Formal models for personality dynamics

Part of a symposium:
Methodologies for Studying Personality Dynamics and Processes
ARP preconference
Personality Dynamics, Processes, and Functioning

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Slides at http://personality-project.org/sapa.html

Outline

First, some advertisements

1. Revelle and Wilt (2017): Analyzing dynamic data: A tutorial. Personality and Individual Differences. (DOI: 10.1016/j.paid.2017.08.020)
    - Examples of multilevel reliability using R and the *psych* package
2. Wilt and Revelle (2017) The Big Five, everyday contexts and activities, and affective experience, Personality and Individual Differences. (DOI: /10.1016/j.paid.2017.12.032)
3. Wilt and Revelle (2017) A personality perspective on situations (in Funder, Rauthman, & Sherman: The Oxford Handbook on Psychological Situations)
4. Revelle, W. and Wilt, J. (2017) The dynamics of affect: the example of anxiety: presented at ISSID, Warsaw, 2017.
5. Revelle. W. and Condon, D. (2015) A model for personality at three levels, Journal of Research in Personality. 56. 70-81.

To state the obvious: People differ

1. People differ over time and situations in their *within individual* patterns of feeling, wanting, thinking and doing
2. People differ *between individuals* in their average patterns of feeling, wanting, thinking and doing
3. People differ in the situations they choose, the subjects they study, the jobs they take, the groups they join, the people they marry
4. Can we model these differences?
5. Can we model these differences at different levels of analysis with one model?

Traits and States

1. To us, personality is the coherent patterning over time and space of affect, behavior, cognition, and desire (the ABCDs of personality). Although many study *mean levels* of the ABCDs, we find it more fruitful to study how the ABCDs *change* over time and across situations. That is, the *dynamics* of behavior.
2. The trait-state distinction is typically seen as the distinction between what one *usually* feels, does, thinks, or wants and what one is feeling, doing, thinking or wanting at the *moment*. This distinction is seen in the instructions for such measures as the State-Trait Anxiety Inventory (Spielberger, Gorsuch & Lushene, 1970) with such instructions as to respond how you normally feel versus how you feel right now.
3. Indeed, Fleeson and his colleagues think of traits as merely the central tendencies of the distribution of personality states (Fleeson, 2001; Fleeson & Jayawickreme, 2015).

Traits, states, and time

1. Inspired by the work of Atkinson & Birch (1970) on the *Dynamics of Action* my colleagues and I have emphasized the temporal sequencing of states and incorporated time as a necessary variable to consider in our models (Revelle & Michaels, 1976; Humphreys & Revelle, 1984; Revelle, 1986; Revelle & Condon, 2015).
2. We refer to the reparameterization of the original DOA model as the CTA model (for Cues-Tendency-Action) (Revelle, 1986; Revelle & Condon, 2015)
3. Although the formalization of this model is a set of differential matrix equations, this can be seen as a flow diagram which results in a dynamic model of rising and falling action tendencies as actions are expressed (Revelle & Condon, 2015).
4. An example of a computational model combining the CTA model with Reinforcement Sensitivity Theory (Gray & McNaughton, 2000) has been given by Brown (2017) as well as others (Fua, Horswill, Ortony & Revelle, 2009; Fua, Revelle & Ortony, 2010).

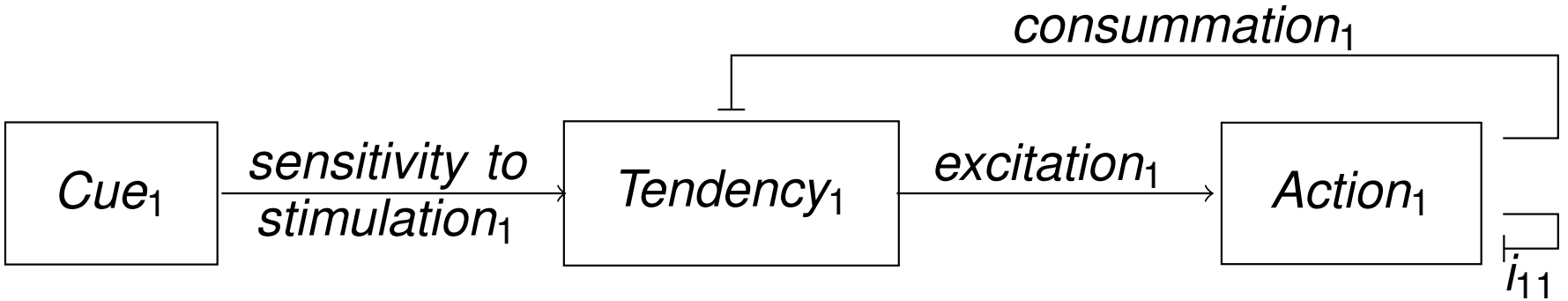
Related models

1. The CTA model is one of a small set of computational models of personality dynamics. It is implemented as the `cta` function in the *psych* package (Revelle, 2018) in R (R Core Team, 2017).
2. Steve Read and Lynn Miller and their colleagues (Read, Vanman & Miller, 1997; Read, Monroe, Brownstein, Yang, Chopra & Miller, 2010; Yang, Read, Denson, Xu, Zhang & Pedersen, 2014) have developed a clearly formulated neural net model of personality dynamics.
3. Alan Pickering (2008) has several dynamic models of Reinforcement Sensitivity Theory (Gray & McNaughton, 2000).
4. Atkinson, Bongort & Price (1977) reported a computer implementation of the Dynamics of Action (Atkinson & Birch, 1970).
5. Ashley Brown is working on releasing the R code for her implementation of an extension of the CTA to include Reinforcement Sensitivity Theory (CTARST).
6. Colin DeYoung (2015) presented a cybernetic model of personality, which is not implemented as a computational model.

The basic model consists of Cues, Tendencies, and Action

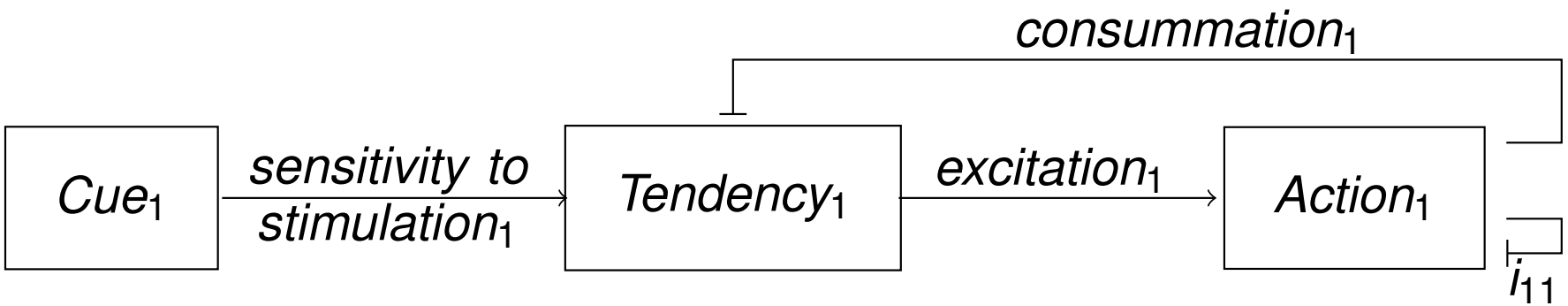
1. Environmental Cues stimulate Tendencies (aka desires/wants)
2. Tendencies in turn excite Actions (aka Behaviors)
3. Doing an Action reduces the Tendency (consummation)
4. Stable individual differences are *sensitivities* to the stimulation of Cues and the strength of excitation given a Tendency.
5. The most important concept is the that these happen over time. Thus, we are modeling *rates of change over time*.

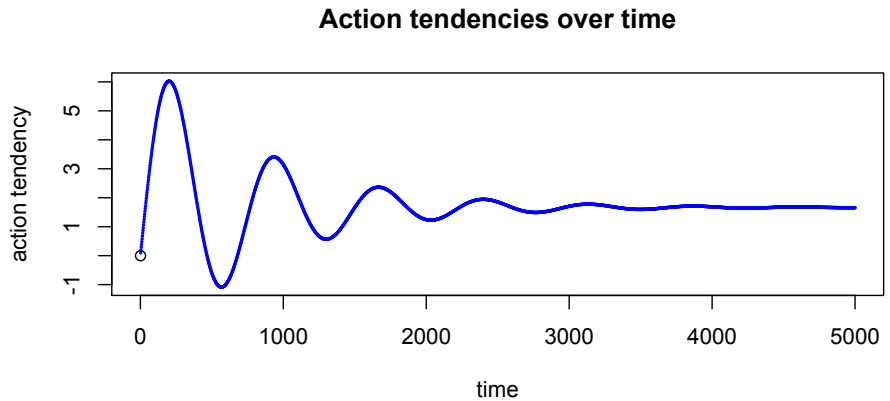
$$dT = sC - cA \qquad dA = eT - iA$$

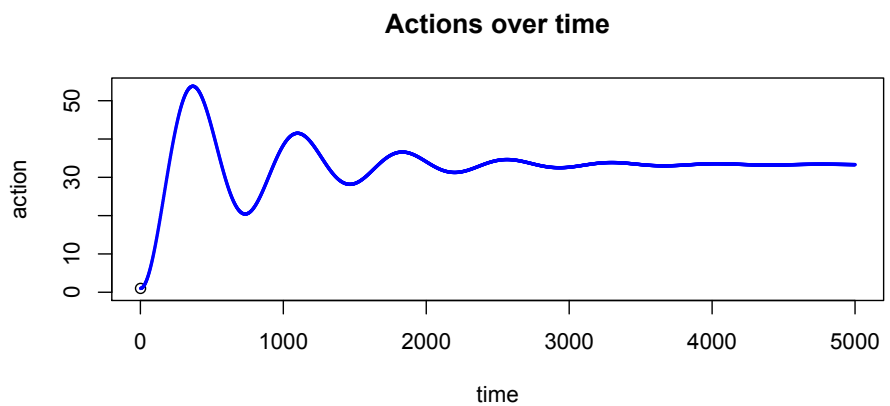


$$dT = sC - cA$$

$$dA = eT - iA$$







A simplified model of the Cues, Tendency, Action model. A cue stimulates action tendencies (desires/wants) which in turn excite actions (behaviors). Doing the action reduces the action tendencies. Asymptotic values of tendencies and actions reflect Cue strength, stimulation, consummatory and inhibitory values.

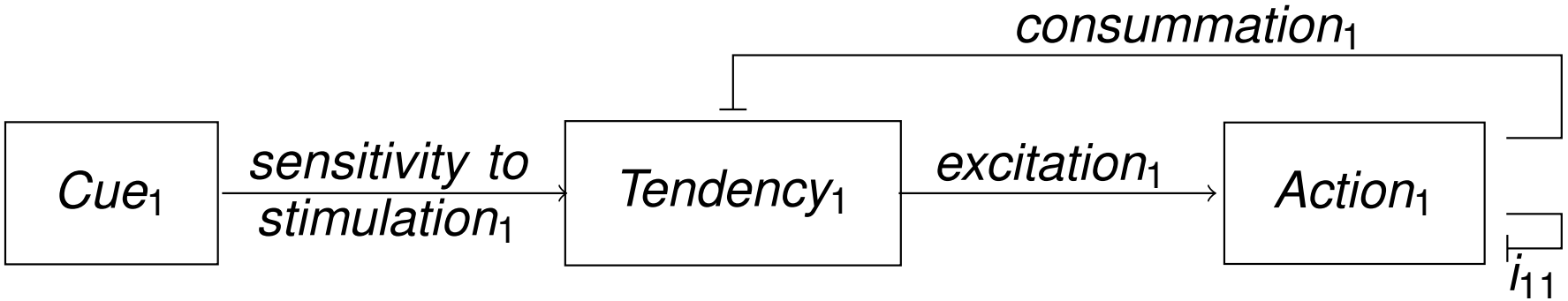
Formal parameters of the model

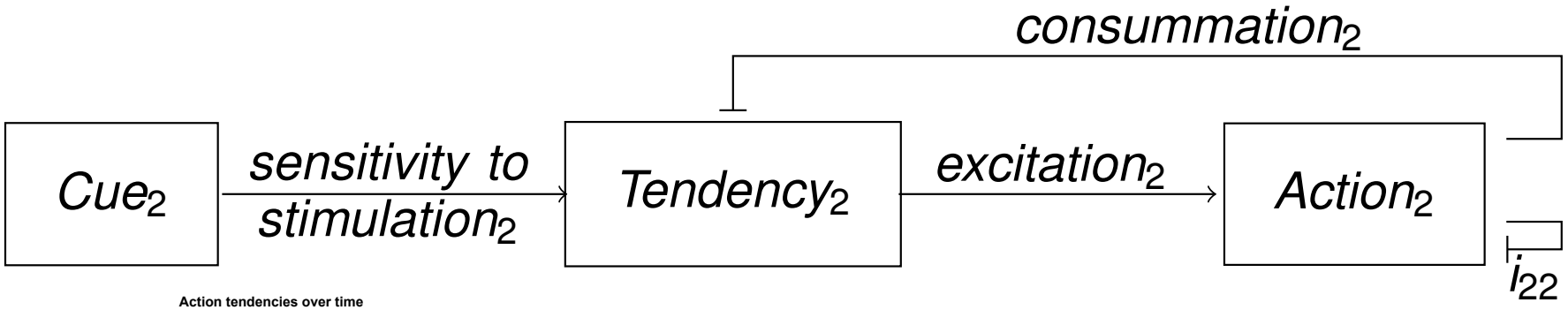
Table: The basic elements of the **cta** model. The environmental input to the system (the cues) are variable as the individual interacts with the world. The strength of these cues upon action tendencies is moderated by the connection strengths in the stimulation matrix. The resulting tendencies have inertial properties (unchanging unless acted upon: increasing when stimulated, decreasing when consummated.) The action tendencies induce actions through the excitation connections. Actions also have inertial tendencies but are reduced by other actions as well doing the action (self inhibition). The connections of the matrices may change over time to reflect learning in a long term response to the reinforcement of actions.

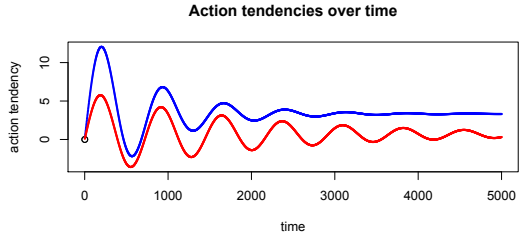
Dynamic Vectors		Stable matrices	
Cues	**c**	Sensitivity to stimulation	**S**
Action Tendencies	**t**	Excitation	**E**
Actions	**a**	Consummation	**C**
		Inhibition	**I**

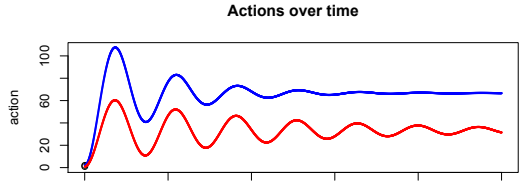
Two compatible actions

$$dT = sC - cA \qquad dA = eT - iA$$









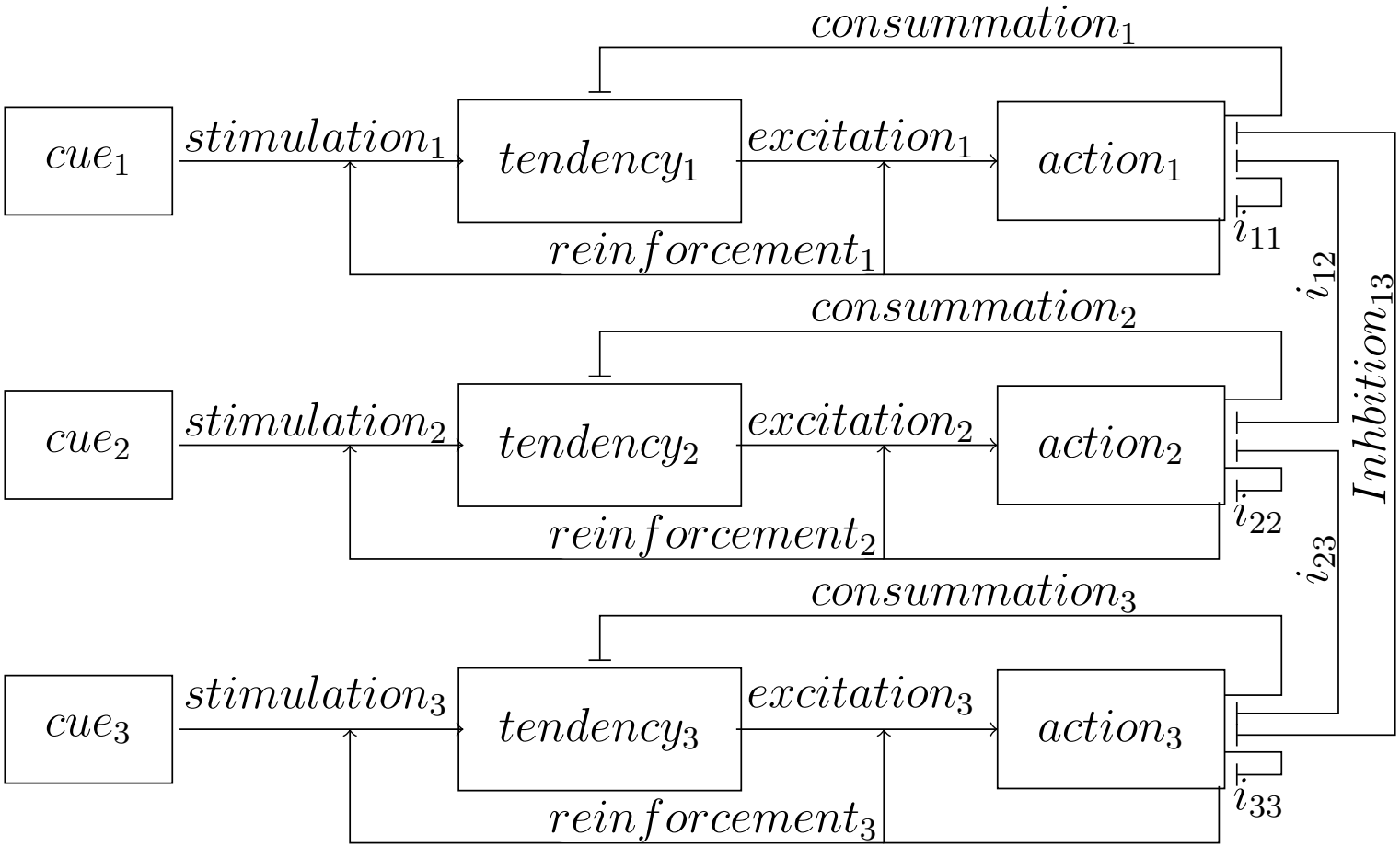
The cues stimulate action tendencies (wants) which in turn excite actions (behavior). Doing the actions reduces the action tendencies. Actions may differ in their consummatory value.

But in general actions are incompatible

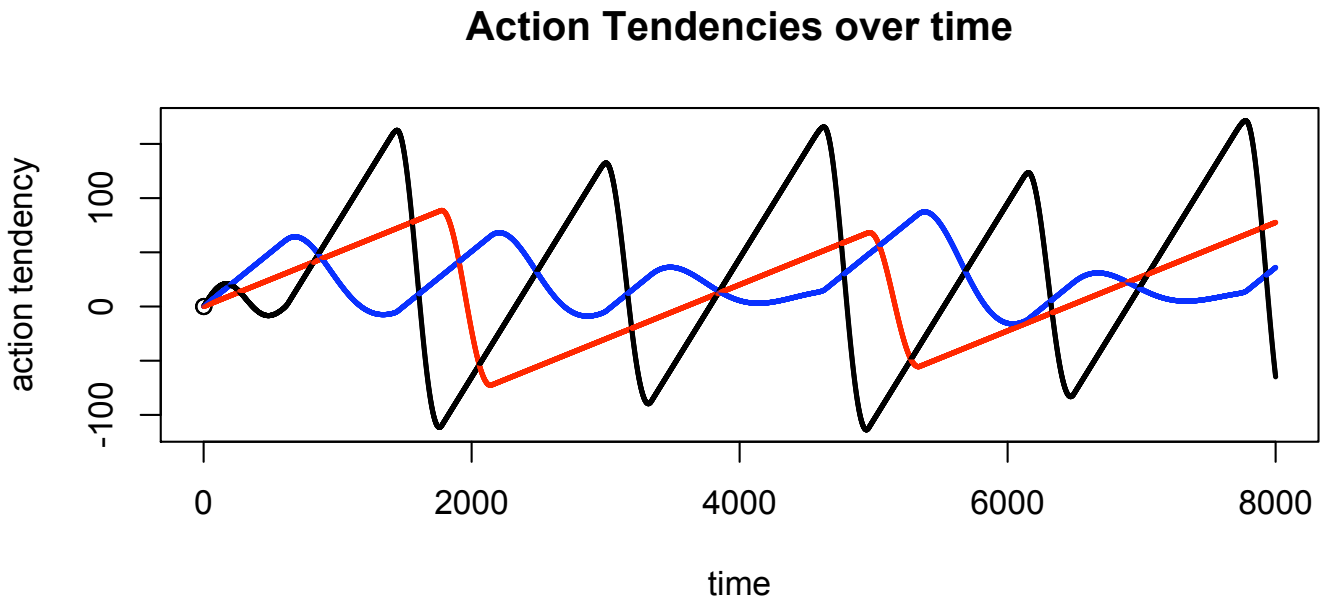
1. Environmental Cues stimulate Tendencies (desires/wants).
2. Tendencies in turn excite Actions (behavior).
3. Doing an Action reduces the Tendency (consummation/liking).
4. Stable individual differences are sensitivity to the stimulation of Cues and the strength of excitation given a Tendency.
5. If actions are incompatible (Some people can not walk and chew gum at the same time), more interesting things happen. (A memorable example of incompatible responses is found in the newt, which copulates under water, but breaths at the surface. By increasing the oxygen content of the atmosphere, the length of each copulatory bout is prolonged (Halliday, 1980; Halliday & Houston, 1991)).
6. Tendencies (wants) run off in parallel, but actions (behaviors) run off in series.

CTA: Cues-Tendency-Action model as a flow diagram representing two matrix differential equations

$$dt = Sc - Ca \qquad dA = Et - Ia$$

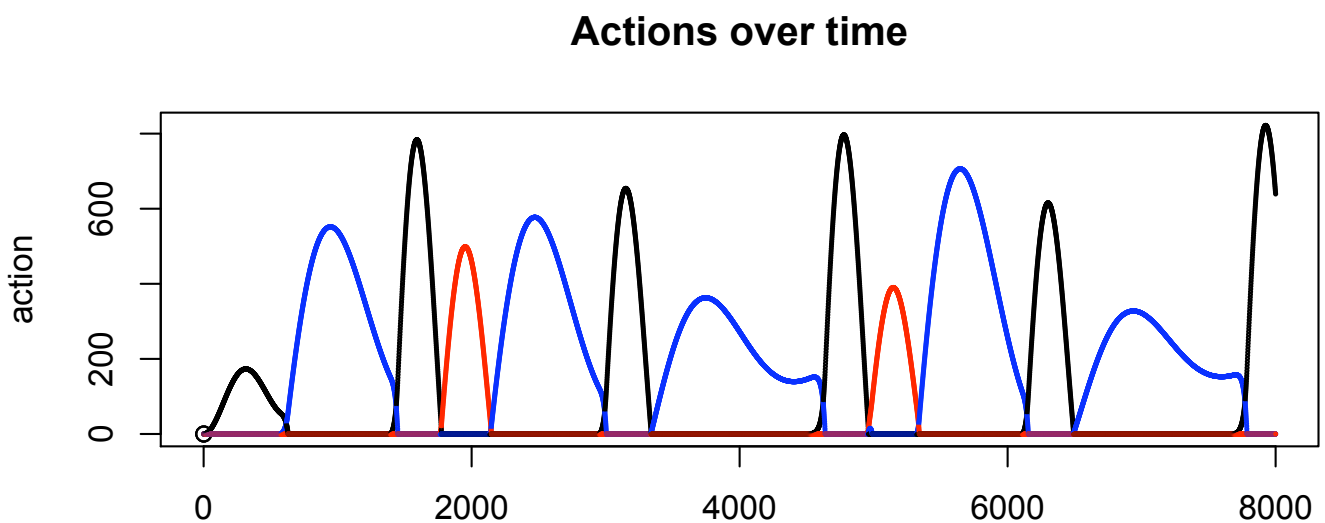


CTA: Three incompatible activities



As scientists:

We infer desires/tendencies as they run off in parallel.



We observe actions (behaviors) as they inhibit other actions and thus happen in series.

Nice equations, nice pictures, but what is the evidence?

1. That motivations have inertial properties is an idea that goes back to Lewin, Adams & Zener (1935) and Zeigarnik (1927) and then later expanded (Feather, 1961; Kuhl & Blankenship, 1979).
   - With the basic assumption that motivational states have *inertia* and resulting carry over from trial to trial we have shown (Revelle & Michaels, 1976) that modeling the prior history of success and failure as a function of task difficulty leads to a reconciliation of the curvilinear models of motivation of Atkinson (1957) with the linear effort model of Locke (1968).
2. We have also shown that it is the *decay rate* of the effect of anxiety impairing performance that is itself a function of trait anxiety (Gilboa & Revelle, 1994).
3. We have suggested that the detrimental effects of anxiety are transitory, with high anxiety hurting performance early but not later in complex tasks (Humphreys & Revelle, 1984).
4. We have shown that thinking dynamically allows us to model situational choice and affective reactions within individuals over time (Wilt & Revelle, 2017a,b).

Modeling between subject differences in within subject variation

1. Josh Wilt and I have examined the *between subject* differences in the *within subject* pattern of emotional response over time by using cell phone-text messaging techniques (Wilt, Funkhouser & Revelle, 2011; Wilt, Bleidorn & Revelle, 2016, 2017).
2. These data as well as experimental manipulations of affect (Smillie, Cooper, Wilt & Revelle, 2012) can be modeled quite well by an extension of the CTA that includes components of RST (Gray & McNaughton, 2000). This work was done by Ashley Brown (2017) and is being prepared for publication.
3. All the models I have shown are written in the open source R language and are included in the *psych* package as the `cta` (which learns, badly) and `cta.15` (which doesn't learn) functions.

Ashley Brown's simulation matches experimental data quite well

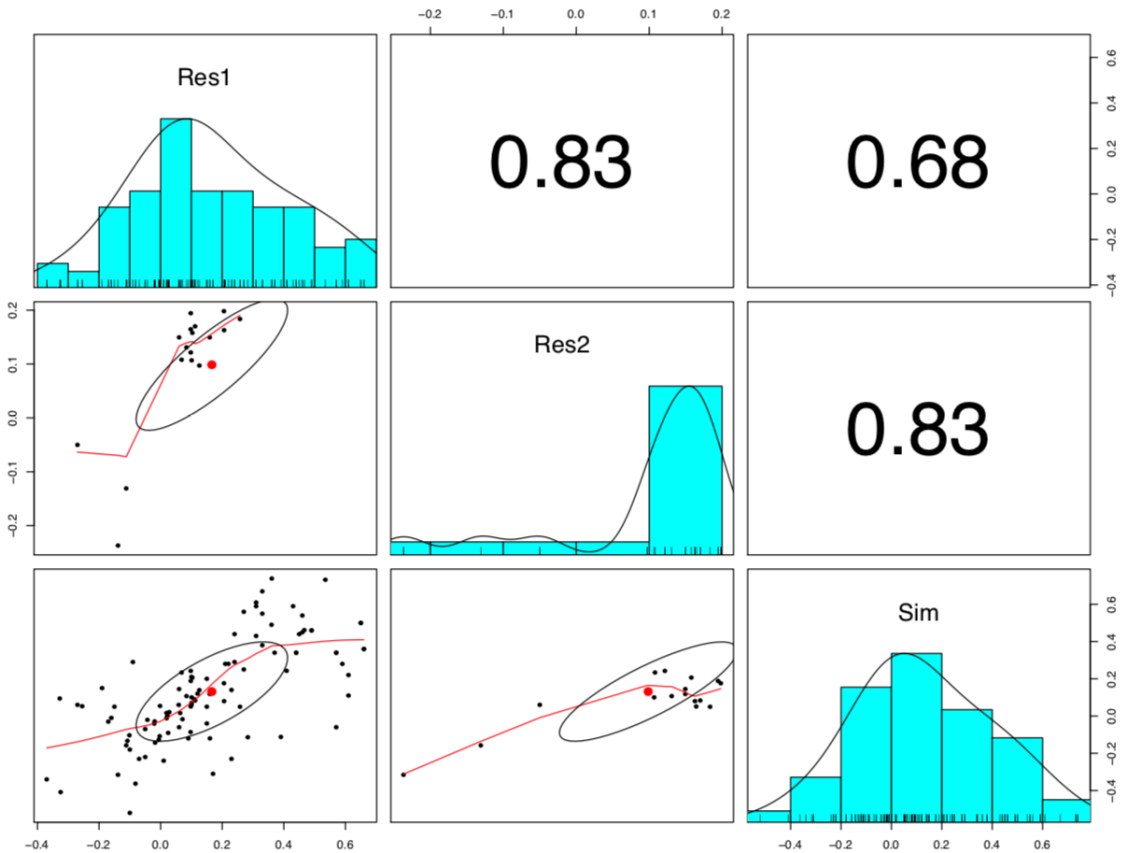


Figure 7.1: Correlations between original and simulated statistics across studies

Simulated effect sizes versus observed (Brown, 2017). Studies modeled include (Smillie et al., 2012; Wilt et al., 2011, 2016)

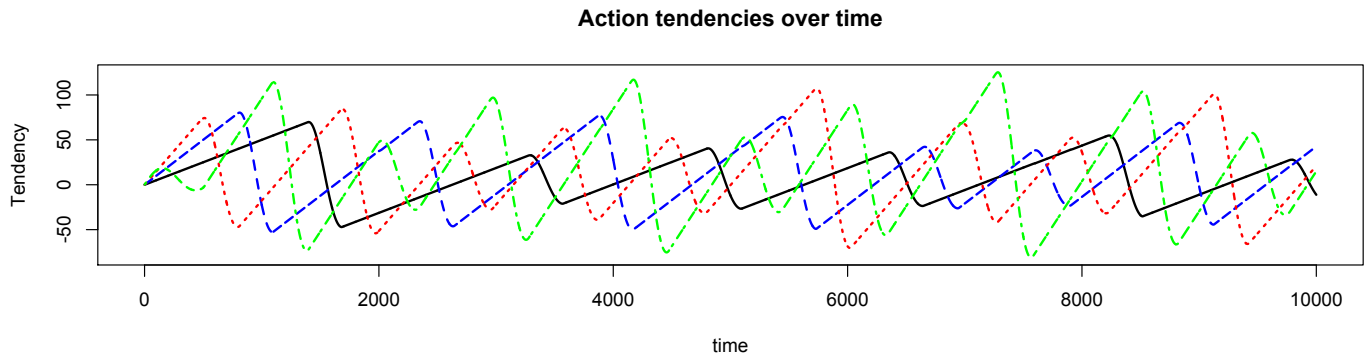
Modeling within person dynamics, between person dynamics

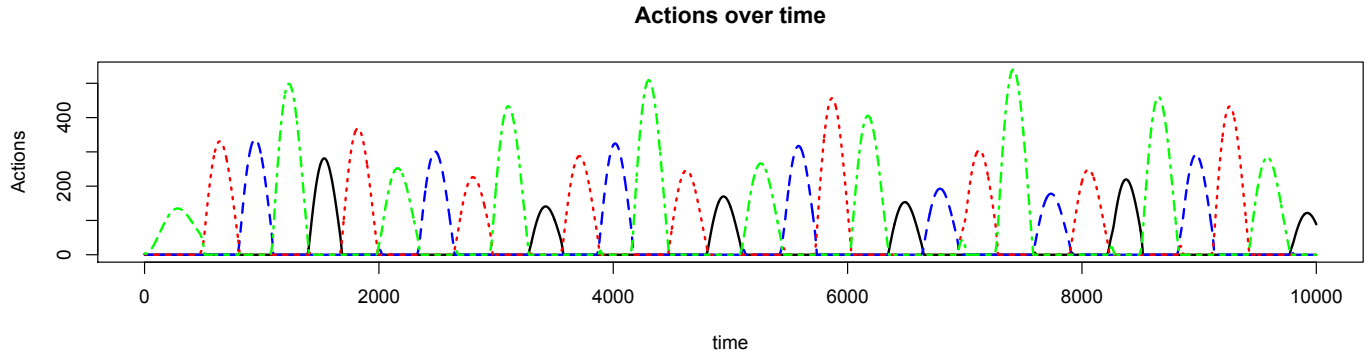
1. Conceptually, CTA is a model of the dynamics of wants/desires/actions within individuals.
2. But this model can easily be extended to between individual behaviors.
3. Each individual can be separately modeled, and their combined behaviors seen as inhibiting each other.
4. The fundamental measures are
   - Growth and decay rates of tendencies as measures of trait sensitivity to cues and actions.
   - choice (doing A implies not doing B, C, D)
   - persistence (how long do you do A)
   - latency (how long do you do B, C, D, before doing A)
   - intensity (Strength of action)

Social behavior

1. Social behavior is typically seen as an example of extraversion and agreeableness. Social interaction can be modeled using the CTA model.
2. The desire (action tendency) of four people reflects their interest in talking and when one person is talking, that inhibits the others.
3. Consider 4 individuals with different sensitivities (growth rates) to cues for talking.
4. One person talking inhibits the others. Desires to talk run off in parallel, but behaviors are sequential.
5. Differences in growth rates result in differences in latency and persistence. Note that one person talks frequently while another is much less involved (Figure 20).

Four People differing in their sensitivities to social behavior





People differ in their growth rates for desire to talk.

Polite people take turns: One person talking inhibits others from talking.

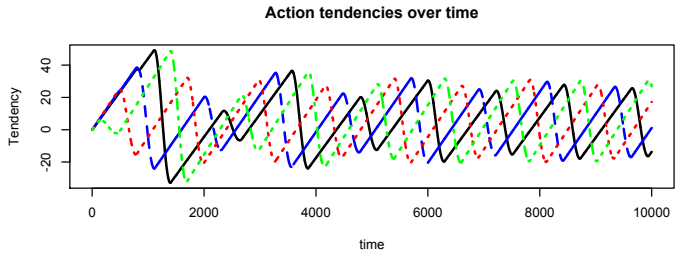
Experimental studies of talking behavior

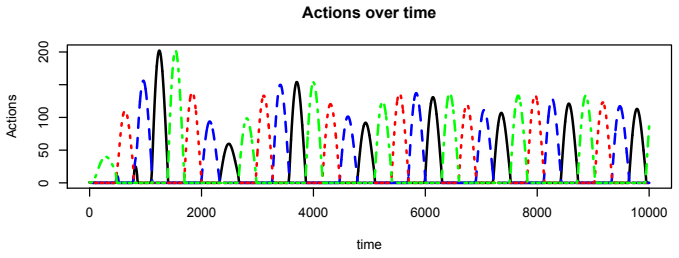
1. John Antill examined the effect of group size on talking behavior for introverts and extraverts (Antill, 1974).
2. In groups of size 2, introverts and extraverts talked an equal amount (this is called conversation and turn taking).
3. But, as group size increased, extraverts tended to dominate the conversation.
4. Lets model this with 3 groups:
   - 4.1 4 introverts (slow growth rates to social cues)
   - 4.2 4 extraverts (high growth rates to social cues)
   - 4.3 2 introverts who have the misfortune of being paired with 2 extraverts

Simulation of 4 individuals differing in their excitation of a tendency

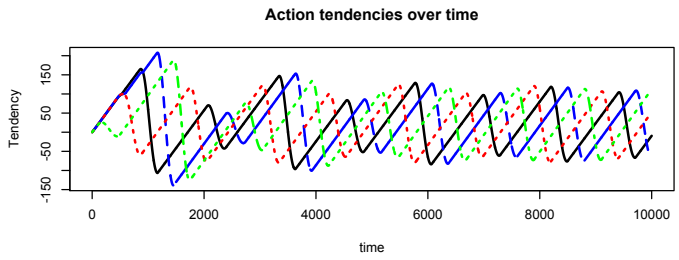
Tendencies (Wants)

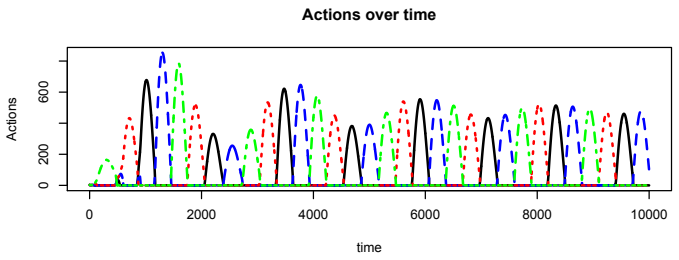
Actions (Behavior)



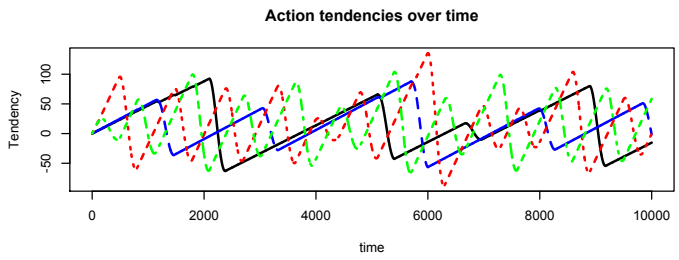


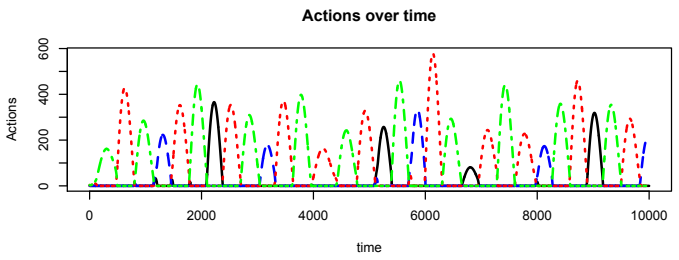
4 introverts share their time





4 extraverts share their time





2 introverts, 2 extraverts extraverts dominate conversation

Behavior varies over time and by context.
Tendencies and Actions can differ in intensity

Modeling the desire to talk and talking behavior

Subject	Sensitivity to cues	Time Spent	Frequency	Av. Tendencies	Av. Actions
		Four introverts			
I1	0.95	0.24	16	6	80
I2	1.00	0.25	16	5	80
I3	1.05	0.24	16	5	83
I4	1.10	0.27	16	6	79
		Four extraverts			
E1	3.95	0.25	16	21	322
E2	4.00	0.24	15	26	335
E3	4.05	0.25	16	20	313
E4	4.10	0.26	15	23	297
		Two introverts, two extraverts			
I1	0.95	0.11	8	14	167
I2	1.00	0.13	9	14	150
E1	4.05	0.37	22	15	215
E2	4.10	0.38	21	15	210
		Full range of Introversion-Extraversion			
IE1	1.00	0.17	11	9	123
IE2	2.00	0.21	14	12	182
IE3	3.00	0.28	18	14	208
IE4	4.00	0.34	19	16	230

Dynamics of behavior can be modeled

1. The study of dynamics is the study of how people change over time.
2. CTA is one way to combine theories of choice, persistence, latency, intensity into a personality model of individual differences.
3. The fundamental stabilities in individuals are how rapidly they change within and between situations
   - Traits are the first derivatives of states.
4. We do not expect constancy in behavior, we expect change.
   - But change is predictable, not random.
   - Traits are rates of change in behavior, not just density distributions of actions.
5. We should expect (and model) change and variation.
   - How rapidly we change in response to situational cues reflects our basic sensitivities to those cues.
   - Behaviors persist until other wants are more salient.

1. Slides are available at personality-project.org/sapa.html.
2. Code is available as `cta` in the *psych* package.
3. Sponsored in part by a grant from the National Science Foundation: SMA-1419324 to support the International Cognitive Ability Resource (icar-project.org).
4. Visit the sapa-project to study personality.
5. Use R in psychological research: personality-project.org/r

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