Modeling the dynamics of action

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Outline

Personality can be modeled at multiple levels of analysis
- Ways of viewing coherence
- Levels of analysis

Dynamic models
- Dynamics of Action (DOA
- Cues, Tendencies, Actions (CTA)

Within individual differences

CTA + Reinforcement Sensitivity Theory
- Reinforcement Sensitivity Theory (RST)
- CTARST

Conclusions and future directions

Personality as coherence over time and space

1. Personality is an abstraction used to describe and explain the coherent patterning over time and space of affect, cognition, and desire as they result in behavior for an individual.
   - Reputation: How others see our behavior.
   - Identity: How we interpret our behavior as the result of our affects and our cognitions.
2. This unique patterning or individual signature reflects a complex set of dynamic processes that can be described at three levels of analysis: within individuals, between individuals, and between groups of individuals.
3. It can be measured at different levels of temporal resolution and different levels of specificity.

Observing and explaining the stream of behavior

- To all observers, the dynamic processes of the stream of feelings, thoughts, motives and behavior show a unique temporal signature for each individual.
- To an individual differences theorist, the how and why individuals differ in their patterns is the domain of study.
- To a biologically minded psychologist, these dynamic processes reflect genetic bases of biological sensitivities to the reinforcement contingencies of the environment.
- To a mathematically oriented psychologist, these dynamic processes may be modeled in terms of the differential equations of the Dynamics of Action.

Multilevel analysis can yield surprising results

Although it is well known that the structure within a level does not imply anything about the structure at a different level, this distinction is frequently forgotten.

1. Various names for the phenomena:
   - Yule-Simpson paradox (Simpson, 1951; Yule, 1903)
   - The fallacy of ecological correlations (Robinson, 1950)
   - The within group–between group problem (Pedhazur, 1997)
   - Ergodicity (Molenaar, 2004)
2. This distinction will be important as we consider models of coherency and differences within-individuals, between-individuals, and between groups of individuals.

Thinking by analogy

1. Anna Baumert and colleagues considered the many theoretical problems facing those of us who want to propose integrative theories (Baumert, Schmitt, Perugini, Johnson, Blum, Borkenau, Costantini, Denissen, Fleeson, Grafton, Jayawickreme, Kurzius, MacLeod, Miller, Read, Robinson, Roberts & Wood, 2017).
2. In a commentary on that article David Condon and I have suggested that it useful when searching for explanations at these multiple levels to consider the physical analogy of weather, climate, and climate change which are all driven by the same underlying cause (the balance of solar radiation and re-radiation) but have complex lower level drivers that have larger immediate effects (Revelle & Condon, 2017).
3. We argued that weather:climate:climate change :: emotion:personality:personality development
4. Thus we search for general models that can be applied at these multiple levels.
5. One such model is the Dynamics of Action (Atkinson & Birch, 1970)

Modeling individual dynamics

Personality is an abstraction used to describe and explain the coherent patterning over time and space of affect, cognition, and desire as they result in behavior for an individual.

1. That people change their behavior over situations is obvious.
2. That people also change their behavior in the same situation is less obvious, but equally important.
3. We need to model the processes that lead to change within and across situations.
4. One such model is the Dynamics of Action (Atkinson & Birch, 1970).
5. Such dynamic models, assessed at different lengths of time, are useful to understand within individual, between individual, and between group differences.

Dynamics of Action: A theory before its time

1. Atkinson & Birch (1970) proposed a motivational model that was both very simple and very complex.
   - A set of simple assumptions such as that motives have inertia and only change if acted upon.
   - Complex in that it required understanding differential equations.
   - Early evidence was supportive but limited to achievement motivation (Revelle & Michaels, 1976; Kuhl & Blankenship, 1979; Atkinson, 1981).
2. A reparameterization of the DoA is also very simple and is somewhat less complex.
   - The Cues-Tendencies-Actions (CTA) model (Revelle, 1986) has been discussed before (Revelle, 2012) and is implemented as part of the `psych` package (Revelle, 2018) in R (R Core Team, 2018).
   - Used in various computer simulations of affective and cognitive behavior (Fua, Horswill, Ortony & Revelle, 2009; Fua, Revelle & Ortony, 2010; Quek & Ortony, 2012).
   - Still requires some understanding of differential equations.

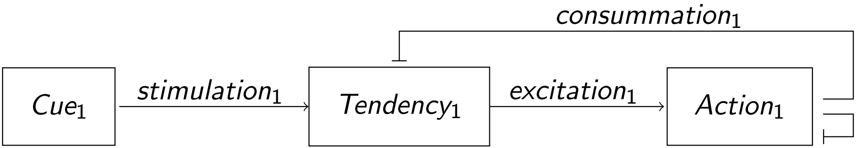
1. David Condon and I reported on the CTA model and showed how it could model personality at three levels of analysis (Revelle & Condon, 2015): within individual changes, between person behavior, and even the niche selection that differentiates groups of individuals as personality develops over time.
   - This paper was light on data and heavy on theory with examples that were said to fit the model but with little evidence.
2. Ashley Brown (Brown, 2017) has extended CTA to include Reinforcement Sensitivity Theory (Gray & McNaughton, 2000; Corr, 2008; Revelle, 2008; Corr, 2016) into the CTARST model.
   - She has implemented the CTARST model as an R package that is still under development and not yet released to CRAN.
   - The CTARST model was tested against several empirical studies we have conducted and shows a good fit to real behavior.
   - We will discuss this in some detail

The basic concepts: Cues, Tendencies, and Actions

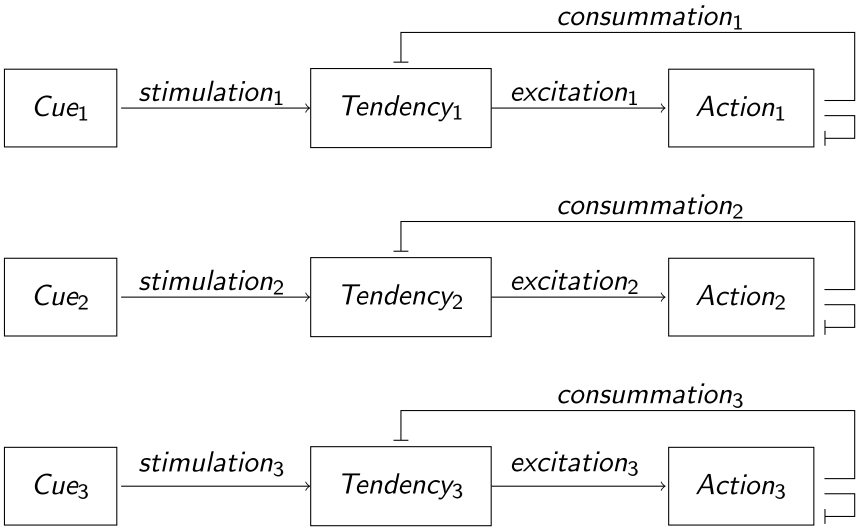
1. Environmental Cues evoke action Tendencies
2. Action Tendencies evoke Actions
3. Actions reduce Action Tendencies
4. Actions inhibit other Actions

This may be summarized in two differential equations

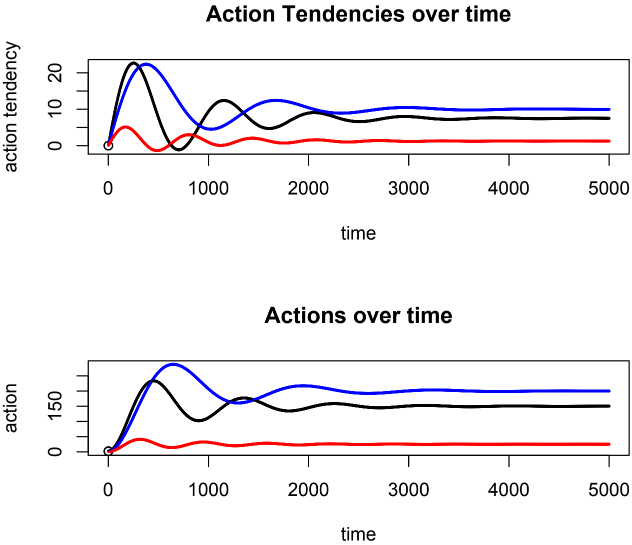
1. $d\text{T} = \text{sC - cA}$
2. $d\text{A} = \text{eT - iA}$
3. where
   - C, T, and A are vectors
   - s, e, c and i are matrices of association strength



3 Cues, 3 Tendencies, 3 Mutually compatible Actions



Three compatible behaviors in a constant environment

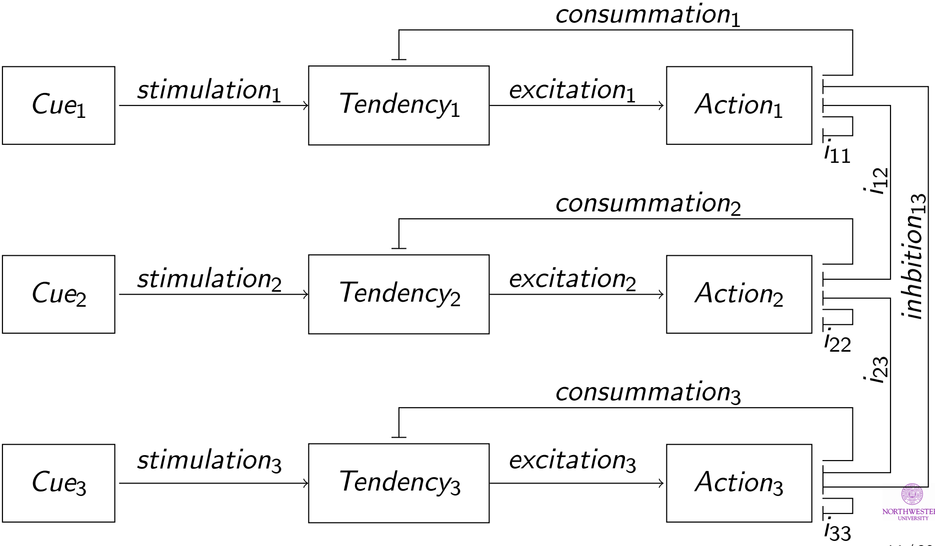


But Actions may inhibit other Actions

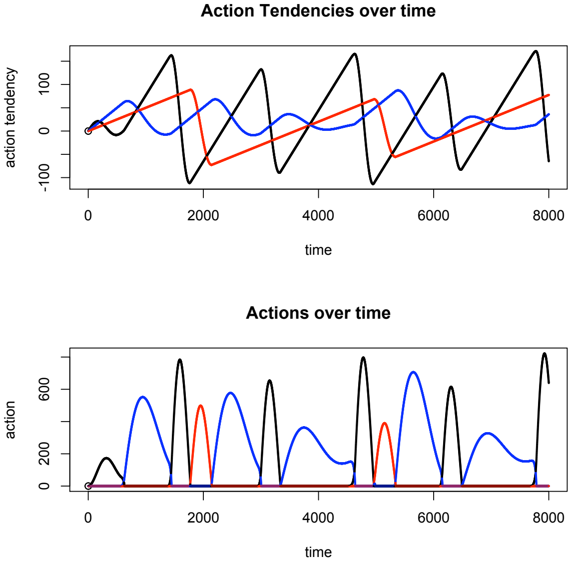
1. The power of a dynamic model is that it predicts change of behavior even in a constant environment where the instigating cues are not changing.
2. With mutually incompatible actions, action tendencies can all be instigated by the environment but only one action will occur at a time.
3. Action tendencies resulting in actions will then be reduced while other action tendencies rise.
4. This leads to a sequence of actions occurring in series, even though the action tendencies are in parallel

3 Cues, 3 Tendencies, 3 Mutually inhibitory Actions

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



3 incompatible actions in a stable environment



Evidence for dynamic models within individuals
Traits as rates of change in states

1. Original model and evidence is summarized in Atkinson & Birch (1970)
   - Predictions for the motivational response to task difficulty derived from Atkinson & Birch (1970) were discussed in Revelle & Michaels (1976) in terms of inertial properties of motivation.
   - Further improvements by Kuhl & Blankenship (1979) who added the full DoA dynamics.
2. Reparameterization of DoA into CTA by Revelle (1986) and some evidence is reviewed in Revelle (2012)
   - Gilboa & Revelle (1994) showed individual differences in decay rates of anxiety on an emotional "Stroop" task.
   - Smillie, Cooper, Wilt & Revelle (2012) show how the trait tendency for positive affect is actually a sensitivity to cues for reward.

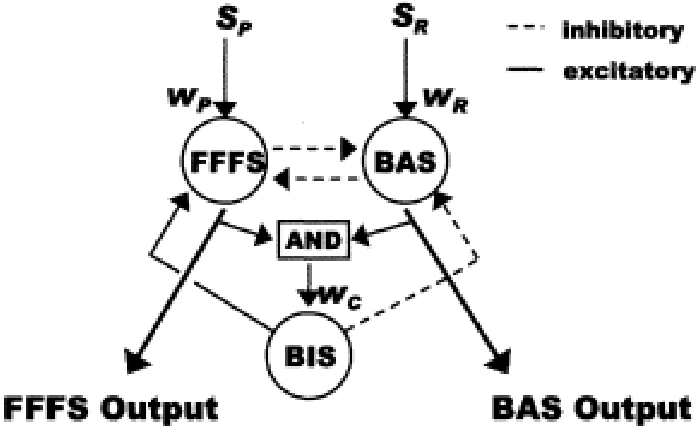
CTA can be applied between individuals as well

1. In our earlier paper, Condon and I suggested that CTA can be used to model within individual changes in affect and behavior as well as between individuals as they compete for limited resources.
2. The evidence for between individuals was a description of talking behavior for people differing in extraversion and simulated data from Antill (1974).
3. Current version of `CTA` and `CTA15` is part of the *psych* package in R. `CTA` is a beginning attempt at learning. `CTA15` is the version of Revelle & Condon (2015)

Reinforcement Sensitivity Theory

1. Developed by Jeffrey Gray and his colleagues (Gray & McNaughton, 2000; Corr, 2008, 2016) and probably the most studied biological model of personality.
2. Three inter-related systems
   - Sensitivity to *Cues* for Reward and the Behavioral Activation System (BAS)
   - Sensitivity to *Cues* for Punishment and the Fight Flight Freeze System (FFFS)
   - Sensitivity to goal conflict and the Behavioral Inhibition System (BIS)
3. These systems act in real time to produce behavior.
4. RST simulations include the work of Pickering & Gray (1999); Pickering (2008); Smillie, Pickering & Jackson (2006).

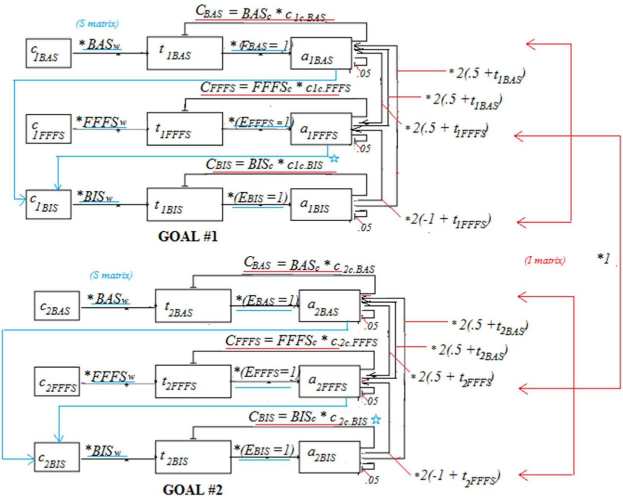
Smillie, Pickering and Jackson's representation of RST



CTARST: Cues Tendencies Action meets Reinforcement Sensitivity Theory

1. Adapting the CTA model to incorporate basic RST parameters is relatively straightforward (Brown, 2017).
2. For a set of goals, each goal may be thought of as exciting the BAS, BIS and FFFS
3. The competition between these systems leads to the resulting behavior
4. Ashley Brown (2017) implemented CTA and RST in the CTARST package in R and compared the model to real data.
5. The problem is how to operationalize affect and choice in a simulation.

CTA + RST = CTARST



Studies fit with CTARST model

- Observed data include those published in:
  - Experiments 1 and 4 in Smillie et al. (2012)
  - Replication 1 in Wilt, Bleidorn & Revelle (2017)
  - Wilt, Funkhouser & Revelle (2011)

CTARST Output

9 Important Variables

- Personalities: 6 parameters; sensitivities to instigating, consummatory BAS, FFFS, BIS cues
- Situations: 6 x (number of goals) param.; instigating, consummatory BAS, FFFS, BIS cues for each goal
- Outcomes: For sets of any or all subjects, experiences, and goals, 9 functions:
  - CTARST computes, for BAS, BIS, and FFFS:
  - Average intensity of system's actions
  - Average duration of system's actions
  - Average falling velocity of system's tendencies
- CTARST returns sets of descriptives for the 9:
  - ...for each subject averaged over all situations
  - ...for each situation averaged over all subjects
  - ...for each of the 9 averaged over subjects and situations
- Also returns data for the 9 averaged over experiences for each subject

CTARST Output

Notation and Relation to Personality DVs

- Instigating and consummatory cue sensitivities (e.g. BAS_w and BAS_c, respectively) can be used to create personality *trait* equivalents, as discussed below.
- Personality and affect *state* equivalents are constructed from the 9 act-and-tendency DVs; for instance:
  - Avg. intensity of BAS-goal acts = $\overline{BAS}_{Ap}$ = positive or pleasant affect, extraversion
  - Avg. intensity of FFFS-goal acts = $\overline{FFFS}_{Ap}$ = negative or unpleasant affect, neuroticism
  - Avg. duration of BAS-goal acts = $\overline{BAS}_{At}$ = *reward velocity*
  - Avg. speed of falling BAS-goal tendencies = $\overline{BAS}_{Tvf}$ = positive or energetic affect
  - Avg. speed of falling FFFS-goal tendencies = $\overline{FFFS}_{Tvf}$ = negative or tense affect

Study 1: Do extraverts get more bang for the buck?

Experiments 1, 4

- Exp 1: Positive, Negative, Neutral mood conditions (btw sub); positive, negative affect (w/in sub)
- Exp 4: Pleasant, Appetitive, Neutral mood conditions; pleasant (PlA), energetic affect (EA)
- Exp 1 State PA = Exp 4 State EA =
$$EA_S = \overline{BAS}_{Tvf}$$
- Exp 1 State NA =
$$NA_S = \overline{FFFS}_{Ap}$$
- Exp 4 State PlA =
$$PlA_S = \overline{BAS}_{Ap}$$
- EPQ Extraversion = $BAS_c + BIS_c + FFFS_c$

Study 2: Velocity explains state personality/affect link

Replication 1; experience-sampled variables

- State Extraversion

$$E_S = \overline{BAS}_{Ap}$$

- State Neuroticism

$$N_S = \overline{FFFS}_{Ap}$$

- State Positive Affect

$$PA_S = \overline{BAS}_{Tvf}$$

- State Negative Affect

$$NA_S = \overline{FFFS}_{Tvf}$$

- (State) Velocity (toward rewards)

$$V_{BAS} = \overline{BAS}_{At}$$

Study 3: Affective synchrony and trait affect

- Trait affect; experience-sampled state affect

- State Pleasant Affect:
$$PA_S = \overline{BAS}_{Ap}$$

- Trait Pleasant Affect:
$$PA_T = -BAS_c$$

- State Unpleasant Affect:
$$UA_S = \overline{FFFS}_{Ap}$$

- Trait Unpleasant Affect:
$$UA_T = -FFFS_c$$

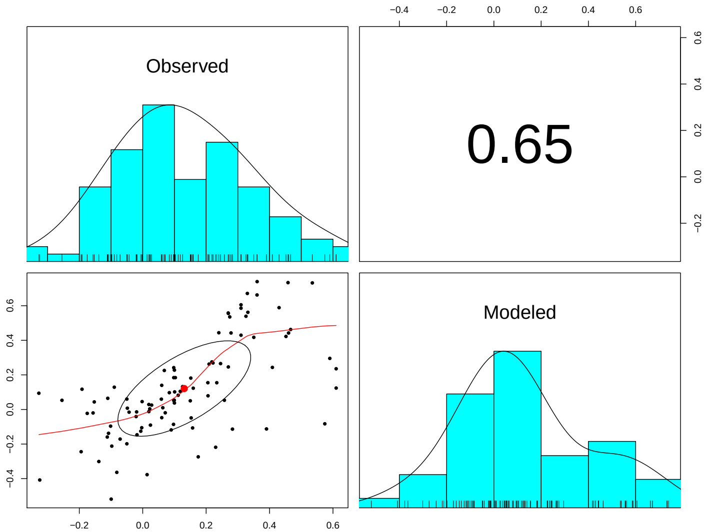
- State Energetic Affect:
$$EA_S = \overline{BAS}_{Tvf}$$

- Trait Energetic Affect:
$$EA_T = BAS_w$$

- State Tense Affect:
$$TA_S = \overline{FFFS}_{Tvf}$$

- Trait Tense Affect:
$$TA_T = BIS_w + FFFS_w - BIS_c$$

Model fit of effect sizes for these studies is not based upon tweaking parameters



Summary

1. People change over time and space.
2. This change can be modeled by conceptualizing rates of change in affect, behavior, cognition and desires as stable personality characteristics.
3. What is stable in someone is how rapidly they change.
4. Models of dynamics are models of choice, persistence, latency and intensity.
5. We have shown that with minimal assumptions such a model (CTARST) can fit real data reasonably well.

Next steps

1. Current version of `CTA` and `CTA15` is part of the *psych* package in R.
2. `CTA` is a beginning attempt at having a learning component to change in response to feedback.
3. Currently is completely deterministic, should be adjusted to be more stochastic.
4. *CTARST* package needs to be released to CRAN or GitHub

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