Excitable Media Model to Measure Cardiovascular Risk

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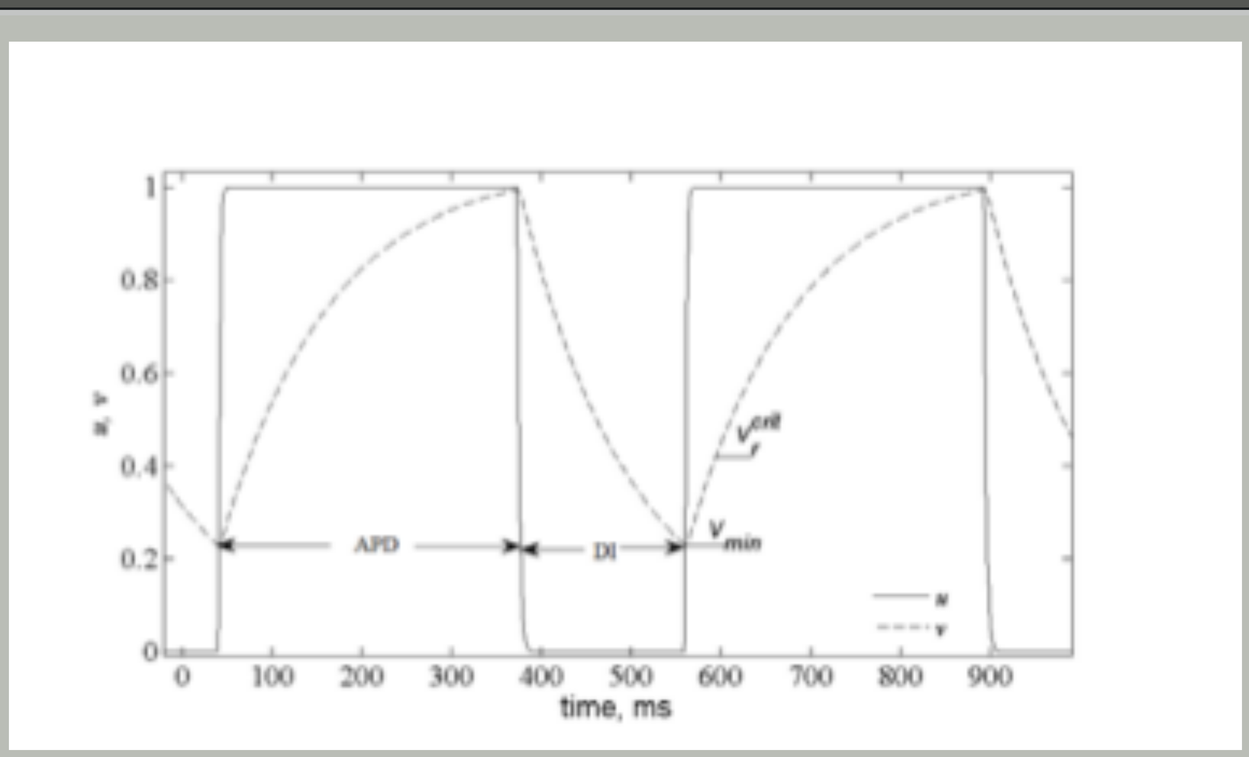
Chernyak-Starobin-Cohen Model

$$\frac{\partial u}{\partial t} - \frac{\partial^2 u}{\partial x^2} = -i(u,v)$$
$$\frac{\partial v}{\partial t} = \varepsilon[g(u) - v]$$

$$i(u,v) = \begin{cases} \lambda u & , \text{ if } u < v \\ u - 1 & , \text{ if } u \geq v \end{cases}$$



Source: Idris, et al (2012)

CSC Model is Solvable

- Chernyak-Starobin-Cohen (CSC) Model is exactly solvable, but tedious
- Instead we decouple the two variables by restricting ***u*** to the value of 0 or 1
- Approximate solution can now be found with a simple separation of variables of the total derivative

Separation of Variables

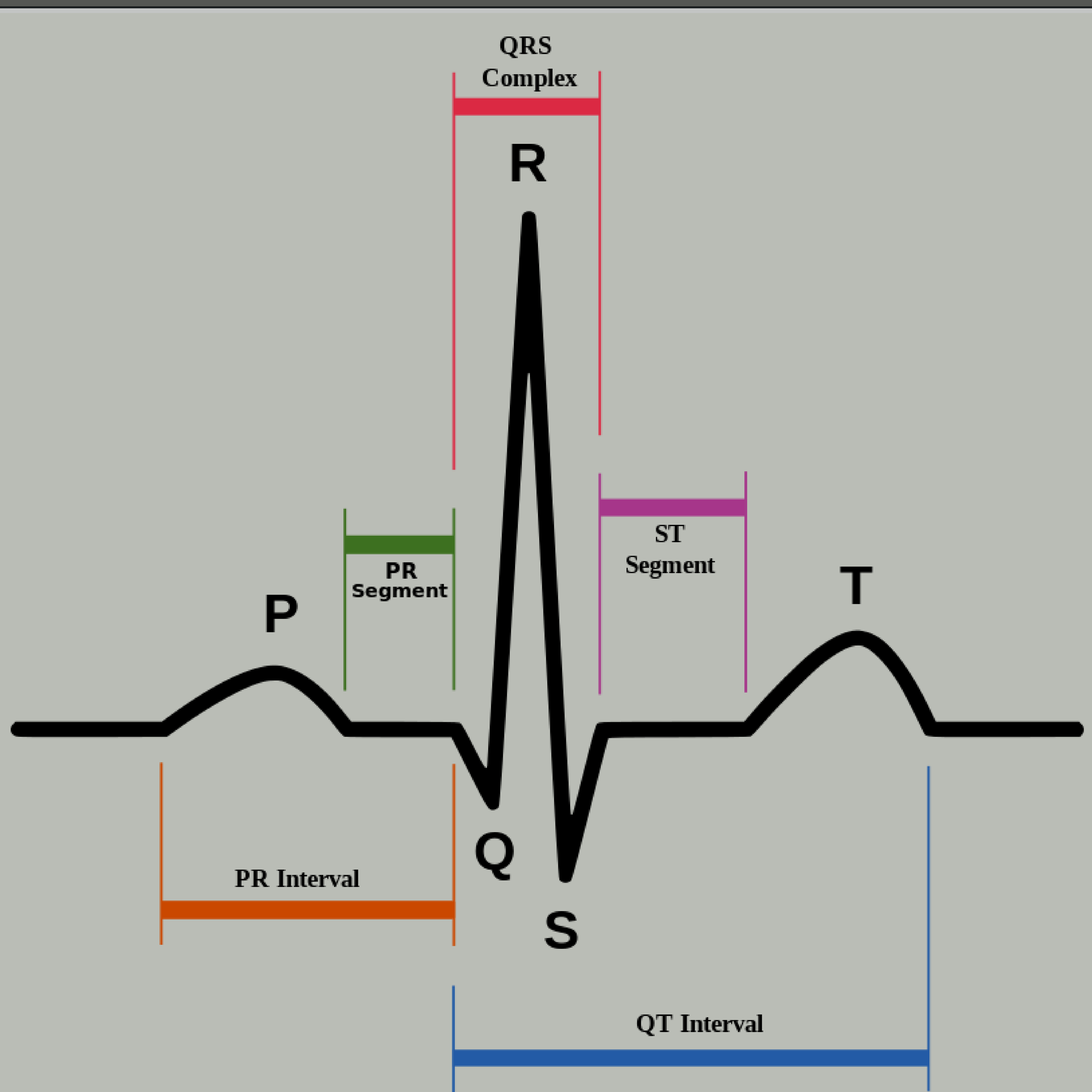
$$\varepsilon \int dt = \int \frac{dv}{\zeta u + v_r - v}$$

Sums Over QT and DI Intervals

$$QT = \frac{1}{\varepsilon} ln\left[\frac{\zeta + v_r - v_{min}}{\zeta + v_r - 1}\right]$$

$$DI = \frac{1}{\varepsilon} ln\left[\frac{1 - v_r}{v_{min} - v_r}\right]$$

Heart Intervals



Source: Wikipedia User:Agateller

Application

- There is a minimum membrane potential (v_r^{crit}) that ***v*** must drop below for another heart beat to start
- Using an ECG measurement from a cardiac patient the ideal model can be fitted
- Solving for the distance between v_r^{crit} and v_{min} predicts the chances of the membrane potential not reaching the minimum voltage for the next beat to start. This distance is called the Reserve of Refactoriness (RoR)

$$RoR = \frac{v_r^{crit} - v_{min}}{v_r^{crit}}$$

Experimental Status

- The paper *Feasibility of Non-Invasive Determination of the Stability of Propagation Reserve in Patients* (2012) establishes the accuracy of the model compared to detailed heart measurements in healthy patients
- Dr. Starobin's team is currently applying the model to analyze CNT toxicity in mice