

Youth and their Artificial Social Environmental Risk and Protective Scores (Ya-TASERPS) Model

Below is a detailed description of the model based on the standard Overview, Design concepts, and Details plus Decision (ODD + D) protocol by Müller et al. (2013). We provide this documentation in order to provide more details about the model and aid others in replicating and extending the model if so desired. The model itself is available at:

<https://www.comses.net/codebase-release/2b6c33c9-1d26-46ab-8246-dba338a57ed3/>

while Figure 1 show the graphical user interface of the model. On the left-hand side we have user-specified inputs along with model outputs. NetLogo 6.1 (Wilensky, 1999) was used to implement the model.

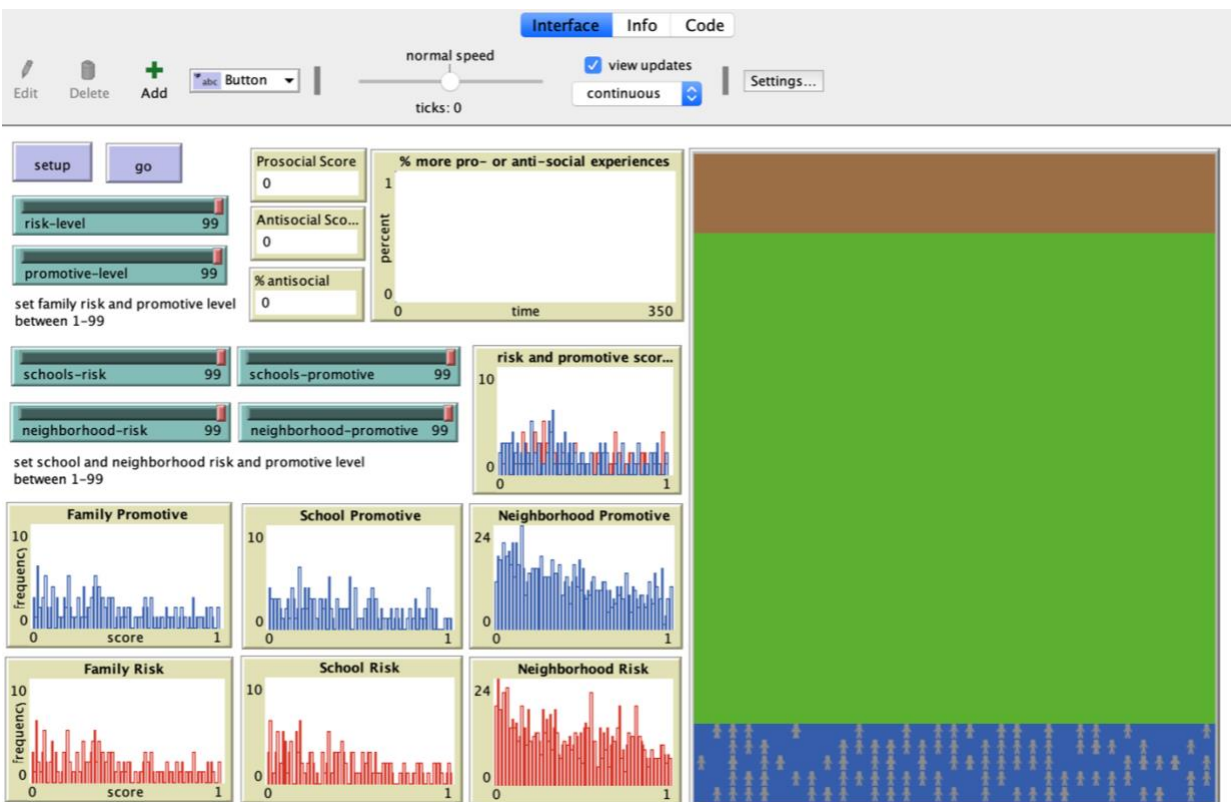


Figure 1. Model Graphical User interface at Initialization.

1. Overview.

1.1: Purpose

This model was developed for exploring a) the premises of interactional theory of delinquency (Thornberry, 1987); and b) how risk and promotive factors accumulate, taking into account risk in the youth's social environment (see Section 2.1). Interactional theory of delinquency is a developmental theory of process that is based on the premise that individual outcomes are the

result of the individual's interaction with their social environment (which will be discussed more throughout Section 2). Additionally, we build on principles of risk and risk assessment approaches in order to simulate the accumulation of risk while also actively exploring the mechanisms proposed by interactional theory of delinquency. This is an abstract, theory-driven model that can be used by scholars and researchers in order to further theory development, specifically in unpacking the specific mechanisms that explain the developmental processes that shape youth engagement in delinquent behaviors.

1.2: Entities, State Variables and Scales

The main entity in this model are the youth agents. Additionally, there are three types of spatial units. Details about the agent parameters are presented in Table 1. Youth agents are assigned family risk and promotive scores and individual risk and promotive scores, which are a cumulative measure of risk and promotive factors. Risk and promotive factors have been extensively identified as predictors of engagement in delinquent behaviors (as will be discussed in Section 2.1). These risk and promotive scores represent the scores these youth would receive if they completed a standardized risk assessment (Baglivio, 2009). Additionally, youth agents will carry an ongoing tally of their prosocial and antisocial experiences, since research suggests that the processes that contribute to prosocial and antisocial outcomes are not the same – for example, the predictors of social connectedness are not the same as the predictors of social exclusion (Lee & Ballew, 2018). These two ongoing tallies capture the youth's behavioral trajectory (Thornberry, 1987).

In addition to the youth agents, there are also three types of spatial units within the model: *home*, *school*, and *neighborhood*. These spatial units do not represent any real landscapes, but rather, are abstractions that encompass the range of prosocial and antisocial influences a youth may encounter in their homes, schools and neighborhoods. Each of these spatial units is characterized by a probability that a youth in that space will encounter a prosocial opportunity and a probability a youth in that space will encounter an antisocial opportunity to simulate the availability and accessibility of institutional resources in the neighborhood which contribute to developmental outcomes (Leventhal & Brooks-Gunn, 2000). Youth agents are not assigned to specific home spaces, so those spatial units do not have any distinct characteristics. They signify that a youth is merely at home, during which time the youth may interact with their family. The family characteristics (i.e., risk and promotive scores) are assigned to the youth agent rather than the home unit. In contrast to risk and promotive factors in the school and neighborhood environment, which can be location dependent, the transmission of risk and promotive factors from the family occurs through interactions with family members rather than being specific to the location of the home.

Each model step represents a day in the life of a youth, during which they go to school, have free time in the neighborhood, and spend time at home with their families. The model runs for 1800 days, approximately 5 years. Our rationale for this is by doing so, the model starts in early adolescence as the youth are beginning to formulate delinquent values (Thornberry et al., 1991), and extends through the teen years and high school graduation when most of them have

reached the age of majority, and thus would be legally recognized as adults (~13 – 18 years old).

Table 1: Parameters and initialization values within the model.

Object	Variable	Theoretical Construct	Value	Reference
Global	1. Promotive-level 2. Risk-level 3. Schools-promotive 4. Schools-risk 5. Neighborhood-promotive 6. Neighborhood-risk	User-controlled, allows for systematic testing.	Between 1-99.	N/A: This is being tested
School and Neighborhood Patches	Pro-opp	Score based on opportunities assigned to place.	Random-exponential (schools-promotive or neighborhood-promotive). Between 0-1.	Thornberry (1987); Harris et al. (2011); Rodriguez (2013).
	Risk-opp	Score based on risks assigned to place.	Random-exponential (schools-risk or neighborhood-risk). Between 0-1.	Thornberry (1987); Harris et al. (2011); Rodriguez (2013).
Youth	Family-risk	Score based on user-defined risk level.	Random-exponential (risk-level). Between 0-1.	Empirical data
	Family-pro	Score based on user-defined promotive level.	Random-exponential (promotive-level). Between 0-1.	Empirical data
	Individual-risk	Individual risk score derived from family risk.	Random-normal (family-risk). Between 0-1.	Lee (2014); Sampson & Laub (1997); Thornberry (1987).
	Individual-pro	Individual protective score derived from family promotive level.	Random-normal (family-pro). Between 0-1.	Lee, 2014; Sampson & Laub, 1997; Thornberry (1987).
	Prosocial	Running tally of prosocial experiences.	0	Lee & Ballew (2017)
	Antisocial	Running tally of antisocial experiences.	0	Lee & Ballew (2017)

1.3: Process Overview and Scheduling

The model sequence consists of three main routines that occur within each day. The flow of these three routines are presented in Figure 2, and are explained in more detail in Section 3.4. These three routines were selected to reflect the major social contexts, and thus influences, in the lives of adolescents – parents (families), schools, and neighborhoods (Sampson & Laub, 1997; Thornberry & Krohn, 2005). Peer influences are embedded within the school and neighborhoods, and any work, religious, or other activities are embedded within the neighborhoods.

Once the agents wake up, they enter the *school routine*, during which a youth makes choices to stay in school or leave school – this is explained further in Section 2.1. If the youth leaves school early, their antisocial score increases – they are at risk of falling behind in their classes, getting arrested for truancy, and/or otherwise getting in trouble. If they stay in school, their prosocial score increases periodically (which is stochastic dependent on the school’s promotive score), since they have stayed within an educational environment and are closer to high school graduation. Similarly, if they have left school early, their antisocial score increases periodically, which is also stochastic and dependent on the school’s risk score – this is discussed further in Section 2.9.

Second is the *after-school routine*, during which a youth may be presented with prosocial or antisocial opportunities, and makes choices about whether to engage in an opportunity – this is also explained further in Section 2.1. If the youth engages in a prosocial opportunity, such as playing on a sports team or working a job at the mall, their prosocial score increases periodically, which is stochastic dependent on the individual’s promotive score. If the youth engages in an antisocial opportunity, such as smoking marijuana with their friends, their antisocial score increases periodically, which is stochastic dependent on the individual’s risk score – this is discussed further in Section 2.9.

Third is the *home routine*, during which a youth’s risk factors or promotive factors may be increased by the socializing influence of their family. For example, message of the importance of staying in school may be reinforced, which would contribute to their promotive score. On the other hand, there may be family members who smoke marijuana and expose the youth to this behavior, thus increasing the youth’s risk score.

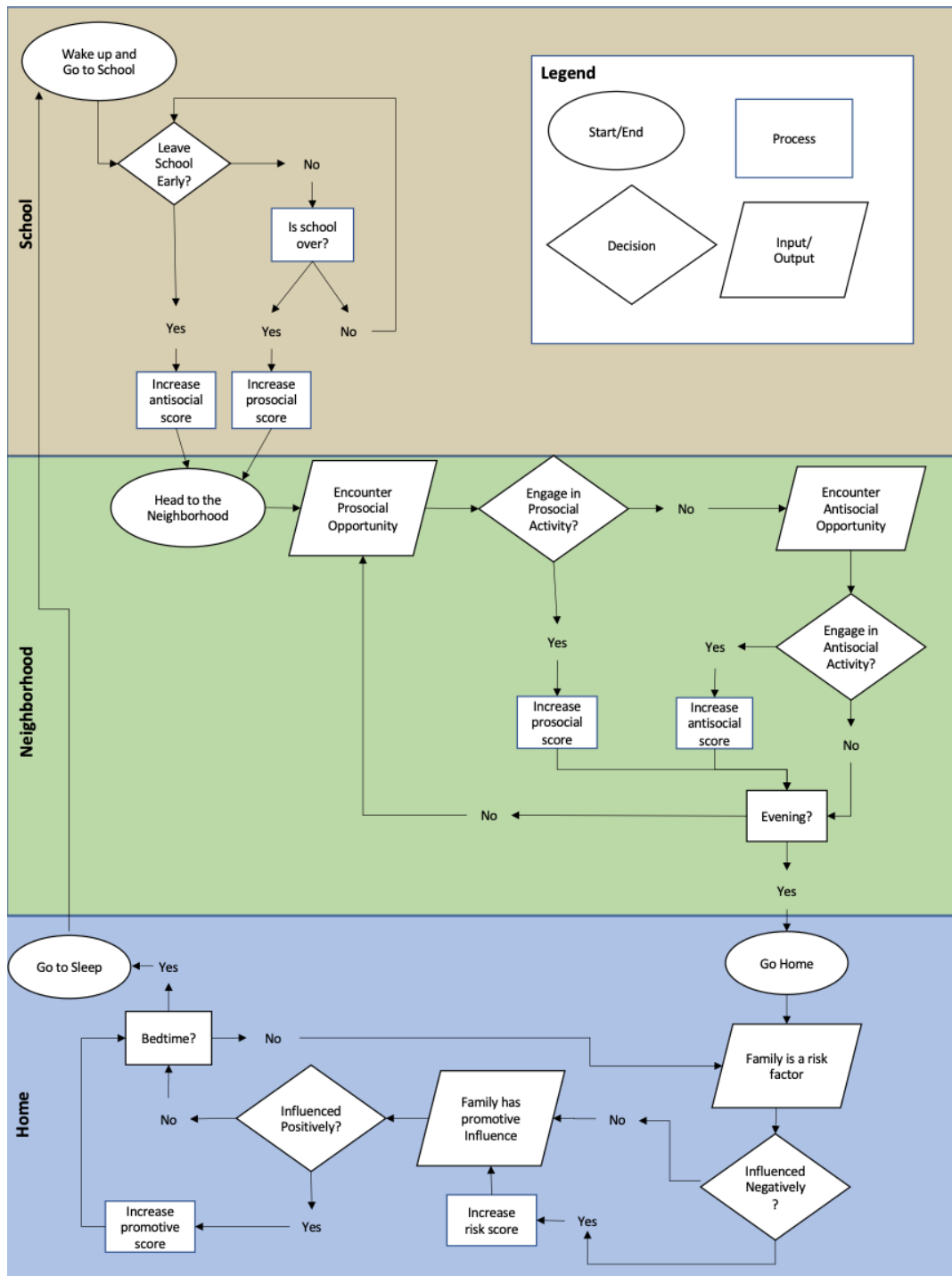


Figure 2: Model flow diagram.

2: Design Concepts

2.1: Theoretical and Empirical Background

This model is guided by Thornberry's (1987) interactional theory of delinquency. The theory is based on the key assertion that *"human behavior occurs in social interaction and can therefore*

best be explained by models that focus on the interactive process" (Thornberry, 1987, p. 864). Thus, an individual's behavioral outcomes (e.g., delinquency) cannot be understood in isolation from their social environment.

Thornberry and Krohn (2005) identify three fundamental premises to the theory. First, interactional theory of delinquency takes a developmental life-course perspective. A life course perspective acknowledges an individual's agency while recognizing that individuals are embedded within social relationships (Elder, 1994). Within this perspective, factors that contribute to the initiation, maintenance, or desistance of delinquency change during developmental periods. Thus, while in childhood, the family plays a critical role in the youth's development, in adolescence, as the youth is becoming more independent, the family plays a less important role while peers and schools begin to play a more important role (Sampson & Laub, 1997; Thornberry & Krohn, 2005). Additionally, delinquent values do not begin to form until early adolescence (Thornberry et al., 1991). Moreover, an individual's success in one developmental stage has implications for success in later stages (Thornberry & Krohn, 2005). Success in adolescence will situate the youth for a successful adulthood, and thus warrants study.

The second premise is *bidirectional causality*, which captures the interaction between the individual and their environment (Thornberry & Krohn, 2005). Not only do factors from an individual's social environment change the youth's risk, but the youth's behaviors and choices also shape the social environments in which they exist (Thornberry & Krohn, 2005). The reciprocal relationship between the youth and their social environment occurs through both the interactions with individuals (e.g., parents, teachers, peers) as well as in the changing set of opportunities available to the youth. Interactions between the youth and their social environment are mutually reinforcing, resulting in behavioral trajectories (e.g., delinquency) that are path dependent (Thornberry, 1987). This process is the result of the ongoing consistency of the individual's behaviors (cumulative continuity) as well as the responses from others that maintain the individual's behaviors (interactional continuity) (Sampson & Laub, 1997). For example, a youth who skips school actively plays a role in shaping their future opportunities – if they continue to make these choices, they may fall behind in school, which may limit their college options. At the same time, there may be maintaining responses from others such as a suspension from school or an arrest for truancy, which would contribute to the disruptions to the youth's academic progress and thus, propel the youth on their current behavioral trajectory.

Finally the third premise of the interactional theory is *proportionality of cause and effect*, which "states that as the magnitude of the causal force increases, the person's involvement in crime (a) becomes more likely and (b) increases in severity" (Thornberry & Krohn, 2005, p. 189). This approach embraces the idea of equifinality in that it isn't about specific causal factors, but rather, the accumulation of causal factors (Arthur et al., 2002).

There is some empirical evidence that supports interactional theory of delinquency, yet existing statistical approaches provide only a limited test of this theory of process -- even studies that

use longitudinal data must rely upon point in time measures with large gaps between those measures (Hoffmann et al., 2013; Jang, 1999; Lee, 2003; Thornberry et al., 1991). One study tested the developmental, life-course perspective premise of interactional theory that there are age-varying effects of family, school, and delinquent peers on adolescents (Jang, 1999). Jang (1999) used multilevel modeling with five waves of data from the National Youth Survey, and found that school and peers have a curvilinear effect while families have a consistent effect on adolescents. This supports the notion that depending on the youth's developmental stage, different factors have stronger or weaker effects.

Studies testing interactional theory of delinquency have tended to focus on the bidirectional causality premise. For example, Thornberry et al. (1991) used three waves of data from the Rochester Youth Development Study, and found reciprocal relationships between a youth's bond to family and school, and engagement in delinquent behaviors. Similarly, Lee (2003) used a structural equation modeling approach with four time points from the National Youth Survey, and tested not only family, but also peers, and found that reciprocal relationships with peers play a stronger role than families. Finally, Hoffman, Erickson, & Spence (2013) also used structural equation modeling with two waves of Add Health data to test the reciprocal relationship between delinquency and academic achievement. They found partial support for interactional theory where academic achievement is related to later delinquency, but delinquency is not directly related to later academic achievement (Hoffmann et al., 2013).

While these studies provide evidence to support bidirectional causality, these rely on several point-in-time estimates that are months or years apart to establish the reciprocal relationships. Thus, existing studies provide only partial tests of the theory, and while they have been promising, they are limited. Using other approaches, such as agent-based modeling, may be useful in testing the generative mechanisms and provides a richer understanding of the phenomena under study by "triangulating" various approaches that have different strengths and limitations.

This model takes a stylized facts approach to modeling interactional theory (Heine et al., 2005). The youth's social environment is highly abstract and is represented only by two scores (factors): risk and promotive. These scores act as the probability that a given youth in that location will be presented with an antisocial opportunity (based on risk score) or prosocial opportunity (based on promotive score). In both instances, the prosocial or antisocial opportunities could be activities (e.g., extracurricular activities, volunteer activities), or could also represent the positive or negative influence of their peers (e.g., graffiti, stealing, smoking pot). When faced with these opportunities, the youth may choose the opportunity presented to them, or may forego the opportunity depending on their own risk and promotive scores. Their choices result in increases to their tally of either antisocial or prosocial experiences, which can be thought of representing the youth's behavioral trajectory.

2.2: Individual Decision-making

Decision-making occurs at the individual level. Each individual holds a set of risk and promotive factors, as well as a tally of antisocial and prosocial experiences. These four factors contribute to the youth's decision when presented with a prosocial or antisocial opportunity in school and in the neighborhood. A youth's risk score increases the likelihood of choosing an antisocial opportunity while a youth's promotive score increases the likelihood of choosing a prosocial opportunity. The interaction of these factors are represented in Figure 3.

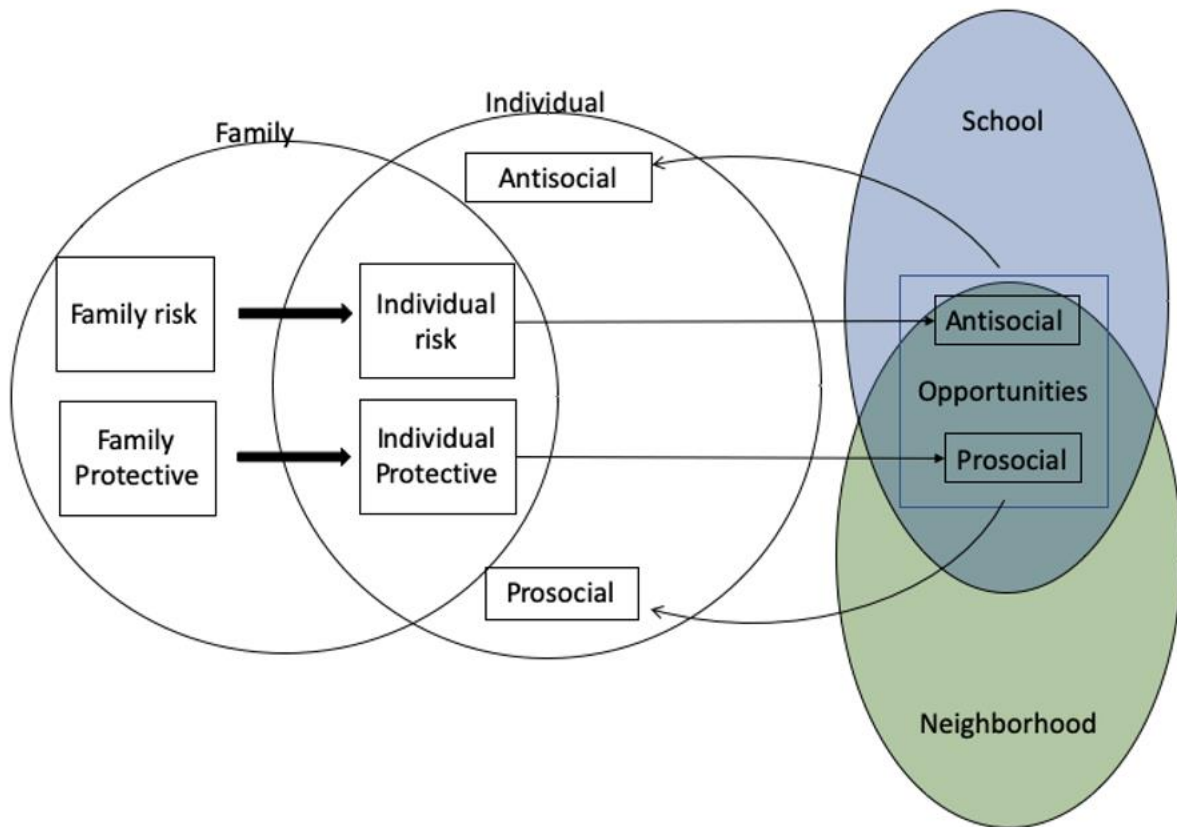


Figure 3: Logic of interactions within the model.

2.3: Learning

While there is no learning per se, agents do adapt and change based on their experiences. A youth's risk and promotive factors and their tally of antisocial and prosocial experiences both are updated after they engage in prosocial or antisocial experiences. Their risk and promotive factors can also be updated by the family, depending on what the family's risk or promotive scores are. The youth's decision-making process does not change – only the quantities that inform their calculations.

2.4: Individual Sensing

The spatial scale of sensing is local, and occurs in the school and the neighborhood setting. Depending on the location's risk and promotive score, a youth may be faced with a prosocial or antisocial opportunity. The youth is only aware of the prosocial or antisocial opportunity, if presented.

2.5: Individual Prediction

The youth do not make predictions. Our rationale for this is that their brain has not fully developed and their future orientation will continue to increase as they make the transition to adulthood; their assessment of risk is different from that of adults (Steinberg, 2008).

2.6: Interaction

This model focuses on interactions between the individual and the environment. Interaction with others is simulated at an abstract level – the individual interacts with their families in the evenings, and thus the family may influence the individual's risk or promotive score during this period. At school, a peer or a teacher's positive or negative influence is captured abstractly in the location risk and promotive score – which a youth in the model will react to.

2.7: Collectives

In the current model, there are no collectives.

2.8: Heterogeneity

Within the model, there is heterogeneity of agents, both youth and locations. Youth vary based on their risk and promotive scores. Each location varies based on its risk and promotive scores, where a risk score increases the likelihood that a youth in that location will be presented with an antisocial opportunity, and a promotive score increases the likelihood that a youth in that location will be presented with a prosocial opportunity.

2.9: Stochasticity

As is common in many agent-based models there is randomness in how certain attribute values are assigned at initialization of the model. For the individual, their family risk and promotive scores are randomly assigned following an exponential distribution centered on a user-set value (as outlined in Table 1). The youth's individual risk and promotive scores are randomly assigned following a normal distribution and centered on their family risk and promotive scores. For the location, the probability of a prosocial or antisocial opportunity is randomly assigned following an exponential distribution and centered on a user-set value. These parameters are used as probabilities. Whether a youth encounters a prosocial or antisocial influence is based on these probabilities. Additionally, whether a youth tally of prosocial or antisocial experiences is increased is also stochastic – since they will be faced with multiple opportunities, but not every opportunity will be so impactful that it affects their behavioral trajectory.

2.10: Observation

The initial distribution of each individual's family risk and promotive factors, and the distribution of the risk and promotive score of each location are initially displayed (see Figure

1). The distribution of individual risk and promotive scores are shown at initialization, which are updated throughout the model. Additionally, the average antisocial and prosocial scores are displayed, as well as the percent of youth in the simulation with an antisocial score that is higher than their prosocial score. There is also a graph that show the percent of youth with a higher antisocial than prosocial score, percent of youth with a higher prosocial than antisocial score, and percent of youth with equal antisocial and prosocial scores.

3: Details

3.1: Implementation Details

The model is implemented in NetLogo 6.1 (Wilensky, 1999).

3.2: Initialization

Upon initialization, the world is created (see Figure 1), which consists of the youths' homes (blue), their schools (brown), and their neighborhoods (green). A youth's movements are likely more restricted at home and at school. Thus, these areas are smaller than the neighborhood, where youth likely have more autonomy and a less predictable range of experiences.

Table 1 shows the initialization values for each variable. Each school cell (which in the model is a unit within the landscape) and neighborhood cell is assigned a probability of encountering both risk and prosocial opportunities, which can be manipulated by the user. This allows the user to systematically altered the youth's environmental risk in order to examine the effect of each on youth outcomes (see Figure 1). Each school and neighborhood location is randomly assigned a risk and promotive probability following an exponential distribution and center on a user-provided value. The exponential distribution was selected based on studies that suggest that risk tends to cluster environmentally (Harris et al., 2011; Rodriguez, 2013; Sampson et al., 2002), and thus would resemble a distribution with more frequent low-risk locations and a few higher risk locations, such as an exponential distribution. These scores are restricted to between 0.01 and 0.99 since in this model, they act as probabilities. In life, there is always some uncertainty, so actual values of 0 and 1 are not assigned.

Next, 150 youth are created and sent to their homes, which is set based on the size of the grid that represents the world so that randomly sending youth to a home cell results in a combination of both spread (i.e., multiple families are represented) and overlap (i.e., households can have more than one youth). The youth are grey, but they will become red if their antisocial experience score is higher than their prosocial experience score, and they will become green if their prosocial experience score is higher than their antisocial experience score. Youth, rather than home cells, are assigned their family-risk and family-protective scores. Similar to the distribution of school and neighborhood risk and prosocial opportunity scores, the family scores are assumed to follow an exponential distribution. This is based on the distribution of actual data from youth on probation from one mid-Atlantic state, where the family risk subscale appears to follow an exponential distribution (see Figure 4). These scores are also restricted to between 0.01 and 0.99, since they act as probabilities in this model. In life, there is always some uncertainty, so actual values of 0 and 1 are not assigned.

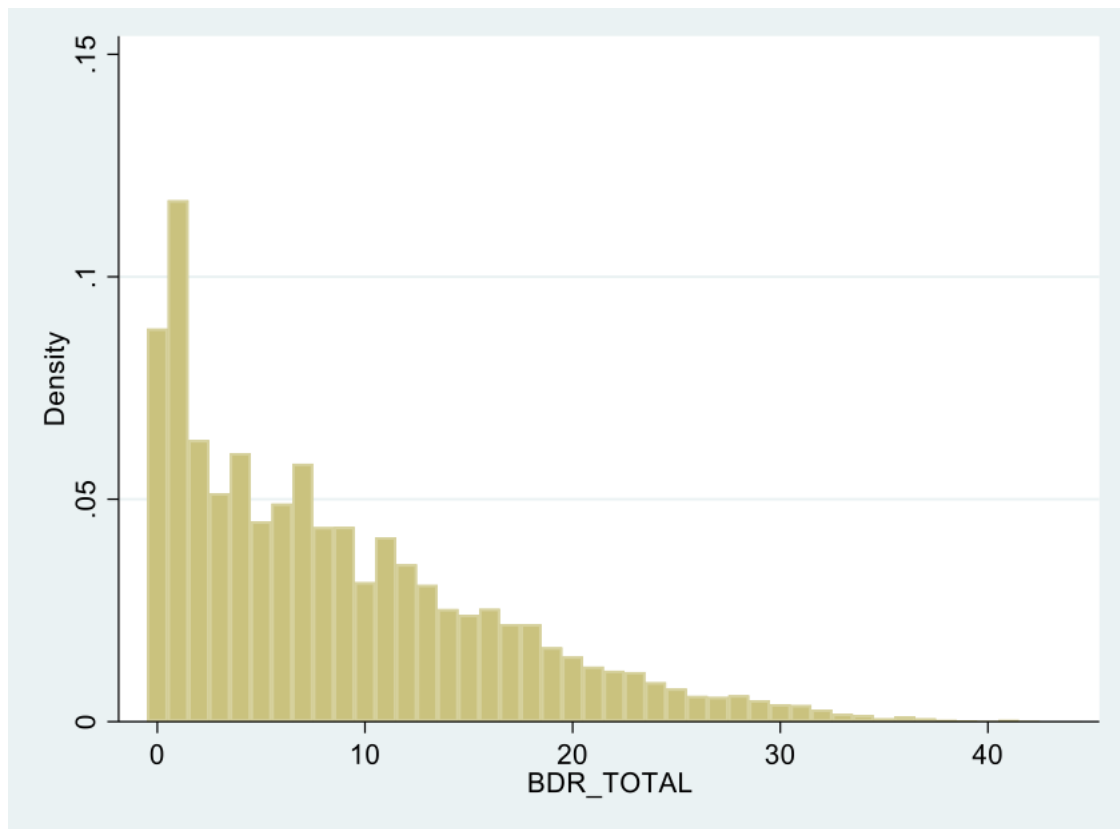


Figure 4: Family dynamic risk scores for youth on probation from one state.

3.3: Input Data

There is no input data.

3.4: Submodels

The model consists of three processes, which is determined by the youth's location and time of day. Throughout these processes, risk and promotive scores act as probabilities: if a location has a higher risk score, there is a higher probability the youth will be presented with an antisocial opportunity. If the youth has a higher risk score, there is a higher probability the youth will choose any antisocial opportunities presented to them. Conversely, if a location has a higher promotive score, there is a higher probability the youth will be presented with a prosocial opportunity. If the youth has a higher promotive score, there is a higher probability the youth will choose any prosocial opportunities presented to them.

At the start of the day, the youth goes directly to school, where they spend 6 hours (7am-2pm). This duration is an estimate based on a typical high school day. At each hour, the youth may be presented with a prosocial opportunity, depending on the probability of a prosocial opportunity assigned to the school location the youth is on. These hourly choices roughly approximate students switching classes during the school day and the interactions/exchanges that occur

during those transitional periods. If the youth chooses the prosocial opportunity, which is based on their individual promotive score (a probability), they move to a different location in the school. If not, they youth may be presented with an antisocial opportunity, depending on the probability of a risk opportunity assigned to the school location the youth is on. In this model, the antisocial opportunity is leaving school early (i.e., playing hooky). Whether the youth takes the opportunity depends on their individual risk score (a probability).

If the youth stays in school for the whole day, the youth's tally of prosocial experiences may increase depending on the youth location's promotive score (i.e., probability of having a lasting positive impact on a student). If the youth leaves school early (i.e., plays hooky), depending on the youth location's risk opportunity, the youth's tally of antisocial experiences may increase (i.e., probability of having a lasting negative impact on the student). If the tally increases, whether prosocial or antisocial, it increases in an equal increment – the overall score relative to the other youth in the model is more informative than a single instance of increasing a youth's tally. This randomness is programmed since it is assumed that every event will not be equally impactful on the youth.

After school ends, the youth has free time. The youth is assumed to be in the neighborhood for 5 hours (2pm-7pm). This represents the youth's growing autonomy, which coincides with the growing influence of peers during this period (Stoddard et al., 2012). During this time, the youth may encounter a prosocial influence depending on their location's promotive score (a probability). These prosocial opportunities could be playing on a soccer team, finding a job at the local pool, or participating in a religious group. If the youth chooses the prosocial opportunity, based on their individual promotive score (a probability), their tally of prosocial experiences will increase. If they do not encounter a prosocial influence, they have a chance of encountering an antisocial influence depending on their location's risk score (a probability). These antisocial influences could be smoking marijuana or drinking alcohol at a party, vandalizing a wall, or stealing some clothes. If the youth chooses the antisocial opportunity, based on their individual risk score (a probability), then their tally of antisocial experiences increases. If the tally increases, whether prosocial or antisocial, it increases in an equal increment – the overall score relative to the other youth in the model is more informative than a single instance of increasing a youth's tally. This randomness is programmed since it is assumed that every event will not be equally impactful on the youth.

At the end of the day, the youth returns to a home location and we assume stays there and awake for 4 hours (7pm-11pm). This is approximately the time it takes to participate in dinner (cooking, eating, and/or cleaning up) and allows for time after dinner before bed. During this time, the individual risk or promotive score can be modified through their families, who are one of their primary socializing influences (J. S. Lee, 2014). Youth may be influenced positively or negatively depending on the family risk and promotive scores (Stoddard et al., 2012). Whether the youth is susceptible to the influence is dependent on their own individual scores. If the youth's risk score is greater, they are susceptible to the antisocial influence. If the youth's promotive score is greater, they are susceptible to the prosocial influence. This operates as a positive feedback loop. Thornberry (1987) describes the youth's behavioral trajectory, where

the reciprocal nature of interactions reinforce each other, resulting in an increasing likelihood of engagement in crime or alternatively, prosocial behaviors.

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