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A KIN SELECTION MODEL OF SUICIDE RISK

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF PSYCHOLOGY

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I dedicate this dissertation to my parents, Kim and Walter Osterman, for providing me with the opportunity and the encouragement to pursue my goals.

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## Abstract

Suicide has rarely been considered from an evolutionary perspective, likely because it appears prototypically maladaptive, and certainly appears to have no adaptive function. The current theory proffers a potential adaptive function of suicide: it might constitute a nepotistic response to pronounced resource scarcity. If this is so, conditions which maximize the adaptiveness of nepotistic behaviors (i.e., when direct fitness costs to the actor are outweighed by the fitness benefits bestowed upon the recipient; Hamilton, 1964) should facilitate suicidality. Controlling for a number of potential confounds, results indicate that individuals with large sibships, poor reproductive prospects, and economically deprived backgrounds are at higher risk for attempting suicide, and that information that might cue infertility (even erroneously) is positively related to suicide attempts among females. Discussion describes the ways in which these results support a nepotistic explanation of suicidality and a number of refinements and extensions that might be considered in future explorations of these ideas.

## A Kin Selection Model of Suicide Risk

Suicide is among the most thoroughly studied phenomena in the social sciences, but is also arguably one of the least understood. While the life circumstances that motivate suicide can be somewhat transparent on occasion (e.g., in terminally ill populations), they are just as often inexplicable. Consider, for instance, Arjun Siddaraju, a 21-year-old man who committed suicide on March 14, 2012, citing in his suicide note the recent dissolution of his romantic relationship as the reason for his decision to end his life (Deccan Herald, 2012). Although we can understand the pain and distress he must have been feeling in the days leading up to his death, it is less easy to understand why he would take such final action in response to a very temporary problem. Cases like his are not uncommon, as a search of any news source for "suicide break up" will quickly show, and as empirical research suggests as well (e.g., Hoberman & Garfinkel, 1988; Fordwood, Asarnow, Huizar, & Reise, 2007). Perhaps because of inexplicable cases such as these, there has been an enormous amount of research on the various intrapersonal, interpersonal, and ecological contributors to suicide risk, and we now have extensive data on the precipitants of suicidal behavior (see deCatanzaro, 1980 and Joiner, 2005 for thorough reviews).

More elusive, however, has been the construction of a comprehensive theory that unites and explains this large amalgamation of facts in a cohesive and useful way. Scholars from a variety of disciplines have attempted to construct such a theory, among them Durkheim's (1897) theory of social dysregulation, Shneidman's (1985) theory of psycheache, Baumeister's (1990) theory of escape from aversive self-awareness, and most recently, Joiner's (2005) interpersonal theory of suicide. While each of these

theories has indisputable merit, all of them are *proximate* theories, meaning that they identify only the immediate causes of suicide. They are, in other words, fundamentally descriptive rather than truly explanatory. In order to achieve a full theoretical understanding of suicide, we eventually need to consider its *ultimate* causation, or to articulate the relationship between suicide and biological fitness. Doing so can not only contribute to our theoretical understanding of suicidality and increase coherency in our vast knowledge of suicide precursors, but it can also facilitate the discovery of previously unknown proximate causes of suicide, and thus potentially inform current suicide intervention and treatment strategies.

**Suicide and Biological Fitness: Past Theory**

To date, the only attempt to describe the ultimate causation of suicide was by Denys deCatanzaro (1980), who proposed that suicide is essentially a failure or malfunction of adaptations that promote life. Thus, it only occurs among individuals with a severely diminished capacity to promote either direct fitness (i.e., their own relative reproductive success), or the fitness of kin (i.e., the relative reproductive success of close relatives). In short, suicide occurs, according to deCatanzaro, when the ability to improve *inclusive fitness* (i.e., the relative reproductive success of one's genes, via the both the individual and the individual's genetic relatives) is diminished. deCatanzaro argued that suicide is not maladaptive for such individuals because they are not able to promote the dissemination of their genes whether they commit suicide or not. Thus, his contention is that suicide is allowed by natural selection to exist because there is typically no selection pressure acting *against* it.

deCatanzaro's argument implies that suicide itself is not an adaptation. The central premise of his theory is that suicide is able to exist, *despite its lack of function*, because it does not deleteriously affect fitness among those who usually enact it. Theoretically, this is a plausible explanation of suicide, but I believe that it insufficiently explains the data in some cases. I will explore some such studies in more detail shortly, which suggest the influence of a selection pressure *favoring* suicide, rather than the simple absence of a pressure acting against it. These findings are not easily explicable unless one presumes that suicide is an adaptation, a heritable behavioral propensity "designed" by natural selection to address a recurrent adaptive problem.

Thus, my central claim in the current project is that suicide is a biological adaptation rather than a byproduct, random noise, or the malfunction of an adaptation. Specifically, I hypothesize that suicide constitutes a nepotistic adaptation designed to help the kin of the suicidal individual survive periods of resource scarcity, and thus that it should be triggered by the convergence of 1) the existence of a sufficiently large number of kin, 2) severely diminished ability to work toward the improvement of inclusive fitness in life (as deCatanzaro also argued), and 3) limited access to resources. Before discussing this theory and associated hypotheses in more detail, it is useful to first discuss the place that nepotism occupies in an evolutionary framework.

**Altruism: The Specific Case of Nepotism**

Although altruism (i.e., behaviors that bestow a benefit upon a recipient at a cost to the actor; Trivers, 1971) toward non-relatives is sometimes argued to pose a problem for evolutionary theory, kin-directed altruism, or nepotism, is easily explicable from a

genetic perspective. Because natural selection operates at the level of the gene rather than the level of the individual, "fitness" is not simply a function of an individual's relative reproductive success (a.k.a., direct fitness; Taylor & Frank, 1996; Frank, 1998), but rather is a function of the relative reproductive success of genes (a.k.a., inclusive fitness; Hamilton, 1964), which are shared among genetic relatives. Thus, an individual can improve inclusive fitness both by behaving toward his/her own benefit, and by behaving toward the benefit of his/her kin—especially close kin, as these individuals share a relatively high proportion of unique genes. Nepotism is adaptive, therefore, because the actor is actually showing favoritism toward other carriers of his/her unique genes.

In addition to depending upon degree of relatedness, the adaptive value of altruism also depends on its fitness cost to the actor and its fitness benefit to the recipient. This relationship is formalized by Hamilton's rule (Hamilton, 1964), which states that a gene promoting a specific altruistic behavior is likely to be favored by selection when its fitness cost to the actor (C) is outweighed by its fitness benefit to the recipient (B) multiplied by the proportion of unique genes shared between the actor and recipient or recipients ($r$): $C < Br$. In other words, the adaptive value of an altruistic act *increases* as relatedness increases and as the benefit of the action increases, and its adaptive value *decreases* as the cost of the act increases. Thus, a particular altruistic behavior will only be favored by natural selection if it provides a *net benefit* to inclusive fitness.

It is useful to highlight two variables that can impact this cost/benefit tradeoff. First, the fitness (or more precisely, the prospective fitness) of the actor (the altruist)

necessarily impacts the fitness cost of a given act. Consider, for instance, two brothers fighting over a potential mate. For any number of reasons (e.g., attractiveness, sperm count/motility, competence in accruing resources), let us suppose that one brother has a high probability of reproducing with this mate and the other has a very low probability of doing so. In this situation, the fitness cost of altruistically ceding to one's brother is dependent upon reproductive viability. If the brother with high viability gives up the mating opportunity, the cost of this act will be quite high, on average, because he is giving up a likely chance of reproduction. But if the brother with low mate value concedes, the cost to him is much lower, as he is unlikely to successfully reproduce even if he is given the chance. It is also worth pointing out that if the high-viability brother concedes, it is likely that *neither* brother will mate, so this would be a costly decision for both brothers, genetically speaking. Thus, the fitness cost of a specific altruistic act is not consistent across individuals—it can be favored by selection in the presence of certain personal characteristics, but can be selected *against* in the presence of other characteristics.

Second, the benefit of an altruistic act is dependent upon the recipient's need for that act of altruism, which is often influenced by the degree of environmental adversity. Consider the scenario of our two brothers again, but imagine that there is a significant dearth of fertile females in the immediate environment. Yielding to one's brother regarding the female in question bestows a substantial benefit upon him, because there are scant mating opportunities available. However, if there is a surplus of fertile and sexually acquiescent females, the benefit bestowed by foregoing one particular mating opportunity diminishes to the point that fitness is more or less unaffected. Thus, the

fitness benefit of a specific altruistic act is not consistent across situations—it can be favored under some environmental conditions and not others.

In summary, nepotism is generally adaptive. However, it can be more or less adaptive depending upon the relative fitness costs imposed and benefits bestowed by the action. The cost to benefit tradeoff is in turn greatly influenced by the reproductive viability of the two parties involved in the transaction, and by the degree of "need," which is often dictated by environmental constraints and demands. With these parameters in mind, I will now turn to the subject of suicide, and how it might impact inclusive fitness for different individuals and within different environments.

**Nepotism: The Specific Case of Suicide**

Because suicide irrevocably destroys one's own reproductive prospects, it clearly does not improve direct fitness. However, it is quite possible that ancestrally, suicide might have sometimes bestowed a fitness benefit upon kin, and was thereby favored by natural selection. There is some empirical precedent for the notion that death-promoting behaviors can positively impact inclusive fitness. For example, some species of amoebae will allow themselves to die in the process of helping their genetic clones to reach nutrient-rich soil (Queller, Ponte, Bozzaro & Strassman, 2003); eagle nestlings lean out of their nests (and fall to their deaths) when food is too scarce to sufficiently feed them and their fellow nestlings (O'Connor, 1978); and male Australian redback spiders allow themselves to be cannibalized during mating in order to prevent the female from subsequently remating and displacing their own future offspring (Andrade, 1996).

Thus, in several species, lethal self-sacrifice is apparently adaptive when it bestows a sufficient benefit upon kin, and at least in the examples above, it bestows such a benefit when resources are scarce, and when the sacrificer's ability to improve inclusive fitness in the future is severely diminished. I posit that the circumstances in which human suicide is most likely to be adaptive are quite similar, specifically: 1) when the actor has a sufficient number of close kin who might benefit (because the coefficient by which the benefit is multiplied, *r*, would be increased), 2) when ability to enhance inclusive fitness is severely diminished (in this case, the fitness cost to the actor is likely to be relatively low, and for reasons I will discuss later, the benefit to kin might also be higher), and 3) when vital resources are scarce (under these circumstances, the "need" for help, and therefore the fitness benefit of suicide to kin, is likely to be relatively high).

First, the number of close kin that one has could contribute to suicide risk because as number of close kin increases, so does the proportion of unique genes shared between the actor and the potential beneficiaries. For example, if an individual's kin is limited to one brother, then the benefit of suicide would be multiplied by .5 according to Hamilton's rule, because 50% of the individual's unique genes are represented in the potential beneficiary on average. But for an individual who has three siblings (or six nieces/nephews, twelve cousins, etc), the benefit of suicide would be multiplied by 1.5, because 150% of the individual's unique genes are represented across the potential beneficiaries. Thus, for the latter individual, suicide is more likely to be adaptive because the benefit of suicide is more likely to outweigh the cost.

Second, diminished ability to improve inclusive fitness—either by reproducing oneself, or by facilitating the reproductive prospects of kin—impacts the adaptiveness of suicide through two potential mechanisms. First, let us consider how the inability to improve *direct* fitness might reduce the cost of suicide. As discussed earlier, the direct fitness cost of a typically costly behavior is reduced among individuals with slim prospects for future reproduction (this is illustrated in the animal models discussed previously: the least healthy of the nestlings roll out of the nest; Australian red-back male spiders allow themselves to be eaten, in part, because the likelihood that they will mate a second time is very low anyway; Forster, 1992). If the fitness cost of a behavior is the extent to which that behavior reduces future reproductive prospects, then fitness cost should vary according to an individual's original probability of reproduction. Suicide always reduces the probability of future reproduction to 0. But this reduction is far greater for an individual with a 0.9 probability of future reproduction than it is for an individual with a 0.1 probability of reproduction. Thus, the extent to which one can improve direct fitness (by reproducing) influences the fitness cost of committing suicide.

Inability to positively contribute to inclusive fitness via kin might also increase suicide risk, but through a different mechanism: by increasing the benefit of committing suicide. Hamilton himself pointed out that one logical consequence of his theory is that behaviors that take too much from close kin will not be favored by selection, because such behaviors will ultimately be deleterious to inclusive fitness (Hamilton, 1964). Thus, if an individual consumes family resources but cannot reciprocate that consumption by, for instance, contributing to the food supply or improving the family's

safety, the inequity of this exchange will eventually become burdensome. In this circumstance, then, the fitness benefit that suicide bestows upon kin would be increased by the removal of a liability. Consistent with this idea, past research has shown that the perception of burdensomeness upon other people, especially kin, is a major risk factor for depression (Allen & Badock, 2003) and suicidality (Filiberti et al., 2001; Joiner et al., 2002).

Third, and finally, scarcity of resources could affect the adaptiveness of suicide by increasing the benefit that suicide bestows upon kin. To illustrate, consider one type of resource shortage that has likely been a recurrent adaptive problem throughout the natural history of our species (and indeed, all living organisms): food shortages. Food availability is naturally unstable (across days, seasons and years), and thus humans have developed a number of adaptations to survive such shortages (e.g., reducing caloric expenditures, relying on suboptimal food sources when preferable food is unavailable). Despite such mechanisms, as food scarcity is prolonged, the probability of survival decreases. If a hypothetical family of 6 must share a limited food supply for an extended period of time, there is a real possibility that all members will eventually starve. However, if the family was reduced to 5 or even 4, the amount of food that each member would have to eat would increase, and thus the amount of time that the family could survive, even with limited resources, would increase. Put another way, if every member of the family continues to strive for survival (and consume food) during a food shortage, it is less likely that any one member will survive. If one or more family members cease to strive for survival, it is more likely that the remaining members will have enough to survive. Thus, suicide might arise as a last resort mechanism to increase

available resources for other family members during a time of relative deprivation, thus improving the probability that the unique genes of the suicidal individual will be passed on to the next generation via his/her close kin.

To summarize, there are three factors that might have significantly contributed to the extent to which suicide was adaptive in our ancestral history, and thus might predict the circumstances under which suicide would most likely be elicited today. The first factor is number of close kin: as the number of genetic relatives (beneficiaries) increases, the coefficient by which the benefit of suicide is multiplied increases. The second factor is ability to contribute to inclusive fitness, either via direct fitness of the actor, or the direct fitness of the actor's kin: as ability to contribute to one's own direct fitness decreases, the cost of suicide decreases, and as ability to contribute to the direct fitness of kin decreases, the benefit of suicide increases. Finally, the third factor is the availability of resources: when resources are scarce, suicide is likely to confer a relatively high benefit upon kin.

**Proximate Causes of Suicide**

These three factors—number of kin, ability to improve inclusive fitness, and resource scarcity—are specific pathways through which suicide might affect biological fitness. However, they are not proximate causes of suicide; they are ultimate causes. In other words, they do not directly cause suicide. Rather, proximate causes of suicide would be cues that, ancestrally, were reliably and uniquely related to these ultimate causes. For instance, poverty does not cause suicide. Rather, there are psychological and physiological changes (e.g., chronic stress, and consequently, chronically elevated cortisol) that are reliably associated with poverty, and these changes are the proximate

causes of suicide, or cues to the potential adaptiveness of suicide at a given point in time.

Therefore, in order to successfully predict suicide, it is necessary to identify these proximate causes, using these three categories to guide new studies/hypotheses, and to organize existing data on suicide. And indeed, when viewed through this lens, the existing literature on suicide does seem to suggest that it occurs in response to cues that, ancestrally, might have been reliably associated with sufficient kin, severely reduced ability to improve inclusive fitness, and shortages of vital resources.

**Cues to kin number.** Unlike some mammals, who use pheromone cues to determine their degree of relatedness with others that they encounter (e.g., Heth, Todrack & Johnston, 1998; Winn & Bedford, 1986), humans seem to use early childhood association to distinguish kin from non-kin (e.g., Bevc & Silverman, 2000; Lieberman, Tooby & Cosmides, 2007). Thus, it is reasonable to assume that it would primarily be the number of individuals with whom one had prolonged contact during early childhood that determines whether or not a large number of kin is "cued," and therefore whether suicide risk is elevated. For humans living presently, this number is most likely to vary with number of siblings. The relationship between family size and suicide is not well-studied, most likely because there is little reason to presume a relationship between sibship and suicide outside of an evolutionary framework. However, in the two studies that actually reported a relationship between sibling number and suicide risk, it was found that indeed, as number of siblings increased, suicide risk in adulthood increased as well (the researchers posited that greater maternal parity might affect suicide as a psychosocial or socioeconomic stressor; Mittendorfer-

Rutz, Rasmussen, & Wasserman, 2004; Riordan, Selvaraj, Stark & Gilbert, 2006). Importantly, this relationship was found even controlling for potentially confounding economic factors.

**Kin number: Cognitive mediators.** For individuals who are experiencing the other risk factors for suicide (i.e., cues to resource scarcity and lack of ability to improve fitness), the relationship between number of kin and suicide might be mediated by the conscious experience of prosocial emotions, or heightened emotional connection to siblings. Specifically, because suicide is presumed to be a nepotistic adaptation, pronounced feelings of guilt, and even love and affection might characterize suicidal individuals' perceptions of their relationships with siblings to a greater extent than is typical. By the same token, the desire to compete with siblings for resources (i.e., feelings and motivations that contribute to "sibling rivalries") might also be reduced among suicidal individuals. Such questions are still open as they have not, to my knowledge, been subjected to empirical investigation (however, see Blake, 1978, who found that altruistic self-sacrifice is positively associated with cohesion in military groups). Although lack of social connection, alienation, and isolation are risk factors for suicide, and positive social relationships are protective against depression and suicide (see Joiner, 2005 for a review), such findings do not preclude the possibility that the experience of certain prosocial emotions toward family members might be a concomitant of suicidality, because isolation and prosocial emotions toward others are not opposite constructs, nor are they mutually exclusive (e.g., consider unrequited romantic love).

**Cues to the inability to improve inclusive fitness.** Second, suicide should also be elicited by cues that one is unable to improve inclusive fitness. Specifically, cues that one is unable to assist kin, and cues to personal lack of reproductive viability should be risk factors for suicide. General health and mobility would be the best cues to one's ability to assist kin in an ancestral environment, as these affect one's ability to physically work toward survival goals. Conversely, poor health and mobility would, as mentioned previously, impose potential burdens upon kin, as they might interfere with the ability of kin to work toward survival goals. Such physical limitations and associated feelings of burdensomeness have been associated in past literature with risk for major depression (Allen & Badock, 2003; Hinrichsen & Emery, 2006; Joiner et al., 2002), which, as I will discuss shortly, might be an important mediator between such cues and suicidality.

Cues to reproductive viability would also include general health/mobility, as well as interpersonal acceptance, and sex-specific cues regarding actual reproductive success. For females, the most reliable proximate indicator of fertility is, of course, the actual production of offspring. For males, who do not gestate offspring, the most reliable proximate indicator of reproductive success is the occurrence of sexual intercourse. Thus, health factors and interpersonal acceptance for both sexes, the actual production of offspring (for females), and frequency of sexual intercourse/number of sexual partners (for males), should have negative relationships with suicide. Importantly, I would not expect children to be as protective against suicide for males as it is for females, because paternal uncertainty makes children a less reliable cue to reproductive success for males. By the same token, I would not expect frequency of

intercourse/number of sexual partners to be as protective for females as it is for males because females have a much more reliable indicator of reproductive success available to them: the actual production of offspring.

Some of these relationships are well established in the literature, and all have support from at least a few studies. Poor physical health is a well-established risk factor for suicide (e.g., Hawton & Fagg, 1988), and improving it by, for example, increasing physical activity tends to decrease depression and risk for suicide (see Penedo, 2005 for a review). Furthermore, individuals with debilitating chronic illnesses and severe health and mobility problems are at higher risk for suicide than the general population (see Greydanus, Patel & Pratt, 2010 for a review). Interpersonal isolation/disconnection is also a powerful predictor of suicide risk (deCatanzaro, 1995; O'Reilly, Truant, & Donaldson, 1990; Rudd, Joiner, & Rejab, 1995), as is the loss of important relationships (Boardman et al., 1999; Conner, Duberstein, & Conwell, 1999; Magne-Ingavar & Oejehagen, 1999; McIntosh, 2002; Van Winkle & May, 1993), particularly romantic relationships. As for the sex-specific viability cues, maternal parity (i.e., number of pregnancies carried to term) has been shown in several studies to negatively predict suicidality (Hoyer & Lund, 1993; Leenaars & Lester, 1999; Qin & Mortensen, 2003), such that as number of children increases, suicide risk for the mother decreases, but the same association has not been reported for males (it is unclear, however, whether this is because the association has not been *studied*, or because it has actually not been *found*). Furthermore, diagnosed infertility among women is also associated with higher suicide risk (Gupta, Jani & Patel, 2000; Link & Darling, 1986; Stack, 2000 [review]), as is menopause (deCatanzaro, 1992; Humphrey, & Palmer, 1990), which signals the end of

fertility. Finally, for men, sexual success was shown to be negatively associated with suicide risk in the one study that assessed this relationship (deCatanzaro, 1984).

A slightly tangential, but interesting note is that across cultures and locales, women are typically more depressed and suicidal than are men (see Hawton, 2000 for a review).[1] Because gender is not obviously related to one's capacity to improve inclusive fitness, this sex difference is curious. One potential explanation for it lies in the differences between modern reproductive patterns and ancestral patterns. Currently, women can postpone reproduction through the use of contraception, which was obviously not available until relatively recently. The result of this new technology is that today, fertile females are likely to remain non-reproductive for years after they reach sexual maturity, whereas in the past, fertile females typically became pregnant within a year or two after the onset of menarche (Jones & Lopez, 2006; Worthman, 1999). If a female did not become pregnant immediately, but instead continued to experience a regular menstrual cycle for many years (as is typical today), this was a fairly reliable indication that she was infertile. Thus, a possible reason for the contemporary sex difference in suicidality is that women are postponing reproduction longer, and are thus receiving (false) signals that they are infertile. Related to this point, it is worth noting that suicide risk varies cyclically for women across the month, peaking during the least fertile phase of the ovulatory cycle (e.g., Baca-Garcia, Diaz-Sastre, de Leon & Saiz-Ruiz, 2000).

[1] Although women generally experience more depression and suicidality, it should be noted that men actually die by suicide at much higher rates than women (Moscicki, 1994). However, it has been argued, persuasively, that this is primarily due to the fact that men typically choose more lethal suicide methods than do women, and not because they are actually more suicidal (Denning, Convell, King, & Cox, 2000).

**Cues to resource scarcity.** Finally, suicide should be elicited by cues that vital resources such as regular access to food, water and shelter are limited. Today, access to such items is primarily controlled by monetary resources. Thus, we might expect that individuals living in economically deprived environments might be at elevated risk for suicide, and indeed, socioeconomic status does seem to be negatively related to suicide (e.g., Kubrin, Wadsworth & DiPietro, 2006; Stockard & O'Brien, 2002; Wadsworth & Kubrin, 2007; Stack, 2000).

**Depression and inclusive fitness.** Major depression is one of the best, if not *the* best proximate predictor of suicide. Suicidal ideation is even included as one of the items on widely used depression inventories (e.g., Beck, Steer, Ball, & Ranieri, 1996). Thus, it is important to articulate where depression might fit in an adaptive model of suicidality. Several theories have been proposed that describe depression as a biological adaptation. For example, one theory posits that the intense psychological pain that characterizes depression is adaptive because it motivates the future avoidance of events that threatened biological fitness in an individual's past (e.g., the loss of a romantic partner or child; e.g., Suarez & Gallup, 1991; Thornhill & Thornill, 1989). Another suggests that depression is adaptive following an intractable loss in a battle for social rank, because it drives the outmatched individual into a submissive role, thus protecting him/her from any further social or physical harm that might be incurred by continuing to battle for rank (e.g., Gilbert, 1992). Yet another theory proposes that major depression is a costly and thus "honest" social signal that one is in need of help following a significant loss of or threat to fitness, and that its adaptive value lies in the help that it elicits from others (Hagen, 2003; Watson & Andrews, 2002). Each of these

theories is distinct from the current proposal in that they all suggest that depression improves the direct fitness of the depressed individual rather than the fitness of close kin (for this reason, it is unclear how such theories would accommodate the fact that depression can and often does result in suicide, as suicide is clearly not conducive to the actor's direct fitness). If depression does benefit direct fitness in any of the ways described above, it might not be well-predicted by the model proposed here. However, there are at least two places that depression could occupy in an inclusive fitness model of suicide.

First, depression and suicide might be affective and behavioral components of the same mechanism. After all, devaluing life, desiring death, and the consideration of suicide itself are all considered to be symptoms of depression, and thus, it is conceivable that depression and suicide are not fundamentally unique constructs. This idea implies that the difference between depression and suicidality is one of degree: depression might be elicited by the same factors as suicide, but be elicited more readily than suicide. If this is the case, depression might be predicted by the model described here in a similar fashion to suicidality, and furthermore might mediate the hypothesized relationships between suicidality and sibship, viability, and economic resources.

A second possibility is that depression and suicide are distinct stages of the same adaptive process, with depression being a necessary but not sufficient first step to produce suicidality. In some cases, depression per se (i.e., without suicide) might fully address the same adaptive problem that suicide would address, and thus never result in any suicidal behavior. The list of typical symptoms of depression includes decreased appetite and psychomotor retardation (a slowing of general movement). Symptoms such

as these might themselves aid in addressing resource deprivation in an ancestral context, obviating suicide in some cases. In the presence of other environmental factors, however, depression might facilitate suicide. Depression symptoms such as social withdrawal, feelings of isolation, hopelessness about the future, and, of course, the actual consideration of suicide all might exacerbate suicide risk. For example, hopelessness about the future might be a cognitive mechanism by which life-preserving mechanisms are suppressed. Social withdrawal might further contribute to the perception that one is not reproductively viable by exacerbating feelings of isolation. And, of course, suicidal ideation can directly facilitate suicide.

If depression and suicide are indeed distinct stages of one process, we might expect depression to be predicted by only a subset of the risk factors proposed by the current theory. For example, it might be predicted by low prospective viability, and interact with sibship and economic deprivation to predict suicidality. In this case, depression could be construed as an emotional proxy for low viability. As another example, both prospective viability and economic deprivation might contribute to depression, and depression might interact with sibship to predict suicidality. Indeed, there is a large literature connecting depression to both viability-related factors, and to economic deprivation: relationships have been well-documented between depression and poor health (Hinrichsen & Emery, 2006), social isolation and rejection (Kendler, 2003; Slavich, Thornton, Torres, Monroe, & Gotlib, 2009; Vihjalmsson, 1993), and low socioeconomic status (e.g., Kim, 2008).

Thus, there is more than one place that depression might occupy in an inclusive fitness model of suicide—if it occupies such a place at all. It is possible that, as other

theorists have argued, depression is an entirely separate adaptive mechanism from suicide, and that it will not be well-described by the model proposed here. But it is also possible that depression and suicide are aspects of the same construct, and that they will be predicted similarly by these risk factors, or that depression and suicidality represent different stages of the adaptive response. The current study will examine the relationships between depression and sibship, reproductive viability and economic deprivation in an exploratory manner to shed light on this question. Assuming that zero-order relationships between depression and these risk factors emerge, I will also evaluate the extent to which depression mediates the relationships between suicidality and any or all of these hypothesized risk factors.

**Summary**

I posit that suicide is a nepotistic adaptation designed to help kin survive extended periods of resource scarcity, and that it is most frequently evoked in individuals who have sufficient kin that might benefit from the behavior, and who have a severely diminished capacity to promote inclusive fitness. Conscious mediators of the relationships between these three factors and suicide could include the extent to which one experiences prosocial emotions toward family members (mediator of sibling number/suicide relationship) and depression (mediator for one or all risk factors). The existing literature on suicide provides a great deal of evidence that is consistent with these propositions, but a direct and integrated test of these hypotheses has not yet been conducted.

## Current Study: Goals and Hypotheses

In the current study, I attempt to replicate and extend existing findings relating suicide to kin number, prospective viability and resource scarcity by analyzing the "public use" data from a four-wave longitudinal study known as The National Longitudinal Study of Adolescent Health (a.k.a., the "Add Health" study). In addition to assessing a wide spectrum of demographic variables, health-related behaviors and risk-taking behaviors, the Add Health survey also includes measures of depression and suicidal behavior. Thus, with the data available in this survey, I will test 9 hypotheses intended to evaluate the theory that suicide is driven, at least in part, by having multiple siblings, low prospective viability, and restricted economic resources—and in particular, the *convergence* of these three risk factors.

**Number of kin.** My first set of hypotheses pertains to number of close kin, specifically siblings. I hypothesize that (1) individuals who have no siblings will be at lower risk for suicide than those who do have siblings. Past literature suggests that such effects should persist even after individuals leave the home (deCatanzaro, 1984; Riordan, Selvaraj, Stark & Gilbert, 2006), and thus I expect this effect to be consistent across waves of data collection. Furthermore, I hypothesize that (2) subjective relationship quality with siblings will statistically mediate the relationship between suicide risk and sibling number. Information regarding the extent of the genetic relationship between the target and siblings is available in the Add Health data, and although I do not predict that this variable will moderate the above predictions, I will examine the effects of actual relatedness in an exploratory manner.

**Reproductive viability.** My second set of hypotheses regards prospective reproductive viability. First, I hypothesize that (3) for both sexes, objective indicators of prospective viability such as general health and attractiveness (as rated by the interviewer), as well as subjective indicators of prospective viability such as social acceptance and self-esteem, will be negatively related to suicide.

Because actual reproduction is the most direct indicator of fertility for females, and sexual activity is the most direct indicator of reproductive success for males, I will use these as central predictors of viability in sex-specific analyses. Thus, I hypothesize that (4) females who are sexually mature and have not had offspring should be at higher suicide risk than those who have had offspring, and that this risk should compound over time (i.e., being sexually mature and non-reproductive for 1 year should not pose as large a risk as being sexually mature and non-reproductive for 5, 10 or 15 years). I also hypothesize (5) that sexually active males will be at lower risk for suicide than males who are not sexually active. I further predict that the combined effect of sexual activity and the production of offspring should be a sex-specific effect. Specifically, I hypothesize that (6) being sexually active and non-reproductive will increase suicide risk for females, but that the production of offspring should not affect the relationship between sexual activity and suicide risk for males.

**Resource availability.** I hypothesize that (7) availability of general resources (i.e., household income) will be negatively related to suicide risk.

**Interaction of risk factors.** I hypothesize that (8) the main effects of sibship, viability and resource availability will be qualified by a three-way interaction between them, such that individuals who have several siblings, who have low prospective

reproductive viability, *and* who are in economically deprived environments will exhibit the highest risk for suicide. Finally, I will also compare two possibilities regarding the role of depression in this model. I hypothesize that (9) either depression will be predicted by the combination of these risk factors in a manner similar to suicide and will mediate the hypothesized interaction to predict suicide, or it will be predicted by and will mediate a subset of these risk factors, and interact with the other(s) to predict suicide.

## Method

### Participants

Participants were 6503 individuals recruited as part of The National Longitudinal Study of Adolescent Health (Add Health). To date, four waves of data have been collected as part of this study. At Wave I of data collection, which occurred during 1994 – 1995, participants (for public use data, N = 6503) were in the $7^{th}$-$12^{th}$ grades. Wave II (N = 4834) was collected in 1996, Wave III (N = 4882) in 2001 – 2002, and Wave IV (N = 5114) in 2007 – 2008. Thus, the data reported here span 12 – 14 years of participants' lives. The survey was administered to a nationally representative, stratified random sample of students in the United States, with special oversamples of ethnic minorities, students with physical disabilities, and pairs of siblings who were related to different degrees (e.g., identical and fraternal twins, full and half siblings, as well as step-siblings and foster siblings).

All central analyses included participants for whom complete data were available across all four waves, which, depending on the variables included in any given analysis, ranged from 3929 to 4864 (not including the analyses that were split by sex,

which resulted in an N approximately half as large). Analysis of missing data revealed that slightly more White participants (3454, 80.5%) than Non-White participants (1654, 74.9%), and more females (2760, 82.2%) than males (2353, 74.8%) remained in the sample by Wave 4. Furthermore, there was a lower average total household income (as measured at Wave 1) among participants who were missing by Wave 4 ($M$ = $44,886.75) compared to those who remained in the sample ($M$ = $48,407.11), but this difference was not significant ($t$ = 1.6, $p$ = .11). Although these demographic differences in attrition rates were relatively small, they do suggest the need for caution when interpreting the results of these analyses. For example, income did not have as strong a relationship with suicidality in the current study as past research would suggest; this could in part be a result of the differential attrition among participants from high- and low-income households.

**Materials**

**Overview.** Focal predictor variables included sibship, a composite of variables related to prospective viability, household income at Wave 1, number of sexual partners, participant offspring, and number of years post-menarche (females). Variables relating to sibling relationship quality and depression symptoms were also assessed as potential mediators. Control variables included age, gender, race, whether or not the participant was adopted (discussed below), religiosity, and whether or not the participant had a family member who had died by suicide in the past 12 months (discussed below). Finally, the outcome of interest was severe suicide attempts (i.e., suicide attempts that required medical attention), and depression was also treated as an

outcome variable in all focal analyses in order to assess how well depression risk is predicted by the current model compared to suicide risk.

**Number of siblings.** At Wave 1, data were available regarding the number of siblings that each participant was currently living with, whether or not they always lived together, and the degree of genetic relatedness between the participant and each sibling (ranging from 100%, or identical twin, to 0%, or step-/adopted/foster sibling). However, only Wave 4 provided the total number of siblings (including those who were not living with the participant at the time of collection), and because it was the most inclusive sibling variable available, this was used as the operationalization of sibship in all focal analyses.

For the exploratory analyses regarding the effects of childhood association vs. actual genetic relatedness, a count of children with whom the participant had always shared a household—regardless of genetic relatedness—and an estimation of *r* were compared for their relative efficacy in predicting suicidality. Number of children with whom childhood association was high was estimated via a count of currently cohabitating siblings (including full, half, step-, and adopted siblings) with whom the participant reported having "always" lived. An approximation of the total *r* was obtained by estimating the relatedness coefficient between the participant and each currently cohabitating sibling (e.g., full siblings were assigned a coefficient of .5, whereas adopted siblings were assigned a coefficient of 0), regardless of whether or not the participant had always lived with the sibling, and summing these individual coefficients. The primary limitation of this method is that relatedness and childhood association information is only available for currently cohabitating siblings, and not for

siblings who may have already left the home prior to the time of collection. Thus, these operationalizations are necessarily approximations (and potentially very rough ones) of how many close childhood associates the participant had, and the total *r* value for all siblings. However, if there is a difference in the predictive utility of these two ways of operationalizing "siblings," it might still emerge even in these restricted data.

**Prospective reproductive viability.** An individual's probability of future reproductive success is influenced by health and fertility (i.e., the physical ability to produce offspring), as well as the probability of being chosen as a mate, or mate value (Andersson, 1994; Sugiyama, 2005). Mate value is influenced by physical attractiveness (Langlois et al., 2000; Rhodes, 2006; Thornhill & Grammer, 1999) and various personality traits (e.g., kindness, trustworthiness; Buss, 1989; Li, Bailey, Kenrick & Linsenmeier, 2002; Kenrick, Sadalla, Groth & Trost, 1990), and also has reciprocal relationships with a number of subjective states, such as perceived social acceptance (Todd & Miller, 1999) and self-esteem (Kirkpatrick & Ellis, 2001; 2006). Thus, to estimate prospective viability, a composite of variables that should be related to fertility and mate value was created.

Objective (or relatively so) indicators of health and attractiveness as well as subjective measures of health, social acceptance and self-esteem were measured at Waves 1 and 2, and were used to create composites of prospective viability. [2] As an objective measure of health, information regarding how often the participant

[2] Similar composites could not, unfortunately, be computed for Waves 3 and 4 because out of the variables mentioned here, only physical and personality attractiveness were assessed at these later waves. However, because the variables used to create these composites should be relatively stable over time, the use of data from only Waves 1 and 2 seemed acceptable.

experienced minor health complaints over the past year (e.g., headaches, stomach aches, fatigue, sore throat/cough) was obtained. Each symptom was rated on a Likert scale from 0 (never) to 4 (every day). These ratings were summed to create a total sickness index. Objective attractiveness was assessed via an interviewer's Likert scale ratings of "physical attractiveness" and "personality attractiveness" from 1 (very unattractive) to 5 (very attractive). Subjective factors relating to physical health and mobility included participants' agreement with the following statements from 1 (strongly disagree) to 5 (strongly agree) "You have lots of energy," "You are physically fit," and "You are well coordinated."

A social acceptance composite was created by averaging participant agreement with the following items (from 1 to 5, as above): "I feel close to people at school," "I feel like I am part of my school," "You feel socially accepted," "You feel loved and wanted" ($\alpha = .79$). A self-esteem composite was created by averaging agreement with the following statements (from 1 to 5, as above): "You have a lot of good qualities," "You have a lot to be proud of," "You like yourself just the way you are," and "You feel like you are doing everything just about right" ($\alpha = .80$). Sickness (reverse-coded) and subjective health/mobility questions, objective physical and personality attractiveness, social acceptance and self-esteem scores were standardized and averaged to create prospective viability composites at both Wave 1 ($\alpha = .71$) and Wave 2 ($\alpha = .72$). The Wave 1 and Wave 2 viability composites were positively correlated ($r = .47$, $p < .001$), and were thus averaged to create a single viability composite for use in all focal analyses.

At each wave, participants provided data regarding their sexual histories and how many offspring they currently had, which are hypothesized to be cues to reproductive success for males and females respectively. The question "How many total sexual partners have you had?" was used to assess sexual success, and a simple count of "daughters" and "sons" from the roster of household members was dichotomized (0 = no offspring, 1 = one or more offspring) and used as a measure of reproductive success. [3] Length of time that females had been sexually mature at the time of data collection was assessed by subtracting the answer to "How old were you when you had your very first menstrual period?" from the participants' reported age.

**Economic deprivation.** The question "About how much total income, before taxes, did your family receive [during the previous year]?" was included in the questionnaire administered to participants' parents/guardians. This constituted the economic deprivation variable used in all focal analyses. Although household income was assessed at all waves, the Wave 1 assessment was seen as preferential because it most closely assessed the economic background of participants. In subsequent waves, participants themselves answered the income question, which might have led to systematic distortions in reported income, particularly among participants from high-income families. For instance, participants who pursued higher education after Wave 1

[3] This variable was dichotomized for two reasons. First, the theoretically relevant distinction for the current investigation was simply whether or not the participant had successfully reproduced. Second, the number of *non-dependent* offspring—like sibship—might actually be positively associated with suicide risk. Thus, using a total count of offspring, without accounting for factors that would influence the dependency of those offspring on the participant (e.g., the age of the children, the extent to which the participant provides care/support for their children) might obscure any protective influence that simply *being reproductive* might have upon an individual. The intricacies of the relationship between offspring and suicidality are excellent topics for future investigations, but are beyond the scope of the goals in the current study.

might have reported no income or very low income while students, despite actually being of high socioeconomic status. Thus, parent-reported income at Wave 1 was considered to be the most accurate indicator of economic deprivation.

**Mediators.** As previously discussed, there should be cognitive/affective mediators of the relationships between these risk factors and suicide. First, quality of relationships with siblings might mediate the relationship between number of siblings and suicide. Participants answered questions regarding the quality of their relationships with each of their siblings. These questions included "How much time do you and [SIBLING NAME] spend together," "How often do you feel love for [SIBLING NAME]," and "How often do you and [SIBLING NAME] quarrel or fight," all rated from 1 (none) to 4 (a lot). Responses to these questions were averaged across siblings, and across Waves 1 through 3 (none of these questions were asked at Wave 4, and the "time with siblings" question was not asked at Wave 3) to create two sibling relationship quality variables: connection to siblings (5 items, $\alpha = .72$), and conflict with siblings (3 items, $\alpha = .62$). These two composites were evaluated as mediators of the relationship between number of siblings and depression and suicidality.

Depression might mediate the relationship between suicidality and all or a subset of these risk factors. A "Feelings Scale" including several questions assessing widely-accepted depression symptoms (e.g., the questions map on well to items from the Beck Depression Inventory; Beck, Steer, Ball & Ranieri, 1996) was also included at Waves 1 and 2. Participants were asked to indicate how often over the last week they "Felt sad," "Felt depressed," "Were bothered by things that usually don't bother you," "Had trouble keeping your mind on what you were doing," "Felt that you were too tired

to do things," "Felt fearful," "Didn't feel like eating, your appetite was poor," "Felt life had been a failure," and "Felt life was not worth living." Ratings of these items were summed to produce a total depression score for Waves 1 ($\alpha$ = .80) and Wave 2 ($\alpha$ = .81). At Waves 3 and 4, only a subset of these questions was included (the last four items were excluded), but the reliabilities for the remaining items were acceptable ($\alpha$s = .75 and .73, respectively). These four depression scores were standardized within wave, and averaged to create a total depression composite across waves ($\alpha$ = .71).

**Suicidality.** At all four waves of data collection, participants who reported in a previous question that they had attempted suicide at least once in the past 12 months were subsequently asked "Did any attempt result in an injury, poisoning, or overdose that had to be treated by a doctor or nurse?" Responses were coded as "0" for "No," and "1" for "Yes." These four responses were averaged across waves to create a single composite of severe suicide attempts.

At each wave, the questionnaire also included questions regarding suicidal ideation and how many times the participant had attempted suicide in the past year (regardless of whether or not the attempt required medical attention). The ideal outcome variable to evaluate the present theory would have been fatal suicide attempts, but given that mortality data were not available for this dataset, reports of severe suicide attempts were the closest approximations of fatal suicide attempts available, and were thus hypothesized to be the most likely to conform to the current hypotheses. For this reason, severe suicide attempts were used as the outcome of interest.

**Control variables.** Age, sex, and race data were obtained at each wave of collection, and were primarily treated as covariates (gender was a focal predictor in a

subset of the analyses). Various studies have shown that age (e.g., Hawton & James, 2005), sex (e.g., Moscicki, 1994), and race (e.g., Jedlicka, Shin, & Lee, 1977) exhibit relationships with suicide that are largely unrelated to the current theory. Race was dichotomized into "White" and "Non-White" given the relatively small proportion of the set that reported a race other than White (60.9%) or Black (19.4%) at Wave 1 (Asian/Pacific Islander = 2.7%, Native American = 1.3%, Missing = 15.7%). Religiosity, which has also been shown to (negatively) relate to suicide risk (e.g., Martin, 1984), was also included as a covariate in all analyses, and was assessed via the question "How important is religion to you," from 0 (Not important at all) to 3 (More important than anything else) scale. This question was included at all four waves of data collection. For focal analyses, responses to this question were averaged across waves, creating an overall composite of religiosity ($\alpha$ = .79).

At Wave 1, participants reported whether or not they were adopted. In the context of the current theory, this variable could conceivably influence the way that sibship relates to suicidality, and will thus be treated as a covariate in all analyses that include sibship. Finally, participants were asked "Have any of [your family] succeeded [in killing themselves during the past 12 months]?" It was deemed important to control for this variable because although suicide attempts by participants might be positively correlated with whether a family member has recently died by suicide (due to the fact that some of the same variables which produce suicidality in the participant would be acting on other members of the family), it might suppress suicidality in some individuals who would otherwise be at risk. From the perspective of the current theory, this would be so because the benefit of suicide would have diminishing returns as the

number of successful attempts within a family increases (i.e., as the number of suicides goes up, the number of beneficiaries goes down). Thus, this was included as a control variable in all analyses.

### Procedure

Wave 1 of The Add Health Study measures consisted of computer-assisted in-home questionnaires (one administered to the participant, and another administered to the participant's parent/guardian), a computer-assisted in-school questionnaire, and a standardized interview; subsequent waves included an in-home questionnaire and standardized interview. The measures described above were drawn from the home and school questionnaires of participants, with two exceptions. The objective attractiveness ratings included in the prospective viability composite were taken from the post-interview questionnaire completed by the interviewer, and the Wave 1 income estimate was administered as part of the parent questionnaire.

## Results

### Depression and Suicidality: Descriptive Statistics

Across all waves of collection, 136 (2.1%) participants reported at least one suicide attempt so severe that it required treatment. As expected, both depression symptoms and severe suicide attempts exhibited moderate to extreme positive skew. Depression had a skew statistic of 1.49 and severe suicide attempts had a skew of 10.34, both of which exceed the recommended range of -1 to 1 required to assume distributional normality. However, it has been argued that given a sample size equal to or exceeding 25 times the absolute value of the skew statistic, statistical inferences based on parametric tests with skewed variables can still be safely considered valid

(Cochran, 1977; Boos & Hughes-Oliver, 2000; as cited in von Hipple, 2010). Both variables met this criterion (even severe suicide attempts would only have required a sample of 259 to safely be submitted to parametric tests), and were thus were not transformed prior to analysis.

**Sibship, Prospective Viability and Economic Deprivation**

**Descriptive statistics.** At Wave 4, sibling data were available for 5103 (99.78%) participants. Total siblings ranged from 0 to 20, and only 2% of participants had more than 8 siblings. To reduce the potential negative impact of outliers, a 95% Winsorisation was performed (i.e., values in the tails of the distribution were brought in to the next lowest/highest values; because more than 2.5% percent of participants had 0 siblings, the bottom tail was not altered). The new sibling estimate ranged from 0 to 8 ($M$ = 2.78, $SD$ = 2.01). At Wave 1, total household income was available for 4929 (75.81%) participants. Income ranged from $0 (unemployed) to $999,000 ($M$ = $47,700, $SD$ = $56,354). To reduce the impact of outliers at the bottom and top of the distribution, a 95% Winsorisation was performed, bringing the lowest incomes up to $6000, and the highest incomes down to $100,000 ($M$ = $59,667, $SD$ = $46,565). The prospective viability composite was normally distributed, with a skew statistic of -0.32.

**Correlations.** Zero-order correlations between depression, severe suicide attempts and all focal predictors and covariates are reported in Table 1. Consistent with hypotheses, sibship and prospective viability both exhibited significant (positive and negative, respectively) relationships with depression and severe suicide attempts, but contrary to hypotheses, household income did not significantly correlate with severe suicide attempts, although it did negatively correlate with depression symptoms.

**Regression analyses.** Depression symptoms and severe suicide attempts were both analyzed using stepwise linear regression. The model included main effects (sibship, viability and income) and covariates (age, race, gender, whether the participant was adopted, religiosity, and whether there was a recent suicide in the family) at Step 1, two-way interactions between focal predictors at Step 2, and the single three-way interaction at Step 3. Total $R^2$ for the models and regression weights for all predictors and covariates are reported in Table 2. The full model significantly predicted depression, $F(13, 3915) = 91.102$, $p < .001$, but the three-way interaction was not significant, and did not improve the predictive value of the model from Step 2, $F$ Change = 1.688, $p = .194$. Severe suicide attempts were also significantly predicted by the model, $F(13, 3915) = 10.42$, $p < .001$, and the three-way interaction did significantly improve the predictive value of the model from Step 2, $F$ Change = 10.15, $p = .001$ (Figure 1). The pattern indicated that, consistent with hypotheses, for low-viability, low-income participants alone, sibship was positively associated with suicide risk, B = .01, $t(3914) = 3.26$, $p = .001$. The simple slopes were not significant for any other values of viability and income.

To determine whether these effects were comparable across males and females, the data were split by sex and then regression analyses were recomputed. As shown in Table 2, these analyses revealed that the 3-way interaction predicting severe suicide attempts was primarily driven by females in the main analysis. Although the pattern of results looked very similar for both females and males (see Figure 2), the interaction was significant for females alone (however, the simple slope for low-viability, low-

income males was marginally significant, B = .0004, $t(1834) = 1.81$, $p = .07$; it was significant for females, B = .001, $t(2093) = 3.10$, $p = .002$).

This sex difference was not hypothesized, and is curious. One potential explanation is informed by a documented tendency for females to attempt suicide more frequently, but for males to die by suicide more frequently (e.g., Moscicki, 1994). If suicidal females are less likely to die by suicide throughout the period of data collection, they are more likely to remain in the dataset at Wave 4; suicidal males, conversely, would be less likely to be present in the dataset by Wave 4. In other words, it is possible that the attrition rate of suicidal males was higher than that of suicidal females, which would lead to a "selection bias" that could diminish the apparent effect of these variables for males. This explanation is supported by the fact that among those participants who reported attempting suicide at Wave 1 (Males = 70, Females = 160), attrition by Wave 4 was higher for males (19, 27.14%) than for females (28, 17.5%). This differential attrition was even more dramatic among participants who reported a severe suicide attempt at Wave 1 (Males = 23, Females = 43): 34.78% attrition (8) among males, compared to 18.60% (8) among females. The cause of this attrition is of course not certain, but the pattern is consistent with the notion that males in this study might have been committing suicide at higher rates than females, thereby distorting the overall results.

**Relatedness vs. Childhood Association: Exploratory Analyses**

Zero-order correlations between depression and severe suicide attempts (at Wave 1 and across all waves) and total siblings (as reported at Wave 4), number of siblings living with the participant at Wave 1, number of siblings who had *always* lived

with the participant as of Wave 1, and an estimated total *r* are displayed in Table 3. Of the four predictors, the undifferentiated "total sibling" report from Wave 4 was most consistently correlated with depression and suicide attempts. The three more nuanced variables were not consistently related to the outcome variables. Number of siblings who were currently living with the participant at Wave 1 most closely conformed to the hypotheses: it was significantly or marginally related to all four outcomes. (Interestingly, the direction of the relationships between siblings who had always lived with the participant and estimated *r* and depression tended to be *negative,* while their relationships tended to be *positive* for severe suicide attempts.) Thus, none of the nuanced sibling variables was as strong or consistent a predictor as the Wave 4 report of total siblings. As previously discussed, this is not surprising given that the nuanced sibling information was only available for siblings *currently* living with the participant, and thus does not include siblings that might have moved out of the house prior to the collection date. The estimated *r* was actually the weakest variable among those evaluated.

**Mediation Analyses**

**Sibling relationships.** Zero-order correlations between sibship, prospective viability, outcome variables, and proposed mediators are reported in Table 4. As shown here, neither sibling connection nor sibling conflict was significantly correlated with severe suicide attempts, obviating formal mediation analyses. Thus, the hypothesis that the relationship between sibling number and suicidality would be explained by sibling relationship quality was not supported.

**Depression.** Next, analyses were conducted to evaluate the potential mediating effect of depression between the focal predictors and severe suicide attempts. Two conceptual possibilities were compared. First, depression and suicide might be affective and behavioral components of the same construct, in which case depression should mediate the three-way interaction between sibship, viability and income to predict suicide risk. Alternatively, it might be the outcome of a subset of predictors (e.g., prospective viability, income, or both), in which case it might mediate one or more main effects (but not the three-way interaction between them), and interact with one or more predictors to predict suicide attempts. Thus, a model was constructed to compare these two possibilities using PROCESS (Hayes, 2012), a computational tool for modeling conditional mediation effects.

PROCESS employs the bootstrapping approach to mediation proposed by Preacher & Hayes (2008), which estimates the path weights to and from mediators via iterated resamples of the data. In the current study, 5000 resamples were performed, and 95% confidence intervals were generated. An indirect path (i.e., the effect of the IV on the DV through the mediator) is determined to be significant if the associated confidence interval does not contain zero. PROCESS additionally allows evaluation of *conditional* mediating effects (i.e., the extent to which the indirect path between two variables through a mediator is influenced by moderators, also known as "moderated mediation" and "mediated moderation"), making it ideal for the purposes of the current study.

The constructed model included all direct paths from predictors and their interactions to severe suicide attempts, as well as all indirect paths from these factors to

suicide attempts through depression, and all possible two- and three-way interaction terms between depression and predictors. Three versions of this model were evaluated, each of which treated viability, sibship or income as the "independent variable," and the other two predictors as moderators ("Model 1," which treats viability as the independent variable, is depicted in Figure 3; Models 2 and 3 are identical, except that sibship and income are treated as the IVs, respectively). It was necessary to test all three model variants in order to obtain estimates of direct and indirect effects of each predictor because only one predictor at a time can be treated as the independent variable. Regression weights and total $R^2$ values for the models (including viability, sibship, income, depression and interaction terms; values for covariates are not displayed, but were included in the models) are displayed in Table 5, and estimates of the conditional direct and indirect effects of viability, sibship and household income are displayed in Table 6. If depression is simply the affective mediator between the multiplicative influence of these factors and suicidal behavior, one would expect the indirect path from the three-way interaction between sibship, viability and income to suicide attempts through depression to be significant, but it was not. This suggests that depression and suicide are *not* simply affective and behavioral components of a single construct.

If depression is a necessary but insufficient precursor to suicidal behavior, we would expect it to mediate a subset of risk factors, and also to perhaps interact with one or more risk factors to predict severe suicide attempts. Examination of the other paths in the model revealed that the direct path from the three-way interaction to suicide attempts was significant even in the presence of depression. Furthermore, depression conditionally mediated the relationships between suicide attempts and each risk factor,

and it also interacted with one risk factor (viability) to predict suicide attempts. The indirect paths from sibship and income through depression to severe suicide attempts were significant, but only at "high risk" levels of the other two predictors (e.g., sibship only contributed to suicide risk through depression when viability and income were low). In contrast, the indirect path from viability through depression to severe suicide attempts was significant at all levels of the other two predictors, except when sibship and income were both high. Taken together, these results seem to indicate that whereas the relationship between viability and suicidality is largely explained by depression, the contributions of the other two risk factors—and particularly the *combination* of all three factors—is not simply explained by increased depression symptoms.

Additionally, depression actually interacted with viability to predict severe suicide attempts, such that depression was only related to severe suicide attempts among low viability participants: the simple slope for high viability participants was not significant, B = .002, $t(3927) = 1.45$, $p = .15$, but the slope for low viability participants was, B = .01, $t(3927) = 9.72$, $p < .001$ (Figure 4). Thus, although the relationship between viability and severe suicide attempts seems to be largely accounted for by depression, viability does interact with sibship and income to predict suicide attempts independently of depression, and it also interacts with depression itself to increase suicide risk.

In summary, depression did explain some of the variance in the relationships between all three focal predictors and suicidality, but the interaction between these factors predicted suicide attempts independently of depression. These results are consistent with the proposition that depression is a necessary but insufficient condition

for suicide, rather than that depression and suicidality are two aspects of the same construct. An additional prediction that might be made based upon this characterization of depression is that sibship, viability and income only predict increased suicide risk given the presence of depression symptoms. Thus, a final analysis was conducted to evaluate whether depression, sibship, viability and income interacted to predict suicide risk.

Severe suicide attempts were regressed upon all predictors, interaction terms and covariates in a stepwise fashion. Step 1 included main effects (sibship, viability, income and depression) and covariates (age, race, gender, religiosity, recent familial suicide, and adopted status), Step 2 included all possible 2-way interactions between predictors, Step 3 included all possible 3-way interactions, and Step 4 included the 4-way interaction between depression, sibship, viability and income. Standardized regression weights for all predictors and interaction terms are presented in Table 7, and indicate a significant 4-way interaction between focal predictors to predict severe suicide attempts (see Figure 5). The interaction pattern indicates that among individuals experiencing few depression symptoms, the 3-way interaction between sibship, viability and income does not significantly predict suicide risk ($p = .98$). However, among participants who experience many depression symptoms, the 3-way interaction is significant ($p < .001$), and the pattern closely resembles the interaction pattern observed in the full set, with the highest suicide risk among participants with many siblings, low reproductive viability and poor economic backgrounds. This result bolsters both the characterization of depression as a necessary but insufficient condition for suicide, and the claim that the other three factors are necessary to predict substantial increases in suicidality.

**Sexual Maturity, Reproduction and Female Suicidality**

**Descriptives.** The numbers of females at each wave who had reproduced were: Wave 1 = 79 (2.4%), Wave 2 = 110 (3.3%), Wave 3 = 780 (23.2%), Wave 4 = 1557 (46.4%). Expectedly, these variables were quite skewed at Waves 1 (6.29) and 2 (5.25), but they were minimally skewed by Wave 3. Average lengths of time that females had been sexual mature (i.e., how many years post-menarche they were) were: Wave 1 = 3.03 (*SD* = 1.89), Wave 2 = 3.85 (*SD* = 1.92), Wave 3 = 9.07 (*SD* = 2.60), and Wave 4 = 16.23 (*SD* = 2.55). All four of these variables were normally distributed (skew statistics ranged from -0.43 to 0.51).

**Correlations.** Partial correlations between years females had been sexually mature, reproductive status, and depression and severe suicide attempts (controlling for age, race, religiosity and income) are presented in Table 8. Neither years sexually mature nor reproductive status exhibited significant correlations with severe suicide attempts. Regression analyses were conducted to examine the hypothesized interaction between these two variables in predicting suicidality.

**Repeated measures regression.** Because predictions involving reproduction and suicide risk specifically concerned how depression and suicidality might increase over time as a function of sexual maturity and reproductive success (or lack thereof), generalized estimating equations (repeated measures regression analyses) were used to evaluate these hypotheses. Each model included length of time the participant was sexually mature, whether or not they had produced offspring, an interaction term between these two variables, and all covariates (viability, income, religiosity, and whether or not there was a recent suicide in the family).

Parameter estimates for all predictors and covariates are reported in Table 9. Length of time that females had been sexually mature marginally interacted to predict serious suicide attempts (see Figure 6): when only a short time had elapsed since reaching sexual maturity, females who had reproduced did not significantly differ from those who had not reproduced. As time since reaching sexual maturity increased, however, risk of committing a serious suicide attempt *decreased* for those females who *had* reproduced, and *increased* for those females who had *not* reproduced. Thus, the hypothesis regarding the interactive effect of length of time since reaching sexual maturity and reproductive success on female suicidality was partially supported.

**Sexual Activity, Reproduction and Gender**

**Descriptives.** Due to the presence of extreme outliers, the estimates of total sexual partners were Winsorised (95%), bringing the extremely high estimates down to 20 ($M$ = 3.63, $SD$ = 5.57), and increasing the normality of the distribution (skew statistic = 1.81). By Wave 4, 36.4% (2365) of participants reported having offspring. Correlations between number of sexual partners, offspring, and covariates are presented in Table 10, and indicate that—consistent with past literature—females reported fewer past sexual partners than males, but were more likely than males to have offspring.

**Repeated Measures Regression Analyses.** Once again, the predictions regarding how number of sexual partners and reproduction would relate to depression and suicidality were time-specific (i.e., it made more sense to evaluate number of sexual partners at each wave rather than creating a composite of average sexual partners across waves), and thus these hypotheses too were evaluated with repeated measures regression analyses. Each model included whether or not the participant had

reproduced, total sexual partners as of the time of collection, gender, all 2-way interactions between these factors, and a 3-way interaction, as well as all relevant covariates (viability, income, age, race, religiosity, and whether or not a family member had recently committed suicide).

Parameter estimates for focal predictors and all covariates are reported in Table 11. Gender and number of sexual partners interacted to predict depression symptoms (Figure 7), such that number of sexual partners was more strongly related to depression among females (B = .59, $t(4865) = 7.75$, $p < .001$) than males (B = .25, $t(4865) = 9.71$, $p < .001$). Contrary to hypotheses, number of sexual partners was positively related to depression symptoms for both sexes. There was also a significant three-way interaction between gender, offspring and number of sexual partners in predicting severe suicide attempts (Figure 8), such that for all males and for females who had few sexual partners, there was no relationship between offspring and suicidality. However, for females with many past sexual partners, there was a negative relationship between offspring and probability of a severe suicide attempt. This interaction largely conformed to hypotheses, except that severe suicide attempts were predicted to be *negatively* related to number of sexual partners among males, but instead no relationship was observed. Thus, the previous finding that sexual success is protective against suicidality for males (deCatanzaro, 1984) was not replicated.

## Discussion

I proposed 9 hypotheses to evaluate the theory that suicide is a biological adaptation designed to facilitate kin fitness. One set of hypotheses (1, 3, 7, and 8) pertained to how sibship, prospective cues to reproductive viability, and income would

predict suicidality, and these were largely confirmed. Sibship and prospective viability did exhibit significant zero-order relationships with depression and severe suicide attempts, and most importantly, sibship, viability and income interacted to predict severe suicide attempts, such that having siblings only increased suicide risk among individuals who were low in prospective viability and came from low income families. These findings support the theory that suicide is a nepotistic adaptation, because this group represents individuals for whom the direct fitness cost of suicide would be lowest and the inclusive fitness benefit of suicide would be the highest.

These effects were sex-specific, however: the predicted main effects and the three-way interaction between sibship, viability and income were only significant for females, although the pattern of results did look similar for males. It is difficult to evaluate whether these results, as discussed previously, are a spurious byproduct of differential attrition between males and females in the dataset, or whether they reflect a true gender difference. It is possible, for instance, that this theory does describe suicidality among females more than males. Although certain types of altruism tend to be more typical of males (e.g., public acts of helping in emergency situations; Eagly & Crowley, 1986; Piliavin, Rodin, & Piliavin, 1969), females are typically more helpful in familial relationships and other close relationships (e.g., Aries & Johnson, 1983). Females are also more sympathetic and empathetic on average than are males (Eisenberg & Lennon, 1983; Hoffman, 1977). Thus, it is possible that a nepotistic model of suicide is more applicable to females than to males, although this explanation is not terribly intellectually satisfying (particularly given that the predicted pattern of results emerged for males, albeit nonsignificantly).

A second possibility is that prospective viability as it was operationalized in this study is more relevant to females than to males (the zero-order correlations between viability and suicidality were slightly higher for females than for males, although they were significant for both sexes). A consistent finding in this study was that females were generally more impacted by factors directly related to reproduction than were males. Thus, it is possible that the most relevant viability cues for males are of a different sort. For instance, perhaps achievement-related cues would be a better operationalization of viability for males. Males are in general more concerned with achievement and status than are females (Atkinson & Raynor, 1974; Kipnis, 1974; Kirkpatrick, Waugh, Valencia, & Webster, 2002; McClelland, Atkinson, Clark, & Lowell, 1953; Veroff, 1977), and most relevantly for the current theory, males' ability to obtain mates is significantly increased by status, achievement and earning potential (e.g., Buss & Barnes, 1986; Symons, 1979; Trivers, 1972), while the same is not true for females. Thus, it is possible that achievement would interact with sibship and economic background to predict suicidality for males in the same way that cues directly related to reproduction interacted with these two variables to predict suicidality in females. Consistent with this idea, it has been found that suicidality is negatively related to GPA among adolescent males, but not among females (Borowsky, Ireland, & Resnick, 2001).

Hypotheses regarding potential mediators of the relationships between suicidality and sibship, viability, and resource availability (Hypotheses 2 and 9) were only partially supported. First, sibling relationship quality did not mediate the relationship between sibship and suicidality. One possible explanation for this null

finding is that the questions used to assess sibling relationship quality assessed the reciprocal aspects of these relationships. As discussed elsewhere, it is well-established that interpersonal connection is prophylactic against suicide, and the responses to the particular questions in this survey were likely influenced both by the connection that participants felt toward their siblings *and* by the extent to which those feelings were reciprocated. It is likely that the profile of suicidal individuals is to experience heightened prosocial emotions toward siblings, but to have such emotions (subjectively or objectively) unreciprocated. For example, feeling close with one's sibling implies a reciprocal connection, and is no doubt a positive and protective influence; such a feeling is likely to indicate to both individuals that they are contributing, in some sense, to the well-being of the other, which could protect against feelings of burdensomeness. In contrast, feeling especially *loving toward* but *unloved by* siblings would intuitively not have the same protective influence against suicidality. Again, the distinction between this hypothesis and the relationships that have been well-established is that the focus here is not upon feelings of isolation or disconnection per se, but upon pronounced feelings of love that are (objectively or subjectively) unreciprocated.

Depression exhibited zero-order correlations with sibship, viability and income in the predicted directions (see Table 1), but it was not predicted by the interaction between these risk factors as severe suicide attempts were, and it did not mediate the three-way interaction to predict suicide attempts. Even more telling was the fact that depression, sibship, viability and income significantly interacted to predict suicide attempts, such that the latter three factors only predicted increased suicidality among depressed participants. These results suggest that depression and suicide are probably

not simply two aspects of the same construct; rather, they are more consistent with the notion that depression is a necessary but insufficient prior condition for suicidality.

Interestingly, sibship, viability and income had additive relationships with depression, which sharply contrasted with the multiplicative relationship that these factors exhibited with suicidality, such that the presence of all three risk factors was necessary to produce significant increases in suicide risk. In other words, whereas depression increases incrementally as a function of these factors, suicide risk seems to exhibit an all-or-none relationship with them, as pressure on a trigger relates to the firing of a gun. One risk factor increases the pressure (depression) on that trigger, and two factors doubles that pressure, but the pressure only becomes sufficient for suicide to "fire" when the third risk factor is applied. The limitation of this metaphor is that it implies that depression is the only factor determining suicide risk, and that sibship, viability and income influence suicidality only to the extent that they increase depression, but the mediation results suggest rather strongly that this is not so. There appears to be an additional pathway through which these risk factors relate to suicide. We might speculate that this second influence is cognitive in nature, with sibship, viability and income comprising a perceptual gestalt that is conducive to suicidality. However we represent this relationship conceptually, it seems clear that these factors relate to depression and suicidality in distinct ways, and that these differences have the potential to tell us meaningful and interesting things about both how depression and suicide relate to each other in an ultimate sense.

With these things said, it is important to note that although these results are consistent with the notion that depression can be described within a nepotistic theory,

they do not exclude the possibility that depression is distinct, in an ultimate sense, from suicidality. In other words, these results do not rule out previously articulated theories of depression, which posit that depression actually improves direct fitness. The fact that viability and economic deprivation were found to contribute to depression is consistent with several previously proposed theories of depression that do not invoke kin selection (e.g., that depression is a response to threatened direct fitness, Hagen, 2003; Watson & Andrews, 2002; Suarez & Gallup, 1991; Thornhill & Thornhill, 1989; or a loss in social status; Gilbert, 1992). Furthermore, it could be argued that the fact that the combination of all three risk factors predicted suicidality and *not* depression is evidence that the adaptive value of depression is not due to an influence on the fitness of close kin. Thus, the question of whether the ultimate causation of depression requires a separate paradigm from the one proposed here or whether it too can be understood via kin selection needs to be clarified via further investigation.

Hypothesis 4 pertained to the effects of sexual maturity and production of offspring on female suicidality. This hypothesis was partially supported: length of time since menarche was positively related to severe suicide attempts among females who had not yet reproduced, but it was negatively related to suicide risk among females who had reproduced (however, this interaction was only marginally significant). This finding is consistent with the proposition that females who postpone reproduction—even though they might be doing so consciously, and might negatively evaluate becoming pregnant at that point in time—are receiving false cues to infertility, which in turn increases risk of depression and suicidality. However, it should be noted that length of time since reaching sexual maturity is confounded with age, which is related to suicide

attempts for reasons potentially (though not necessarily) unrelated to the current theory. Unfortunately, statistically controlling for age in this analysis was not possible, because the age-controlled effect of the *difference between* current age and age at menarche would have simply been the effect of age at menarche. Thus, further research examining the potential mediators of this relationship (discussed below) would necessary before any firm conclusions can be drawn.

The final set of hypotheses (5 and 6) pertained to the role of number of sexual partners and reproduction, and how these factors might influence males and females differentially. Hypotheses were partially supported: having many sexual partners was a risk factor for females, particularly when they had no offspring. Consistent with hypotheses, reproduction did not have an effect on male suicidality, but the expected negative relationship between sexual partners and male suicidality did not emerge. Indeed, sexual partners and suicidality were not related among males. The explanation for this null finding could be related to the discussion above: perhaps sexual success is not as important to males as is achievement or access to resources. An important limitation of this analysis is the strong likelihood that having offspring is somewhat confounded with marital status, and unfortunately, marriage data in the Add Health study were incomplete (i.e., an explicit marital status question was asked at Wave 2, but not at Waves 3 and 4, which included questions about participants' "current or most recent partner," but did not provide clear indications of whether the participant was currently married). Thus, the effect found here cannot be clearly attributed to offspring per se: it might be due to the fact that participants who had offspring were also more

likely to be married, or at least in committed relationships. Replicating this effect accounting for marital status is necessary before drawing any inferences.

Taken together, these results provide evidence that suicide is predicted by an interaction between sibship, reproductive viability and economic background, and are consistent with the theory that suicide is a nepotistic adaptation. Furthermore, some analyses suggested that, at least for females, indictors of reproductive viability and actual reproductive success are protective against suicide, but further research is needed to clarify the proper interpretation of these findings.

**Limitations**

The practical implications of these findings might well be questioned, given that the total variance for which each model accounted was modest at best (although each model was statistically significant, the total explained variance ranged from 3 to 7% for severe suicide attempts). In part, these small values are due to the fact that suicide is an extremely rare event. In the U.S., the annual rate of death by suicide is approximately .0001 (0.01%), and it is estimated that suicide attempts are about 11 times as common (.0012, 0.12%; Centers for Disease Control and Prevention) as deaths by suicide. Over all waves, the rate of severe attempts in this set was .0068 (0.68%), which is higher than the general population (potentially due to the age of the sample—suicide risk spikes in late adolescence/early adulthood—or to the fact that certain disadvantaged demographic groups were oversampled), but still quite low. Because these events are so rare, the rate of severe attempts even within the group of participants with all evaluated risk factors was still very low, which would have contributed to the low regression weights and total $R^2$ values observed in this study. With this said, it is significant that the predicted

value for average severe suicide attempts in low-viability, low-income individuals was more than *four times* higher if they had siblings than if they did not, even if the absolute increase in average severe suicide attempts was only .02.

Just as importantly, however, these models had objectively lower predictive value than they might have because they did not include some other known predictors of suicide, such as feelings of burdensomeness, bereavement, and whether participants were in a stable, committed relationship such as marriage. Some such variables were not included because they were not available, and others because they were not relevant to the focal questions in the current study. Nonetheless, demonstrating that these factors provide additional information above and beyond such predictors, and exploring the ways in which these factors might moderate the relationships between these other predictors and suicide could be a valuable next step in this line of research. For instance, examining the relative contributions of being married and having offspring to suicide risk would be informative.

Another limitation to this research is that it is correlational, as is all research on suicidality. I included a number of important covariates in these analyses to assist in allaying concerns that the relationships demonstrated here might be spurious. However, the possibility of unconsidered confounds is ever present in research of this nature. For this reason, an important next step in this research is to identify potential cognitive and biological mediators between these factors and suicidality. Identifying these mediators will help to strengthen claims of causality between suicide and the risk factors tested here and would provide further tests of the validity and usefulness of applying kin selection theory to the problem of suicide. The relationship between suicide and the

state of fertile non-reproduction in females, for instance, might be mediated by a number of hormonal factors, unconscious connections between the chronic experience of the menstrual cycle and infertility, both, or alternatively, it could be completely accounted for by a gradual increase in pain tolerance (i.e., due to the common experience of dysmenorrhea, or pain associated with uterine contractions), which has been shown to be associated with suicide risk (Joiner, 2005). This association might also be due to the life circumstances that are often associated with reproduction, such as being in a committed relationship, which have psychologically protective influences in and of themselves. If such associations are fully explained by factors that can parsimoniously account for suicide risk without invoking nepotism, then this would be strong evidence against the utility of the current theory. If, however, there are additional mediators that are directly related to cues to the fitness costs and benefits that suicide places upon the suicidal individual and his/her kin, this would suggest that a kin-selection model of suicide is useful.

A further limitation of this study was that the outcome variable was not actual fatal suicide attempts, which is the true construct of interest. However, the comparisons of depression and severe suicide attempts provided some interesting insights. First, the focal interaction (sibship, viability and income) did not predict depression, but did predict severe suicide attempts (even when depression itself was added to the model). These differences indicate that, as discussed above, suicidal behaviors, and particularly those that are likely to result in fatalities, are part of a construct that is either quantitatively or qualitatively different from depression (most likely the latter).

However, an important next step in evaluating this theory will be to replicate these effects in predicting fatal suicide attempts.

A specific limitation of the comparisons between the utility of different sibling estimates in predicting suicidality was that genetic versus childhood association information was incomplete. This was, therefore, not a conclusive test of the extent to which genetic relatedness and childhood association amongst siblings contribute to suicide risk. It would be useful to conduct a conceptual replication of these tests by obtaining complete sibling information from a clinical sample of suicidal individuals, and comparing the predictive value of how long and during what ages the participants lived with each sibling, to the actual relatedness of siblings. Past research has suggested a negative, linear relationship between how many years two children lived together before the age of 12 and the probability that they will engage in sexual intercourse (Bevc & Silverman, 2000). We might extrapolate from this finding that length of association between siblings before age 12 is a strong cue to relatedness, and would thus be a stronger predictor of suicidality. However, Segal (1984) found that monozygotic twins (who share 100% of their unique genes) exhibit significantly more helping behavior toward each other than dizygotic twins (who, like all siblings, share 50% of their genes). This relationship might be mediated by a number of factors other than degree of genetic relatedness per se, but it nonetheless implies the need for more direct investigation of the mechanisms by which sibship affects suicidality.

Investigations of sibship and suicide might also be benefited by obtaining viability estimates not only from the suicidal individual, but from his/her siblings. It is possible that relative viability compared to one's siblings constitutes a unique risk factor

above and beyond one's "absolute" viability. In other words, "absolute" viability (whether one's probability of reproduction is greater than 0) clearly should contribute to suicidality, but the *relative* probabilities that two siblings will be reproductively successful might also impact the likelihood of one becoming suicidal over the other. Thus, a more complete examination of sibship would include not just numbers of siblings, but also the personal characteristics of those siblings compared to the suicidal individual, as these should be nearly as important in determining suicidality in the target individual as their own characteristics.

**Future Directions**

Aside from studies to address the methodological and theoretical ambiguities discussed above, there are several extensions of the current findings that would be interesting and useful. First, determining conscious mediators might be useful in bolstering claims about the relationships between suicide and the factors examined in this study. Furthermore, such examinations would shed light on how and why these mechanisms work, which could further our understanding of suicidality as a nepotistic construct. Second, examining the roles of genetic, neurochemical and endocrinological markers of suicidality in the context of the factors proposed in this study would be useful for a number of reasons. Primary among them is the fact that this theory depends on the assumption that suicidality is a biological adaptation, and as such, that it is genetically heritable. Investigating whether depression- and suicide-related genes interact with the factors described here would be important in evaluating the validity of describing suicide as a nepotistic adaptation.

**Sibling mediators.** The relationships between suicidality and prospective viability and income are interesting and deserve further empirical attention in order to discover what specifically explains them. However, these relationships are somewhat intuitive. The positive relationship between sibship and suicidality observed in this study is the least intuitive and least studied in the suicide literature, and needs to be explained in a proximate sense. Sibling relationship quality—at least as it was operationalized here—did nothing to account for the association between sibship and suicidality. There are several possible factors that could account for the sibship-suicidality association, and would be potentially interesting next steps for this research. First, Joiner has established in a number of studies (see Joiner, 2005 for a review) that feeling burdensome, particularly upon kin, is a robust predictor of severe suicidality. Such findings complement the possibility discussed above, that pronounced but unreciprocated prosocial emotions toward kin mediate the relationship between family size and suicidality. As sibship increases, so does competition for parental investment, especially in low-income households. Rather than engaging in competition, however, low-viability individuals might be more prone to feeling burdensome and undeserving of care compared to their siblings (which could be described as a prosocial or altruistic orientation). Relatedly, it could be that such individuals are *actually* more prone to relative neglect or lack of parental investment as a function of sibship, because parental investment in any one child would be diluted as sibship increased, and possibly because parents might be more likely to preferentially invest in offspring who would "maximize returns." Thus, it could be actual reduced investment, increased feelings of burdensomeness, or both that mediate the sibship-suicide relationship.

**Prosocial orientation.** Because generally decreased or selectively decreased parental investment could plausibly lead to either a concession on the part of the neglected offspring (e.g., suicide), or to increased competition, it would be illuminating to examine what factors are conducive to these two outcomes. Within the context of the current theory, an obvious candidate to explain these different responses would be prospective viability: low viability offspring might be more likely to concede, whereas high viability offspring might be more likely to compete.

A recent study provided evidence that individuals with high fluctuating asymmetry (a strong negative correlate of attractiveness; Fink, Neave, Manning, & Grammer, 2006) are also more likely to possess personality traits related to prosociality, such as empathy and agreeableness (Fink, Neave, Manning, & Grammer, 2005; Holtzman, Augustine & Senne, 2011). Additionally, Archer and Thanzami (2009) found that mate value was a strong, positive predictor of aggression (a common concomitant of competition) in young men. These findings provide precedent for the idea that low viability individuals might indeed be more likely to have a prosocial or cooperative orientation, and that high viability individuals might be more likely to have a competitive orientation. Furthermore, a handful of studies have demonstrated that depressed moods induce helpfulness (Cialdini & Kendrick, 1976; Lerner, 1982; Reykowski, 1982; it should be noted that these authors suggested a negative-state relief model to explain these findings, but a meta-analysis of relevant literature found little support for this explanation of the findings, Carlson & Miller, 1987). Although depressed mood is of course distinct from clinical depression, such findings do inspire curiosity regarding whether individuals with clinical depression or those experiencing

suicidality might also be especially likely to engage in prosocial or helping behaviors. Taken together, these findings bolster the theoretical link between suicidality and altruism, and suggest the need for further research linking cooperative personality traits (e.g., the "altruistic personality," Rushton, Fulker, Neale, Nias, & Eysenck, 1986; and/or general prosocial orientation, Rushton, Chrisjohn, & Fekken, 1981) with factors that predict suicide (like prospective viability), and indeed with suicidality itself.

For instance, it is conceivable that individuals with several suicide risk factors might be more likely to generate gracious explanations for the bad behavior of others (i.e., be less likely to automatically attribute negative behavior to a disposition), and especially for the bad behavior of family members. They might also have an easier time forgiving family members, and be less inclined to retaliate against them for wrongdoing. Some studies have shown that forgiveness is itself perceived as an altruistic act (as evidenced by the fact that recipients of forgiveness feel compelled to reciprocate with a favor, Kelln & Ellard, 1999; Wallace, Exline, & Baumeister, 2008), and thus might be more likely among individuals who believe themselves to be burdensome upon (or "in the debt" of) family members. Such inclinations would be consistent with and might even directly perpetuate a general orientation toward assisting family over oneself.

It would also be interesting to examine whether viability predicts one's likelihood of risking one's own life to save a sibling (e.g., agreeing to a potentially life-threatening organ donation). In fact, it would not be unreasonable to call such acts "suicidal." Although these behaviors differ from our prototypical conception of the phenomenon (i.e., they need not be preceded by depression, although they could be, nor

even involve a conscious intention to end one's own life), the basic underpinnings of both behaviors would theoretically be very similar from the perspective of this theory: it should be most likely when the fitness cost is minimal (viability is low), and the potential gain is maximal (viability of sibling is high, and need is high). Thus, demonstrating the relationship between viability and behaviors that can unambiguously be called kin-directed altruism would be helpful in bolstering the theoretical connection between viability and prototypical suicidality.

If there is a relationship between altruistic or prosocial traits and suicidality (or at least risk factors for suicide), it might have implications for suicide interventions, especially if this connection is consciously accessible for suicidal individuals. If suicide is, at least in part, an attempt to provide a benefit or repay a "debt" to family that the suicidal individual feels is impossible to provide through life, treatment strategies might focus on highlighting the ways in which the individual does or can provide for his/her family, whether that contribution is concrete (e.g., monetary resources, time caring for other family members) or abstract (e.g., providing advice and emotional support).

**Biological mediators.** Several genetic and neurochemical markers have been identified as risk factors for depression and suicide. For example, people who carry at least one short allele in the polymorphic region 5-HTTLPR (part of a gene that codes for the serotonin transporter), are far more likely to develop major depression in the course of their lives (Caspi et al., 2003; Collier et al., 1996; Karg, Burmeister, Shedden & Sen, 2011; Kendler et al., 2005) and are more likely to commit suicide (Gibb, McGeary, Beevers & Miller, 2006; Malloy-Diniz, et al., 2011; Mann et al., 2000) compared to carriers of two long alleles. The most recent studies of this polymorphism

indicate that it does not facilitate depression/suicidality per se, but rather increases sensitivity to social support. Thus, in supportive environments, carriers of the short allele are actually *less* likely to develop depression compared to carriers of two long alleles. Only in environments in which social connection is low (e.g., childhood maltreatment, Caspi et al., 2003; supportive childhood environment, Taylor et al., 2006; individualistic as compared to collectivistic cultures, Chiao & Blizinsky, 2010) does the short allele increase depression risk (this environmental interaction has been found for suicide risk as well, Gibb et al., 2006).

It would be informative to examine whether the factors proposed in the current study moderate the influence of this polymorphism on suicide risk. It is conceivable that in addition to social support, the effects of this gene promote sensitivity to other contextual cues relevant to suicide, as it is described by the current theory. Furthermore, such moderations would be important to a nepotistic explanation of suicide because presumably polymorphisms that can promote suicide risk would be clustered within families, and as discussed elsewhere, the benefit of suicide has diminishing returns as multiple members of the same family enact it. Thus, for such an adaptation to develop, the expression of a "suicide gene" would need to be moderated, to a certain extent, by whether or not others in the family have died by suicide.

Altruistic personality traits have also been shown to have a genetic component. Provided a correlation emerges between suicidality and self-reported altruism/prosocial orientation, it might also be useful to explore these genes as they relate to suicide risk. Findings from twin studies indicate that as much as 50% of the variance in some prosocial traits might be due to genetic influence (Rushton et al., 1986; Rushton, 2004).

Recently, polymorphisms of a few specific genes have been identified as possible contributors to prosocial behavior. Not surprisingly, one such candidate is the gene that codes for the oxytocin receptor (OXTR), and another is AVPR1A, which codes for the vasopressin 1a receptor (Israel et al., 2008, 2009; Lerer et al., 2008; Levin et al., 2009; Meyer-Lindenberg, 2008). Both oxytocin and vasopressin are neuropeptides that have been strongly associated in past research with (among other things) social bonding in females and males, respectively.

Currently, there are conflicting reports of how oxytocin and vasopressin relate to suicide. Some reports have found no relationship between vasopressin and suicidality (Brunner et al., 2002), while others have indicated a positive relationship between vasopressin levels and suicidality (Inder, et al., 1997; Meynen, et al., 2006). These latter studies proposed that the relationship was mediated by stress (i.e., vasopressin is one of the substances released in response to acute stressors), but it is conceivable that it might also play a mediating role in the relationship between social connection (which presumably promotes altruistic intent and behavior) and suicide risk.

Although one recent study reported a negative relationship between CSF oxytocin concentration and suicidal intent among attempters (Jokinen et al., 2012), the researchers did not find that oxytocin levels significantly predicted the likelihood of *dying* by suicide. Furthermore, clinical depression is associated with higher plasma oxytocin levels (Meynen, Unmehopa, Hofman, Swaab & Hoogendijk, 2007; Parker, et al., 2010; Purba, Hoogendijk, Hofman, & Swaab, 1996). These findings are representative of a seemingly conflicted literature on oxytocin and well-being. Although oxytocin is a “bonding hormone,” and is released in response to positive social

experiences such as affectionate touch, breastfeeding, orgasm, and so forth, it is also released in response to stressful events such as a jeopardized romantic relationship (Taylor, Saphire-Bernstein & Seeman, 2010), it is elevated among sufferers of social anxiety (Hoge, Pollack, Kaufman, Zak, & Simon, 2008; Marazziti et al., 2006), and experimental administration of oxytocin can increase retaliation to defection in a cooperation game (see De Dreu, 2012 for a review). This evidence has led some to suggest that oxytocin's real role in sociality is to promote bonding in general, but rather to promote sensitivity and responsiveness to social cues, both positive and negative (Declerck, Boon and Kiyonari, 2009). If this is true, it might be reasonable to hypothesize a positive relationship between oxytocin and suicidality (if not in *levels* of oxytocin, then perhaps in the density of oxytocin receptors in certain areas of the brain), and that oxytocin might mediate the relationship between suicidality and sibship, given low viability and an economically deprived or otherwise stressful environment.

Another recent study identified a polymorphism in one section of the COMT gene ($Val^{158}Met$), which regulates how fast dopamine is broken down in the synapse (and thus how much dopamine is available to be received by the postsynaptic cell) that might also regulate altruistic behavior (Reuter, Frenzel, Walter, Markett, & Montag, 2011). Individuals with a "Val/Val" genotype have lower levels of available dopamine than do those with a "Met/Met" genotype. Reuter and colleagues (2011) found that carriers of at least one Val allele were significantly more altruistic (i.e., they donated about twice as much money to a charity when given the opportunity to do so) as those with two Met alleles. Interestingly, this same polymorphism has also been related to the subjective intensity of reward. Compared to Met/Met individuals, carriers of at least one

Val allele experience less subjective reward to the same pleasant stimulus, report lower levels of overall subjective well-being, and report that "pleasant events" happen to them less often in their day-to-day lives (Wichers et al., 2008). Given that anhedonia is a core feature of clinical depression and suicidality, findings such as this one support the idea that the relationship between suicidality and prosocial behavior is one worth examining at both a behavioral and a genetic level.

**Conclusion**

The current findings provide initial support for the theory that suicide is a nepotistic adaptation, and suggest that investigating suicide from an evolutionary perspective might be useful. Not only does such a theory help to unify a large body of existing research on suicide, but it provides a generative framework within which novel hypotheses might be formulated, and previously undiscovered connections between suicide risk factors might be forged. Further research exploring cognitive, genetic and neurochemical mediators of the relationships found in the current study would facilitate our theoretical understanding of suicide. Furthermore, such an understanding might also have important practical applications for the ways in which suicide outreach should be targeted, and perhaps how interventions for suicidal patients should be approached. If suicide is nepotistic, this could inform how suicide prevention messages are framed, and what practitioners should focus upon in the treatment of suicidality.

## References


Allen, N. B., & Badcock, P. B. T. (2003). The social risk hypothesis of depressed mood: Evolutionary, psychosocial, and neurobiological perspectives. *Psychological Bulletin, 129,* 887-913.

Andersson, M. (1994). *Sexual Selection.* Princeton, NJ: Princeton University Press.

Andrade, M. C. B. (1996). Sexual selection for male sacrifice in the Australian redback spider. *Science, 271,* 70-72.

Archer, J. & Thanzami, V. (2009). The relation between mate value, entitlement, physical aggression, size and strength among a sample of young Indian men. *Evolution and Human Behavior, 30*(5), 315-321.

Aries, E. J. & Johnson, F. L. (1983). Close friendship in adulthood: Conversational content between same-sex friends. *Sex Roles, 9,* 1183-1196.

Atkinson, J. W. & Raynor, J. (1974) *Motivation and achievement.* New York: Wiley.

Baca-Garcia, E., Diaz-Sastre, C., de Leon, J., & Saiz-Ruiz, J. (2000). The relationship between menstrual cycle phases and suicide attempts. *Psychosomatic Medicine, 62,* 50-60.

Baumeister, R. F. (1990). Suicide as escape from self. *Psychological Review, 97*(1), 90-113.

Beck, A. T., Steer, R. A., Ball, R., & Ranieri, W. (1996). Comparison of Beck Depression Inventories –IA and –II in psychiatric outpatients. *Journal of Personality Assessment, 67*(3), 588-597.

Bevc, I., & Silverman, I. (2000). Early separation and sibling incest: A test of the revised Westermarck theory. *Evolution and Human Behavior, 21,* 151-161.

Blake, J. A. (1978). Death by hand grenade: Altruistic suicide in combat. *Suicide and Life-Threatening Behavior, 8*(1), 46-59.

Boardman, A. P., Grimbaldeston, A. H., Handley, C., Jones, P. W., & Willmott, S. (1999). The North Staffordshire Suicide Study: A case-control study of suicide in one health district. *Psychological Medicine, 29,* 27-33.

Boos, D. D.& Hughes-Oliver, J. M. (2000). How large does *n* have to be for *Z* and *t* intervals? *The American Statistician, 54*(1), 121-128.

Borowsky, I. W., Ireland, M., & Resnick, M. D. (2001). Adolescent suicide attempts: Risks and protectors. *Pediatrics, 107,* 485-493.

Brunner, J., Keck, M. E., Landgraf, R., Uhr, M., Namendorf, C., Bronisch, T. (2002). Vasopressin in CSF and plasma in depressed suicide attempters: preliminary results. *European Neuropsychopharmacology, 12*(5), 489-494.

Buss, D. M. (1989). Sex differences in human mate preferences: Evolutionary hypotheses tested in 37 cultures. *Behavioral and Brain Sciences, 12*, 1-49.

Buss, D. M. & Barnes, M. (1986). Preferences in human mate selection. *Journal of Personality and Social Psychology, 50*(3), 559-570.

Carlson, M., & Miller, N. (1987). Explanation of the relation between negative mood and helping. *Psychological Bulletin, 102*, 81-108.

Caspi, A., Sugden, K., Moffitt, T. E., Taylor, A., Craig, I. W., Harrington, H., McClay, J., Mill, J. et al. (2003). Influence of life stress on depression: Moderation by a polymorphism in the 5-HTT gene. *Science, 301*(5631), 386-389.

Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. Web-based Injury Statistics Query and Reporting System (WISQUARD): www.cdc.gov/ncipc/wisquars.

Cialdini, R. B. & Kendrick, D. T. (1976). Altruism as hedonism: A social development perspective on the relationship of negative mood state and helping. *Journal of Personality and Social Psychology, 34*, 907-914.

Chiao, J. Y. & Blizinsky, K. D. (2010). Culture-gene coevolution of individualism-collectivism and the serotonin transporter gene. *Proceedings of the Royal Society B, 277*, 529-537.

Cochran, W.G. (1977). *Sampling Techniques.* New York: Wiley.

Collier, D. A., Stoper, G., Li, T., Helis, A., Catalano, M., Di Bella, D., Arranz, M. J., Murray, R. M., Bengel, D. Muller, C. R. et al. (1996). A novel functional polymorphism within the promoter of the serotonin transporter gene: possible role in susceptibility to affective disorders. *Molecular Psychiatry, 1*(6), 450-453.

Conner, K. R., Duberstein, P. R., & Conwell, Y., (1999). Age-related patterns of factors associated with completed suicide in men with alcohol dependence. *American Journal on Addictions, 8*, 312-318.

deCatanzaro, D. (1980). Human suicide: A biological perspective. *The Behavioral and Brain Sciences, 3*, 265-290.

deCatanzaro, D. (1984). Suicidal ideation and the residual capacity to promote inclusive fitness: A survey. *Suicide and Life-Threatening Behavior, 14*(2), 75-87.

deCatanzaro, D. (1992). Prediction of self-preservation failures on the basis of quantitative evolutionary biology. In: R. W. Maris, A. L. Berman, J. T. Maltsberger, et al., (Eds.), *Assessment and prediction of suicide,* 607-624. New York: Guilford.

deCatanzaro, D. (1995). Reproductive status, family interactions, and suicidal ideation: Surveys of the general public and high-risk groups. *Ethology & Sociobiology, 16,* 385-394.

Deccan Herald (2012, March 15). Inspector's son kills self, cops in oblivion. Retrieved April 1, 2012, from http://www.deccanherald.com/content/234824/inspectors-son-kills-selfcops-oblivion.html.

Declerck, C. H., Boone, C., & Kiyonari, T. (2010). Oxytocin and cooperation under conditions of uncertainty: The modulating role of incentive and social information. *Hormones and Behavior, 57*(3), 368-374.

De Dreu, C. K. W. (2012). Oxytocin modulates cooperation within and competition between groups: An integrative review and research agenda. *Hormones and Behavior, 61*(3), 419-428.

Denning, D. G., Convell, Y., King, D., & Cox, C. (2000). Method choice, intent, and gender in completed suicide. *Suicide and Life-Threatening Behavior, 30,* 282-288.

Durkheim, E. (1897). *Le suicide: Etude de socologie.* Paris: F. Alcan.

Eagly, A. H., & Crowley, M. (1986). Gender and helping behavior: A meta-analytic review of the social psychological literature. *Psychological Bulletin, 100,* 283-308.

Eisenberg, N., & Lennon, R. (1983). Sex differences in empathy and related capacities. *Psychological Bulletin, 94,* 100-131.

Filiberti, A., Ripamonti, C., Totis, A., Ventafridda, V., De Conno, F., Contiero, P., & Tamburini, M. (2001). Characteristics of terminal cancer patients who committed suicide during a home palliative care program. *Journal of Pain and Symptom Management, 22,* 544-553.

Fink, B., Neave, N., Manning, J. T., & Grammer, K. (2005). Facial symmetry and the 'big-five' personality factors. *Personality and Individual Differences, 39*(3), 523-529.

Fink, B., Neave, N., Manning, J. T., & Grammer, K. (2006). Facial symmetry and judgements of attractiveness, health and personality. *Personality and Individual Differences, 41*(3), 491-499.

Fordwood, S. R., Asarnow, J. R., Huizar, D. P., & Reise, S. P. (2007). Suicide attempts among depressed adolescents in primary care. *Journal of Clinical Child & Adolescent Psychology, 36*(3), 392-404.

Forster, L. M. (1992). The stereotyped behavior of sexual cannibalism in *latrodectus-hasselti thorell (araneae, theridiidae),* the Australian redback spider. *Australian Journal of Zoology, 40*(1), 1-11.

Frank, S.A. (1998). *Foundations of Social Evolution*. Princeton, NJ: Princeton University Press.

Gibb, B. E., McGeary, J. E., Beevers, C. F., Miller, I. W. (2006). Seriotonin transporter (5-HTTLPR) genotype, childhood abuse, and suicide attempts in adult psychiatric inpatietns. *Suicide and Life-Threatening Behavior, 36*(6), 687-693.

Gilbert, P. (1992). *Depression: The Evolution of Powerlessness.* East Sussex, UK: Lawrence Erlbaum Associates Ltd.

Greydanus, D., Patel, D. & Pratt, H. (2010). Suicide risk in adolescents with chronic illness: Implications for primary care and specialty pediatric practice: A review. *Developmental Medicine & Child Neurology, 52*(12), 1083-1087.

Gupta, B. D., Jani, C. B., & Patel, B. J. (2000). Infertility: Etiology of suicide in woman. *International Journal of Medican Toxicology & Legal Medicine, 3*(1).

Hagen, E. H. (2003). The bargaining model of depression. In P. Hammerstein (Ed.), *Genetic and Cultural Evolution of Cooperation* (pp. 95-124). Cambridge, MA: MIT Press.

Hamilton, W.D. (1964). The genetical evolution of social behaviour, I and II. *Journal of Theoretical Biology, 7,* 1-16, and 17-52.

Hawton, K. (2000). Sex and suicide: Gender differences in suicidal behavior. *The British Journal of Psychiatry, 177,* 484-485.

Hawton, K. & Fagg, J. (1988). Suicide, and other causes of death, following attempted suicide. *The British Journal of Psychiatry, 152,* 359-366.

Hawton, K., & James, A. (2005). Suicide and deliberate harm in young people. *British Medical Journal, 330,* 891-894.

Hayes, A. F. (2012). An analytical primer and computational tool for observed variable moderation, mediation, and conditional process modeling. *Manuscript under review.*

Heth, G., Todrank J., & Johnston, R. E. (1998). Kin recognizion in golden hamsters: evidence for phenotype matching. *Animal Behaviour, 56*(2), 409-417.

Hinrichsen, G. A., & Emery, E. E. (2006). Interpersonal factors and late-life depression. *Clinical Psychology: Science and Practice, 12*(3), 264-275.

Hoberman, H. M. & Garfinkle, B. D. (1988). Completed suicide in children and adolescents. *Journal of the American Academy of Child & Adolescent Psychiatry, 27*(6), 689-695.

Hoffman, M. L. (1977). Sex difference is empathy and related behaviors. *Psychological Bulletin, 84,* 712-722.

Hoge, E. A., Pollack, M. H., Kaufman, R. E., Zak, P. J., & Simon, N. M. (2008). Oxytocin levels in social anxiety disorder. *CNS Neuroscience Theory, 14,* 165-170.

Holtzman, N. S., Augustine, A. A., & Senne, A. L. (2011). Are pro-social or socially aversive people more physically symmetrical? Symmetry in relation to over 200 personality variables. *Journal of Research in Personality, 45*(6), 687-691.

Hoyer, G., & Lund, E. (1993). Suicide among women related to number of children in marriage. *Archives of General Psychiatry, 50,* 134-137.

Humphrey, J. A. & Palmer, S. (1990). The effects of race, gender, and marital status on suicides among young adults, middle-aged adults, and older adults. *Omega: Journal of Death and Dying, 22*(4), 277-285.

Israel, S., Lerer, E., Shalev, L., et al. (2008). Molecular genetic studies of the arginine vasopressin 1a receptor (AVPR1a) and the oxytocin receptor (OXTR) in human behavior: from autism to altruism with some notes in between. *Progress in Brain Research, 170,* 435-449.

Israel, S., Lerer, E., Shalev, I., et al. (2009). The oxytocin receptor (OXTR) contributes to prosocial fund allocations in the dictator game and the social value orientations task. *PLoS ONE, 4,* e5535.

Jedlicka, D., Shin, Y., & Lee, E. S. (1977). Suicide among Blacks, *Phylon, 38,* 448-455.

Joiner, T., Pettit, J. W., Walker, R. L., Voelz, Z. R., Cruz, J., Rudd, M. D., & Lester, D. (2002). Perceived burdensomeness and suicidality: Two studies on the suicide notes of those attempting and those completing suicide. *Journal of Social and Clinical Psychology, 21,* 531-545.

Joiner, T. (2005). *Why people die by suicide.* Cambridge, MA: Harvard University Press.

Jokinen, J., Chatzittofis, A., Hellstrom, C., Nordstrom, P., Unvas-Moberg, K., Asberg, M. (2012). Low CSF oxytocin reflects high intent in suicide attempters. *Psychoneuroendocrinology, 37*(4), 482-490.

Jones, R. E. & Lopez, K. H. (2006). *Human Reproductive Biology, Third Edition.* Burlington, MA: Academic Press.

Karg, K., Burmeister, M., Shedden, K., & Sen, S. (2011). The serotonin transporter promoter variant (5-HTTLPR), stress, and depression meta-analysis revisited: evidence of genetic moderation. *Archive of General Psychiatry, 68*(5), 444-454.

Kendler, K. S. (2003). Life event dimensions of loss, humiliation, entrapment, and danger in the prediction of onsets of major depression and generalized anxiety. *Archives of General Psychiatry, 60*(8), 789-796.

Kendler, K., Kuhn, J., Vittum, J., Prescott, C., & Riley, B. (2005). The interaction of stressful life events and a serotonin transporter polymorphism in the prediction of episodes of major depression: a replication. *Archives of General Psychiatry, 62*(5), 529-535.

Kenrick, D. T., Sadalla, E. K., Groth, G., & Trost, M. R. (1990). Evolution, traits, and the stages of human courtship: Qualifying the parental investment model. *Journal of Personality, 58,* 97-116.

Kim, D. (2008). Blues from the neighborhood? Neighborhood characteristics and depression. *Epidemiologic Review, 30,* 101-117.

Kipnis, D. M. (1974). Inner direction, other direction and achievement motivation. *Human Development, 17*(5), 321-343.

Kirkpatrick, L. A., & Ellis, B. J. (2001). An evolutionary-psychological approach to self-esteem: Multiple domains and multiple functions. In G. Fletcher, & Clark, M. (Eds.), *The Blackwell handbook of social psychology, Vol. 2* (pp. 411-436). Oxford: Blackwell.

Kirkpatrick, L. A., & Ellis, B. J. (2006). The adaptive functions of self-evaluative psychological mechanisms. In M. H. Kernis (Ed.), *Self-esteem: Issues and answers* (pp. 334-339). New York: Psychology Press.

Kirkpatrick, L. A., Waugh, C. E., Valencia, A., & Webster, G. D. (2002). The functional domain specificity of self-esteem and the differential prediction of aggression. *Journal of Personality and Social Psychology, 82*(5), 756-767.

Kubrin, C. E., Wadsworth, T., & DiPietro, S. (2006). Deindustrialization, disadvantage and suicide among young black males. *Social Forces, 84*, 1559-1579.

Inder, W. J., Donald, R. A., Prickett, T. C.R., Frampton, C. M., Sullivan, P. F., Mulder, R. T., Joyce, P. R. (1997). Arginine vasopressin is associated with hypercortisolemia and suicide attempts in depression. *Biological Psychiatry, 42*(8), 744-747.

Langlois, J. H., Kalakanis, L., Rubenstein, A. J., Larson, A., Hallam, M., & Smoot, M. (2000). Maxims or myths of beauty? A meta-analytic and theoretical review. *Psychological Bulletin, 126*, 390-423.

Leenaars, A. A., & Lester, D. (1999). Domestic integration and suicide in the provinces of Canada. *Crisis, 20,* 59-63.

Lerer, E., Levi, S., Salomon, S., Darvasi, A., Yirmiya, N., Ebstein, R. P. (2008). Association between the oxytocin receptor (OXTR) gene and autism: relationship to Vineland Adaptive Behavior Scales and cognition. *Molecular Psychiatry, 13*, 980-988.

Lerner, M. J. (1982). The justice motive in human relations and economic model of man: A radical analysis of facts and finctions. In V. Derlega & J. Grzelak (Eds.), *Cooperation and helping behavior: Theories and research* (pp. 249-278). New York: Academic Press.

Levin, R., Heresco-Levy, U., Bachner-Melman, R., Israel, S., Shalev, I., Ebstein, R. P. (2009). Association between arginine vasopressin 1a receptor (AVPR1a) promoter region polymorphisms and prepulse inhibition. *Psychoneuroendocrinology, 24*, 901-908.

Li, N. P., Bailey, J., Kenrick, D. T., & Linsenmeier, J. A. (2002). The necessities and luxuries of mate preferences: Testing the tradeoffs. *Journal of Personality and Social Psychology, 82*, 947-955.

Lieberman, D., Tooby, J., & Cosmides, L. (2007). The architecture of human kin detection. *Nature, 445*, 727-731.

Link, P. W., & Darling, C. A. (1986). Couples undergoing treatment for infertility: Dimensions of life satisfaction. *Journal of Sex & Marital Therapy, 12*(1), 46-59.

Magne-Ingavar, U., & Oejehagen, A. (1999). Significant others of suicide attempters: Their views at the time of the acute psychiatric consultation. *Social Psychiatry & Psychiatric Epidemiology, 34,* 73-79.

Malloy-Diniz, L. F., Neves, F. S., de Moraes, P. H., De Marco, L. A., Romano-Silva, M. A., Krebs, M. O., & Correa, H. (2011). The 5-HTTLPR polymorphism, impulsivity and suicide behavior in euthymic bipolar patients. *Journal of Affective Disorders, 133*(1-2), 221-226.

Mann, J. J., Huang, Y. Y., Underwood, M. D., Kassir, S. A., Oppenheim, S., Kelly, T. M., Dwork, A. J., & Arango, V. (2000). A serotonin transporter gene promoter polymorphism (5-HTTLPR) and prefrontal cortical binding in major depression and suicide. *Archive of General Psychiatry, 57*(8), 729-738.

Martin, W. T. (1984). Religiosity and United States suicide rates, 1972-1978. *Journal of Clinical Psychology, 40*(5), 1166-1169.

Marazziti, D., Dell'Osso, B., Baroni, S., Mungai, F., Cantena, M, Rucci, P., Albanese, F., Giannacci, G., et al. (2006). A relationship between oxytocin and anxiety of romantic attachment. *Clinical Practice and Epidemiology in Mental Health, 2,* 28-33.

McClelland, D. C., Atkinson, J. W., Clark, R. A., & Lowell, E. L. (1953). *The achievement motive.* New York: Appleton-Century-Crofts.

McIntosh, J. L. (2002). *U.S.A. suicide statistics for the year 1999: Overheads and a presentation guide.* Washington, D.C.: American Association of Suicidology.

Meyer-Lindenberg, A. (2008). Impact of prosocial neuropeptides on human brain function. *Progress in Brain Research, 170,* 463-470.

Meynen, G., Unmehopa, U. A., van Heerikhuize, J. J., Hofman, M. A., Swaab, D. F., & Hoogendijk, W. J. G. (2006). Increased arginine vasopressin mRNA expression in the human hypothalamus in depression: A preliminary report. *Biological Psychiatry, 60*(8), 892-895.

Meynen, G., Unmehopa, U. A., Hofman, M. A., Swaab, D. F., Hoogendijk, W. J. G. (2007). Hypothalamic oxytocin mRNA expression and melancholic depression. *Molecular Psychiatry, 12,* 118-119.

Mittendorfer-Rutz, E., Rasmussen, F., & Wasserman, D. (2004). Restricted fetal growth and adverse maternal psychosocial and socioeconomic conditions as risk factors for suicidal behaviour of offspring: a cohort study. *Lancet, 364,* 1135-1140.

Moscicki, E. K. (1994). Gender differences in completed and attempted suicide. *Annals of Epidemiology, 4*(2), 152-158.

Nekanda-Trepka, C. J., Bishop, S., & Blackburn, I. M. (1983). Hopelessness and depression. *British Journal of Clinical Psychology, 22,* 49–60.

O'Connor, R. J. (1978). Brood reduction in birds: Selection for fratricide, infanticide and suicide? *Animal Behaviour, 26,* 79-96.

O'Reilly, R. L., Truant, G. S., & Donaldson, L. (1990). Psychiatrists' experience of suicide in their patients. *Psychiatric Journal of the University of Ottawa, 15,* 173-176.

Parker, K. J., Kenna, H. A., Zeiter, J. M., Keller, J., Blasey, C. M., Amico, J. A., Schatzberg, A. F. (2010). Preliminary evidence that plasma oxytocin levels are elevated in major depression. *Psychiatry Research, 178,* 359-362.

Penedo, F. J. (2005). Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry, 18*(2), 189-193.

Piliavin, I. M., Rodin, J. A. & Piliavin, J. (1969). Good Samaritanism: An underground phenomenon? *Journal of Personality and Social Psychology, 13,* 289-299.

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods, 40,* 879-891.

Purba, J. S., Hoogendijk, W. J., Hofman, M. A., Swaab, D. F. (1996). Increased number of vasopression- and oxytocin-expressing neurons in the paraventricular nucleus of the hypothalamus in depression. *Archives of General Psychiatry, 53,* 137-143.

Qin, P., & Mortensen, P. B. (2003). The impact of parental status on the risk of completed suicide. *Archives of General Psychiatry, 60,* 797-802.

Queller, D. C., Ponte, E., Bozzaro, S., & Strassmann, J. E. (2003). Single-gene greenbeard effects in the social amoeba. *Science, 299,* 105-106.

Reuter, M., Frenzel, C., Walter, N. T., Markett, S., & Montag, C. (2011). Investigating the genetic basis of altruism: The role of the COMT Val158Met polymorphism. *Social Cognitive and Affective Neuroscience, 6*(5), 662-668.

Reykowski, J. (1982). Motivation and prosocial behavior. In V. Derlega & J. Grzelak (Eds.), *Cooperation and helping behavior: Theories and research* (pp. 352-375). New York: Academic Press.

Rhodes, G. (2006). The evolutionary psychology of facial beauty. *Annual Review of Psychology, 57,* 199-226.

Riordan, D. V., Selvaraj, S., Stark, C., & Gilbert, J. S. E. (2006). Perinatal circumstances and risk of offspring suicide. *British Journal of Psychiatry, 189,* 502-507.

Rudd, M. D., Joiner, T., & Rajab, M. (1995). Help negation in suicide. *Journal of Consulting & Clinical Psychology, 63,* 499-503.

Rushton, J. P. (2004). Genetic and environmental contributions to pro-social attitudes: A twin study of social responsibility. *Proceedings of the Royal Society B, 271,* 2583-2585.

Rushton, J. P., Chrisjohn, R. D., & Fekken, G. C. (1981). The altruistic personality and the Self-Report Altruism Scale. *Personality and Individual Differences, 2,* 293-302.

Rushton, J. P., Fulker, D. W., Neale, M. C., Nias, D. K. B., & Eysenck, H. J. (1986). Altruism and aggression: The heritability of individual differences. *Journal of Personality and Social Psychology, 50,* 1192-1198.

Segal, N. L. (1984). Cooperation, competition and altruism within twin sets: A reappraisal. *Ethology and Sociobiology, 5,* 163-177.

Shneidman, E. S. (1985). *The definition of suicide*. New York: Wiley.

Slavich, G. M., Thornton, T., Torres, L. D., Monroe, S. M., & Gotlib, I. H. (2009). Targeting rejection predicts hastened onset of major depression. *Journal of Social and Clinical Psychology, 28,* 223-243.

Stack, S. (2000). Suicide: A 15-year review of the sociological literature part ii: Modernization and social integration perspectives. *Suicide and Life-Threatening Behavior*, *30*(2), 163-176.

Stockard, J., & O'Brien, R. M. (2002). Cohort variations and changes in age-specific suicide rates over time: Explaining variations in youth suicide. *Social Forces, 81,* 605-42.

Suarez, S. D. & Gallup Jr., G. G. (1991). Depression as a response to reproductive failure. *Journal of Social and Biological Structures, 8*(3), 279-287.

Sugiyama, L. (2005). Physical attractiveness in adaptationist perspective. In D.M. Buss (Ed.), The handbook of evolutionary psychology (pp. 292-342). New York: Wiley.

Symons, D. (1979). *The evolution of human sexuality.* New York: Oxford University Press.

Taylor, P.D., & Frank, S.A. (1996). How to make a kin selection model. *Journal of Theoretical Biology, 34,* 654-674.

Taylor, S. E., Saphire-Bernstein, S., & Seeman, T. E. (2010). Are plasma oxytocin in women and plasma vasopressin in men biomarkers of distressed pair-bond relationships? *Psychological Science, 21,* 3-7.

Taylor, S. E., Way, B. M., Welch, W. T., Hilmert, C. J., Lehman, B. J., Eisenberger, N. I. (2006). Early family environment, current adversity, the serotonin transporter promoter polymorphism, and depressive symptomatology. *Biological Psychiatry, 60,* 671-676.

Thornhill, R., & Grammer, K. (1999). The body and face of woman: One ornament that signals quality? *Evolution and Human Behavior, 20,* 105-120.

Thornhill, R. & Thornhill, N. W. (1989). The evolution of psychological pain. In R. Bell (Ed.), *Sociobiology and the Social Science* (pp. 73-103). Dallas: Texas Tech University Press.

Todd, P. M., & Miller, G. F. (1999). From pride and prejudice to persuasion: Satisficing in mate search. In G. Gigerenzer, P. M. Todd, and the ABC Research Group (Eds.), *Simple heuristics that make us smart* (pp. 287-308). New York: Oxford University Press.

Trivers, R. L. (1971). The evolution of reciprocal altruism. *Quarterly Review of Biology, 46,* 35–57.

Trivers, R. L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual selection and the descent of man: 1871-1971* (pp. 136-179). Chicago: Aldine.

Van Winkle, N. W., & May, P. (1993). An update on American Indian suicide in New Mexico, 1980-1987. *Human Organization, 52,* 304-315.

Veroff, J. (1977) Process vs. impact on men's and women's achievement motivation. *Psychology of Women Quarterly, 1*(3), 283-293.

Vihjalmsson, R. (1993). Life stress, social support and clinical depression: A reanalysis of the literature. *Social Science & Medicine, 37*(3), 331-342.

von Hipple, P. (2010). Skewness. In M. Lovric (Ed)., *International Encyclopedia of Statistical Science.* New York: Springer.

Wadsworth, T. & Kubrin, C. E. (2007). Hispanic suicide in U.S. metropolitan areas: Examining the effects of immigration, assimilation, affluence, and disadvantage. *American Journal of Sociology, 112,* 1848-1885.

Watson, P. J. & Andrews, P. W. (2002). Toward a revised evolutionary adaptationist analysis of depression: the social navigation hypothesis. *Journal of Affective Disorders, 72*(1), 1-14.

Wichers, M., Aguilera, M., Kenis, G., Krabbendam, L., Myin-Germeys, I., Jacobs, N., Peeters, F., Derom, C., et al. (2008). The catechol-O-methyl transferase $Val^{158}$Met polymorphism and experience of reward in the flow of daily life. *Neuropsychopharmacology, 33*(13), 3030-3036.

Winn, B. E. & Bedford, M. V. (1986). Kin recognition and choice of males by wild female house mice (mus musculus). Journal of Comparative Psychology, Vol 100(1). 72-75.

Worthman, C. M. (1999). Evolutionary perspectives on the onset of puberty. In W. R. Trevathan, E. O. Smith, J. J. McKenna (Eds.), *Evolutionary Medicine* (pp. 135-164), New York: Oxford University Press.

Table 1

*Zero-order correlations between sibship, prospective viability, income, covariates, depression and severe suicide attempts.*

| Predictor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Depression (AW) | . | | | | | | | | | |
| 2. Severe Suicide Attempts (AW) | .16*** | . | | | | | | | | |
| 3. Sibship (W4) | .15*** | .05*** | . | | | | | | | |
| 4. Prospective Viability (W1&2) | -.40*** | -.09*** | -.08*** | . | | | | | | |
| 5. Household Income (W1) | -.13*** | -.02 | -.23*** | .12*** | . | | | | | |
| 6. Age (W1) | -.06*** | .00 | .05*** | -.07*** | -.01 | . | | | | |
| 7. Race (W1) | -.09*** | .02 | -.18*** | -.02* | .20*** | -.01 | . | | | |
| 8. Gender (W1) | .19*** | .02$^{\dagger}$ | .05*** | -.00 | .01 | -.04*** | -.02 | . | | |
| 9. Adopted (W1) | -.02 | -.02 | -.07*** | .03** | -.00 | -.02$^{\dagger}$ | -.01 | -.02$^{\dagger}$ | . | |
| 10. Religiosity (AW) | -.03* | -.05*** | .09*** | .16*** | -.09*** | -.05*** | -.27*** | .12*** | -.01 | . |
| 11. Recent Suicide in Family (AW) | .08*** | .11*** | .02 | -.04** | -.03$^{\dagger}$ | -.02$^{\dagger}$ | .01 | .03** | .00 | -.01 |

*Note*: $^{\dagger}p \leq .1$; $^{*}p \leq .05$; $^{**}p \leq .01$; $^{***}p \leq .001$; Race coded as 1 = White, 0 = Non-White; Gender coded as 1 = Male, 2 = Female; Adopted and Recent Suicide in Family coded as 1 = Yes, 0 = No; "W1" = Wave 1, "W1&2" = Wave 1 and 2 composite, "AW" = All Wave composite, "W4" = Wave 4.

Table 2

*Multiple regression analyses of depression and severe suicide attempts as a function of sibship, prospective viability, income and covariates.*

| | All Participants | | | | Males Only | | | | Females Only | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Depression (AW) | | Severe Suicide Attempts (AW) | | Depression (AW) | | Severe Suicide Attempts (AW) | | Depression (AW) | | Severe Suicide Attempts (AW) | |
| Predictor | $\beta$ | *t*-test | $\beta$ | *t*-test | $\beta$ | *t*-test | $\beta$ | *t*-test | $\beta$ | *t*-test | $\beta$ | *t*-test |
| Sibship (W4) | .08*** | 5.25 | .04* | 2.52 | .03 | 1.16 | .03 | 1.07 | .12*** | 5.67 | .05* | 2.19 |
| Prospective Viability (W1&2) | -.39*** | -25.69 | -.06*** | -3.27 | -.39*** | -17.08 | -.03 | -1.42 | -.40*** | -19.38 | -.07** | -3.14 |
| Household Income (W1) | -.06*** | -3.91 | -.00 | -0.21 | -.03 | -1.23 | -.02 | -0.85 | -.08*** | -3.89 | .01 | 0.39 |
| Sibship*Viability | .01 | 0.48 | -.04* | -2.25 | .02 | 0.73 | -.03 | -1.33 | .00 | 0.07 | -.05$^{\dagger}$ | -1.92 |
| Sibship*Income | -.01 | -0.88 | -.01 | -0.32 | -.02 | -0.72 | -.03 | -1.09 | -.01 | -36 | .00 | 0.19 |
| Viability*Income | -.02 | 1.31 | .03$^{\dagger}$ | 1.88 | .01 | 0.42 | .04 | 1.48 | .03 | 1.38 | .03 | 1.25 |
| Sibs*Viability*Income | .02 | 1.30 | .06*** | 3.19 | .02 | 0.61 | .03 | 1.27 | .02 | 1.11 | .07** | 2.96 |
| Age (W1) | .02 | 1.44 | -.01 | -0.83 | .05* | 2.29 | -.03 | -1.14 | -.00 | -0.1 | -.01 | -0.22 |
| Race (W1) | -.08*** | -5.63 | -.00 | -0.21 | -.09*** | -4.17 | -.02 | -0.68 | -.08*** | -3.92 | .00 | 0.07 |
| Gender (W1) | .20*** | 13.75 | .04* | 2.43 | - | - | - | - | - | - | - | - |
| Adopted (W1) | .02 | 1.30 | -.01 | -0.67 | .01 | 0.65 | .02 | 0.94 | .02 | 1.13 | -.03 | -1.36 |
| Religiosity (AW) | -.01 | -0.66 | -.05** | -3.06 | -.04$^{\dagger}$ | 1.85 | .00 | 0.06 | -.05* | -2.29 | -09*** | -3.9 |
| Recent Suicide in Family (AW) | .05*** | 3.52 | .11*** | 6.95 | .05* | 2.15 | .25*** | 11.06 | .05** | 2.69 | .03 | 1.24 |
| Total $R^2$ | 0.23 | | 0.03 | | 0.18 | | 0.07 | | 0.23 | | 0.04 | |

*Note*: $^{\dagger}p \leq .1$; *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$; Race coded as 1 = White, 0 = Non-White; Gender coded as 1 = Male, 2 = Female; Adopted and Recent Suicide in Family coded as 1 = Yes, 0 = No; "W1" = Wave 1, "W1&2" = Wave 1 and 2 composite, "AW" = All Wave composite, "W4" = Wave 4.

Table 3

*Zero-order correlations between total siblings, estimated* r, *and total number of siblings who have always lived with the participant.*

| Predictor | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| 1. Sibship (W4) | . | | | | | | |
| 2. Siblings: Currently Living with *P* (W1) | .38*** | . | | | | | |
| 3. Siblings: Always Lived with *P* (W1) | .27*** | .89*** | . | | | | |
| 4. Estimated *r* (W1) | .27*** | .91*** | .91*** | . | | | |
| 5. Depression (W1) | .14*** | .03* | -.01 | .00 | . | | |
| 6. Severe Suicide Attempts (W1) | .04** | .02$^{\dagger}$ | .02$^{\dagger}$ | .02 | .13*** | . | |
| 7. Depression (AW) | .15*** | .02$^{\dagger}$ | -.02 | -.01 | .82*** | .12*** | . |
| 8. Severe Suicide Attempts (AW) | .05*** | .02$^{\dagger}$ | .02 | .02 | .12*** | .72*** | .16*** |

*Note*: $^{\dagger}p \leq .1$; $*p \leq .05$; $**p \leq .01$; $***p \leq .001$; "W4" = Wave 4; "W1" = Wave 1, "AW" = All Wave composite; "*P*" = Participant.

Table 4

*Zero-order correlations between sibship, viability, potential mediators, and depression and severe suicide attempts.*

| Predictor | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Sibship (W4) | . | | | | |
| 2. Prospective Viability (W1&2) | -.08*** | . | | | |
| 3. Sibling Connection (W1-3) | -.02 | .15*** | . | | |
| 4. Sibling Conflict (W1-3) | -.05** | -.06*** | -.10*** | . | |
| 5. Depression (AW) | .15*** | -.40*** | -.08*** | .12*** | . |
| 6. Severe Suicide Attempts (AW) | .05*** | -.09*** | -.01 | -.00 | .16*** |

*Note*: $^{**}p \leq .01$; $^{***}p \leq .001$; "W1" = Wave 1, "W1&2" = Wave 1 and 2 composite, "W1-3" = Wave 1 - 3 composite, "AW" = All Wave composite, "W4" = Wave 4.

Table 5

*Multiple regression models of severe suicide attempts as a function of sibship, viability, income and depression.*

| | Model 1: "IV" = Viability | | Model 2: "IV" = Sibship | | Model 3: "IV" = Income | |
|---|---|---|---|---|---|---|
| Predictor | B | *t* -test | B | *t* -test | B | *t* -test |
| Prospective Viability (W1&2) | -.000 | -0.25 | -.000 | -0.08 | -.000 | -0.07 |
| Sibship (W4) | .002† | 1.81 | .002* | 2.12 | .002* | 1.95 |
| Household Income (W1) | .000 | 0.21 | .000 | 0.12 | .000 | 0.21 |
| Viability * Sibship | -.001† | -1.70 | -.001† | -1.71 | -.001 | -1.18 |
| Viability * Income | .001 | 0.99 | .001 | 0.53 | .001 | 1.13 |
| Sibship * Income | .000 | 0.09 | .000 | 0.00 | .000 | -0.22 |
| Viability*Sibship*Income | .002** | 2.61 | .003** | 2.93 | .002** | 2.85 |
| Depression (AW) | .007*** | 7.03 | .006*** | 5.70 | .006*** | 5.80 |
| Depression*Viability | - | - | -.004*** | -4.91 | -.004*** | -4.93 |
| Depression*Sibship | .001 | 1.09 | - | - | .001 | 1.01 |
| Depression*Income | -.001 | -1.42 | -.001 | -1.26 | - | - |
| Depression*Via*Sibs | - | - | - | - | -.000 | -0.23 |
| Depression*Via*Inc | - | - | .000 | 0.12 | - | - |
| Depression*Sibs*Inc | -.000 | -0.45 | - | - | - | - |
| Total $R^2$ | .049 | | .055 | | .055 | |

*Note:* †p ≤ .1; *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$; "W1&2" = Wave 1 and 2 composite, "AW" = All Wave composite, "W4" = Wave 4; Models also include age, sex, race, adopted, religiosity, and recent suicide in family as covariates.

Table 6

*Conditional direct and indirect effects of "independent variables" on severe suicide attempts at levels of the*

| | | | | Direct Effects | | Indirect Effects | |
|---|---|---|---|---|---|---|---|
| Predictor | Viability | Sibship | Income | B | *t*-test | Point Estimate | 95% CI |
| Model 1: "IV" = Viability | | Low | Low | .003 | 1.60 | -.002 | **-.004 to -.001** |
| | | Low | High | -.002 | -0.20 | -.004 | **-.004 to -.000** |
| | | High | Low | -.005*** | -3.24 | -.002 | **-.006 to -.002** |
| | | High | High | .002 | 0.74 | -.002 | -.004 to .000 |
| Model 2: "IV" = Sibship | Low | | Low | .005*** | 4.25 | .001 | **.000 to .002** |
| | Low | | High | .002 | 0.30 | .000 | -.000 to .001 |
| | High | | Low | -.002 | -1.27 | .000 | -.000 to .001 |
| | High | | High | .003 | 1.61 | .000 | -.000 to .000 |
| Model 3: "IV" = Income | Low | Low | | .002 | 1.15 | -.000 | -.001 to .000 |
| | Low | High | | -.003$^{\dagger}$ | -1.85 | -.001 | **-.002 to -.000** |
| | High | Low | | -.001 | -0.92 | .000 | -.000 to .000 |
| | High | High | | .003$^{\dagger}$ | 1.86 | -.000 | -.000 to .000 |

*Note:* $^{\dagger}p \leq .1$; ***$p \leq .001$; Significant confidence intervals are bolded; "W1&2" = Wave 1 and 2 composite, "AW" = All Wave composite, "W4" = Wave 4.

Table 7

*Multiple regression analysis of severe suicide attempts as a function of sibship, viability, income and depression symptoms.*

| Predictor | $\beta$ | *t*-test |
|---|---|---|
| Sibship (W4) | .04* | 2.30 |
| Prospective Viability (W1&2) | -.01 | -0.25 |
| Household Income (W1) | .00 | 0.05 |
| Depression (AW) | .11*** | 5.56 |
| | | |
| Sibship*Viability | -.02 | -1.26 |
| Sibship*Income | .02 | 1.04 |
| Sibship*Depression | .01 | 0.49 |
| Viability*Income | .01 | 0.25 |
| Viability*Depression | -.07*** | -3.69 |
| Income*Depression | -.02 | -1.04 |
| | | |
| Sibs*Viability*Income | .05* | 2.37 |
| Sibs*Viability*Depression | .02 | 1.03 |
| Sibs*Income*Depression | .02 | 0.91 |
| Viability*Income*Depression | .01 | 0.60 |
| | | |
| Sibs*Viability*Income*Depression | .07*** | 3.33 |
| | | |
| Age (W1) | -.02 | -0.97 |
| Race (W1) | .01 | 0.58 |
| Gender (W1) | .01 | 0.82 |
| Adopted (W1) | -.01 | -0.80 |
| Religiosity (AW) | -.05** | -3.09 |
| Recent Suicide in Family (AW) | .10*** | 6.57 |
| Total $R^2$ | 0.06 | |

*Note*: *$p \leq .05$; ***$p \leq .001$; Race coded as 1 = White, 0 = Non-White; Gender coded as 1 = Male, 2 = Female; Adopted and Recent Suicide in Family coded as 1 = Yes, 0 = No; "W1" = Wave 1, "W1&2" = Wave 1 and 2 composite, "AW" = All Wave composite, "W4" = Wave 4.

Table 8

*Females: Partial correlations between viability, years sexually mature, total offspring, and depression and suicidality.*

| Predictor | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Prospective Viability (W1&2) | . | | | |
| 2. Years Sexually Mature (W4) | -.04$^{\dagger}$ | . | | |
| 3. Offspring (W4) | .001 | .06* | . | |
| 4. Depression (AW) | -.43*** | .00 | .11*** | . |
| 5. Severe Suicide Attempts (AW) | -.10*** | .01 | .02 | .20*** |

*Note*: $^{\dagger}p \leq .1$; $*p \leq .05$; $**p \leq .01$; $***p \leq .001$; Offspring coded as 1 = 1+ offspring, 0 = No offspring; Control variables: Age, race, religiosity, and income; "W1 and 2" = Wave 1 and 2 composite, "AW" = All Wave

Table 9

*Females: Repeated measures regression analyses of depression and severe suicide attempts as a function of number of years sexually mature and reproductive success.*

| | Depression | | Severe Suicide Attempts | |
|---|---|---|---|---|
| Predictor | B | Wald's $\chi^2$ | B | Wald's $\chi^2$ |
| Years Sexually Mature (AW) | .00 | .01 | .19 | 1.24 |
| Offspring (AW) | -.43*** | 33.77 | -.45** | 6.91 |
| Sexually Mature*Offspring | -.05 | .41 | -.31$^{\dagger}$ | 2.91 |
| Prospective Viability (W1&2) | -1.13*** | 467.29 | -.61*** | 27.23 |
| Income (W1) | -.20*** | 17.61 | .03 | .83 |
| Race (W1) | -.59*** | 29.31 | -.14 | .22 |
| Religiosity (AW) | -.11** | 7.51 | -.31** | 9.45 |
| Recent Suicide in Family (AW) | .87*** | 10.09 | .90* | 5.04 |

*Note*: $^{\dagger}p \leq .1$; $*p \leq .05$; $**p \leq .01$; $***p \leq .001$; Race coded as 1 = White, 0 = Non-White; Offspring coded as 1 = 1+ offspring, 0 = No offspring; Recent Suicide in Family coded as 1 = Yes, 0 = No; "W1" = Wave 1, "W1&2" = Wave 1 and 2 composite, "AW" = measurements from all waves; Depression and suicide attempts are measured at all waves.

Table 10

*Zero-order correlations between sex partners, reproductive success, gender and covariates.*

| Predictor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1. Total Sex Partners (W4) | . | | | | | | | |
| 2. Offspring (W4) | -.05** | . | | | | | | |
| 3. Gender (W1) | -.16*** | .22*** | . | | | | | |
| 4. Prospective Viability (W1&2) | -.04** | .00 | -.00 | . | | | | |
| 5. Income (W1) | -.00 | -.12*** | .01 | .12*** | . | | | |
| 6. Age (W1) | .01 | .11*** | -.04*** | -.07*** | -.01 | . | | |
| 7. Race (W1) | -.04** | .02 | -.02 | -.02* | .20*** | -.01 | . | |
| 8. Religiosity (AW) | -.12*** | .09*** | .12*** | .16*** | -.09*** | -.05*** | -.27*** | . |
| 9. Recent Suicide in Family (AW) | .03* | .02 | .03** | -.04** | -.03$^{\dagger}$ | -.02* | .01 | -.01 |

*Note*: $^{\dagger}p \leq .1$; *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$; Offspring coded as 1 = 1+ offspring, 0 = No offspring; Race coded as 1 = White, 0 = Non-White; Gender coded as 1 = Male, 2 = Female; Recent Suicide in Family coded as 1 = Yes, 0 = No; "W1" = Wave 1, "W1&2" = Wave 1 and 2 composite, "AW" = All Wave composite, "W4" = Wave 4.

Table 11

*Repeated measures regression analyses of depression and suicidality as a function of sex partners, reproductive success and gender.*

| | Depression | | Severe Suicide Attempts | |
|---|---|---|---|---|
| Predictor | B | Wald's $\chi^2$ | B | Wald's $\chi^2$ |
| Offspring (AW) | .09 | .78 | .71 | 1.37 |
| Total Sex Partners (AW) | .11*** | 21.53 | .03 | .09 |
| Gender (W1) | .93*** | 196.94 | .57* | 5.95 |
| Gender*Sex Partners | .24*** | 30.81 | .28* | 5.88 |
| Gender*Offspring | .07 | .27 | -.64 | .96 |
| Offspring*Sex Partners | -.05 | 1.04 | .19 | .96 |
| Gender*Offspring*Sex Partners | -.12 | 2.01 | -.58* | 4.39 |
| Prospective Viability (W1&2) | -.99*** | 811.9 | -.50*** | 25.88 |
| Income (W1) | -.15*** | 23.46 | -.07 | .4 |
| Age (AW) | -.48*** | 312.32 | -45*** | 11.67 |
| Race (W1) | -.52*** | 52.04 | -.21 | .95 |
| Religiosity (AW) | -.01 | .31 | -.20* | 5.63 |
| Recent Suicide in Family (AW) | .55** | 9.06 | 1.62*** | 48.13 |

*Note*: *$p \leq .05$; **$p \leq .01$; ***$p \leq .001$; Offspring coded as 1 = 1+ offspring, 0 = No offspring; Gender coded as 1 = Male, 2 = Female; Race coded as 1 = White, 0 = Non-White; Recent Suicide in Family coded as 1 = Yes, 0 = No; "W1" = Wave 1, "W1&2" = Wave 1 and 2 composite, "AW" = measurements from all waves; Depression and suicide attempts are measured at all waves.

*Figure 1.* Average number of severe suicide attempts across all waves as a function of prospective viability, number of siblings and income. Estimates plotted at +/- 1 *SD* for each predictor. $R^2$ = .03.

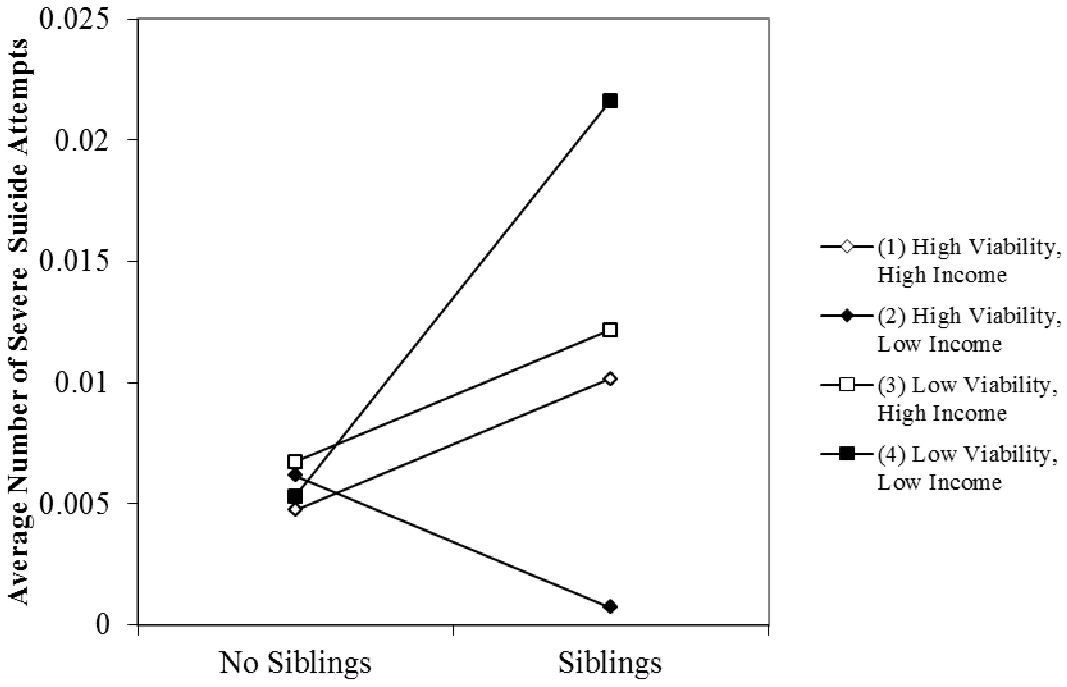

*Figure 2.* Average number of severe suicide attempts for males and females across all waves as a function of prospective viability, number of siblings and income. Interaction is significant among females, but *not* among males ($p$ = .20); however, slope of (4) is marginally significant among males, $p$ = .07. Estimates plotted at +/- 1 *SD* for each predictor. $R^2$ Females = .05, $R^2$ Males = .07.

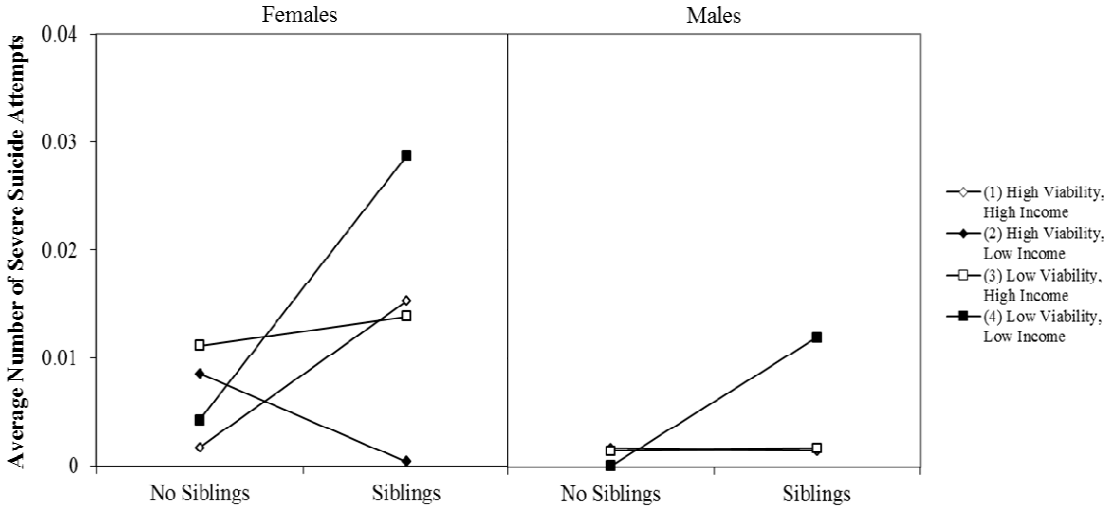

*Figure 3.* Conceptual and statistical diagrams of a conditional mediation model of the direct and indirect effects of prospective viability on severe suicide attempts (Model 1). Path labels are unstandardized regression weights.

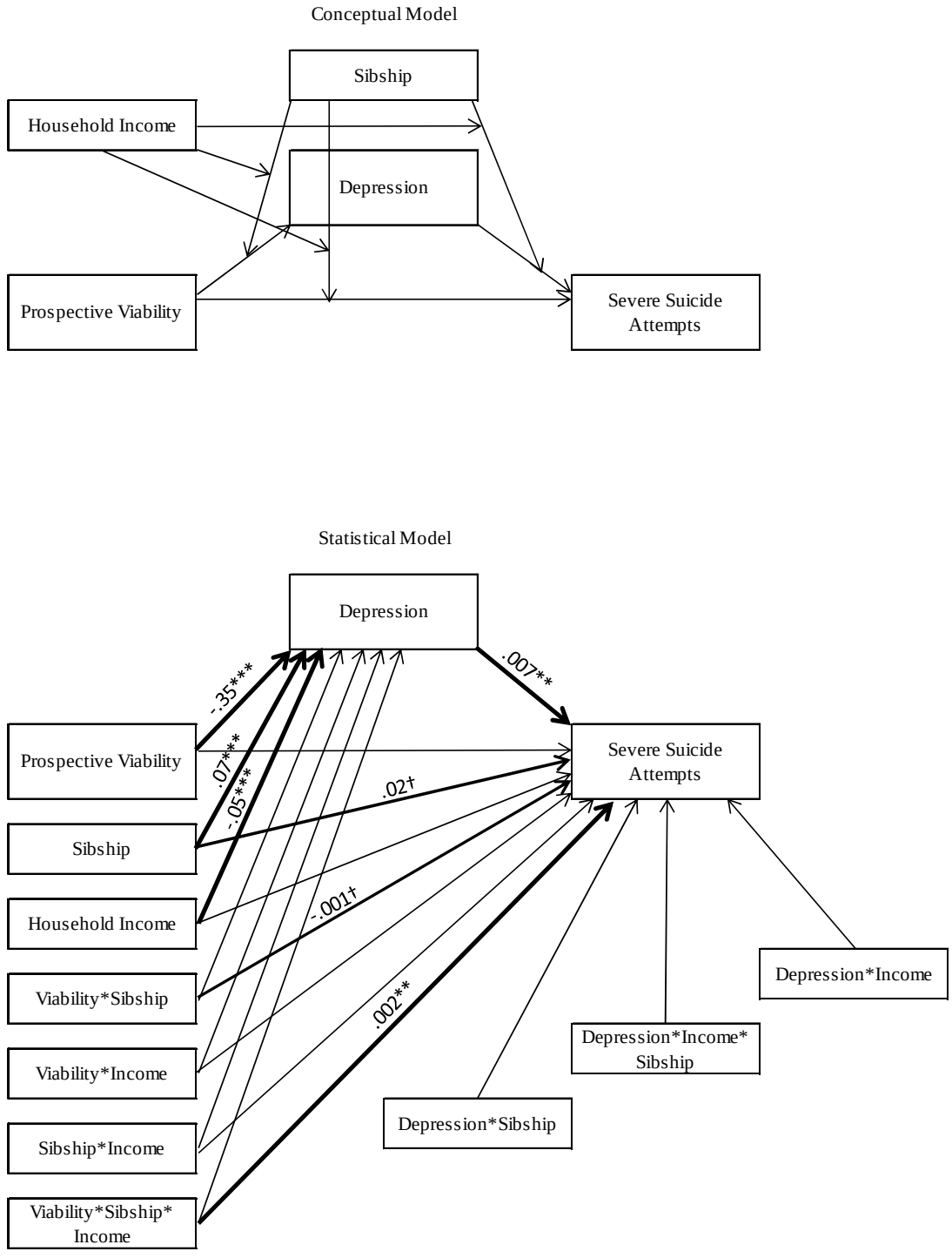

*Figure 4.*Average severe suicide attempts as a function of prospective viability and self-reported depression symptoms. Estimates plotted at +/- 1 SD for both predictors.

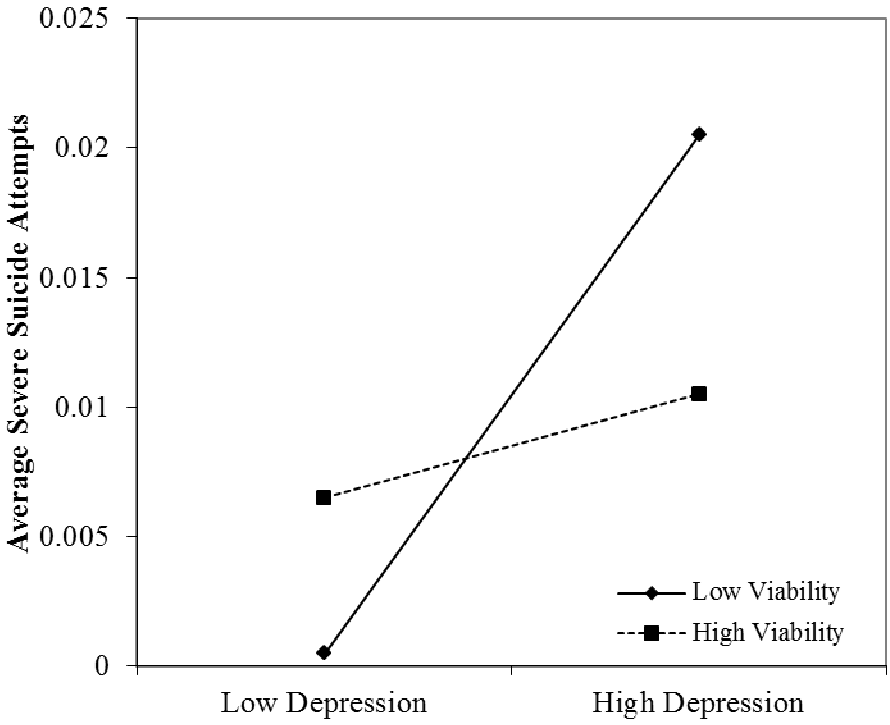

*Figure 5.* Average severe suicide attempts as a function of sibship, prospective viability, income and depression symptoms (panes represent participants below and above the median number of depression symptoms). Estimates plotted at +/- 1 SD for each predictor.

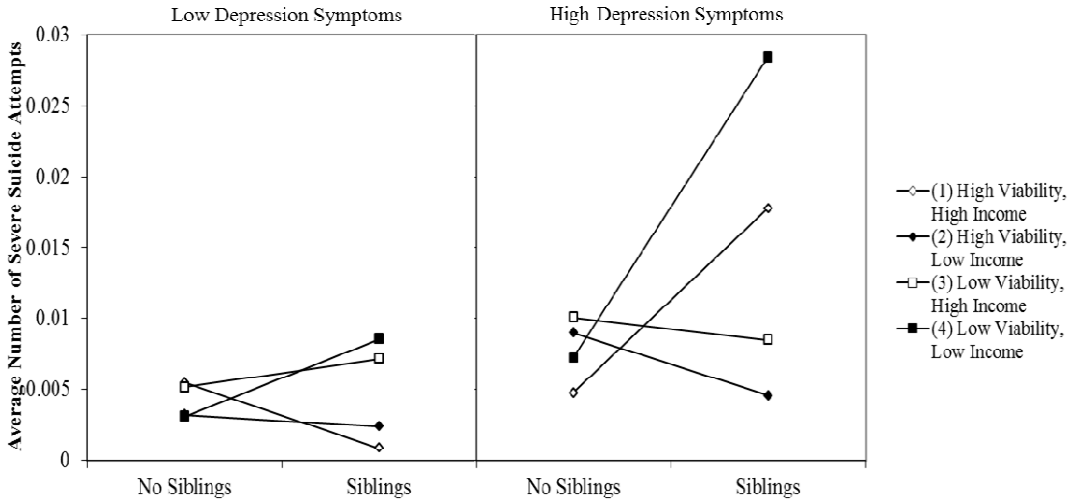

*Figure 6.* Females: Probability of a severe suicide attempt across all waves of data collection as a function of length of time sexually mature and reproductive success. Estimates plotted at +/- 1 *SD* for years sexually mature.

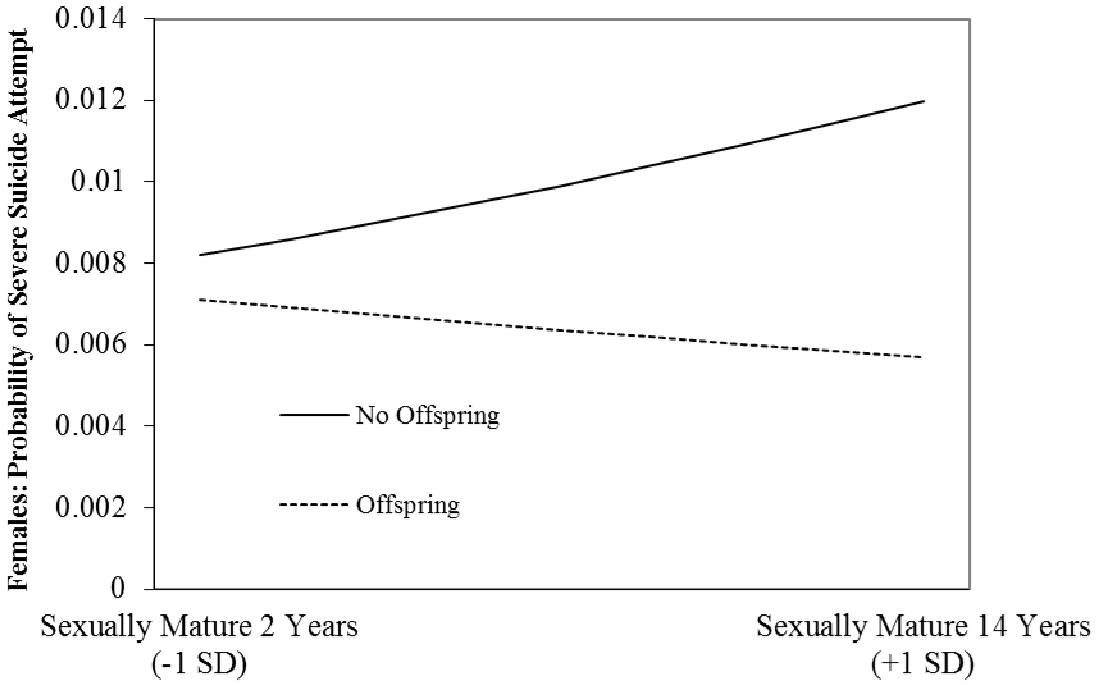

*Figure 7.* Average depression symptoms as a function of sexual partners and gender. Estimates plotted at +/- 1 *SD* for sexual partners.

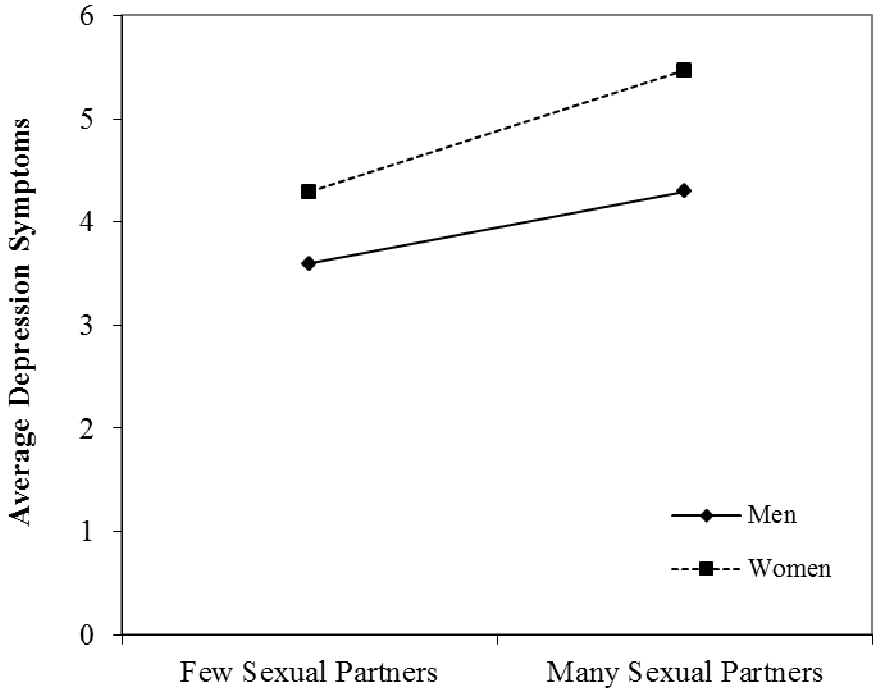

*Figure 8.* Probability of a severe suicide attempt across all waves as a function of number of sexual partners, reproductive success and gender. Estimates plotted at +/- 1 *SD* for continuous predictors.