the context of adolescent sexual decision making, this means that adolescents who are engaging in a new sexual activity for the first time, or even a familiar activity with a new

partner, will likely employ a slower decision making process resulting in extensive weighing of the emotional and cognitive pros and cons of choosing to engage in a sexual activity. When engaging in this deliberative process, an adolescent may weight short term, immediate outcomes (i.e., physical pleasure, intimacy with a partner) more significantly than longer-term outcomes (i.e., avoiding an STI or pregnancy), resulting in increased risk taking. Even adolescents, who have clear future goals that exclude early childrearing, may choose to have sex without a condom in order to achieve the more immediately salient short-term goal of trust and intimacy with their partners.

Lack of experience with certain situations can also significantly interact with working memory capacity and subsequent sexual decision-making. Working memory capacity describes one's capacity to hold multiple pieces of information 'on-line' in one's immediate mental processes in order to perform a task (Cowan, 2005). New information and experiences burden working memory by occupying the brain with capturing details. This dedication of cognitive resources can create limitations in the amount of new information that an individual can retain, process, and integrate (Cowan, 2005). Working memory capacity has been found to develop in a linear fashion throughout adolescence (Blakemore & Choudhury, 2006; Luciana, Conklin, Hooper, & Yarger, 2005; Nagy, Westerberg, & Klingberg, 2004). Because the period of adolescence involves a vast number of novel experiences, adolescents may face challenges in attempting to retain and apply all of the new information and skills they have learned, especially in interactions that are particularly "charged" with emotions.

In the context of sexual decision-making, adolescents strive to retain cues related to novel experiences in romantic and sexual interactions. Some examples of these cues may include what elicits a positive response from a potential partner; what words and actions enhance a romantic interaction; how to propose a sexual encounter; and how to put on a condom. Because sexual experience only represents a small portion of the burden on adolescents' working memory capacity, this information may be competing with memories

including navigating a new, larger school, more complicated social and academic demands, and increasing personal responsibilities. While adolescent brain development contributes to increases in working memory capacity, this capacity may still not be sufficient for adolescents to retain and effectively employ information, especially in states of high arousal, in a way that results in improved sexual health outcomes.

As adolescents gain experience making sexual decisions, they are more likely to be able to better engage their enhanced cognitive capacity. This translates into decreased burdens on their working memory capacity and increased ability to use a gist representation, or generalized framing of a decision, to make their sexual choices, resulting in more balanced weighting of short and long term goals and pros and cons (Rivers et al., 2008). Increased experience making sexual decisions, including setting boundaries, refusing sex, and refusing to have sex without protection, not only helps adolescents make better sexual decisions in the short-term, but also lays the foundation for how they will make sexual decisions in the future.

Social-emotional Development

Emotion can lead to direct behaviors and provide an important feedback system, which facilitates learning and cognitive integration after an experience has taken place (Baumeister, Vohs, DeWall, & Zhang, 2007). As adolescents prepare to separate from their family of origin and take on adult responsibilities, they undergo significant social and emotional transformation. Adolescent neuroimaging has uncovered two components of social development: social-cognitive and social-affective development (Crone & Dahl, 2012). Social-cognitive development, involving the knowledge and skills needed to understand and navigate social situations, has been linked to a network of brain regions that include the medial prefrontal cortex (mPFC) and the temporoparietal junction (TPJ) (Crone & Dahl, 2012). The interaction of the activation of these two parts of the brain contributes to the development of social skills and capacities, specifically related to one's ability to engage in pro-social behavior (Crone & Dahl, 2012;

Eisenberg, Fabes, & Spinrad, 2007). Similarly, social-affective development, centered in the temporal pole and the insula, influences adolescents' capacity to experience empathy and experience social acceptance and rejection (Crone & Dahl, 2012). Developmentally, pro-social behavior holds great importance as adolescents grapple with engaging in romantic relationships and negotiating sexual limits, while also developing their own sense of self. Being able to master pro-social behavior influences adolescents' success in relationships, mating, and future sexual behavior throughout their life course.

The neural development linked to emotional processing also highly influences adolescent behavior. Adolescents, despite their increasing self-control, are highly motivated to find novel, exciting, and sensual experiences (Casey et al., 2008). Maturation of aspects of the limbic system involved in affective processing and regulation, leads to increased reward-seeking and sensation-seeking behavior in adolescents (Casey et al., 2008). Neuroscience has focused on this development and activation occurring in the ventral striatum (VS) – the reward center of the brain – and its connection to the prefrontal cortex (Crone & Dahl, 2012).

Functional MRI data has illustrated that while adolescents have increased striatal activation compared to children when experiencing rewards, they have decreased striatal activation compared to adults when anticipating rewards (Crone & Dahl, 2012). While increased VS activation during adolescence has traditionally been associated with increased sensation seeking and risk-taking, some new research suggests that in the context of meaningful pro-social behavior, it may also be associated with declines in risk-taking (Telzer, Fuligni, Lieberman, & Galván, 2012). The limited capacity of adolescents to predict the emotional pleasure of rewards coupled with an enhanced capacity to experience rewards may help explain their risk-taking and sensation seeking behavior (Crone & Dahl, 2012). As a highly affective and sensual experience, sex creates both an opportunity for physical and psychological excitation and sensuality and a continued opportunity for novel experiences with new partners and/or new activities.

Peer Influence

As a result of brain development, adolescent risk-taking is uniquely influenced by peer presence and peer pressure (Forbes & Dahl, 2010; Gardner & Steinberg, 2005; Pfeifer et al., 2011). Neuroscience has demonstrated that the presence of peers can enhance an adolescent's drive towards reward-seeking behaviors as peer presence simulates the reward circuitry in the brain (Chein et al., 2011; Sunstein, 2008). Early adolescents also experience greater activity in the regions of the brain associated with reward processing (VS and medial prefrontal cortex) when they engage in self-evaluative processing (Pfeifer et al., 2013).

Both sexual partners and platonic peers influence adolescent sexual encounters. Sexual partners are physically present during sexual encounters and have outcome expectations for the relationship that contribute to intimacy and fidelity. In addition, platonic peers often share values and expectations related to sexual behavior and have been found to influence one another's sexual behavior (Ali & Dwyer, 2011; Dishion & Tipsord, 2011). The effect of peers on the neural reward circuitry can increase risk taking both when planning for and engaging in sexual encounters. When adolescents discuss sexual behavior with their platonic friends, they may increase their plans to take sexual risks and seek out pleasure and rewards in future sexual encounters. Similarly, when engaging in a sexual encounter, the presence of their romantic partner augments the stimulation of the reward circuitry in the brain occurring from the physical and emotional arousal. This intense pleasure stimulation contributes to the challenge adolescents face in engaging in rational, premeditated thought processes when pre-contemplating and engaging in sexual experiences.

Willingness vs. Intentions

One of the greatest challenges in addressing unplanned risk taking using a rational framework results from the fact that adolescents' willingness to engage in sexual behaviors is often implicit, while their plans and intentions are explicit. Implicit attitudes, linked to the reward center of the brain, have been found to differentially influence and predict adolescent behavior

(van Goethem, Scholte, & Wiers, 2010). While an adolescent can clearly articulate an explicit behavioral intention or plan to engage in or abstain from a specific sexual behavior, he may simultaneously have a conflicting, implicit willingness or openness to engage in that behavior (Gibbons, Gerrard, Reimer, & Pomery, 2006).

When adolescents lack experience in making a decision related to a specific behavior, their behavioral willingness, rather than their behavioral intention, is more likely to predict their behavior, resulting in less forethought and contemplation prior to taking action (Gibbons et al., 2006). This may result because the context in which a young person makes a plan for sexual behavior is often affectively neutral, in the absence of peers, and in a state of non-arousal. The inverse is true when the decision is made in an affectively charged context and state of high arousal, shaped by the presence of their partners and perceived peers. When the context of the plan better matches the context of the decision, behavioral intention becomes a better predictor of behavior (Gibbons et al., 2006), but this rarely occurs in sexual decision making, in which arousal is increased by a variety of internal and external factors.

Using emerging neuroscience to inform sex education policy and practice

Linking the field of neuroscience to the fields of education and public health has proved challenging and there has been an ongoing discussion about how to best integrate the learning into the classroom setting (Beauchamp & Beauchamp, 2012; Geake & Cooper, 2003; Johnson, Blum, & Giedd, 2009). Efforts have been made to integrate an understanding of neuroscience into policy and programs related to adolescent health (e.g. minor consent laws, graduated drivers' licenses, and substance use interventions) (Johnson et al., 2009; Steinberg, 2009; Steinberg et al., 2009; Wiers et al., 2006; Wiers, Van De Luitgaarden, Van Den Wildenberg, & Smulders, 2005), and classroom education (Geake & Cooper, 2003) with mixed results. Despite this early mixed success, more recent neuroscience findings may be able to improve the impact of sex education. Neuroscience has demonstrated how social and emotional factors, which extend beyond a rational decision-making framework, significantly influence adolescent sexual

behavior in a number of ways. The recent research documenting the interaction between developmental factors that influence emotions, affect, and cognition in sexual decision-making points to a need to better integrate these components into sex education. However, the path to integrating neuroscience into school-based sex education is far from straight forward. This represents a challenging task, given the variability of students' experience of sex education in classrooms. Bridging our understanding of adolescent brain development to our sex education policies and practices holds promise. In this section, we present a number of areas in which neuroscience could be considered in conceptualizing, implementing and evaluating sex education curricula. While some school-based sex education does integrate some of the components described below, we advocate for more comprehensive application of these concepts across curricula. **Table 1** summarizes the recommendations outlined below.

Examples of Innovations Using Neuroscience

Revisiting the theoretical foundation of curricula

Reviewing and revising the theoretical underpinnings of existing school-based sex education holds promise. As outlined above, neuroscience has helped to highlight the importance of viewing sexual decision making beyond a rational framework. Rationally based sex education curricula fail to address that adolescents often have competing short-term and long-term goals in sexual decision-making. In addition, it is very challenging to create a classroom environment for youth to practice employing decision-making skills that accurately reflects the real context in which they will be making sexual decisions. While enhanced cognitive capacity serves adolescents in states of non-arousal, traditional sex education, which focuses primarily on giving information and building skills, fails to address the transitional state of the social, emotional, and cognitive capacity of adolescents and its influence on their sexual decision making. While some sex education curricula extend beyond a rational decision-making framework, a more universal move in this direction is needed to improve the educational impact.

Translating neuroscience into practice requires applying theories that helps to bridge the fields. The field of social psychology has proposed dual process theories, which divide cognition into two general categories: controlled and automatic (Gawronski & Creighton, 2013). Over 23 theories have attempted to capture the interaction of these two functions in general decision making (Gawronski & Creighton, 2013; Reyna & Rivers, 2008) and a number of them focus on the role of both cognition and emotion in adolescent health decision making (Gerrard, Gibbons, Houlihan, Stock, & Pomery, 2008; Reyna, 2004; Wiers, Houben, Roefs, Hofmann, & Stacy, 2010). Recognizing that decision-making is not a solely cognitive process, dual process theories reflect the concepts supported by recent developments in neuroscience, and integrate the role of affect and emotion, behavioral willingness (Gibbons et al., 2009), memories and mental representations of people or settings associated with risk (Gibbons et al., 2009), implicit processes (Wiers et al., 2010), and risk-avoidant values that are stimulated by specific situational context (Reyna & Farley, 2006; Reyna, 2004), into decision making frameworks. Expanding the theoretical underpinnings of sex education curricula to include concepts from dual process theories holds great promise.

Fuzzy-trace theory, which proposes a gist and a verbatim pathway, has been one of the primary dual process theories used to explore adolescent risk taking generally and sexual risk taking specifically (Reyna & Farley, 2006). Fuzzy-trace theory has been used to examine how adolescents engage emotion, prior experience, and information when making a decision (Rivers et al., 2008). Upon encountering a new decision-making opportunity, an adolescent relies on prior experience with related decisions and integrates new information from the novel experience. As people gain experience with making a decision, their dependence on verbatim memory of the decision's context, process and consequences decrease and their dependence on generalized, rapid, "gist" based decision-making increases (Reyna & Farley, 2006; Rivers et al., 2008). Rivers, Reyna, and Mills (2008) define gist as "the meaning an individual extracts from information (i.e., semantic representation), which reflects the individual's knowledge,

understanding, culture, and developmental level” (p.36). Individuals are motivated to develop a gist to maintain efficiency in decision-making because they are physically unable to retain all of the information they receive (Reyna, 2004). As a result, they retain the *essence* of the facts and experiences they encounter. Upon encountering a new decision-making opportunity, an individual must rely on prior experience with related decisions and integrate new information from this novel experience. As people gain experience with making a decision, their dependence on verbatim memory of the decision’s context, process and consequences decrease and their dependence on generalized, rapid, “gist” based decision making increases. Repeated experience with the use of gist reinforces its perceived value and selects for utilization.

In alignment with Fuzzy-trace theory, due to their inexperience, when adolescents employ cognition during decision making, they may put greater weight on the *benefits* of engaging in sexual behavior than on the *risks* associated with the behavior, resulting in adverse outcomes (Rivers et al., 2008). In the context of adolescent sexual decision making, this means that adolescents who are engaging in sexual activity for the first time will likely employ a slower decision making process that may lead to extensive weighing of the emotional and cognitive pros and cons of choosing to engage in a sexual activity. Counter to the image of adolescents making fast impulsive decisions that lead to risk taking, Fuzzy-trace theory predicts that when engaging in a slow, deliberative process resulting from lack of experience, an adolescent may weight short term, immediate outcomes (i.e., physical pleasure, intimacy with a partner) more significantly than longer-term outcomes (i.e., avoiding an STI or pregnancy) resulting in increased risk taking (Rivers et al., 2008). As adolescents gain experience making sexual decisions, they are more likely to use a gist representation, or generalized framing of a decision, to make their sexual choices (Rivers et al., 2008).

While Fuzzy-trace theory holds that the development of health protective gists leads to improved decision making, it remains unclear how to best support the development of gist.

Some research suggests that adolescents who endorse a greater number of gist-like values (e.g. “Better to focus on school than on sex”; “Better to wait to have sex when you are not ready”) engage in less sexual risk taking (Rivers et al., 2008, p. 120). Similarly, Mills et al. (2008) examined the confusing fact that high perceptions of risk related to sexual behavior can be both positively and negatively associated with sexual risk taking behavior. The results of this research indicate that endorsing simple values or gist representations to avoid risk (e.g., “Better safe than sorry”) contributed to a protective effect of reducing risk behavior, while verbatim representations (e.g., “I am likely to get pregnant in the next six months”) engaged rational processes that resulted in increased risk taking (Mills, Reyna, & Estrada, 2008). Developing strategies in sex education curricula to strengthen health protective gist representations may increase their potential for success.

While gist-like concepts have been successfully integrated into sex education curricula, translating these educational components into the development of a health protective gist presents challenges. While adolescents may explicitly endorse the values described above, they may not fully understand or even be aware of their implicit values related to sexual behavior. Recognizing that intention to use condoms often does not lead to condom use behavior, van Empelen and Kok (2006) examined how behavioral intention and behavioral willingness influence adolescents’ condom use behavior. Even when adolescents are able to explicitly articulate their plans to use condoms, and endorse pro-condom values, they may not be aware of the factors that influence their implicit willingness to engage in unprotected intercourse. The conclusions of this research highlighted the importance of experience and context on sexual decision-making (van Empelen & Kok, 2006). In steady sexual relationships where condom use had been explicitly discussed and had become a habit, behavioral willingness was less likely to influence condom use behavior (van Empelen & Kok, 2006). In contrast, in the context of casual sex occurring in a novel context with an unfamiliar partner, independent of preparatory behaviors (purchasing, carrying and negotiating about condoms),

behavioral willingness played an important mediating role in condom use behavior (van Empelen & Kok, 2006).

While some sex education curricula do address behavioral willingness, addressing implicit, gist-like attitudes in an effective way remains allusive. In an effort to provide detailed information, classroom presentations often focus on facts and verbatim representations, rather than focusing on simpler gist representations. The majority of existing curricula aim to help young people understand the prevalence of STI infections, the modes of transmission, and the best means of prevention (Kirby & Laris, 2009). Most young people can clearly explain that they intend to avoid STIs and many can describe a clear plan of action. In a classroom setting where youth are discussing STIs, the overwhelming majority of youth express explicit intentions to use condoms or abstinence to prevent transmission. Where existing sex education often falls short is by failing to offer opportunities for youth to explore under what circumstances their willingness may deviate from their intentions. While a plan to use condoms during intercourse may explicitly sound like a good way to avoid STI infection, implicit willingness to have unprotected sex in the absence of condoms may be more predictive of future behavior. While a rationally based sex education curriculum focuses primarily on building skills and knowledge related to the preparatory behaviors, a dual process based curriculum would integrate creative strategies that help youth identify and influence their behavioral willingness to engage in risk taking behaviors and shift implicit attitudes related to sexual behavior. A review of existing curricula and a reframing of the lessons taught through a dual process model represents an initial first step in reframing sex education so that it can incorporate new neurological findings.

Integrating activities into sex education that explore both implicit and explicit beliefs and associated emotional outcomes may better prepare adolescents when they are faced with the actual decision. Activities that help adolescents identify their implicit attitudes related to sexual behavior may provide an opportunity for them to examine the difference between implicit and explicit attitudes and develop strategies to account for both. In addition, activities that provide

adolescents with an opportunity to explore the emotional weights associated with various behaviors may help them better understand their own motivations and better predict their future behavior.

Early attempts to operationalize dual process theories in field-based interventions have led to promising results in changing health behaviors related to alcohol use (Wiers et al., 2006; Wiers, Rinck, Kordts, Houben, & Strack, 2010). Wiers et al. (2010) were able to successfully change heavy drinkers' action tendencies to drink alcohol by shifting implicit attitudes related to alcohol through use of the alcohol Approach Avoidance Test. Using a simple push-pull computer simulation, participants pushed away images related to alcohol and pulled towards them images of soft drinks (Wiers et al., 2010). Participants who had been "trained" to push alcohol images away were able to perform this task more quickly, had significant changes in implicit attitudes related to avoidance of alcohol, and consumed less alcohol during taste tests (Wiers et al., 2010).

This serves as one promising example that independent of explicit cognition, measuring and shifting implicit attitudes can lead to improved health behavior. While it would require a great deal of creativity and sensitivity to develop a similar tool for sex education, it deserves further exploration. As discussed above, peers play an influential role in sexual decision-making that includes both implicit and explicit components. While some evidence-based sex education curricula provide information and skills to help address peer pressure, this approach only addresses the explicit components associated with decision-making. Providing a training tool and supporting education materials wherein adolescents pushed away images associated with prioritizing peers' expectations and pulled closer images associated with prioritizing their own expectations may help address the more implicit expectations and bolster the potential for a true behavioral impact. As schools continue to increase their use of technology in classrooms, such a tool could be more easily integrated into sex education programs or included as a homework assignment for students to complete outside of the classroom.

Pretesting curricula

Extensive investment is required to develop, pilot, and test research-based sex education curricula. Evaluating the effectiveness of sex education on behavior change outcomes has proven challenging and neuroscience offers opportunities to help us better assess and predict the impact of health education messages. In an innovative use of neuroscience, Falk and colleagues (2012) found that using functional MRI (fMRI) in a small sample of individuals to detect activity in a region in the medial prefrontal cortex (mPFC) of the brain previously associated with behavior change, was more effective in predicting behavioral change response than using the same sample's self reports (Falk, Berkman, & Lieberman, 2012). In this study, participants were both asked to review and explicitly self-report the effectiveness of three stop-smoking advertisements (Falk et al., 2012). In addition, fMRI was used to measure activity in a specific region in the MPFC, while participants viewed the ads (Falk et al., 2012). The advertisement participants explicitly ranked as least effective stimulated the greatest MPFC activity and resulted in the most stop smoking calls to a smoking cessation hotline when aired nationally (Falk et al., 2012). Moving beyond a traditional pilot of sex education curricula, this strategy holds great promise for using neuroscience to better predict an activity's potential to move beyond giving information to motivating behavior change.

While piloting a multi-session curriculum in a laboratory in an fMRI scanner is unrealistic, using scanner technology to compare neural responses to key components of sex education curricula with self-reports and behavioral data from participants may help disentangle the question of which program components have greater potential to lead to positive behavior change. In addition, under experimental conditions, this could be used to compare activities across curricula to compare the neural activity associated with different versions of similar activities. As Falk et al (2012) described, activities that stimulate increased MFPC activation could be theoretically examined to understand the educational components that lead to increased behavior change.

Because fMRI technology is limited to use in a laboratory, coupling fMRI methods with electroencephalography (EEG) methods in simulated or actual classrooms could add to our understanding of which components of sex education have the greatest potential behavioral impact. As a more portable technology, EEG has been used in real and simulated classrooms with children and adolescents to measure brain activity resulting from a range of factors including effects of sleep restriction (Beebe, Rose, & Amin, 2010) and acquisition of language skills (Tallal, 2000). In addition, EEG has been used extensively to explore the link between brain activity and emotion (Davidson, 2004). Coupling EEG data from students as they participate in sex education in a classroom setting with fMRI data gathered in a laboratory would increase our understanding of how different curricula components lead to brain activation that helps to predict behavior change and emotional learning. In addition, comparing neural activation during educational activities with non-subjective measures, such as accessing sexual health clinical services or negative pregnancy and STI tests, may shed light on which program components have the greatest behavioral effects. Using fMRI and EEG to test and pilot existing best practice curricula and to support the development of new curricula may enhance the potential for sex education to bridge the gap between providing information to education that increases the likelihood of generating real and protective behavior change.

Enhancing emotional learning in the classroom

While shifting the theoretical underpinnings of sex education creates opportunities for development of new strategies to expand emotional learning in the classroom, it also requires the development of other expanded educational approaches. Behavioral research and neuroscience suggests that young people improve their sexual decision making with increased experience, and specifically emotionally relevant experience. As suggested by Fuzzy-trace Theory above, with experience, adolescents move from relying on rational processes, which may result in increased risk taking, to engaging health protective heuristics that improve their

sexual health outcomes. Yet, educators have struggled to provide integrated experiential learning into sex education.

The *Healthy Choices: Relationships, Sexuality, and Family Planning* Program designed for use with the RealCare Baby®, an abstinence only program, marketed as “experiential learning technology” (Realityworks, 2013), serves as an example of a failed attempt in this arena. Designed to give teens some parenting experience in hopes that it will delay sexual debut, the program has been shown to have little impact on teenagers’ attitudes, beliefs, or intentions related to parenting or their sexual and contraceptive behavior (Somers & Fahlman, 2001; Tingle, 2002). While adolescents may be able to explicitly state their desire to avoid parenting after experiencing the infant simulator, they may not be aware of their implicit beliefs or their potential influence on their sexual behavior. Despite providing adolescents with the negative affective experience of caring for a demanding infant simulator, the curriculum does not provide any experiential learning related to the more implicit, affective desires to engage in sexual behaviors or negotiate sexual situations.

Similarly, role plays, a component of the most effective curricula, attempt to simulate negotiating condom use or discussing healthy relationships. Very limited research has looked at the specific impact of role-plays in adolescent health education and the majority has focused on substance use behavior (Nichols, Birnel, Graber, Brooks-Gunn, & Botvin, 2010). While helpful in highlighting important skills, role-plays often fail to capture the true emotional content of a real-time experience. Role plays can reinforce skills that can be applied in a controlled social context, but it is unclear if they help adolescents gain experience in translating those skills in highly emotional contexts that activate their implicit attitudes. Adolescents who had not explicitly planned to engage in unprotected sex, may not be able to apply the experience of negotiating condom use in a role-play situation to an unexpected sexual encounter, in which a condom is not available. Additional research that explores the effectiveness of role-playing, and the extent to which role plays enhance emotional learning would help highlight their role in effective sex

education. In addition, it would be helpful to determine in which doses and contexts role plays are most effective (e.g., what types of and how many role plays should be part of curricula).

With the increasing use of technology in and outside the classroom, computer-based strategies to simulate experience hold promise. Many efforts have been made to enhance traditional classroom learning environments with the use of virtual technology (Pan, Cheok, Yang, Zhu, & Shi, 2006). Focusing specifically on health behavior, the European project, eCIRCUS (Education through Characters with Emotional-Intelligence and Role-playing Capabilities that Understand Social interaction) has researched the role of technology in classrooms in supporting social and emotional learning related to bullying behavior (Sapouna et al., 2010). During the intervention, students engaged with the virtual environment for 30 minutes per week over a period of 3 weeks where they observed bullying situations in a school environment (Sapouna et al., 2010). Youth who participated in the virtual reality experience were less likely than controls to become victims of bullying, suggesting that the virtual learning helped participants learn strategies to cope with bullying situations (Sapouna et al., 2010). This research demonstrates the use of virtual environments to help youth apply knowledge and skills in emotionally charged contexts.

Recognizing that virtual realities are incredibly popular with 10-15 year olds and provide an opportunity to offer health information and model healthy behavior, the Centers for Disease Control and Prevention (CDC) has provided innovation funding to expand the use of social media in health education and promotion (Centers For Disease Control and Prevention, 2010). The CDC has also begun to explore the application of virtual learning related specifically to sexual health through The Second Life® Sexual Health Public Education and Outreach simulator (SIM) (Centers For Disease Control and Prevention, 2010). Second Life® has been used to distribute information about contraception, sexual health, STI transmission and other sexual health issues (Kamel Boulos & Toth-Cohen, 2009). The SIM also hosts expert speakers on HIV that avatars can attend and provides the “AIDS-related Kaposi Sarcoma Experience”

where participants can experience the social reaction from others of having KS lesions (Kamel Boulos & Toth-Cohen, 2009, p. 281). While evaluating the impact of virtual experiences presents unique challenges, the majority of participants using the sexual health SIM found the experience useful and 39% said that they had learned something new (Kamel Boulos & Toth-Cohen, 2009). While this SIM was geared towards adult users and the primary focus of this SIM was to provide information, it holds promise for enhancing school-based sex education. In addition to enhancing classroom education, virtual reality settings can serve as a tool parents who feel uncomfortable educating their children about sexual behavior and contraception.

Another example of using technology to increase the emotional salience of learning is the interactive video, *Seventeen Days* (www.seventeendays.org). The goal of the video is to highlight choice points and behavioral alternatives in sexual situations (Downs et al., 2004). The video becomes interactive by pausing for 30 seconds at key critical decision junctions and providing an opportunity for the audience to engage in a cognitive rehearsal and imagine how they would respond to the specific situation (Downs et al., 2004). Compared to youth who received the same content through a book form, at 3 months post-intervention, young women who watched the video were more likely to report abstaining from intercourse and less likely to report having been diagnosed with chlamydia (Downs et al., 2004). These promising results suggest that giving adolescents the opportunity to practice applying sexual knowledge in a highly emotionally arousing situation may translate into more effective application of knowledge and skills in a real sexual encounter.

Building on this early experience using technology to enhance emotional learning, integrating virtual reality software and video into traditional classroom sex education provides an opportunity for young people to gain virtual experience related to relationships and sexual health. Emotional experiences in virtual environments correlate with emotional experiences in real life, offering opportunities to use this as a venue for emotional learning (Riva et al., 2007). Thus, in a controlled and monitored environment, adolescents are able to gain emotional

experience related to a broad range of experiences, including asking someone on a date, experiencing a break-up, talking about sexual limits, making sexual choices, selecting contraception, and experiencing the different outcomes of sexual decisions and their impact upon other aspects of their lives. Enhancing a classroom lesson about healthy relationships by having students utilize a SIM or interactive video executing a specific assignment related to healthy relationships and communication would be an opportunity to apply knowledge in a more affectively charged environment. Virtual environments can also provide an opportunity to link school based sex education to discussions with parents in the home. Parents can engage in the virtual environments to learn more about the content of school based sex education and enhance their understanding of the social and emotional factors that influence sexual choices.

In a multi-session sex education program, enhanced emotional learning and experience through technology offers an opportunity to gain continual experience and feedback on an ongoing basis and allow adolescents to gain experiences and build skills in a very low risk environment. Follow up learning modules to reinforce classroom learning experiences may be helpful as most adolescents have access to computers and social media. Given that adolescents are increasingly more technologically savvy than adults and use technology in new and innovative ways, youth participation in developing and utilizing new educational technology tools may also be key.

Enhancing evaluation

In addition to improving sex education curricula, evaluations of school-based sex education must capture key components of dual process theories. Given the complexity of sexual decision-making and the types of existing curricula commonly provided, we must expand our efforts to measure and document success, as well as learn whether the theoretical approaches proposed here are effective and of sufficient strength. While many sex education evaluations ask about behavioral intentions (e.g., “How likely are you to have sex in the next 6 months?”), some fail to explore behavioral willingness (e.g., “If the opportunity arises, how

willing are you to have sex in the next 6 months?”). Similarly, in addition to measuring how much knowledge participants have gained, evaluations should universally capture how likely participants are to use condoms and how confident they feel about using the knowledge they acquire through the educational program. While many existing best practice evaluations integrate these questions, expanding integration of these questions into explicit evaluation tools will help expand our theoretical conceptualization of how to operationalize willingness and intentionality in interventions. In addition, it will help identify the behavioral characteristics of participants who are able to explicitly identify the skills they need to bridge the gap between information and action.

Participatory evaluation methods, including youth-led evaluation (London, Zimmerman, & Erbstein, 2003) and most significant change (MSC) (Davis & Dart, 2005), also provide opportunities to better understand the components of programs that have the greatest impact on behavior. MSC uses story-based evaluation to facilitate the detection of unexpected changes particularly in complex interventions that produce diverse outcomes (Dart & Davies, 2003; Davis & Dart, 2005). The narratives in MSC help to outline how participants experience changes in knowledge and how knowledge is linked to changes in behavior and result in desired outcomes (Dart & Davies, 2003). Employing MSC to assess the impact of classroom sex education would help illuminate some of the links between classroom activities, knowledge, skills, values and behavior. Similarly, youth-led evaluation moves beyond traditional evaluation indicators to engage program participants in employing qualitative and quantitative methods to assess the impact. Youth engaged evaluation enhances the impact of classroom sex education by providing youth an opportunity for civic engagement and youth development while simultaneously enhancing the quality of evaluation outcomes (Checkoway & Richards-Schuster, 2003). Expanding existing sex education evaluation efforts to include participatory components promises to increase our understanding of the true impact of these curricula.

Improving strategies to evaluate sex education will be key to better understanding its true impact (Constantine, 2012). Traditional surveys and self-report methods capture only explicit attitudes related to sexual behavior and fail to capture important implicit information that significantly influences sexual decision-making. Employing creative evaluation strategies that examine how current behavioral interventions influence implicit attitudes will provide new insight into what programs are the most effective in positively changing behavior. Integrating implicit attitude testing into pre- and post-testing and into sex education evaluation plans will improve the understanding we have of the effects of these types of interventions.

Conclusion

Experts have identified the key components of effective school-based sex education (Kirby & Laris, 2009). Rather than abandoning existing sex education efforts, lessons from neuroscience may provide an important set of innovations and insights for expanding existing sex education to include strategies that build on dual process theories and address adolescents' implicit and explicit attitudes related to sexual behavior, and in turn, improve adolescent sexual health outcomes. Policies to support research and innovation to better understand the concepts of behavioral willingness and intention, implicit and explicit cognition, and rational and emotional decision-making, in relationship to adolescent sexual behavior, will facilitate the development of more effective behavioral interventions.

In the current funding climate, wherein social programs face increasing scrutiny, strengthening sex education programs and coupling them with rigorous evaluation will help policy makers and funders make more informed decisions and invest in truly effective sex education programs. To achieve the integration of this new learning, policies are needed to support innovation related to sex education. The two major national programs funding sex education currently provide limited support for innovation. In 2010, Congress allocated \$155 million over five years to the US Department of Health and Human Services' Office of Adolescent Health's Teen Pregnancy Prevention (TPP) Program and approximately 16% (\$25

million) was dedicated to the development of innovative strategies related to comprehensive sex education and pregnancy prevention (US Department of Health and Human Services, 2011). Similarly, only 13% (\$10 million) of the \$75 million allocated for the Personal Responsibility and Education Program (PREP) is dedicated to funding to innovation (Department of Health and Human Services, 2012). In contrast to this limited support for sex education, in 2011 NIH awarded approximately \$5.5 billion to support neuroscience research (Society for Neuroscience, n.d.). Policies that facilitate leveraging the expansive resources allocated to neuroscience to promote translational science can greatly improve the impact of sex education.

Clearly, as school based sex education is a very marginal component of the curriculum teachers tackle each year, efforts to expand educational strategies to include learning from neuroscience into sex education would need to include resources for capacity building. District and school level policies would need to be established in order to support teachers in expanding their teaching beyond the model of rational based learning. Some educators may feel uncomfortable going beyond the traditional provision of educational messages and would need opportunities to build their skills in this area. While these training efforts would improve sex education, they would also improve teachers' capacity to move beyond rational learning in other programs of their curricula. Similarly, training and equipment will be needed to support teachers in integrating technology-based learning into the classroom. A number of private foundations and public programs support integrating technology into classrooms. Leveraging these resources to support sex education has the potential for enhancing school based sex education and the curriculum in general.

As neuroscience continues to provide a better understanding of adolescent decision-making, we can take steps now to improve sex education policies and practices. Due to the limited efficacy of rationally-based sex education programs and the promising leads from neurological studies, we must renew efforts to integrate dual process theories in the field of sex education. We must move towards developing sex education interventions, evaluation

strategies, and supportive funding streams that advance dual process approaches in sex education. In addition, continuing to support primary research to better understand adolescent brain development and activation specific to sexual decision-making, sexual arousal and sexual behavior will offer opportunities to improve and strengthen sex education. We need to encourage bridges between health educators, researchers, and policy makers to explore opportunities to integrate discoveries about brain development and neuroscience in the laboratory into practices and innovation in the field. The more we understand about the relationship between adolescent emotional and cognitive development and sexual decision-making, the more progress can be made in determining how these factors can be best targeted through school-based sex education. Since current sex education efforts continue to have limited success, testing the applicability of newer scientific findings as a means of improving interventions seems prudent.

Building on the existing infrastructure of what we have learned is effective in school-based sex education and integrating lessons from neuroscience about social-emotional development and its role in adolescent sexual decision-making increases the potential for success. Available science offers an explanation for why current sex education efforts continue to have a limited impact on adolescent sexual health outcomes. Supporting the positive sexual development of U.S. youth requires that we improve the ways we prepare young people to face sexual and other types of important decision-making that impacts their lives. A better understanding of the role that brain development plays in adolescent sexual decision-making will facilitate the development of improved policies, services, and practice. Innovation is needed to address the gap between the country's current investments in school-based sex education and the sexual health status of adolescents. In order to preserve funding and support school-based sex education, we must advance sex education from being adequate to being effective and utilize results from recent neuroscience research to inform our policies and best practices.

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