Published in final edited form as:

Curr Opin Psychol. 2018 August ; 22: 84–88. doi:10.1016/j.copsyc.2017.08.038.

Evolutionary Processes in Suicide

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Abstract

Suicidal behavior contains several dynamic elements. Due to its complexity, empirical science may approach suicide through various avenues. One underutilized approach is taking an evolutionary perspective. Our review of the literature presents two evolutionary processes that may be implicated in suicidal behavior, namely eusocial behavior and antipredator response behaviors. Studies have indicated that aspects of suicidal behavior parallel self-sacrificial behavior in eusocial animals, and that systems similar to hyperarousal-shutdown systems involved in antipredator behaviors may be activated among suicidal individuals. Research on brain activity and decision-making processes among suicidal individuals also suggests that eusociality and antipredator response behaviors in suicide may not be mutually exclusive. These processes represent novel sources of information and potential solutions regarding suicide.

The earliest recorded account of suicidal thoughts and behaviors in humans can be traced back to at least 2000 B.C.E. [1]. For historical context, this predates the invention of the abacus – arguably one of the more recent pivotal markers of our societal evolution – by at least a thousand years. Considering the thousands of years suicide has existed as a recorded element of human life, it is conceivable that its origins – much like those of other behaviors that have followed us throughout millennia (e.g., laughing, crying, and fear responses) – can be traced to evolutionary mechanisms that developed for our survival and that of our genes. Interestingly, suicide has also reliably carried with it devastating effects for these millennia – even the account referenced above details specific instances of angst and suffering [1] – and no *clear* evidence of evolutionary advantages. Thus, it is possible that some element(s) within these evolutionary systems may have become deranged, not serving its/their original purpose or functioning as it/they did initially. It is also plausible that through rigorous empirical study of suicide in the context of these systems, suicide research may glean new viable directions for reducing problems associated with suicide and reducing death by suicide.

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Conflict of Interest Statement: Evolutionary processes in Suicide

All resources for the present paper (i.e., access to journals/articles/presentations) were provided by Florida State University. Authors declare no conflict of interest pertaining to the present manuscript.

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The present paper is intended to explore the science behind two evolutionary systems that have been implicated with suicidal behavior, namely eusociality and antipredator responses. We also discuss recent empirical evidence for the association between suicide and such systems. Finally, it is our intention for this paper to pose the question of how to utilize this evolutionary perspective to continue advancing suicide research.

Eusociality and Suicide in Humans

One evolutionary lens through which human suicidal behavior can be viewed is eusociality. A species is considered eusocial if they exhibit four characteristics: (1) a multigenerational care of the young; (2) cooperative care of the young; (3) division of labor; and (4) a form of labor involving defense of a communal region [2]. The fourth criterion, which involves a member of a species willingly dying for its community, is the rarest, with only approximately 20 species being classified as eusocial, depending on the criteria being used [3, 4, 5, 6, 7, 8]. The literature on eusocial behavior has often debated whether humans serve as an example of eusociality, with several supporting the claim that humans are eusocial, and attributing much of our evolutionary success to this quality [e.g., 9, 10].

Despite the evolutionary success of our species, elements of our eusocial nature may become deranged, which can prove lethal. This has been argued to be the case with suicide [11]. Joiner and colleagues [11] posit that suicide is a derangement of eusocial behavior and self-sacrificial behavior, a defense mechanism that commonly occurs across eusocial animals [12], may be a key element involved in this derangement. What Shorter and Rueppel [13] term “self-removal” is one of the five major categories that they describe of self-sacrificial behavior found in eusocial animals. Self-removal in eusocial species is seen during periods of infection [13]. Joiner and colleagues [11] suggest that suicide is a form this self-removal. From the perspective of suicide as a derangement of this mechanism, it is argued that individuals who die by suicide view themselves as a drain upon society and/or their interpersonal relationships.

Further support indicating that suicide may be a derangement of self-sacrificial behavior lies in parallel aspects of suicide and self-sacrifice in the eusocial sense. For example, in the hours and days preceding a suicide attempt, individuals often exhibit a state of overarousal, withdraw from social activities, and believe that their death is worth more than their life [see 39]. Overarousal is consistently seen before self-sacrificial behavior in the face of a predator in nonhuman eusocial species [e.g., 14, 15, 16]. Among suicidal humans, overarousal can also be viewed as a similar response to self-predation [e.g., 17; more discussion to follow]. Withdrawal is also seen in eusocial species choosing to isolate themselves to prevent infection [18, 19, 13]. Among suicidal humans, this withdrawal element often manifests as social withdrawal [see 39]. However, it may also manifest as withdrawal from eating [11], which is also associated with the self-predation response mentioned above [17]. Ample research has illustrated that dysregulated eating behaviors are strongly associated with suicide [see 20]. Indeed, along with suicidal ideation, attempts, and/or a plan with intent for suicide, irregularities in appetite and weight also constitute DSM-5 symptoms of depression [21], further supporting their relatedness.

In summation, several examples exist of eusocial species choosing to sacrifice their life for the survival of the majority [6, 22, 23, 24, 25, 26], and a similar mindset has been noted in suicidal humans. There is overlap in patterns of overarousal, withdrawal, and feelings of burden upon others that are each found in both scenarios. Based on these similarities, Joiner and colleagues [11] argued that suicide is a derangement of humankind's eusocial nature.

Suicide and the Antipredator Response

Recently, Joiner and Stanley [17] proposed that the phenomenology of intense suicidality in humans may mimic mammalian antipredator defense reactions. Namely, in suicide, humans appear to activate three systems that prey animals utilize when confronted with the threat of a predator: (1) the behavioral activation system (BAS), which is activated by appetitive stimuli (in this case, death); (2) the fight-flight-freeze response system (FFFS); and (3) the behavioral inhibition system (BIS) [27]. According to neurobiological accounts, in the case of antipredator defense reactions, the BIS involves coactivation of both the BAS and FFFS, such that it inhibits behavior when the two systems are in opposition (e.g., reducing likelihood of foraging when predators are nearby, despite hunger). Such danger of death is one of the only stimuli that causes animals to heighten their arousal and vigilance while simultaneously engaging in shutdown behaviors (e.g., withdrawal). For instance, the presence of a predator activates the FFFS, triggers arousal and agitation, and prepares a creature to vigorously fight or flee. The same presence of a predator is equally likely to cause a creature to reduce foraging and reproductive behaviors, as well as more generally decrease all activity in an effort to avoid the predator [28].

These patterns are also all demonstrated in soon-to-be suicide decedents, who themselves are both predator and prey [17]. Imminent suicide risk appears to be characterized by a preoccupation with death and suicidal intent [29, 30, 31]. Less commonly discussed characteristics of individuals experiencing imminent suicide risk are shutdown states and overarousal states that typically operate in opposition [17]. Shutdown phenomena may include social withdrawal, cessation of activities (e.g., lack of alcohol use, even in those with daily drinking habits for decades), and marked weight loss due to self-starvation, each of which have been observed in the preceding hours and days before a suicide decedent's death [32, 33]. Several manifestations of overarousal have also been linked to suicidal thoughts, behaviors, and death, including agitation [34, 35], insomnia and nightmares [36, 37], and irritability [38], the latter of which Joiner and Stanley [17] suggest can manifest as disgust with self and/or others [39].

Although both shutdown and overarousal states are common antipredator responses that have been implicated in acute suicidality, their joint involvement in suicidality has been subjected to little empirical scrutiny. However, one body of research has recently documented and proposed the existence and utility of a new suicide-specific diagnostic entity, acute suicidal affective disturbance (ASAD) [30, 40, 41]. ASAD characterizes the occurrence of these states alongside fixations on suicidal intent and may reflect such biologically driven antipredator defensive reactions. Given the concordance of these theories with the aforementioned biobehavioral eusociality theory of suicide [11], it may be worth exploring further the utility of a framework that includes the simultaneous activation of

predator and prey systems in suicidal individuals, in a manner that parallels that which is found in the antipredator responses described above.

The Coalescence of Eusociality and Antipredator Response in Suicide through Systems of Decision-Making

Given that both of these theoretical perspectives are founded in evolutionary principles, it can be expected that at least some elements of these evolutionary processes can be studied empirically. Indeed, an array of studies have found that certain cognitive, biological, and behavioral processes that involve two distinct decision-making systems [42] function differently among suicidal individuals, as discussed by Mann [43].

The first system (S1) is highly active and involuntary, completing tasks such as intuiting an anger expression and potential danger, and responding accordingly [42]. S1 can be conceptualized as an activating and agitating system, similar to the hyperarousal state created by the BAS and the FFFS discussed above in our discussion of antipredator responses. The other system (S2) is more effortful and involved, used in operations such as calculating complex arithmetic problems or focusing on long-term gratification [42]. S2 requires high effort and it regulates S1 behaviors. As such, deficiencies in S2 parallel deficiencies in the BIS response discussed above. This results in a dysregulation of the BAS and FFFS and impairments in the ability to inhibit S1-type decisions/behaviors/calculations, such as an erroneous analysis of costs and benefits of one's death to society. This example is of particular import, as it is implicated in the processes described in our discussion of eusociality.

Several studies illustrating the role of S1 and S2 in suicide exist. For instance, Wagner and colleagues [44] found that compared to controls, individuals with previous suicide attempts had a significantly thinner dorsolateral prefrontal cortex (DLPFC), an area associated with S2 functions and inhibiting S1 responses [45]. Similarly, Willeumier and colleagues [46] demonstrated significantly diminished DLPFC received blood flow in suicide decedents, as compared to depressed individuals who did not die by suicide. Milak and colleagues [47] further demonstrated that hyperfunction of the anterior cingulate cortex (ACC), which has been shown to be associated with S1 operations [48] is significantly associated with severity of depressive symptoms. The same study demonstrated that hypofunction of the DLPFC was significantly associated with severity of depressive symptoms as well, such that the activation of DLPFC was negatively associated with severity of depressive symptoms.

Regarding behavioral evidence of the roles of S1 and S2 in suicidal behavior, there are studies demonstrating patterns that also suggest similar difficulties with inhibiting the response of S1. For instance, one study found that the trajectory of suicidal thoughts and behaviors is such that initially, suicidal thoughts are more malleable and one's environment may be more impactful, whereas in later stages of the suicidal process, behaviors become more engrained and associated with underlying mental illness, such that suicidal behavioral tendencies resembled a compulsion rather than calculated efforts [49]. Further research has also illustrated similar effects among adolescents. Copelan, Messer, & Ashley [50] found that among recent adolescent attempters, there was a subset of individuals who did not

report suicidal ideation, but all of whom suffered from either severe akathisia (i.e. physical restlessness) in response to medication, severe adjustment disorder symptoms resulting from a recent stressor, or both. Further, adolescents in this study reported attempting as a direct result of a stressor, almost as if by impulse. Both studies illustrate that among suicidal individuals, it appears to be the case that S2 does not successfully suppress S1, and further, that the activation and agitation present among the suicidal individuals in these studies appears to align well with the antipredator responses discussed above.

Concluding Remarks

In sum, we have presented two evolutionary processes theorized to be associated with suicide. The empirical support for these theorized processes illustrates how they are, in fact, quite intertwined and that there is a body of literature revolving around Kahneman's [42] two-system model of decision-making that appears to address facets of each of these processes. However, it is worth noting that the studies discussed herein were not aimed directly at elucidating the functions of these two processes in suicide. It is our hope that with the theoretical perspectives and empirical evidence discussed in the present paper, we can stimulate the investigation of these evolutionary processes within the suicide literature and, in doing so, discover new approaches for decreasing the occurrence of suicide.

Acknowledgments

Funding Sources: This research was supported in part by a grant from the Military Suicide Research Consortium, an effort supported by the Office of the Assistant Secretary of Defense for Health Affairs under Award No. (W81XWH-10-2-0181; W81XWH-16-2-0003). Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the Military Suicide Research Consortium or the Department of Defense (Washington, DC, United States)

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- Evolutionary processes have recently been implicated in suicidal behavior
- Suicidal human behaviors parallel eusocial behavior
- Hyperarousal-shutdown behaviors in suicidal humans parallel antipredator responses
- Neuroscience and psychology support the involvement of these processes in suicide
- These processes are not exclusive and represent new directions for suicide research