Modeling Instrumental Conditioning – The Behavioral Regulation Approach

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Abstract

Basically, instrumental conditioning is learning through consequences: Behavior that produces positive results (high "instrumental response") is reinforced, and that which produces negative effects (low "instrumental response") is weakened. Instrumental conditioning plays a major role in learning, but the content of such learning might be desired (e.g. correct cause-effect association) or undesired (superstitious behavior/beliefs). We apply the (relatively) recent behavioral regulation approach to develop a generic system dynamic model of a "classroom example" of instrumental conditioning. The model captures essential aspects of the theory and it enhances understanding of how desirable learning may be promoted and undesired outcomes restrained during an instrumental conditioning process.

The psychology of contiguity

Human beings are extremely sensitive to coincidence, i.e. contiguity in time and space of different events. According to Vyse [1, p. 60] this fact "is both an often overlooked psychological truth and a monumental understatement." Learning is frequently based on noting that events occur closely together – for example, in time. An example is the ability of children to learn the rules of grammar: By observation and experiment on noting co-occurrences, children acquire schemes capable of generating quite complex behavior. But cues-to-causality such as co-variation to infer, and 'learn' causal relations in the environment, may be erroneous in particular instances and lead to the acquisition of superstitious beliefs, with potential for severe human error – learning of falsehoods, "superstitious learning" [2, p. 229-30].

Contiguity in time and space plays a crucial role both in learning of truths and "learning" of falsehoods. The empirical study of contiguity effects on learning began arguably as early as in the 1890's with the studies of Pavlov on classical conditioning [3, p. 41ff] and Thorndike on instrumental (or operant) conditioning [3, p. 81ff]. The basic principle of instrumental conditioning is learning through consequences, what Thorndike called the *Law of Effect*: Behavior that produces positive results is strengthened, and that which produces negative effects is weakened.

The work by Pavlov and Thorndike elicited great interest and generated new research by Watson, Skinner, Hull and others. The success of conditioning studies made behaviorism – the tenet that psychology should only be concerned with the objective data of behavior – a dominant view in psychology, including theories of learning, for decades [4, Ch. 2]. Few learning theorists subscribe today to (radical) behaviorism, but most would agree that the influence of behaviorism can still be felt in e.g. instructional design.

The richness of aspects in learning has lead to a similar richness of theories of learning: behaviorism; cognitive theories of learning (e.g. meaningful learning, schema theory, situated cognition); developmental theories of learning (Piaget's genetic epistemology and others); etc. A pragmatic view would acknowledge that such theories are incomplete and should be seen as complementary or supplementary. But some people take radical stances, going far in ignoring or even opposing other "isms".

Our interest in instrumental conditioning originated from studies of erosion of security and safety awareness [5-7]. We have argued that superstitious learning caused by reinforcement of non-compliant behavior coupled with misperception of risk is likely to play an essential role in the erosion of standards of security and safety. In [8] we extend the system dynamic model for erosion of standards of security and safety developed by one of us. A brief presentation of the model and of its implications for information security is given in [9].

However, the models of instrumental conditioning developed for the issues of security (and safety) are by nature restricted. Instrumental conditioning is central for theories of learning, including organizational learning, and for the acquisition of superstitious behavior and beliefs [1, Ch. 3, p. 69ff, Ch. 4, p. 93ff]. This is where this paper comes in, i.e. modeling the dynamics of instrumental conditioning in a general framework, aiming at capturing essential aspects while keeping an open eye for possible new directions for the psychology of instrumental conditioning. We are hopeful that system dynamical models of this important phenomenon might lead to new

insights in human psychology while contributing to our understanding of how to promote desirable learning and to restrain superstitious thinking and behavior.

The behavioral regulation theory of instrumental conditioning

Instrumental conditioning is learning through consequences: Subject's behavior that produces positive results (high "instrumental response") is reinforced, and that which produces negative effects (low "instrumental response") is weakened. Two aspects are central: (1) Introduction of a contingency between a highly desirable event ("reinforcer") and one perceived by the subject as less desirable ("instrumental response"); needless to say, the instrumental response is the learning goal while the reinforcer is the instrument to employ for achieving the learning goal. (2) Contiguity between instrumental response and reinforcer [3].

The above exposition is likely to be quite abstract for the reader unfamiliar with concepts of instrumental conditioning. We ask for a little patience – the modeling case following soon ("Kim's case") should help.

The behavioral regulation theory is a relatively recent development that answers two key questions about instrumental conditioning, viz. what makes something effective as a reinforcer and how does the reinforcer produce its effect [10-12].

The behavioral bliss point (BBP) is a key concept: According to the behavioral regulation theory [10-12] organisms have a preferred distribution of activities in any given setting. When organisms are free to act as they please, the preferred distribution of activities is their "behavioral bliss point." The instrumental conditioning procedure disrupts the BBP. The organism adapts to such event by switching to a constrained choice of distribution of activities, typically a higher rate of instrumental response and lower rate of reinforcer response.

The behavioral regulation theory generalized the concept of homeostasis from physiology to behavior. Behavioral homeostasis is analogous to physiological homeostasis in that both involve defending the optimal ("preferred") level of a system. Physiological homeostasis keeps physiological parameters (body temperature, e.g.) close to an optimal or ideal level. The homeostatic level is "defended" in that deviations from the target temperature trigger compensatory physiological mechanisms that return the systems to their respective homeostatic levels. In behavioral regulation, what is defended is the organism's BBP.

Instrumental conditioning procedures are response constrains. They disrupt the free choice of behavior and interfere with how an organism makes choices among the available responses. The instrumental conditioning procedure does not allow the organism to return to the behavioral bliss point. But the organism can achieve a contingent optimization by approaching its bliss point under the constraints of the instrumental conditioning procedure.

Modeling human behavior under instrumental contingency

Modeling case

Domjan exemplifies the essential aspects of the behavioral regulation theory of instrumental conditioning with the hypothetical case of a teenager, Kim. Normally, she spends her 3 ½ after-school hours this way: Half an hour a day doing school work and 3 hours a day listening to music (the remaining 20 ½ hours of Kim's day are assumed to be allocated to "fixed posts," such as e.g. sleeping, eating, school, other obligations). Her parents would like to introduce an instrumental conditioning procedure to increase the amount of time Kim spends doing school work. So far, Kim has distributed her total available time (3 ½ hours per day) in 6:1 proportion between music listening and school work. Kim's parents require that Kim should divide her available time equally (1:1) between both activities [3, p. 130-3]. Notice that in this context music listening – Kim's favorite activity – acts as reinforcer (R), while (more) school work – the desired "learning" outcome by Kim's parents – is the instrumental response (IR). Notice further that Kim's preferred 6:1 distribution between these two activities is her behavioral bliss point (BBP).

"Kim's case" is an excellent point of departure for developing a system dynamical model of human behavior under instrumental contingency. We assume that Kim's parents know the basics of instrumental conditioning theory and that they ensure that Kim is immediately "rewarded" for her school work with music listening [3, cf. p. 91, on the importance of immediate reinforcement]. However, according to the behavioral regulation theory the instrumental conditioning procedure itself does not provide an unambiguous result. How Kim reacts to the instrumental conditioning procedure depends on the costs and benefits of the available activities. If school work is much more unpleasant for Kim than giving up music listening time (low benefit:cost ratio), then she will reduce her music listening and keep her school work effort as before or only increase it slightly. But if Kim loves music time while she is not too aversive to school work (high benefit:cost ratio), she will largely comply with the conditioning constraint by doing more school work.
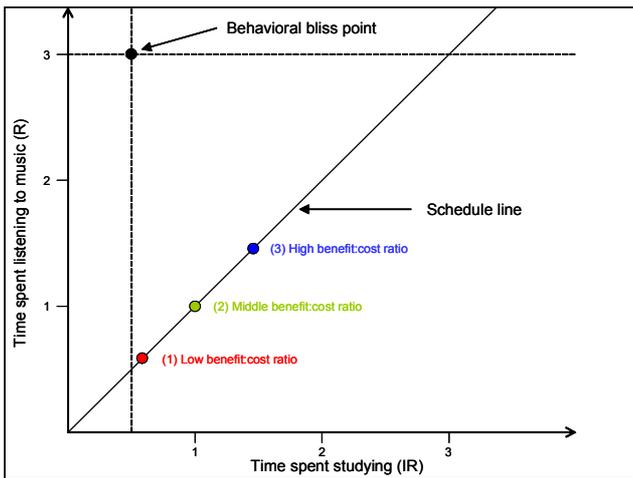
Figure 1 *The "behavioral bliss point" is Kim's preferred distribution of activities if she is free to choose. The imposed instrumental conditioning procedure defines the "schedule line". The points (1)-(3) illustrate three possible final conditioning states depending on Kim's aversion of school work and liking of music listening.*

Figure 1 illustrates the concept of the *schedule line*: It describes the relationship between the instrumental response (school work) and the reinforcer (music time). The three points on the schedule line illustrate three possible *final* states for Kim's conditioned behavior, viz. (1) low benefit:cost ratio, (2) middle benefit:cost ratio, (3) high benefit:cost ratio. Since only the extreme case of 1 hr 45 min for each activity would add up to the 3 ½ after-school hours, we assume that Kim finds some substitute activities to fill in.

In the next sections we will develop models of Kim's behavior under instrumental contingency. We start with a basic model that is gradually extended:

- Basic model of instrumental conditioning
- Model of instrumental conditioning with cost-benefit sector
- Returning to the behavioral bliss point – Extinction of instrumentally conditioned behavior

The final model describes what happens if Kim's parents are unaware that stopping the instructional conditioning procedure leads to extinction of conditioned behavior.

Figure 2 depicts the corresponding reference modes in phase space (Reinforcer vs Instrumental Response): Note that only in the extreme case (1.75 hr = 1 hr 45 min) Kim returns directly to her BBP. Otherwise, she increases her music listening first through regaining the time she devoted to the substitute activities as the result of the imposed contingency, and only next through cutting down on the school work. A more courageous strategy of return to the BBP would involve a simultaneous decline in the instrumental response and increase in the reinforcer. For our purpose, however, we assume that Kim follows the more careful approach. As Kim's behavior returns to the BBP her parents would at some

point understand what is going on and react by reapplying the instrumental conditioning procedure.

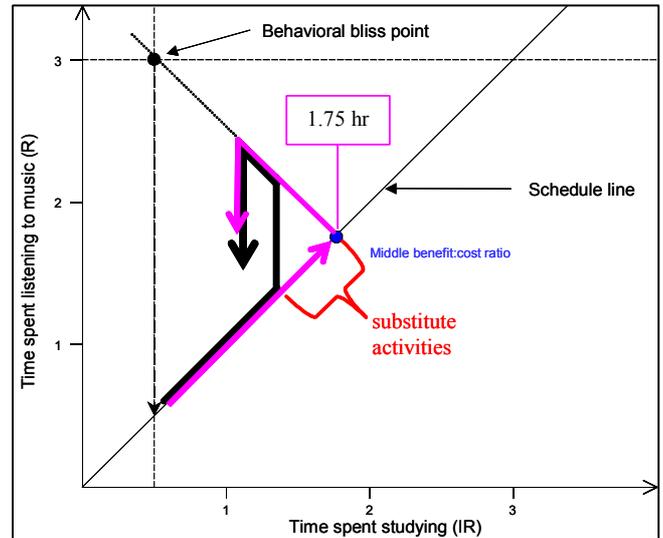This issue and other policy aspects we discuss in the final section on "Policy analysis".

Figure 2 *Reference behavior mode: Believing that Kim's instrumental response is entrenched, Kim's parents relax the instrumental conditioning procedure. The instrumental response becomes weaker and moves toward the behavioral bliss point until Kim's parents catch up and reimpose the instrumental contingency.*

Basic model of instrumental conditioning

We simplify the issue of benefits and costs by assuming that Kim prefers to maximize her music listening time. The reference behavior mode is as follows: To begin with Kim is free to follow her inclinations and she distributes her activities according to her BBP. When her parents introduce the instrumental contingency Kim is not yet conditioned, her school work time is ½ hours and the imposed instrumental contingency forces her to reduce music listening time to the same amount of time as school work. Gradually, the "reward" experienced following school work leads Kim to spend more time on school work until she reaches the maximum available time of 1 hr 45 min for each activity.

In Figure 3 the basic parameters are *Behavioral Bliss Point*, *Instrumental Contingency*, *Instrumental Response* and *Reinforcer*. *Behavioral Bliss Point* is a constant array {3 hr, 0.5 hr} describing the preferred distribution of activities in terms of hours for music listening and school work. *Instrumental Contingency* is 1:1 ratio of school work to music listening time. *Instrumental Response* (a stock capturing accumulated learning by instrumental conditioning) is the daily amount of school work in hours, while *Reinforcer* is the daily amount of music listening in hours.
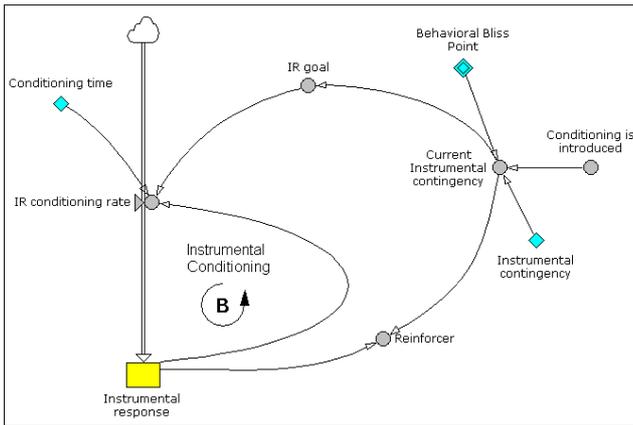
Figure 3 *Basic model of instrumental conditioning.*

The switch *Conditioning is introduced* expresses that the conditioning procedure is imposed at simulation time *t = 30 hr*, implying that Kim's response is "free" to begin with and "instrumental" for *t ≥ 30 hr*. This switch makes the variable *Current Instrumental contingency* equal to Kim's free choice until *t = 30 hr* and equal to the imposed instrumental contingency afterwards. As a consequence, the instrumental response goal *IR goal =0.5 hr* for *t < 30 hr* is determined by Kim's BBP and *IR goal =1.75 hr* for *t ≥ 30 hr* by the imposed *Instrumental Contingency*, which for the basic case implies spending the entirety of the 3 ½ after-school hours equally for school work and music listening. In the system dynamical model this fact is expressed in that *Reinforcer* is a dependent variable (arrows point to *Reinforcer*, no arrows point from *Reinforcer*).

The core of the model is the balancing "Instrumental Conditioning" loop. The instrumental conditioning procedure – imposed through *Instrumental Contingency*, and expressed by *IR goal* – creates a gap between *Instrumental Response* (here school work time) and *IR goal*. We assume a standard first order goal seeking loop with time constant *Conditioning time = 10 hr*.
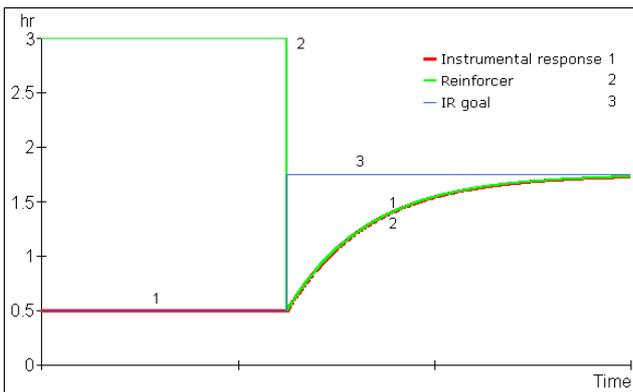

Figure 4 *To begin with, Kim's behavior is in accordance with her behavioral bliss point (2: Reinforcer=Music listening; 1: Instrumental response=School work). The instrumental conditioning procedure establishes a new goal (3) for the instrumental response (corresponding to 1:1 distribution of her*

two activities). Accordingly, her school work improves and reaches the goal asymptotically while her music listening (after the sudden drop forced by the start of the instrumental conditioning procedure) follows the same pattern. Note: The simulation time is different from normal time in that the conditioning session runs so-to-speak for 3 ½ hours a day.

The behavior of the model is illustrated in Figure 4. Note that the value of *Reinforcer* (here, music listening time) follows from the value of *Instrumental Response* according to the imposed *Instrumental Contingency*.
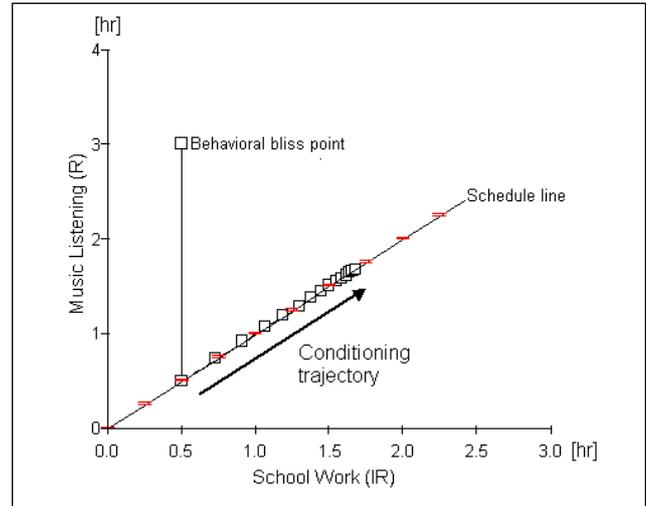

Figure 5 *The conditioning path, Instrumental Response (IR) vs. Reinforcer (R).*

Figure 5 depicts the model behavior as phase diagram in activity space. To begin with, Kim's behavior is described by her BBP. Upon introduction of the instrumental contingency, her activities correspond to the lowest point on the schedule line. With increasing conditioning effect her behavior moves the schedule line upwards until the maximal effect of the instrumental conditioning procedure is reached.

The simulation model is very simple. The equations are found – as Powersim model and in text format – in our home page.

Model of instrumental conditioning with cost-benefit sector

According to our basic model of instrumental conditioning the employed instrumental conditioning procedure is highly effective in that Kim fully reallocates her two activities (school work & music listening) within her free 3 ½ after-school hours. However, a crucial factor determining how an individual adjusts her behavior to schedule constraints is the availability of substitutes for the reinforcer [13]. If no substitutes are available for the reinforcer activity the instrumental conditioning procedure is effective. If substitutes (e.g. TV watching instead of music listening) are available, depending on the amount of satisfaction they provide, the instrumental response will be less than expected and, possibly, not occur at all.

Explicit consideration of substitute reinforcer activities would make the simulation model unnecessarily complicated. Much of the same effect is implicitly achieved by considering the costs of the imposed instrumental contingency.

To describe such costs remember that the instrumental contingency implies a disruption of the preferred activity ratio (as defined by the BBP). We introduce the variable *Costs of Instrumental contingency* to express the costs of such disruption. We model the impact of the costs as an inverse proportional factor on the instrumental response goal, *IR goal*: I.e. the higher the costs are, the smaller *IR goal* becomes. Another way of expressing this is that in the limit of no instrumental conditioning the costs function will assume the value unity (expressing no cost impact).

For the exact definition of the costs function we refer to the model equations in our home page. Here in the main text we characterize the costs function by its slope and by its behavior for low, medium and high values of the instrumental contingency:

1. The slope is positive – the higher the demands on Kim (in terms of the instrumental contingency), the higher the costs.
2. For low values of the instrumental contingency, i.e. for slight disruptions of the BBP, the costs function approaches unity.
3. For medium values of the instrumental contingency, the value of the costs function satisfies the requirement that the instrumental response achieves its maximal feasible level, i.e. equal to the total available time of 3 ½ hours minus time spent on reinforcer.
4. For high values of the instrumental contingency, the costs function satisfies the requirement that *IR goal* equals the time Kim allocates to school work at the BBP. In other words, attempts to squeeze much school work by demanding, say, that Kim has to do 100 times as much school work as music listening will lead to Kim just doing whatever she always did in terms of school work – in our example 30 minutes – and to give up music listening as too costly.[1] The reader might like to check that for the actual case (as described above in terms of a total 3 ½ hours of after-school time distributed according to a 6:1 ratio at the BBP) the costs function will asymptotically approach the value of 7 for high values of the instrumental contingency.

Note that we describe the costs function in qualitative terms (i.e. referring to "low", "medium" and "higher" values of the instrumental contingency). What levels are "low", "medium" or "high" will depend on the subject's (here Kim's) personality.

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[1] The tacit assumption is being made that Kim – as responsible person – will not retaliate to the unreasonable demand from her parents by reducing her school work.

To illustrate the point consider the definition of the costs function for Kim:

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'Costs of Instrumental contingency' = 1 +
    'Effect of Instrumental contingency
    on the Costs function' * ('Max costs
    of instrumental contingency'-1)
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where *Max costs of instrumental contingency* are the costs corresponding to very high values of the instrumental contingency. *Effect of Instrumental contingency on the Costs function* is normalized (returning values in the interval 0..1).
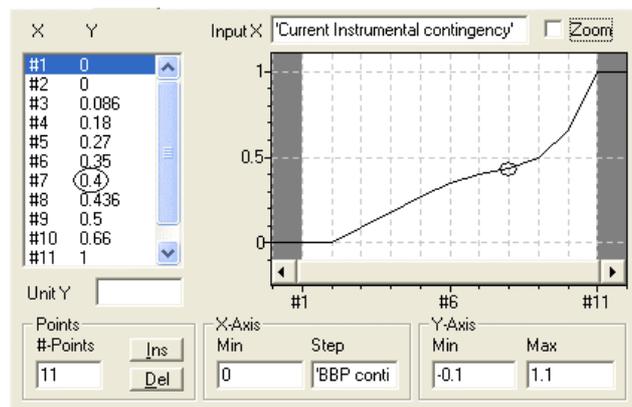

Figure 6 *'Effect of Instrumental contingency on the Costs function'. The point marked with a circle corresponds to 'Instrumental contingency'=1 the value 0.4 corresponding to the value 2 for the costs function itself. For further details, see main text.*

Figure 6 shows *Effect of Instrumental contingency on the Costs function* as function of *Instrumental contingency*. We assume that the imposed contingency of 1 is actually the optimal one resulting in a relatively large increase in school work. Further, we assume the costs of this contingency to be 2. A further increase in the instrumental contingency would lead to a rapid increase in the costs function with a corresponding decline in *IR goal* and, thus, in the actual instrumental response.
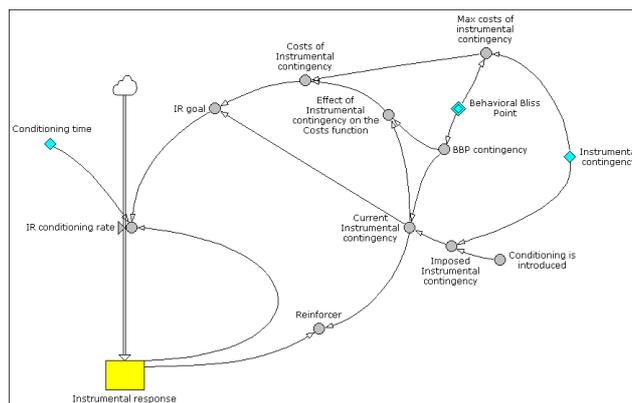

Figure 7 *Instrumental conditioning with cost sector.*

The stock-and-flow model is shown in Figure 7.

Figure 8 shows runs with (a) *Instrumental Contingency = 0.5*, (b) *Instrumental Contingency = 1* and (c) *Instrumental Contingency = 1.5.*
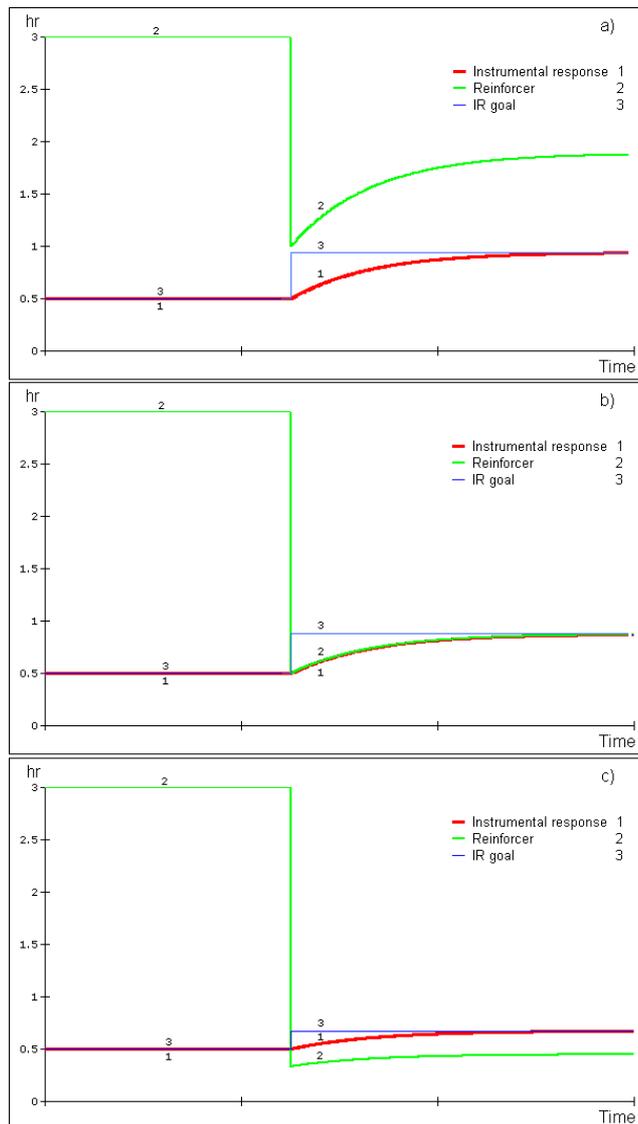

***Figure 8** Runs of the simulation model of instrumental conditioning with costs sector for a) Instrumental contingency=0.5; b) Instrumental contingency=1.0 and c) Instrumental contingency=1.5.*

Notice how the increasing costs lead to less and less effective instrumental conditioning: The sum of school work and music listening time decreases from (a) to (c) – expressing that substitute activities take over for the intended reinforcer (music listening time). As in Figure 4, simulation time is the "effective" conditioning time, i.e., one must interpret the simulation time as multiple of "conditioning sessions" (in Kim's case 3 ½ hours per day). Probably, the only reinforcers able to force an organism to strive for them at whatever costs are primary biological drives (i.e. those necessary for the organism's survival). Other reinforcers will be less appealing to the organism, i.e. it will be less ready to invest more costs in order to reap those reinforcer's benefits. It seems clear that an appropriate pairing of reinforcer and instrumental response activities is crucial for the success of the instrumental conditioning procedure.
The equations of the model are found in our home page.

Returning to the behavioral bliss point – Extinction of instrumentally conditioned behavior

If the reinforcer for a previously conditioned instrumental response is withheld, implying that the individual is permitted to perform the instrumental response but the reinforcer is no longer given, the individual continues responding for a while. However, after some time the absence of reinforcement results in a decline in instrumental response – "extinction of instrumental behavior" [3, p. 113ff].

In Kim's case there should be no reason for her parents to consciously provoke extinction of the desired conditioned behavior (increase of school work time). However, such undesired outcome might surface if Kim's parents misinterpret, or rather *misperceive*, what is going on. Ignorant of the subtleties of instrumental conditioning, and because sustenance of the instrumental contingency incurs costs (time, effort, possibly money), Kim's parents will relax their control of Kim's behavior if they perceive her conditioned behavior as entrenched. The extinction process will imply that Kim returns to her BBP. On noticing this, Kim's parents might reinstall the instrumental conditioning procedure, etc. Accordingly, one would expect "homeostatic" oscillations in the level of *Instrumental Response*.

For the time being we ignore – potentially highly interesting – "higher order" aspects, such as increase of Kim's parents understanding of instrumental conditioning procedures (leading them to sustain the instrumental contingency forever), changes in Kim's preferred distribution of activities (more school work might imply better grades, i.e. a new reinforcer that might increase her motivation and her liking of school subjects, thus changing Kim's BBP). In other words, in this section we aim at developing an enhanced simulation model in accordance with a naïve regular oscillation pattern for the instrumental response.

Figure 9 shows an enhanced model[2] with four balancing feedback loops, viz. "Instrumental Conditioning," "Extinction of Conditioned Behavior", "Homeostatic Adjustment of Compliance" and "Adjustment of Reinforcer Appeal". The first loop is basically as discussed before (p. 4). The second loop, "Extinction of Conditioned Behavior", describes the goal seeking process whereby *Instrumental Response* (and, as a consequence, *Reinforcer*) is attracted to the set points defined in the BBP. The third loop, "Homeostatic Adjustment of Compliance," is the main addition. As *Instrumental Response* approaches *Min Planned Response* the perceived

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[2] The model equations are found in our home page.

discrepancy between the two declines and Kim's parents stop enforcing the instrumental contingency. The extinction process begins and *Compliance with the imposed instrumental contingency* depletes, leading to a gradual decline in *Followed Instrumental Contingency* and thus in *IR goal*. The decline in *Followed Instrumental Contingency*

triggers the "Reinforcer Appeal Adjustment" loop: *Instrumental contingency* becomes smaller, *Costs of Instrumental* contingency get lower (the reinforcer's "appeal" increases, so-to-speak), so that the depletion of *IR Goal* becomes less pronounced.
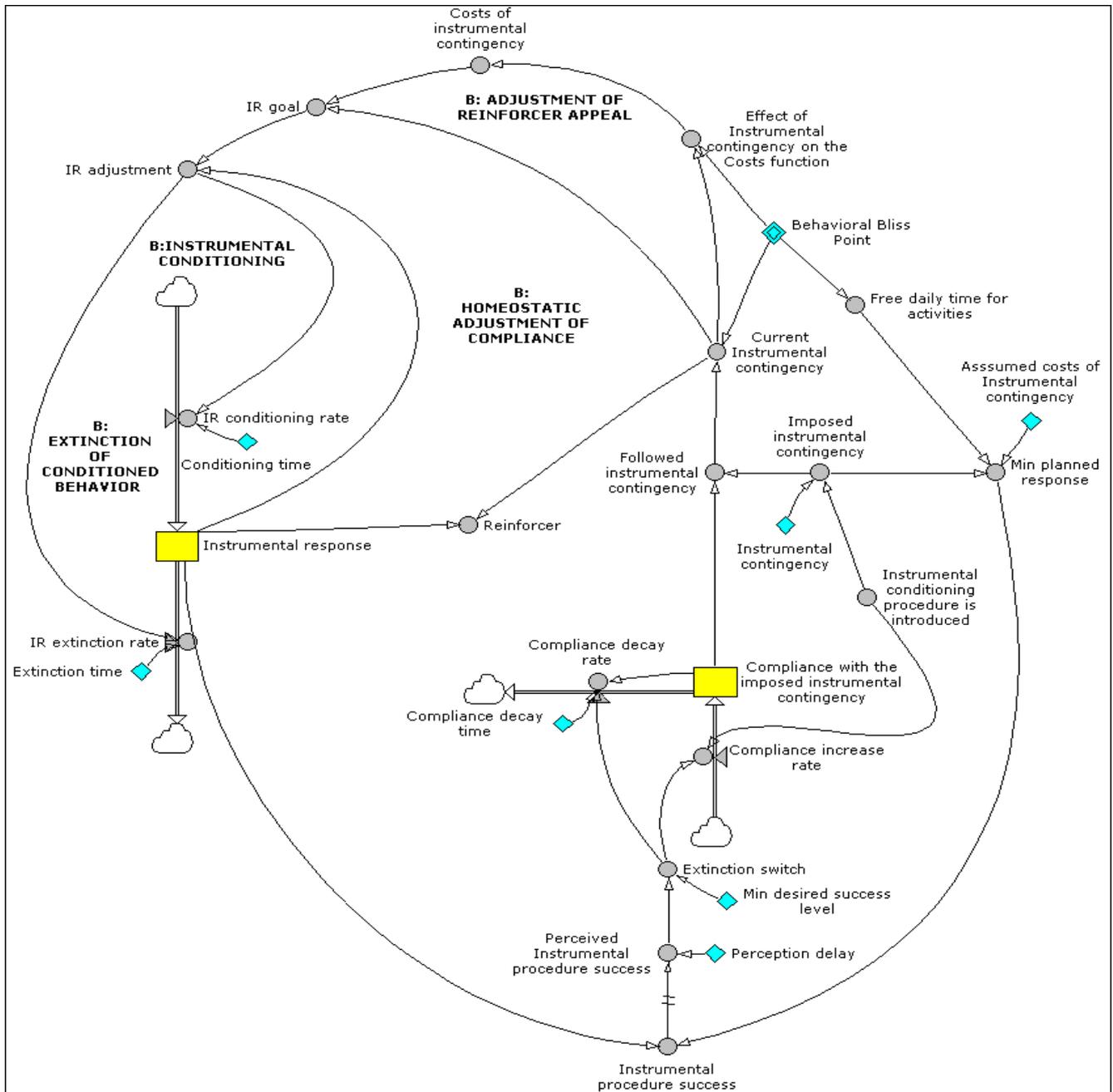

***Figure 9** Full model with instrumental conditioning and extinction of conditioned behavior depending on costs and perceptions.*
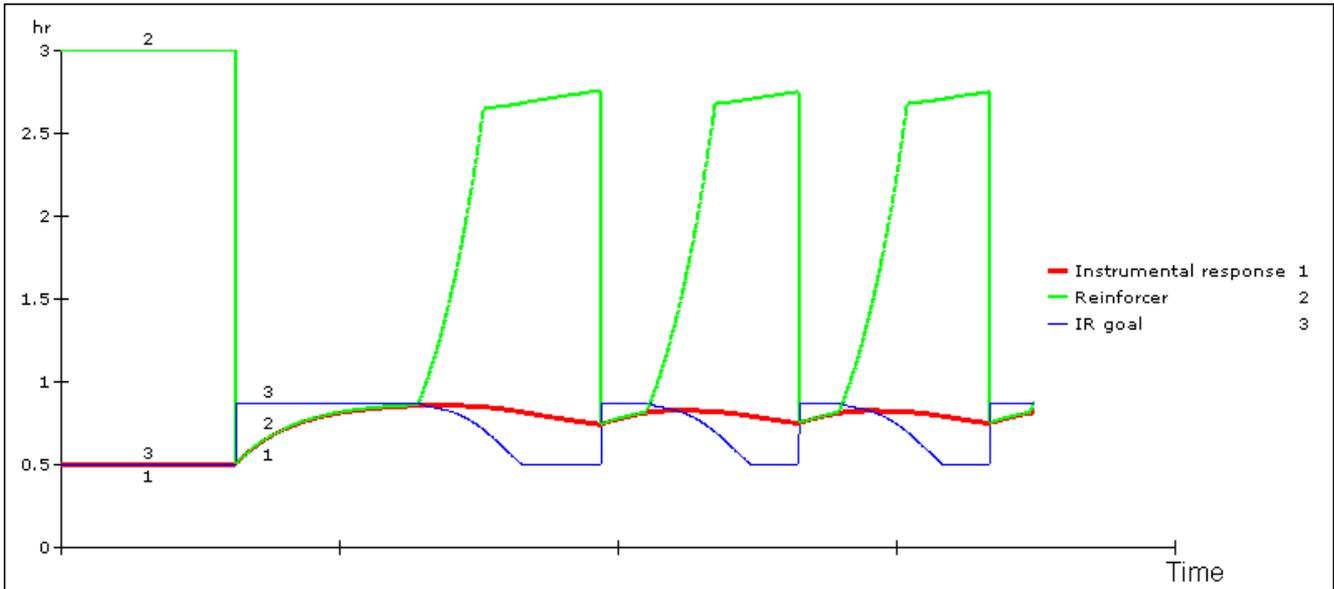
Figure 10 *Homeostatic oscillations of 'instrumental response' and 'Reinforcer'. As in Figure 4 and Figure 8 simulation time is the "effective" conditioning time.*

Figure 10 displays the homeostatic oscillations of the main variables, viz. *Instrumental response* and *Reinforcer*. For the first third of the simulation the behavior is basically as in Figure 8b. Since Kim apparently is fully conditioned, her parents discontinue the enforcement of the instrumental conditioning procedure. With some delay, Kim adjusts her music listening time (reinforcer) toward her preferred level while school work (instrumental response) stays constant for a while. At the point when the sum of both activities fills completely the available time slot (her 3 ½ after-school hours) further expansion of music listening time goes in detriment of school work. With some delay, Kim's parents understand what is going on and reintroduce the instrumental contingency. The story nearly repeats itself, the shape of the second, third, etc. cycle being different from the first because of the different "starting points" (i.e. Kim is not fully deconditioned when her parents reintroduce the instrumental conditioning procedure).

In the activity space, the behavior is as shown in Figure 11. To begin with, Kim's behavior is described by her BBP. Upon introduction of the instrumental contingency, her activities correspond to the lowest point on the schedule line. With increasing conditioning effect her behavioral point moves the schedule line upwards. When Kim notices that her parents are not monitoring her performance (the instrumental contingency has been removed because Kim appears to be fully conditioned) the extinction of the conditioning behavior (return to the BBP) begins. First, Kim increases her music listening time (vertical path up, corresponding to Kim's maximizing her music listening time until the available time slot is filled). Second, Kim reduces school work (short diagonal segment

up to the left). When Kim's parents reintroduce the instrumental conditioning procedure the line drops vertically. From now on, the behavior in activity space is described by the trapezium to the right (corresponding to the shorter cycles in Figure 11).
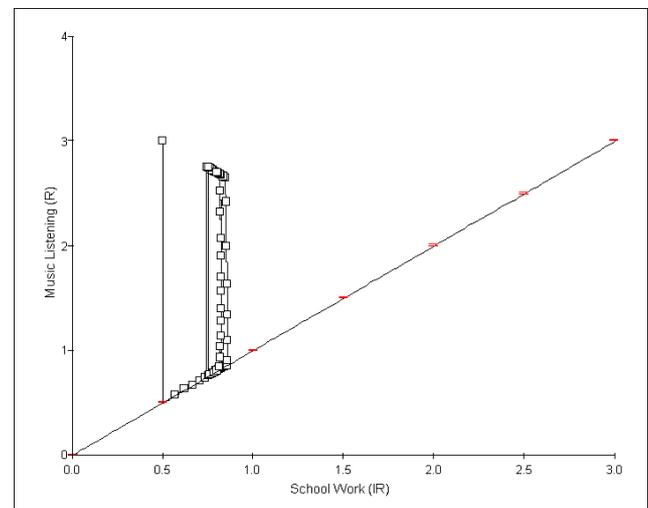

Figure 11 *Instrumental Response (IR) vs. Reinforcer (R) – general case.*

If the costs function is set to 1, Kim will ultimately spend the available time slot equally between school work and music listening. Assuming that the instrumental conditioning procedure is operative until this happens, the behavior in activity space is as shown in Figure 12.
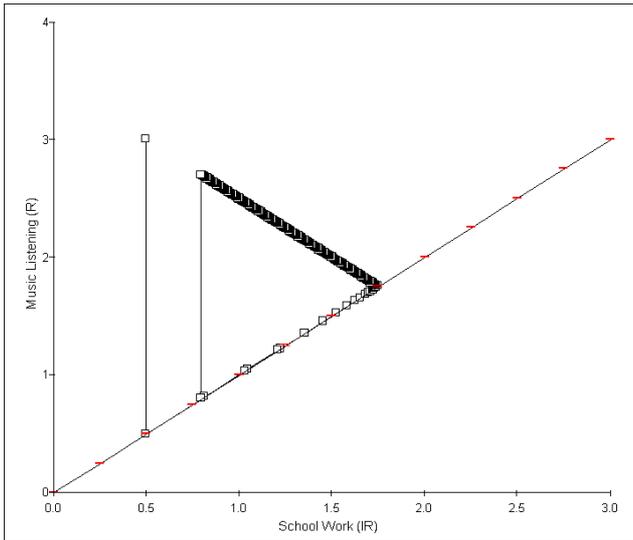
Figure 12 *Instrumental Response (IR) vs. Reinforcer (R) – special case of constant costs function, very small tolerance of deviation from the target behavior, long perception delay.*

Policy analysis

The behavioral regulation approach explains how an organism's behavior may be shaped by an instrumental conditioning procedure. We have emphasized that choice of the appropriate reinforcer is of key importance for the success of the instrumental conditioning procedure. If the reinforcer is not attractive enough, or its attractiveness decays rapidly in face of constraints introduced by the instrumental contingency, the conditioning process will fail. On many occasions, however, it may be difficult to predict how the instrumental contingency may impact the reinforcer's appeal. Consider the following outcome of the instrumental conditioning procedure imposed by Kim's parents (Figure 13):
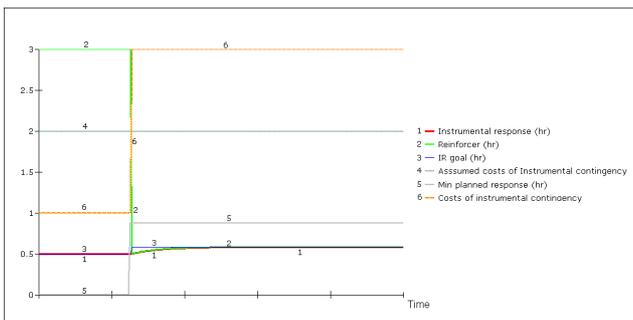

Figure 13 *Policy behavior with increased costs.*

Upon introduction of the instrumental conditioning procedure Kim reduces her music listening time. However, although the instrumental contingency in a sense is operative (1:1 relation of school work to music listening time) she never reaches the daily study load expected by her parents (despite the fact that they never give up enforcing the instrumental contingency!). Compare the simulation outcome presented in Figure 13 above with the

one presented in Figure 4. The only difference in parameter settings for the two simulation runs is a change in Kim's cost-benefit function: In the original case Kim followed the costs function as defined in p. 5ff. Now, we accelerated the decay of music listening attractiveness by increasing the function value associated with the instrumental contingency from 2 to 3. Kim's parents misperceive the decay of music listening attractiveness and therefore estimate erroneously the daily school work load that may be conditioned by music listening. Since they do not update their estimate of music listening attractiveness decay, they continue to wait until Kim's study load reaches their estimate, maintaining throughout the simulation period the maximum enforcement of the instrumental contingency.

The simulation outcome illustrates problems that occur if the instrumental conditioning procedure is designed using inaccurate estimates. If the original overestimated level of the planned instrumental response is not adjusted, the instrumental contingency enforcement will continue forever. This is not a desirable situation, since in most cases the enforcement involves substantial costs. The situation may be resolved in two ways: (1) The planned and actual instrumental response discrepancy tolerance interval is diminished, or (2) the estimates used to arrive at the planned instrumental response are revised.

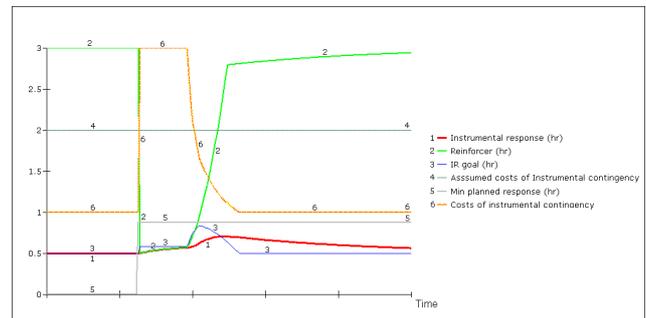We illustrate point (1) and (2) with Figure 14-15, respectively.

Figure 14 *Diminishing the planned and actual instrumental response discrepancy tolerance interval.*
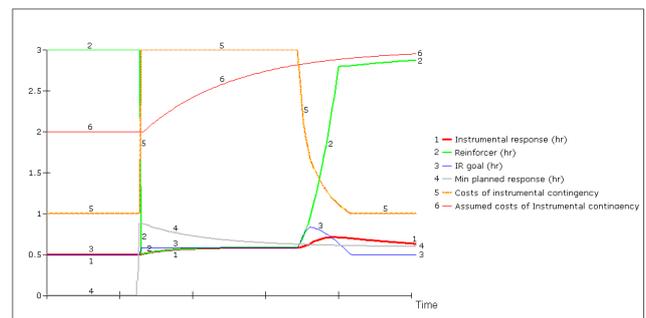

Figure 15 *Revising the estimates used to arrive at the planned instrumental response.*

In this context, the oscillatory behavior discussed in this section may be relevant for such issues of quasi-oscillatory behavior of standards of protection. Improvements in protection (against organizational accidents, computer virus threats, terrorists, etc) are often put in place during the period immediately following a bad experience. Protection is eroded as a consequence of several factors: Accidents, virus attacks, terrorism,… are by nature sporadic events; improved defenses often pave the road for more immediate concerns, such as e.g. increased throughput. Patterns of long-term erosion of standards with interspersed transient improvements of protection triggered by (minor) incidents until a major accident occurs remind of the behavior of an "unrocked boat" [14, p. 6-20].[3] In our instrumental conditioning approach to security/safety issues, the instrumental contingency is the perception of risk, declining with apparent "success" during the long periods between sporadic bad experiences, the instrumental response is the standard of protection [5-9].

Discussion

The behavioral regulation theory of instrumental conditioning is readily expressed as a basic system dynamic model that illustrates learning by contiguity between instrumental response and reinforcer. In realistic situations the agent imposing the instrumental conditioning procedure will be guided by perceptions and so will the recipient of the conditioning procedure too. This results in a far more complex "homeostatic system" exhibiting oscillatory behavior.

While instrumental conditioning is typically identified with behaviorism, the explicit consideration of enforcer and subject of the instrumental conditioning procedure introduces a new and exciting dimension. Inclusion of aspects such as the enforcer's subjective perceptions of the procedure effectiveness or the subject's conditioning "costs", points to holistic views of learning with potentially fruitful paths to accommodate various perspectives.

Other interesting aspects, which we will come back to in future work, concern how the subject's BBP might be influenced by downstream effects of the conditioning procedure. In Kim's case, successful instrumental conditioning might imply a dramatic improvement of her school performance, with subsequent redistribution of her preferred activities (i.e. a change of BBP). On the other hand, more school work might backfire, e.g. if Kim is struggling with difficult subjects that she is not able to master on her own. This, in turn, might possibly lead to increased aversion to school work. In other words, issues like learning method, success/failure, motivation, etc, become relevant. Again, this shows how a point of departure commonly associated with behaviorism, when paired with dynamic models, quickly grows to extended views of learning.

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[3] Reason gives Constance Perin credit for coining the metaphor of the "unrocked boat" (opus cit., p. 20, note 4).

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