Engineering Control Theory
Applied:
On Prevention
Science Terms

Ty A. Ridenour, Ph.D., M.P.E.
Center for Education and Drug Abuse Research
University of Pittsburgh
Chair, Early Career Preventionists Network
Chair, SPR Database Taskforce
Member, SPR Steering Committee, Bio Taskforce
### Control Theory Terms and Prevention Science Concepts

<table>
<thead>
<tr>
<th>Control Theory Term</th>
<th>Definition</th>
<th>Prevention Concept</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Block Diagram</td>
<td>Graphical representation of the signals and subsystems that comprise a closed-loop control system</td>
<td>Flow chart, concept diagram</td>
<td>Graphical presentation of sequence of steps involved with a prevention program</td>
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<td>Closed-loop</td>
<td>“Behavior” of a system after a controller is implemented</td>
<td>Manualization of intervention</td>
<td>Standardization of how a preventive intervention ought to be delivered</td>
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<td>Controller, Decision Policy, Decision Rule</td>
<td>Set of mathematical relationships that translate deviation from a setpoint into settings for a manipulated variable(s)</td>
<td>Preventionist, policy, community leaders</td>
<td>Person(s) or policy who design, select and implement a prevention program</td>
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<td>Control Engineering</td>
<td>Science that considers how to manipulate system variables to transform dynamic behavior from undesirable to desirable</td>
<td>Prevention science</td>
<td>Science that considers how to improve precursors of pathological outcomes to improve development from dysfunctional to functional</td>
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<td>Control Error</td>
<td>Difference between a controlled variable and a setpoint; the goal of a control system is for control error to be zero</td>
<td>Severity of risk</td>
<td>Degree of an individual’s pathological development</td>
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<td>Controlled Variable (Y)</td>
<td>(c = sp – Y) Variable(s) that a control system is designed to maintain at a setpoint</td>
<td>Outcome (Y)</td>
<td>Characteristic that is used as an indicator of one’s level of (dys)functional development</td>
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<td>Disturbance Rejection</td>
<td>How well a control system manipulates variables to maintain controlled variables at the desired setpoint in spite of disturbance variables</td>
<td>Resiliency</td>
<td>How well an individual maintains healthy development in spite of environmental stressors and change</td>
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<td>Disturbance Variable (d)</td>
<td>Influences on the controlled system that cannot be manipulated by the controller; they are external (exogenous) to the system</td>
<td>Moderators, exogenous variables (X)</td>
<td>Variables that cannot be altered but nevertheless effect the result of an intervention within individuals</td>
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<td>Feedback Control</td>
<td>Strategy in which a controlled variable is compared to a setpoint. Based on any discrepancy between a controlled variable and its setpoint (control error), the controller issues changes in manipulated variables to move the discrepancy toward zero.</td>
<td>Intermediary outcome assessment</td>
<td>Measurement of an individual’s developmental outcome and compared to a threshold level to determine if, how much and specific factors where improvement is needed</td>
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<tr>
<td>Feedforward Control</td>
<td>Strategy in which changes in a disturbance variable is monitored and countered by adjustments in a manipulated variable(s)</td>
<td>Risk assessment, needs assessment</td>
<td>Assessment of factors that putatively affect propensity for (dys)functional development for the purpose of determining which factors to intervene upon</td>
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<td>Manipulated Variable (u)</td>
<td>Variable that is adjusted to bring a controlled variable to equal a setpoint (e.g., dosage magnitude)</td>
<td>Experimental variable (X)</td>
<td>Element of a preventive intervention (e.g., dosage) that is adjusted to improve an individual’s outcome</td>
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<td>Open-loop</td>
<td>Dynamical system that lacks a controller</td>
<td>Natural history</td>
<td>State of development without intervention</td>
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<td>Offset</td>
<td>A sustained discrepancy between the level of a controlled variable and a setpoint</td>
<td>Impairment, deficit</td>
<td>Dysfunctional level of an outcome that is unlike to improve with extant intervention</td>
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<tr>
<td>Process</td>
<td>The dynamical system that is under study</td>
<td>Etiology, ontogeny</td>
<td>Developmental processes leading to an outcome</td>
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<tr>
<td>Setpoint (sp)</td>
<td>The desired level / value of a controlled variable</td>
<td>Clinical goal</td>
<td>Threshold level of outcome which demarcates dysfunctional versus functional</td>
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<td>Setpoint Tracking</td>
<td>How well manipulated variables can be adjusted to maintain the controlled variable at the setpoint</td>
<td>Efficacy, impact, effectiveness</td>
<td>How well targets of prevention respond to intervention to bring an outcome to the clinical goal</td>
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<td>Transfer of Variance</td>
<td>Process whereby variability in a controlled variable is minimized by accordingly varying manipulated variables</td>
<td>Tailoring of intervention</td>
<td>Intervention modifications in terms of delivery or components, based on recipient characteristics (e.g., risk factors), to increase the probability of meeting or maintaining the clinical goal.</td>
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Outline of Early Risers Program

Child School Support
- Monitoring of school performance, mentoring as needed

Child Skills
- Socio-emotional skills training (PATHS), literature appreciation, creativity activities

Family Support
- Goal setting, motivational enhancement, parenting skills training, brokering community services per need

Parenting Skills
- Parent education in effective parenting practices

From: August et al., 2001; 2007; personal communication, 2010
Flow Chart of SMART Design for Ongoing Study of Early Risers

Child School Support/Family Support: Advocate assistance with school attendance, accessing services

Child Skills Augmentation: Summer Program; Regular School Year Program

Family Skills Augmentation: Parenting education, individualized home visitation skills training

From: August, Bloomquist et al., Personal Communication, May 2010
Rivera Example Block Diagram

Clinical Judgment

Parental Function Goal $pF_{Goal}$

Decision Rules

If $PF(t)$ is “Very Poor” then Weekly Visits
If $PF(t)$ is “Poor” then Bi-Weekly Visits
If $PF(t)$ is “Below Threshold” then Monthly Visits
If $PF(t)$ is “At Threshold” then No Visits

Intervention $I(t)$

Disturbances (e.g. job loss, stress) $D(t)$

Process (Open-Loop)

Outcome: Child Conduct Disorder

Review Interval ($T=1$ or 3 months)

Family Functioning Questionnaire

Parental Function $PF(t)$
Early Risers SMART Design as a Block Diagram with Nested Feedback Loops

**Clinical Judgment**
- **Absenteeism or School Maladjustment**
  - Decision Rules (x)
    1st deliver A
    2nd deliver B1 / B2
    3rd deliver all
  - A. Child/Family Support
  - B1. Child Skills Training
  - B2. Family Skills Training

**Disturbances (x)**
- (e.g., life events)
  - Process (x)
    Intervention fidelity, moderators, mediators, etc.

**Outcome (Y)**
- Conduct Problems
  - Review Interval (T=3 months)
  - Sensors
    - 0-1 absences;
    - ½ SD improvement on any of Strengths & Difficulties Questionnaire

**Needs Assessment**
- Intervention mediators / moderators
- Response to intervention
  - responders: maintain intervention;
  - nonresponders: provide augmentation intervention
Inspection of Individual Outcomes

Attendance

Participant Index

time (Month)
How Can Prevention Benefit from Engineering Control Methods?

Value-added analytic techniques

Providing useful, to date unparallel concepts

Methods to examine & improve an individual’s outcomes of preventive intervention
How Can Engineering Control Benefit from Prevention Science?

Research funding / collaboration

Provide parameter estimates for models

Input on strengths and areas of need for adapting methods to behavioral health
