The Neuroprediction of Criminal Recidivism

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Abstract

Criminal recidivism rates in the United States have consistently been rising within the past decade. Although various causes for the issue have been targeted, they have never been holistically explored in regard to their fields. Here, we identify social, psychological, and the more novel neurological risk factors that have been correlated with higher rates of recidivism and examine the manner in which their influence upon recidivating tendencies can shift depending on the intensity and presence of other factors. To represent the results of individualized complex relationships between these factors, we propose that a statistical model of linear regression will be best suited. This work may also benefit the development of more personalized therapies due to its consideration of individualized risk factors.

1 Introduction

Much research has been covered regarding the area of criminality and imprisonment; however, one area remains vastly unexplored– recidivism. Defined as the "tendency for a criminal to re-offend" by Oxford Languages, recidivism rates within the United States alone have been upwards of 60 percent [Alp18], suggesting that our current modes of rehabilitory treatment for prisoners during their first convictions are ineffective in achieving their purpose of deterring criminality. Thus, in order to limit these re-entry rates and improve the quality and retention of treatment, our target must shift from the therapies themselves to factors that influence recidivism rates.

Within this paper, we will investigate the most weighted social, psychological, and neurological variables that impact recidivism rates. For the purposes of this paper, social variables will consist of any environmental influences that deter an individual's way of life substantially, psychological variables will center around the manifestation of social variables in behavior, and neurological variables will comprise of the neurobiological determinants of recidivist tendencies. While each of these variables independently affects and subsequently, predicts the behaviors of individuals, they are impacted by one another as well.

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These form synergistically interactive, nullifying, and super-additive relationships, among other types, with one another. The intricacies of which are pertinent in reflecting a most accurate depiction of a more individualized manifestation of the complex phenomenon that is recidivism, eliciting a need for these variables to be considered in tandem with each other rather than in isolation.

Though we must examine the risk factors of recidivism, we must also apply their effects to aid us in discovering their effects on recidivism in conjunction with one another– that is, discovering how these variables can help us predict recidivism. Building a predictive model for recidivism with these variables proves advantageous for developing individualized approaches to medicinal or cognitive therapy in rehabilitory treatment, which would assist in preventing recidivism in criminal offenders. The capacity for this neuro-predictive model to consider every major variable is critical in answering the question of how we can most accurately predict whether a former convict will recidivate. Furthermore, rather than relying on human, expert assessments of risk for a defendant to re-offend, statistical models supplied with collections of scientific knowledge of each of these variables have proven to be more objective and more accurate in classifying the recidivism rates of prior offenders [Lin20]. Thus, we assert that a statistical model that analyzes social, psychological and neurological variables in conjunction with one another to impact recidivism will most accurately predict the tendency for a criminal to recidivate.

2 Recidivism: Understanding the Issue

To understand how we can predict recidivism, it is critical to first note the gravity of the issue of recidivism itself. Within the United States, 44 percent of released prisoners recidivate in the first year after being released from incarceration [Alp18]. Within three years, an estimated 68 percent of released prisoners were arrested, 79 percent within 6 years, and 83 percent within 9 years, indicating that even the aforementioned 60 percent overall rate of recidivism is not entirely representative of the reality of these largely climbing rates and suggesting that recidivism rates and time are directly correlated. Across crime types, 23.8 percent of those reconvicted were those with assault convictions while drug-related crime offenders encompassed recidivism rates of 13.5 percent [SC16]. Other crime subtypes, while their rates of recidivism are not as high as assault and drug-crimes, included larceny, homicide, manslaughter, and burglary. Whether or not these criminals resort to committing the same crime as they had prior to their first stay in prison is largely variable. However, looking outside of the United States, Norway and Denmark, for example, have the lowest rates of recidivism at 20 percent and 29 percent, respectively, while Ireland is closer to the United States' aforementioned 60 percent recidivism rate with an average of 51 percent [Yuk19]. These comparisons reveal that recidivism rates have the potential to be lower, but the reason they are lower depends on the country's approach in limiting recidivism rates by either increasing or decreasing certain risk factors.

In the broadest sense, before identifying specific risk factors, we must examine a more general trend in the tendencies of individuals to recidivate– the acclimation to normalcy. After their initial release from prison, convicts often gain a sense of hope regarding the possibility for a more reformed life as rehabilitative measures seek to implement. However, this sense of hope often diminishes once prisoners recognize that much of their former circumstances that had caused them to commit a crime in the first place still exist and still directly affect them (many of these circumstances being attributed to instability either in the workplace, housing, lifestyle, or financial). These instability-causing measures further distance the former convicts from their desired sense of normalcy or one that they seek to establish in their new, post-release life [Vis03]. And it is this distancing from normalcy that increases rates of recidivism within individuals. While each former convict fosters a sense of distance from "normal" life, each individual is also influenced by unique social, psychological, and neurological variables that may either heighten or decrease their potential recidivist tendencies.

3 Social Variables

3.1 Financial Insecurity

With the mention of broader instability comes the more narrowed aspect of financial instability, which is perhaps the most prominent social variable correlated with recidivism. Upon release from their first conviction, when prisoners remain in cyclical financial instability, most often due to generational poverty [Hol04], they retreat to areas of residence that typically accommodate lower-income individuals. These areas, receiving less of a financial foundation for education and housing, have lower education rates, and their residents, due to their lack of education and lack of an ability to receive employment, leads to insecurity in their housing as well [Kir18]. Thus, financially insecure individuals heighten their focus upon maintaining stable civil necessities, preventing them from getting jobs with a livable wage. This further creates financial insecurity from the lack of recurring income and causes these individuals to resort to criminal activities once more to sustain themselves [Han10]. While recidivating individuals facing financial insecurity do recognize the illegal nature of their criminal activities, the barriers to them sustaining themselves legally prove far greater of an obstacle to their livelihood than the immorality of their actions, crafting criminal activities as more appealing and increasing their probability to recidivate.

3.2 Past Prison Conditions

The conditions of the prisons during a criminal's initial conviction provide insight into their later actions and at times, also their tendency to recidivate. In particular, the distance from the prison to the closest town is negatively corre-

lated with the state of mind of the prison's residents. A larger distance most often would suggest higher costs of transportation from the town and to the prison, decreasing the number of social volunteers that would typically be able to engage with prisoners in these facilities [Dra11]. The foremost purpose of these visiting volunteers is to provide the prisoners with a sense of social appreciation and involvement and a closer perception of normalcy to some extent despite their current separation from society. However, a larger distance from prisons would decrease the already minimal social engagement and interaction that these prisoners have due to higher costs of transportation and lack of forefront accessibility. This isolates the prisoners further from their desired sense of normalcy starting from their initial prison stay and carrying over with more weight into their life post-release. Additionally, the distancing from normalcy only becomes heightened if a convict has multiple past convictions [Mul11] because a habitual pattern has been made for recidivating.

4 Psychological Variables

4.1 Substance Abuse

The consumption of mal-effective substances has a significant effect upon recidivism rates with alcohol and drug abuse coinciding as the most weighted factor, drug abuse as the next, followed by substance abuse by parents [Mul11], and alcohol abuse alone [Dow02]. Importantly, substance abuse is positively correlated with rates of recidivism even when controlling for other correlated environmental and psychosocial variables. It has been proposed that addiction to drugs or alcohol causes prisoners to recidivate in order to fund this often-expensive habit [Ben08], which fuels financial insecurity as well. Seeking pleasure through a psychopharmacological change removes oneself from reality and, thus, from a sense of reason and rationality when regarding one's actions [Pie17]. Likewise, drug use is correlated with lower standards of mental health [oDA21], providing even more basis for a lapse of rationality in performing an action, which would further dissociate links to a rational state of mind.

4.2 Childhood Emotional and Physical Neglect

Childhood maltreatment has been linked to several psychological deficits in behavior. Childhood maltreatment has been attributed to a lack of the formation of inter-personal relationships, processing positive task information, and emotional self-regulation [Taf08]. In the sense of analyzing these factors to societal standards, each of these traits lead to a lack of social engagement, which is integral in preserving a healthy psychological well-being and greater life satisfaction [Par09]. Individuals are not able to effectively distinguish between a societally- or an individually beneficial task as compared to a destructive one. This leads to the inability to perceive criminal acts as wrongdoings and often prompts maltreated individuals to engage in them more readily. This is espe-

cially the case when aided by a lack of emotional self-regulation which would cause these individuals to guide their actions as per their instantaneous emotional level rather than any form of cognitive restraint over them. With these effects falling under the categories of emotional and physical neglect, childhood maltreatment and, more specifically, neglect may have a significant effect and may act as a strong predictor for recidivism [Rya13].

4.3 Domestic Abuse

Ranking just below emotional and physical neglect, domestic or sexual abuse has a 12 percent frequency among criminal offenders [Kim16]. Observing domestic abuse alone may inflict high levels of psychological distress within a child, and the magnitude of these levels of distress significantly heightens if a child may be housed in a domestic abuse shelter, due to the implication of both repeated exposure to the abuse and the severity of the violence [Fan99]. Merely observing domestic abuse, however, only constitutes a small percentage of the experiences of children growing up in these environments. In fact, most of them experience child abuse as well [Edl01], a phenomenon deemed "dual exposure" – i.e., being both abused as a child and witnessing it. Dual exposure more readily deters the behavioral development of these children away from what is considered to be healthy [Her08]. This often leads to depression, anxiety, and externalizing behavior problems such as delinquency and violence perpetration, indicating that even throughout adolescence and adulthood, abused children tend to internalize their emotions [McL].

Such internalization may be due to the fact that during childhood, the child could neither turn to the victim nor perpetrator for emotional support [Bol09]. Internalizing their emotions may lead to aggressive manifestations of their behavior, mirroring typical criminal behavior. Dually exposed children remain at a higher risk for exhibiting these internalizing behaviors throughout adulthood as well, only intensifying their nature and subsequently intensifying the risk of engaging in aggressive and criminal behaviors [Moy10]. Since these behaviors remain consistent even post-release from prison, the rates of recidivism of abused children also increase as a result of these internalizing behaviors having been ingrained from childhood.

4.4 Single Parenthood

Only 43 percent of inmates report having lived with both parents while 57 percent report that they were raised in "other arrangements" [Gla08]. Single parenthood constitutes a majority of these "other arrangements" with children growing up in single-parent households being linked to a lack of cognitive development [Dem96], decrease in their emotional well-being, and poor educational and social performance in school [Fel81]. Additionally, divorce can act as a significant factor for raising stress within these children [Fel81]. Due to the lessened presence of adult figures in their lives, these children demonstrate less conformity to social norms, laws, and regulations [Hir17]. As a result, they often

devolve into criminal behaviors or acts and such juvenile delinquency has been attributed to higher rates of recidivism as an adult [Gil15]. Moreover, single parenthood as a factor in and of itself has been positively correlated with crime rates [Kro21].

4.5 Parental Incarceration

This net increase in recidivism is especially prominent in children with formerly incarcerated parents. For the purposes of this paper, "formerly incarcerated" will refer to parents incarcerated after their child's birth. Children with incarcerated parents are essentially raised in a single-parent household but the effect of parental incarceration in its uniqueness takes the form of discrimination against these children by outside individuals with many inflicted with trauma, shame, and low self-esteem as a result [Sim00]. In terms of their changes in their social and emotional development, children of incarcerated individuals often exhibit declining school performances and increased aggression and antisocial behaviors [Kin02]. In their adolescence, these children may inculcate stress, anxiety and take drugs prematurely, in most cases, leading to life-long issues with substance abuse [Cra03], the effects of which have been detailed above.

These effects result from the unfulfilled attachment needs of the children [Smy17], who now have little to no one to turn to [Chr09] especially in the case of incarcerated mothers [Mur05]. The loss of the presence of this incarcerated parent may also lead to a decline in the household income for their family, creating a financially insecure household [Mur05], and thus, impacting the child's sense of normalcy. Considering all of these main risk factor effects and other minorly impactful ones, children with incarcerated parents are up to six times more likely to become incarcerated themselves [Cox09], and in tandem with their deeply rooted emotionally suppressive tendencies, this trend of incarceration can become long-lasting and devolve into cyclical recidivism rather than an isolated instance of imprisonment.

4.6 Anti-Social Behavior

Characterized by a lack of regard for the rights of others, antisocial behavior remains a prominent factor in determining how well a former prisoner can adjust back to their typical lives. Antisocial behaviors may consist of a lack of moral reasoning [Bec02], offloading blame from themselves into others, and a self-justifying mindset as well as aggressive tendencies [Lip07]. Unlike the aforementioned internalizing effects of psychiatric disorders like depression and anxiety, antisocial personality disorder encompasses externalizing properties, and thereby, increases the impulsivity of anti-social patients [Mar19] and their likelihood of committing criminal acts. Anti-social patients may also find it difficult to adhere to a "sense of coherence" or SOC, which signifies an individual's adaptive ability to cope with their life as meaningful. This can affect their ability to make commitments, manage their problems, and perceive life as ordered

and structured [Ant87]. High SOCs have been correlated with lower recidivism rates [Ant87], and the converse is subsequently true [Ris09].

5 Neurological Variables

While social and psychological factors may seem more prominent and inherent within an individual's life experience, another mode of influence is that of the brain– or neurological factors. Brain activity may affect recidivism independently, as each experience of an individual inherently has an effect upon the brain. Alternatively, psychological and social factors may also evince themselves as the result of a neurological impact. This may consist of reduced gray matter volume– the amount of neuronal cells in that area– or heightened activity of a particular brain area among other effects, making it all the more vital to consider brain activity as a biomarker for recidivating tendencies. In combination with the fact that brain imaging and scans are more reliable metrics than a subjective gauge of psychological traits as determined through self-reported tests, neurological factors must be considered in addition to psychological and social variables in order to build the most accurate reflection of an individual's life experiences that may have prompted or will prompt them to recidivate.

5.1 Anterior Cingulate Cortex (ACC)

Located in the front part of the brain, the ACC has been attributed to controlling complex cognitive processes like decision-making [Mul08], social interactions [Etk11], and empathy [Gu10]. Noting the importance of rational decision-making in removing oneself from cyclical patterns of crime, low ACC activity has been correlated with higher rates of rearrest [Aha13]. This could be due to the individual's minimized ability to interact with others emotionally and socially as well as declining their ability to make rational decisions. Without these capacities being disrupted, persons with low ACC activity may have a propensity towards irrational behavior often in the form of criminal activities. ACC volume may be reduced due to lesions to that area, a lack of emotional support, or abuse [Ono09], among other causes [Kit06], which have previously been identified as factors that would independently increase recidivism, but examining ACC volume may be a more explicit measure of their manifestation within an individual and their effects upon recidivism.

5.2 Amygdala

Another important brain area for emotional regulation and decision making is the Amygdala, which is located deep in the middle temporal lobe. Typically involved in processes of fear or rather distinguishing threatening stimuli from non-threatening ones, the amygdala serves as a hub for discerning between emotional reward and punishment [Dav01]. Aberrations and general abnormalities

in the amygdala have been associated with psychopathic behaviors– characterized by a general lack of empathy [Boc11]– and these behaviors have a large criminal turnout [Ske10]. Falling under this subgroup of abnormalities in this region, reduced gray matter volume in the amygdala has been correlated with higher rates of recidivism [Kie18] due to the lack of empathy as well as emotional processing and reciprocation that would result from the reduced gray matter volume in the amygdala.

5.3 Age

While considering the chronological age of an individual is important in discerning their likelihood to recidivate, biological age may be a more accurate measure, the difference between each component being that chronological age pertains to the actual age of the individual while biological age refers to the influence of the physiological and neurobiological experiences of an individual upon the biological rate of maturation of the brain [Kie18]. While two individuals may have the same chronological age, they would exhibit differences in their experiences, thereby altering the rate of their age, biologically, thus prompting consideration of biological age in relation to chronological age as a factor in age-related crime. In fact, offenders younger than the age of 21 had a recidivism rate of 67.6 percent as compared to that of offenders at the age of 65 or above with a recidivism rate of 13.4 percent [SC17]. Such differences in recidivism rates may be related to the lack of development of certain brain structures within younger individuals– in particular, reduced gray matter volume and density in the amygdala (as explained above), temporal pole, and orbitofrontal cortex [Kie18].

The temporal poles are regions thought to be involved in moral decision making, emotional awareness [Gal00], and theory of mind [Hee03], but reduced gray matter volume in these areas leads to a lack of moral consideration during decision making [Mol02] and lack of emotional awareness [Ols07]. This predisposes some individuals with reduced gray matter in the temporal pole to exhibit psychopathic tendencies, especially when in combination with reduced gray matter in the amygdala. Reduced gray matter in the orbitofrontal cortex, typically involved in enforcing valuation in decision-making [Ber13] and action adherence [Ham15] as well as flexible decision-making [How15] and evaluating outcomes of possible decisions [Kri05] would have an adverse effect, eliciting less evaluation of possible outcomes of a behaviors. This would subsequently prompt a higher likelihood of recidivism due to a higher tendency to commit less favorable actions [Kie18]. Considering the effects of age upon underdeveloped brain structures and the increased likelihood of engaging in criminal behaviors as a result, age seems to be a factor well-suited for predicting recidivism.

6 The Risk Factors' Interactions

When taken independently, each of the aforementioned factors influence an individual's tendency to recidivate, but the magnitude of this influence can be altered once considered in conjunction with other factors. That is, social and psychological variables may alter neurobiological structures in such a way that they increase or decrease rates of recidivism [Stu16] as can be seen by how financial instability has been associated with the onset of stress and inflammation in higher capacities than is typical, the latter of which has been linked to greater degrees of antisocial behavior in individuals [Wan17]. However, the reverse can also be true– that antisocial behavior may cause high degrees of stress and inflammation, but neither can be claimed with certainty due to the correlative nature of these relationships (Figure 1), making comprehensive consideration of all of these variables of heightened importance.

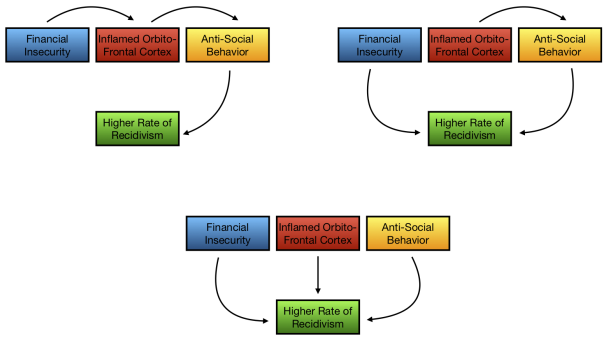

Figure 1: Figure 1. Chart of Possible Causal Interactions Between Financial Instability, an Inflamed Orbito-Frontal - Cortex, Anti-Social Behavior, and Recidivism

By no means is Figure 1 (see above) an exhaustive representation of the possibilities of the relationships that financial insecurity, an inflamed orbito-frontal cortex, anti-social behavior, and higher rates of recidivism have with one another. Rather, Figure 1 addresses a very specific example of the unclear interactions between correlated social, psychological, and neurological variables and aims to highlight the complexity of these relationships in order to more accurately depict the manifestation of recidivism risk factor interactions.

It should also be noted that while risk factors can more directly have effects on one another, with two or more factors present, isolated from one another, the rates of recidivism can still be affected as well. And so, it is important to consider how much each variable is "uniquely contributing" [Mus19] to the change in

the recidivating tendency of an individual in addition to how these factor's significance may shift because with every individual's circumstances, they have differing quantities of these factors present themselves or external influences that would affect the weights of these factors. Thus, considering an individual's circumstances holistically is incredibly important to collecting a more precise prediction of their recidivating tendency. Mere personal analysis and medicinal examination may not be the most effective way to evaluate these properties. To analyze the shifting weights of these variables' influence upon recidivating tendencies, statistical models, having been supplied with the information of which variables are typically more influential, would be more effective as their generated assigned weights to each factor, changing with the input values of each individual's unique circumstances, would simplify and expedite the process of prediction.

7 Perspective: Predictive Modeling

Linear regression models, in particular, seem to be well suited to represent reentry data– specifically, hierarchical generalized linear models [Mow17]. Linear models in general assign a Beta coefficient, or weight, to every factor depending on the quality of the factor, which it determines through its receiving of previous recidivism data and what variables have historically had more effect in comparison to their current data, and the other factors present, allowing the Beta coefficients to be in flux to some extent but centered around the individual. Alongside the assigning of Beta coefficients when fitting recidivism risk factor data to a hierarchical generalized linear models, these models would eliminate any endogenous or error-correlated results [Hor95] as well as map the results across various waves, separated by time intervals, which would indicate at which temporal wave an individual's recidivating tendency is the highest, lowest, and the various degrees therein. Analyzing recidivism risk factors with a multi-level model such as a hierarchical generalized linear model would allow for more precise data in that not only is endogeneity eliminated and tendencies evaluated with the complex relationship between each variable, but also the tendencies are mapped on a temporal expanse [Mow17].

8 Discussion

Through this review, our initial hypothesis was supported– that a statistical model analyzing the most influential social, psychological, and neurological risk factors would be the most effective in relating the complexities in their relationships with one another and depicting a more accurate result of an individual's recidivating tendency. The delegating of weights to each factor as a variable in accordance with the presence and intensity of others as well as the considering of many variables at one time indicates a sophisticated way to examine the manifestation of the complex behavior of recidivism in a multilevel model, like

the hierarchical generalized linear model, proving to be best suited for analyzing the conditions of recidivism predicting factors.

Such a model proves itself as a way to understand the nuances and intricacies of recidivism and its manifestation holistically, that is, in social, psychological, and neurological settings rather than in isolation from one another, the latter of which has more typically been assessed in academic and scientific literature regarding this area of study. Building such a model, considering each of these spheres of influence in tandem with one another, collects a more accurate representation of an individual's experience in life and thereby, the collection of motivators that may have pushed them to recidivate as opposed to considering only one field or the variables in isolation, which would only reflect a more selective and therefore, more error-prone segment of these motivators. Fashioning a more specific representation and understanding of an individual's experience lends itself to developing personalized therapies, rehabilitory or medicinal, which could be tailored to combat the individual's recidivism risk factors and thus, engender targeted recoveries for offenders as well, reducing their likelihood to recidivate and building overall, greater welfare for their way of lives.

Examining the data from other countries, it is clear that recidivism rates can be lowered substantially in comparison to our current rate of 60 percent1, see "Recidivism– Understanding the Issue", but with outstanding factors such as a comparatively lower rate of governmental financial assistance to offenders, intervention seems to be limited in its expanse. However, rehabilitory measures in other countries, with the Swedish One-to-One Program taken as the most notable, have been successful, utilizing the completion of mainly therapy-based discussion seminars during offenders' initial prison stays as a mode of reducing recidivism rates by nearly 15 percent [Ber19]. Psychologically-targeted interventions such as the One-to-One Program have been the most effective recidivism-counter as of yet, however, social factors such as financial stress seem to transcend even these measures, so utilizing therapies that are more holistically-aimed, much like the factors themselves, may be a venture to consider in later research.

Building such a model, however, does not come without its limitations and ethical concerns especially given its predictive nature. Addressing the perception that neuropredictive tools can definitively predict phenomena, no tool can predict matters with absolute certainty, so discretion must be advised in regard to its application and implementation. Integrating this model as a conclusive measure of whether someone will recidivate or not would encroach upon an individual's way of life especially if they do not have a future with recidivism in its outcome, and necessitating rehabilitation measures for individuals with higher recidivating tendencies would similarly infringe upon their rights to free-will and privacy [Fuc06]. However, with this paper, we are simply proposing a model that is intended for the optimal method of reducing recidivism rates and increasing the quality of life for criminal offenders, and we are removed from any mal intent that would be at the disposal of the operator. The original purpose of the model remains unmoved– personalized therapies for more targeted recoveries and better rehabilitory measures– and its implementation should bear

these targets in mind.

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