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Advances in the model of hierarchical complexity (MHC)

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ABSTRACT

The model of hierarchical complexity (MHC) has a long history that only in very recent years resulted in its formal specification as a general model. A brief history of the origins of the notion of hierarchical complexity follows. This is done in order to identify what the steps were and also those who played key roles in the model's development over these many years.

In tracing the evolution of the MHC, there are four periods, each involving different people. The two earliest periods were Commons' pre-college years, college and graduate school years, followed by a period of more active and direct development from 1973 to 1982. After the model was developed, there were advances in the period from 1982 to present.

KEYWORDS: history, stage, model of hierarchical complexity, neo-Piagetian, mathematical developmental theory

» SOME BACKGROUND ON THE MODEL OF HIERARCHICAL COMPLEXITY

Pre-college years

When Commons was 12, he read Isaac Asimov's (1951) *Foundation*. The character Hari Seldon had a new theory of psychohistory about the mathematical, psychological and historical character of societal evolution. Today, it would be seen as a contribution to cultural evolution. The main idea was that mathematical psychology could be used to predict the future or at least understand it. His account was in narrative form.

College and graduate school years

While at Columbia University as a graduate student in the Faculty of Pure Science from 1966 to 1973, Joan Borrison, Commons' partner at the time, was taking a course from Jane-Ellen Huttonlocker and Brian Sutton-Smith at Teachers College, Columbia University. She was complaining bitterly about the book she was assigned. It was a book by Inhelder and Piaget (1958). The book turned out to be a life turning point for Commons. He found Inhelder and Piaget's account of development was fascinating. He felt strongly that there was something about Inhelder and Piaget theory that was right. Commons thought that it explained why people were not crazy per se or irrational in their actions. Rather, he thought human beings simplified the world in a fashion that resulted in illusions. But Commons did not agree with all of Inhelder and Piaget's ideas. He did not like the logical framework that Inhelder and Piaget employed in their model because it was based on a form of rationality (i.e. logic). Logic is too restrictive. Others (Wason, 1968) have shown that the logical basis for their formal stage failed empirically. There are other relationships between events and actions besides logic. But, Commons thought Inhelder and Piaget had the right stages when the substages were counted as stages. Pascual-Leone (1970) has also successfully argued this case. To Commons, stage theory seemed to be much broader than Inhelder and Piaget had set forth. It also seemed that stage theory could be applied to all organisms' actions and not limited to just humans. The reliance on the "clinical method" that required interviews did not seem necessary.

Acknowledgment: We thank Deanna Kuhn who made all of this possible.

1973 to 1982

Commons' realization was that task analysis could be used to replace the "clinical" method. Task analysis breaks down tasks into a sequence of task actions that are sufficient to accomplish that task. Task analysis comes from within behavior analysis, information processing theory, and psychophysics. With 12 years of mathematics, physics and experimental psychology as an undergraduate and graduate student, Commons thought about tasks in a very precise and mathematical way.

In 1975, while at *Northern Michigan University*, the idea of developing the model of hierarchical complexity started when Commons and Patrice Miller met Deanna Kuhn again at the meeting of the Society for Research in Child Development which met in Denver. She previously was at *Columbia University.* At the time she was a professor at *California State University at Fullerton*. They worked on some developmental research using the plant problem (Kuhn & Brannock, 1977; Kuhn, Ho & Adams, 1979). The plant problem is a rough analog of Inhelder and Piaget's pendulum problem (Inhelder & Piaget, 1958). In the plant problem, a participants' task

was to isolate the variable that predicted plants' health condition and exclude the variables that would not. The possible variables were: ***a)*** having or not having leaf lotion; ***b)*** dark or light plant food; ***c)*** a lot or little water. One of the differences between the plant problem and the pendulum problem is that the plant problem was something that people had much more experience with. Few people would have taken physics, which would have taught them about the pendulum.

Table 1. example of the plant problem's informational episodes (Commons, 1975)

big pot	leaf lotion	dark plant food	little water	→	sick
small pot	no leaf lotion	light plant food	lots of water	→	healthy
big pot	leaf lotion	light plant food	lots of water	→	sick
small pot	leaf lotion	light plant food	little water	→	sick
big pot	no leaf lotion	dark plant food	lots of water	→	healthy
small pot	no leaf lotion	dark plant food	little water	→	healthy

Table 2. Six out of the ten sample test questions: Look back at the examples. After being treated in the way shown, will the plant be healthy or sick?

small pot	leaf lotion	dark plant food	lots of water	→	healthy or sick?
big pot	no leaf lotion	light plant food	little of water	→	healthy or sick?
big pot	leaf lotion	dark plant food	little of water	→	healthy or sick?
small pot	leaf lotion	light plant food	lots of water	→	healthy or sick?
small pot	no leaf lotion	light plant food	lots of water	→	healthy or sick?
big pot	no leaf lotion	dark plant food	little water	→	healthy or sick?

Commons thought that for a well-designed psychology experiment, one had to better control how the variables and their values would appear in the task. The initial solution to this was to add a variable to Kuhn's version of the plant problem. The values for the variable that Commons added in 1976 were: Big Pot or Small Pot (See Table 1). In this new version, a plant was treated in six ways, as laid out in the first, six informational episodes. Sometimes it would be healthy after being treated this way and sometimes it would be sick. After reading the informational episodes, participants would then be shown the test episodes, which they were to respond to. Six of these are shown in Table 2.

As shown in Table 1, not only was it important that there be four variables that were always present in each episode, but there should be also only two values of each variable. Each variable had to occur in the same physical location; otherwise it would make it harder to see it as a clear variable and lead to confusion. There had to be exactly six episodes in the informational part of the task. With only four episodes, the task demands made the problem at the abstract order. There had to be two more plausible values of each possible cause (variables) per episode and two less plausible values of each possible cause per episode. All odd number versions would not have equal number of healthy or sick plants. With four variables and two values per variable, this produces $2^4 = 16$ possible forms for an episode. Note that "cause" is really bidirectional here. One could predict the outcome from the "cause" and the outcome could predict the "cause." Last, the variables in an episode could occur in $4! = 24$ orders. That meant, if variable order were changed, there could be 24 different problems.

Even with controlling for the constraints discussed above, no matter what was tried, there were issues with the new version of the plant problem that could not be solved. In that version, as in the simpler three variable version. all single cause episodes also have the complement set of the other variables as causes. So, if one variable, such as the amount of water given the plant, was to be associated with the plant being healthy, a combination of the rest would also be associated with the plant being healthy. The goal of only having a single cause turned out to be impossible.

This was confirmed empirically, after administering the new version to a group of participants, when there were two people who used a combination of variables to correctly predict the outcome. Commons realized that there were still problems that could not be solved even after all the balancing of all the values of the variables and outcomes. The mathematical fact was that there are always dependencies of causes in any finite set. Any finite causal system that has a single causal variable will also have the complement of the rest of the variables as "causal" variables as well. Only a system with infinite causal information could have only one cause.

That year, Commons, Miller, and Kuhn (1982) conducted a study of what courses people took if they scored concrete stage versus formal stage. The last problem of the plant problem was that the variable of whether leaf lotion was used or not had a "negative" versus a complementary value. All the other variables were complementary choices. This was corrected in the laundry problem which is used up until the present. An example of the laundry problem is shown in Table 3.

Table 3. Example of the laundry problem (1977): A cloth was stained with red lipstick. There are six ways it can be washed. Sometimes it will be clean after being washed and sometimes it will be dirty.

brand A bleach	powdered soap	blue booster	cold water	→	dirty
brand B bleach	liquid soap	pink booster	hot water	→	clean
brand A bleach	powdered soap	pink booster	hot water	→	dirty
brand B bleach	powdered soap	pink booster	cold water	→	dirty
brand A bleach	liquid soap	blue booster	hot water	→	clean
brand B bleach	liquid soap	blue booster	cold water	→	clean

Table 4. Six sample test questions of the possible ten of the laundry problem: Look back at the examples. After being washed, will the cloth be clean or dirty?

brand B bleach	powdered soap	blue booster	hot water	→	clean or dirty?
brand A bleach	liquid soap	pink booster	cold water	→	clean or dirty?
brand A bleach	powdered soap	blue booster	cold water	→	clean or dirty?
brand B bleach	powdered soap	pink booster	hot water	→	clean or dirty?
brand B bleach T	liquid soap	pink booster	hot water	→	clean or dirty?
brand A bleach	liquid soap	blue booster	cold water	→	clean or dirty?

The limitations of the Plant problem and Piaget's theory's led Commons (1976A, B) to view the constraints of each structural aspect of the problems. In comparing the two problems, Commons contrasted two properties of the problems: ***a)*** What was causal in the plant problem was arbitrary versus what was causal in the pendulum problem was fixed; ***b)*** Any finite causal system that had a single causal variable will also have the complement of the rest of the variables as "causal" variables. An infinite causal system could have only one cause. Commons then recognized that reflecting on the structure of the problems could not be done within the formal stage. He found that comparing the structural aspects within the problems formed two separate systems with different properties. One property was the arbitrariness of what would be a cause and the other was the finite versus infinite source of information about possible causes. Hence, he had identified a new stage, first called *the structural analytic stage* and later the metasystematic at the suggestion of Deanna Kuhn around 1980.

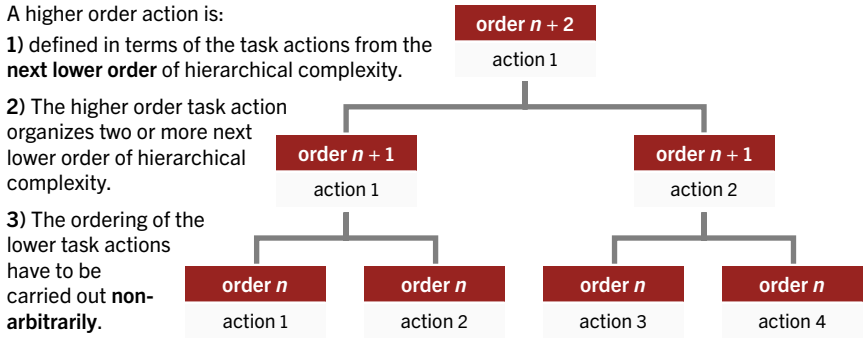

Figure 1. the three axioms of the MHC

After coming to Harvard in the fall of 1977 as a postdoctoral fellow of Deanna Kuhn's, Commons began to work with Francis Asbury Richards (Rick Richards). They wanted to develop a problem that would take insights from Commons' comparisons of the differing structures of Kuhn and Brannock's (1977) plant problem and Inhelder and Piaget's (1958) pendulum problem. At that time, there was no adequate means to decide whether the structural analytic stage was a new stage or just another version of the formal stage. Commons and Richards constructed the four-story problem to show the difference between the structural analytic stage and the formal stage. The structure of the plant problem was still used, but they had variants with different content: the laundry, pendulum (Inhelder & Piaget, 1958) and paint versions. Richards and Commons developed the V. P. Vanktesh story, Bad Bart the gambler, the Washing machine story, and the Richard Regan story (Commons & Richards, 1978; Commons, Richards and Kuhn, 1982). The problem was a rough analog of Gödel's (See Heijenoort, Jean van, 1967) incompleteness problem in the sense that systems of formal stage relationships would be compared. It was at that point we divided the "stage demands" of the task from the stage of performance on that task, something that few other researchers considered.

In 1978, Commons and Richards began to develop their first pass at the *general stage model* which later became the *model of hierarchical complexity*. The model was later published in the book *Beyond Formal Operations* (1984). Identification of the metasystematic stage was one of the foundations of what led to the general stage model. Commons and Richards started with just three stages: ***a)*** the first being Inhelder and Piaget's (1958) formal stage; ***b)*** the second was the systematic stage that was suggested by Herb Koplowitz (1981). The case for this stage was later published in his chapter (Koplowitz, 1984). Koplowitz presented a case which he called cyclical causality; ***c)*** The third stage was the metasystematic (formerly called the structural analytic stage). The model was published as the general model of stage (Commons & Richards, 1984). Theo Linda Dawson suggested the name the model of hierarchical complexity around 1997.

What is the model of hierarchical complexity?

There are two kinds of complexity of task actions. The commonly recognized one refers to the horizontal complexity often measured by the number of bits. Each "yes or no" question that is answered by correctly completing any task is representative of just one bit. For more horizontally complex tasks, the issue is how many bits of information there are embedded in a task. The number of bits is descriptive of the amount of horizontal complexity.

In contrast, the model of hierarchical complexity offers a different method of analyzing the difficulty of tasks. The model of hierarchical complexity (MHC) is a neo-Piagetian mathematical model. It is a newer form of stage theory that is both an advance on and a simplification of Piaget. MHC allows for the measurement of stage performance. It deconstructs tasks into the component actions that must be done to complete a task correctly at each order of hierarchical complexity (OHC). Each of these actions is necessary to build the behavior needed to successfully complete a task. A higher order action is: ***a)*** defined in terms of tasks actions from the ***next lower*** order of hierarchical complexity; ***b)*** the higher order task action ***organizes*** two or more less complex actions; ***c)*** the ordering of the lower task actions have to be carried out ***non-arbitrary*** way. This is shown in Figure 1.

The model of hierarchical complexity (MHC) identifies 17 ***orders of hierarchical complexity***. Hence it looks at how the required task actions are organized into a "tree" structure (Figure 1). It is designed to account for development within a life-span and evolution across species. Stage is simply the order of hierarchically complexity of a task correctly carried out. The model's unidimensional *measure of order of hierarchical complexity* is on an equally spaced ordinal scale. The tasks are that of organizing actions that address problems presented or inferred. hierarchical complexity applies to any tasks and the set of events or occasions within them in which information is organized. The kinds of entities that organize information include humans and their biological systems as well as their social organizations, nonhuman organisms, and machines, including computers. The reason it applies so broadly is that it is a simple mathematical method of specifying tasks, and the tasks may contain any kind of information. Thus, its use of purely quantitative principles makes it universally applicable in any

context. This enables a standard quantitative analysis of hierarchical complexity in any setting, because it eliminates dependence on mentalistic, cultural, or other contextual explanations.

1982 to present

In 1981 and 1982, in many phone calls with Kurt W. Fischer, he suggested the name abstract stage for the early formal stage of Inhelder and Piaget's. He also suggested that the preoperational stage be split and that Commons read Biggs and Collis (1982). They had identified what we call the sentential stage 6 coming before the preoperational stage 7. The even-earlier preoperational stage that preceded the sentential stage was what Commons later called nominal stage 5. Fischer also suggested Commons and Richard read his seminal article (1980) in which Fischer laid out a good deal of the stage sequence. Commons and Richard were not aware of the article before, otherwise it would have saved them a lot of work. Yet they came up with almost the same stage sequences as Fischer's levels independently. Commons and Richards credited Fischer's work in the 1984 book but their model differed from what Fischer had. The general stage model had more stages: stage 0 for computers, stage 5 nominal, stage 14 paradigmatic, and stage 15 cross-paradigmatic. It would be flexible because it was possible to add stages in between, which happened in 2014 as described later. This was because there were no tiers that would fix the number of level to four per tier. Also there was no end to the stages as shown by the addition of stage 16 in 2013 as will also be discussed later.

The crucial insight that solved the major problem in Commons and Richard's 1984 version of the general stage model came when he was driving to Mexicali with Roger Dunn in 1984. Commons was working on collaborating with Jesús Francisco Galaz Fontes of Facultad de Ciencias Humanas de la Universidad Autónoma de Baja California, Mexicali. The collaboration was on the existence of formal stage reasoning in non-literates. He was explaining to Dunn about his model. Dunn asked how the organization of action was different from a chain of behavior. Commons answered that in a chain, the organization of the subtask actions were arbitrary, whereas in the organization of lower stage tasks the organization of actions could not be arbitrary. This is because that organization usually has to work in the real world. The conversation was crucial because they agreed on the nonarbitrary requirement of developing each stage. It was clear that higher order complexity task actions had to be defined in terms of lower order ones. This concept was published in Commons, Richards and Armon (1984).

As Commons, Richards and Armon (1984) were editing the *Beyond Formal Operations* book, they decided that it could initiate a new field of positive adult development .The new positive adult development field would be different from the traditional field of adult development and aging because the postformal stages from metasystematic on develop only from early adulthood on. Hence these developments were termed positive adult development. The stages of development in that field would be more coherent if they had a comparative table of stages from the different postformal stage proposers (Commons, Richards and Armon (1984).

More stages were added in the order in which they are discussed: ***a)*** stage 14 for the paradigmatic stage, which is a prerequisite for stage 15 cross-paradigmatic stage; ***b)*** computational stage 0 for computers and programming was added after the book; ***c)*** the meta cross-paradigmatic stage 16 was added in 2013; ***d)*** in 2014, the sensory or motor stage was split with the new automatic stage 1 being added.

In 1990, Jonalu Johnstone, Jeremy B. Straughn, Maryellen Meaney, Julia H. Weaver, Erica Lichtenbaum, Sharon R. Krause, with Dorothy L. Danaher, Cheryl Armon, Suzanne Benack, and Dawn Schrader wrote the first scoring manual called *Applying the General Stage Scoring System* (GSSS, 1990). This was to help other people to score interviews and later to construct instruments using the model of hierarchical complexity. The present system for constructing instruments based on systematically constructed vignettes began with Joseph Anthony Rodriguez (1992). Rodriguez and Commons adapted the stages for making the multisystems task to the new Doctor–Patient vignettes (Commons & Rodriguez, 1993). Theo Dawson made a key contribution in 1996 when she said Rasch analysis should be used to analyze results instead of signal detection.

R. Duncan Luce told Commons and his son Lucas in the summer of 2003 that distribution was the core idea that made things work in measurement theory. In mathematics, one of the differences between a ring and a group is that a ring has two mathematical operations with distributivity, for example times and plus. Here, Commons had generalized distributivity into the non-arbitrary organization of lower stage actions. This was general enough to fit all of thought and action, and yet powerful enough to generate stages. Luce mentioned that this can be clearly seen in the mathematical notion of distribution. The non-arbitrary axiom has major implications. For example, at the concrete stage 9, there is irreducibility of long multiplication to simple addition and multiplication.

The most extensive revision of the model of hierarchical complexity was completed in August of 2004. After working a year and a half with R. Duncan Luce, Alexander Pekker and Commons straightened out the formal mathematical theory. Pekker was a graduate student in mathematics at Harvard. He cleaned up the mathematics of the model. He also systematized the meaning of non-arbitrary ordering of lower order actions with combinatorial mathematical theory, showing that not all combinations of behaviors were allowed.

Later, in 2012, Commons' research assistant Eva Yujia Li mentioned that in order for a person to understand the crossparadigmatic stage, that person has to be at one stage higher. In this case, because commons is the person who invented crossparadigmatic stage, he himself had to be as least one stage higher. The invention can be done by induction. The higher stage was later named meta-crossparadigmatic stage.

Starting from July 2014, a new stage was developed. Before 2014, the model of hierarchical complexity (MHC) had 16 orders. However, applying the model to explain the development of operant conditioning (originally order 2) from respondent conditioning (originally order 1) in non-human animals, led to the discovery of another new stage. The old stage sensory or motor order 1 had to be separated into two new orders. The revised order 1 was renamed the *automatic* order 1 and the new order 2 as *sensory or motor*. Thus there are now 17 orders of hierarchical complexity and their corresponding stages.

» ADVANCES

From that early period, there have been a very large number of advances in the model of hierarchical complexity. The implications of the model have become much clearer across the years. These include understanding the nature of development as well as how when combined with the value of consequences of behavior, a very powerful model for predicting most behavior has emerged. The generality to all domains has also expanded. A sample of these advances are listed next with references when these references are available.

1. Commons, M. L., Richards, F. A. & Kuhn, D. (1982). Systematic and metasystematic reasoning: A case for levels of reasoning beyond Piaget's stage of formal operations, *Child Development,* 3, 1058–1069. Retrieved from http://dareassociation.org/Papers/Systematic%20and%20Metasystematic%20reasoning1982.pdf

This was the first publication to introduce four stages after Piaget's formal stage, and the general stage model which was later to be called the model of hierarchical complexity. Different from other attempts in the developmental literature to try to postulate "postformal operational" stage of cognition, the model of hierarchical complexity's four postformal stages constituted a quantitatively distinct structure or stage of action, problem solving and reasoning. An instrument (four story problem) was developed to assess these modes of cognition, in systematic and metasystematic stage reasoning. The first European scholar who used the same four story problem (Commons, Richards & Kuhn, 1982) was Eeva Kallio. She published her first article based on her MA thesis in developmental psychology (Kallio & Helkama, 1991). She continued critical discussion of these three stages (Kallio, 1995).

2. Commons, M. L., Miller, P. M. & Kuhn, D. (1982). The relation between formal operational reasoning and academic course selection and performance among college freshmen and sophomores. *Journal of Applied Developmental Psychology*, *3*, 1–10. Retrieved from http://www.dareassociation.org/Papers/The%20Relation%20between%20formal%20operational%20reasoning1982.pdf

This study showed that concrete stage performing students did not take any courses with mathematics in them including all the science courses. Formal stage performers according to the MHC and Inhelder and Piaget's criteria did. This showed that stage was a strong predictor of other behaviors, such as academic course selection.

3. Commons, M. L. & Rodriguez. J. A. (1990). "Equal access" without "establishing" religion: the necessity for assessing social perspective-taking skills and institutional atmosphere. *Developmental Review*, *10*, 323–340. Retrieved from http://dareassociation.org/Papers/Equal%20Access%20without%20Establishing%20religion1990.pdf

This paper introduced the application of the model of hierarchical complexity to stages of social perspective taking. It showed how MHC could be applied to major legal decisions. There is a possibility that the Supreme Court or other courts have used this article in some of their decisions.

4. Commons, M. L. (1991). A comparison and synthesis of Kohlberg's cognitivedevelopmental and Gewirtz's learning-developmental attachment theories. *J. L. Gewirtz & W. M. Kurtines (Eds.) Intersections with attachment,* 257–291). Hillsdale, NJ: Erlbaum Associates, Inc.

Kohlberg's cognitive developmental and Gewirtz's learning developmental approaches to attachment were compared. The two approaches were synthesized yielding the sequence of attachment stages and stage-change processes.

5. Commons, M. L., Krause, S. R., Fayer, G. A., & Meaney, M. (1993). Atmosphere and stage development in the workplace. In J. Demick & P. M. Miller (Eds.). *Development in the Workplace* (pp. 199–220). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc. Retrieved from http://dareassociation.org/Papers/CommonsKrauseFayerMeaney1993.pdf

This paper presented a method for characterizing the relationship between individuals and their workplace environment with respect to individual moral development. The model of hierarchical complexity was used to investigate and characterize individual development and the stage of development embodied in the workplace environment.

6. Sonnert, G., & Commons, M. L. (1994). Society and the highest stages of moral development. *Politics and the Individual*, *4* (1), 31–55. Retreived from http://dareassociation.org/Papers/Society%20and%20Highest%20Moral%20Dev.html

This paper discussed the higher stages in Kohlberg's stage theory of moral development. It resulted in the first re-definition of Kohlberg's highest moral stages 5 (metasystematic) and 6 (paradigmatic) in a non-arbitrary way that satisfied the criteria from the model of hierarchical complexity for what constitutes a stage.

7. Commons. M. L., Lee. P., Gutheil, T. G., Rubin, E., Goldman, M., & Appelbaum, P. L. (1995) Moral stage of reasoning and the misperceived "duty" to report past crimes. *International Journal of Law and Psychiatry, 18* (4), 415–424. Retrieved from http://dareassociation.org/Papers/Moral%20State%20of%20Reasoning1995.pdf

This paper examined clinicians' sensitivity to the rights of patients in two domains: the false duty to report past crimes (misprision) and the duty to report patients' future potential for violence. This was the first application of the model of hierarchical complexity to the professional relationship between doctors and their patients.

8. Commons, M. L., & Goodheart, E. A. (1999). The philosophical legacy of behaviorism. *The Philosophical Foundations of Behaviorism*, 9–49.

The paper argues that as decentration progresses in human beings, mentalistic notions of causes of behavior such as free will are replaced by non-mentalistic or more behavioral notions of causes. Behavior analysis was explained with respect to the model of hierarchical complexity. In the model of hierarchical complexity, an event is processed as data and classified in terms of task-required hierarchical organization of required response. By this time, the name model of hierarchical complexity had superseded the general stage model.

9. Commons, M. L., & Wolfsont, C. A. (2002). A complete theory of empathy must consider stage changes. *Behavioral and Brain Sciences*, *25* (1), 30–31.

In the paper, a sequential, hierarchical stage model of empathy accounted for a comprehensive range of empathic behaviors. Empathy is part of emotions. This paper showed that the model accounted for emotional development and not just cognitive development. In the paper, an illustrative table, "Stages of Empathy" was provided to demonstrate how increasingly hierarchically complex empathic behaviors emerge at each stage, beginning with the infant's "automatic empathy" and ending with the advanced adult's "coconstruction of empathetic reality." It showed that the model of hierarchical complexity can characterize empathy behaviors from infants to adulthood.

10. Commons, M. L., & Richards, F. A. (2002). Organizing components into combinations: how stage transition works. *Journal of Adult Development*, *9* (3), 159–177.

This was the first paper to explicate the nature of transition steps between stages in the model of hierarchical complexity. The model of hierarchical complexity of tasks leads to a quantal notion of stage, and therefore delineates the nature of stage transition. The model shows that there was only one stage sequence for stage transition.

11. Commons, M. L., & Richards. F. A. (2003). Four post formal stages the handbook of adult development, *The Springer Series in Adult Development and Aging*, 199–219. Retrieved from http://www.tiac.net/~commons/Four%20Postformal%20Stages.html

A detailed introduction of the four postformal stages was presented in this paper. The term "postformal" has come to refer to various stage characterizations of behavior that successfully address more hierarchically complex behaviors than those behaviors found in Piaget's last stage—formal operations. These stages are generally seen only in adults. Other postformal research that was directed toward an understanding of development in a single domain. The model of hierarchical complexity is standard universal model that addresses all tasks in all domains.

12. Commons, M. L., & White, M. S. (2003). A complete theory of tests for a theory of mind must consider hierarchical complexity and stage. *Behavioral and Brain Sciences, 26* (5), 606–607.

This was the first presentation to introduce stacked neural networks by using the model of hierarchical complexity as a frame. It explained the limitation of the traditional neural networks and the advances of the new hierarchical stacked neural networks.

13. LaLlave, J. (2005). The acceptability of arguments in favor of and against the Iraq War. *Conflict & Communication Online*, *4* (2), 1–16. Retrieved from http://dareassociation.org/Papers/Iraq%20War.LaLlave.pdf

This paper presented research pertinent toward the prevention and constructive transformation of conflicts. It proposed models that have external validity in the fields of political argumentation expert evaluation and testimony, psychological assessment and journalist reporting.

14. Commons, M. L., Rodriguez, J. A., Adams, K. M., Goodheart, E. A., Gutheil, T. G., & Cyr, E. D. (2006). Informed consent: do you know it when you see it? Evaluating the adequacy of patient consent and the value of a lawsuit. Psychiatric Annals, 36, 430–435. Retrieved from http://dareassociation.org/Papers/Informed%20Consent%202006.pdf

In this paper, the helper-person instrument was used to test how well practitioners engaged in informed consent. The helper person instrument consisted of six vignettes ranging in hierarchical complexity from primary to metasystematic. This measurement of individuals' stage of reasoning about helping predicted how positively mental health practitioners are seen and whether or not they will be sued and for how much.

15. Ross. S. (2006). effects of A structured public issues discourse method on the complexity of citizens' reasoning and local political development (doctoral dissertation). Retrieved from http://dareassociation.org/Papers/Sara%20Nora%20Ross%20Dissertation.doc

The model for hierarchical complexity was used to structure the reasoning about issues that would increase in political development. This shows that the model is good for accounting for phenomena in the separate social science of political science, and not just simple behaviors.

16. Robinett, T. (2006). Moral reasoning and political affiliation in liberal and conservative voters: applying a model of hierarchical complexity (doctoral dissertation) Retrieved from http://dareassociation.org/Terri.Robinett_Dissertation_2006.pdf

A study analyzed the similarities and differences in moral and reasoning stages between liberal and conservative voters. This study utilized the model of hierarchical complexity to relate various individual performances on multiple measures of moral reasoning. Although the model of hierarchical complexity did not predict political affiliation, it did support the notion that the test items were measuring moral reasoning stages, which provides support for Kohlberg's stage theory. Education-level and household income were found to be highly correlated and significant predictors of

political affiliation while level of religiosity was correlated with and found to be a significant predictor of one's identification as a liberal or a conservative. This study shows that stage and value (conservative versus liberal) are not always related.

17. Commons, M. L., & Miller, P. M. (2007). How early negative caregiving experiences relate to stage of attachment. *Behavioral Development Bulletin*, *13*, 1417. Retrieved from http://dareassociation.org/Papers/BDB%203.%20Early%20Negative%20Caregiving%20Experiences.pdf

The paper explained how negative behaviors have an effect on stages of adult development of attachment by using the model of hierarchical complexity. Extreme negative early experiences, such as abuse or neglect, often lead to arrested development in the subdomains, such as the interpersonal domain, in which such experiences occurred. The model of hierarchical complexity helped to explain how different stage behavior attachment issues should be responded to with different approaches. This showed how reinforcement contingencies (value) affect emotional stage.

18. Miller, P. M., & Commons, M. L. (2007A). Stages of infant development, as illustrated by responses to the peekaboo game in infants. *Behavioral Development Bulletin*, *13*, 1823. Retrieved from http://dareassociation.org/Papers/BDB%204.%20Infant%20stages%20peek-a-boo.pdf

In this paper, infant developmental changes were characterized by the model of hierarchical complexity. A possible developmental stage sequence for peek-a-boo and its comparison to the same stage sequences of other infant behaviors was discussed. This showed that the early stages in the model of hierarchical complexity can analyze and explain infant developmental behaviors.

19. Miller, P. M., & Commons, M. L. (2007B). How are the processes by which people become attached influenced by stage of development? *Behavioral Development Bulletin*, *13*, 2429. Retrieved from http://www.dareassociation.org/Papers/BDB%205.%20Processes_People%20Become%20Attached.pdf

Attachment processes are those events that are involved in developing and strengthening the attachment behaviors at different stages. The model of hierarchical complexity provided a rationale for specifying the order of development of attachment processes. It was used to examine the attachment process for children from age eight to ten years.

20. Commons, M. L., Goodheart, E. A., Pekker, A., Dawson, T. L., Draney, K., & Adams, K. M. (2008). Using Rasch scaled stage scores to validate orders of hierarchical complexity of balance beam task sequences. *Journal of Applied Measurement*, *9* (2), 182–199. Retrieved from http://dareassociation.org/Papers/Commons%20URM.pdf

The studies listed in the paper examine the relationship between the analytic basis underlying the hierarchies produced by the model of hierarchical complexity and the probabilistic Rasch scales that placed both participants and problems along a single hierarchically ordered dimension.

21. Day, J. M. (2010). Religion, spirituality, and positive psychology in adulthood: A developmental view**.** Journal of Adult Development, 17, 215–229.

The article considered contributions of religious commitment and spiritual practice to well-being and cognitive-developmental theoretical models. It also related bodies of empirical and clinical research with religious and spiritual development across the life cycle, with particular attention to questions related to positive adult development. The model of hierarchical complexity could be used to analyze religious related issue in respect of adult development.

22. Commons, M. L., Miller, P. M., Li, E. Y., & Gutheil, T. G. (2012). Forensic experts' perceptions of expert bias. *International Journal of Law and Psychiatry 35* (5–6), 362–371. Retrieved from http://dareassociation.org/Papers/CommonsMillerLiGutheil2012.pdf.

The purpose of this study was to find out how potentially biasing different situations were perceived to be. Another focus of the current study was to understand perceived bias from a psychophysical perspective. In the paper, the reason why some biases are easier to identify and overcome than others was identified. According the model of hierarchical complexity, more difficult items required higher stages. A factor analysis showed that the higher the stage, the less biasing they were perceived to be. This shows that the model of hierarchical complexity was useful in understanding the degree of bias in various situations.

23. Commons, M. L., Li, E. Y., Richardson, A. M., Gane-McCalla, R., Barker, C. D., & Tuladhar, C. T. (2014). Does the model of hierarchical complexity produce significant gaps between orders and are the orders equally spaced? *Journal of Applied Measurement*, *15* (4), 1–29.

The paper shows that, in the model of hierarchical complexity, there was no overlap between the Rasch-scaled item scores at one order of complexity, and those of the adjoining orders. There are "gaps" between the stages of performance on those items. And after testing for equal spacing between the orders of hierarchical complexity, it was found that the orders of hierarchical complexity were equally spaced.

24. Commons, M. L. & Tuladhar, C. T. (2014). Developmental behavior analytic therapy part I: easier done than said. *Behavioral Development Bulletin, 19* (2), 1–10.

Developmental behavior analytic therapy (DBAT) is the first behavioral therapy with developmental underpinnings. This paper introduces DBAT by presenting a composite case study. It also discusses the theoretical underpinnings of this therapy. DBAT aims to help individuals with behavioral problems change specific problem behaviors that consequently help them to lead more satisfying lives. It aims to alter specific behavioral problems,

because the biological susceptibility to such behavioral problems is a given. It is suggested that this therapy be used as an adjunct to conventional therapies that specialize in helping individuals cope with behavioral problems. DBAT is different from other contemporary or behavioral analytic therapies, as it integrates a behavioral developmental stage model, the model of hierarchical complexity (MHC), into its working. The foundation of this therapy is the theory that behavioral developmental stages and value of consequences of a behavior interact to predict an individual's behavior, and also suggests that behavioral problems affect both behavioral developmental stage and value of consequences.

25. Commons, M. L. & Tuladhar, C. T. (2014). Developmental behavior analytic therapy part ii: procedures and case studies, *Behavioral Development Bulletin*, *19* (2), 11–21.

This paper discusses the case studies applying developmental behavioral analytic therapy (DBAT), a new behavioral therapy with developmental underpinnings. It also lays out the sequence of procedures of this therapy. The procedures have been illustrated with examples from six case studies of individuals who have undergone the therapy. It also presents the methodology and results of intervention using DBAT on those six individuals. With DBAT, five out of the six individuals achieved their target behaviors and increased their developmental stages. The positive results yielded from this small sample suggest potential benefit and success of DBAT therapy.

26. Commons, M. L., Commons-Miller, L. A. H., Salaita, R. J., & Tuladhar, C. T. (2014). Stars that crash. *Behavioral Development Bulletin, 19* (2), 100–110.

The present study introduces a model explaining what leads stars to crash and assesses risk factors that lead stars to crash in a sample of 18 celebrities who have had a downfall. Downfalls include alcoholism, drug abuse or addiction, mental illness, myriad relationship problems, death, suicide or other life-changing disasters. First, the paper theorizes that individuals' early environments and social forces, such as assortativeness and affiliation, contribute to their narcissistic traits. The model illustrates how these risk factors including narcissistic traits and the adult environments of stars lead them to engage in behaviors that lead to their downfalls. To examine the usefulness of this model, the paper examined the lives of famous celebrities (i.e., "stars") who had public downfalls ($n = 18$) using secondary sources. It assessed the risk factors involved in the crashing of stars. In concordance with the proposed model, results showed that what the majority of these cases had in common were: Atypical early environments, such as abandonment and trauma, over-indulgent or absent wealthy parents, or an early career; and adult environment conditions, such as colluding social groups and entourages. These factors could be linked to stars having extramarital affairs damaging their marriage or careers; bankruptcy; or alcohol and/or drug addiction. In some cases these factors have led to stars having accidents, or deaths. Furthermore, the study shows that there is a positive correlation between the number of risk factors present and the severity of the downfall of the stars.

27. Li, E. Y., Commons, M. L., Miller, J. G., Robinett, T. L., Marchand, H., Ost, C. M., & Ross, S. N. (2014). Relationship among measures within the social and moral development domain. *Behavioral Development Bulletin*, *19* (2), 106–113.

This paper investigates using the model of hierarchical complexity (MHC) as a framework to study individual's stages of moral understanding. As an improvement from traditional stages of moral development, 15 stages of moral understanding were generated using the model of hierarchical complexity. Data were collected in four separate studies on how participants make choices in specific moral dilemmas. Each study presented five or six vignettes of arguments, each constructed to have different orders of hierarchical complexity. Participants rated the quality of arguments on a 1 to 6 scale. A Rasch analysis produced stage scores for each of the stories. The Rasch scores were regressed against the order of hierarchical complexity of each vignette. These were Counselor-Patient: $r(3) = .992$; Anti-Death-Penalty: $r(3) = .919$; Incest –No Report: $r(3) = .916$; Incest-Report: $r(3) = .624$. The result showed that Rasch scores of vignettes were predicted by their orders of hierarchical complexity, suggesting that the model of hierarchical complexity was a good framework to study stage of moral understanding.

28. Ross, S. N., Commons, M. L., Li, E. Y., Stålne, K., & Barker, C. D. (2014). Toward defining order 16 and describing its performance for the model of hierarchical complexity. *Behavioral Development Bulletin, 19* (3), 33–36.

We trace the first four years of the new theoretical discourse on the definition order 16 of hierarchical complexity. Tasks performed at this order are similarly classified as stage 16 performances. Until this current discourse began, the highest order identified using the MHC was order 15, named cross-paradigmatic. In different groupings, several MHC theorists have discussed the properties and definition of this new order. To this point, an explicitly collaborative effort has yet to be undertaken. To reach agreement on definition and properties of order 16 and task performances at that order will likely require us to agree on more complex than usual hierarchical complexity-based scoring criteria and inter-rater standards. To meet these new challenges, these criteria and standards must be precise enough, complex enough, and general enough to apply across the uncommonly disparate and high-level examples proposed thus far as performances at stage 16. Since these methodological foundations have not yet been developed, to date our discourse is comprised of some who consider the process of defining the new order and empirically demonstrating it further along than others do. This theoretical development terrain promise intense and promising work ahead on this breakthrough in applying the MHC, its contributions to behavioral development theory, and the measurement of the most complex human accomplishments recognized thus far.

29. Tuladhar, C. T., & Commons, M. L. (2014). Correspondence between some life-span stage theory developmental sequences of stages and levels. *Behavioral Development Bulletin*. *19* (3), 24–27.

Good comparisons of development sequences have been made in the past. The model of hierarchical complexity is one developmental sequence which has often been compared to other developmental sequences including: Piaget & Inhelder (1969); Fischer & Bidell (1998); Colby and Kohlberg's (1987a, 1987b) 9 point stages and moral maturity scores (mms) of moral judgment. However, Colby and Kohlberg's 13 point scale has never been assessed in making comparisons to other scales. The current paper constructed a comparison table of all five models, including Colby and Kohlberg's 13 point scale, which together cover the developmental stages of an entire life-span. Adjustments had to be made to the 9 point and 13 point scales. The formula, OHC = 3 + 2 * (Stage of Colby & Kohlberg's), was introduced to demonstrate the relationship between the orders of hierarchical complexity and Kohlberg's stages of development.

30. Commons, M. L., & Jiang, T. R. (2014). Introducing a new stage for the model of hierarchical complexity: a new stage for reflex conditioning. *Behavior al Development Bulletin*, *19* (3), 1–8. Retrieved from http://baojournal.com/BDB%20WEBSITE/archive/BDB%2019.3-A01.pdf

The paper introduced the new stage 1 in the model of hierarchical complexity. The original sensory or motor stage 1was split into two stages. The new automatic stage 1 had respondent conditioning removed from it. By introducing the new stage, single cells behavior could be better understood. The revised sensory or motor stage 2 explained respondent conditioning (originally order 1) in non-human animals.

31. Commons, M. L., Miller, L. S., & Giri, S. (2014). A model of stage change explains the average rate of stage of development and its relationship to the predicted average stage ("smarts"). *Behavioral Development Bulletin*, *19* (3).

A number of different previous methods for measuring "smarts" have led to the model of hierarchical complexity (MHC), a context free neo-Piagetian mathematical model of behavioral complexity. It provides a way to classify tasks as to their hierarchical complexity. Using the model of hierarchical complexity, this study examines how differences in rate of stage change results in a difference in the highest average stage (smarts") attained by 70 year old adults. The average stage of development ("smarts") was shown to be predicted by the log of age with an $r = .79$. It uses data from Colby, Kohlberg, Gibbs, Lieberman (1983) to test the model. It also predicts that on the average there is one stage of development during adulthood.

32. Harrigan, W. J., & Commons, M. L. (2014). The stage of development of a species predicts the number of neurons. *Behavioral Development Bulletin*, *19* (3).

This paper asked the question: does energy density as a represented by number of neurons of organisms increase as stage of animals' increases? This paper also addresses the question of why brains evolved in the first place. The stage of development of several species was assessed. The model of hierarchical complexity successfully predicts the number of neurons in different species.

33. Giri, S. P, & Commons, M. L., Harrigan, W. J. (2014). There is only one stage domain, put in the published information. *Behavioral Development Bulletin*, *19* (3).

The study used the model of hierarchical complexity (MHC) to test the theory that different skills in development would develop in synchrony, allowing an individual to solve tasks from various domains using the same mental structure for each task. The MHC instruments used were the empathy, helper person, counselor patient, breakup, caregiver, algebra, balance beam, infinity and laundry instruments. The analysis showed that person scores on each instrument loaded on the first factor (92.156% of the variance). This agrees with the model of hierarchical complexity's assumption that there is only domain in development.

34. Commons, M. L., Giri, S. P. & Harrigan, W. J. (2014). The small effects of non-hierarchical complexity variables on performance. *Behavioral Development Bulletin*, *19* (3).

This study was designed to test the effect of small variables on task performance. The variables tested were hierarchical complexity, place in order, the number of calculations needs, the size of the numbers, and the causal variable position. Participants were asked to solve problems from task sequences from the Logic/mathematics/physical science subdomains. The results showed that order of hierarchical complexity has a very strong predictive role and accounts for most of the variance. The other variables only made very small contributions.

35. Commons, M. L., & Thexton, C. S. (2014). Stages of investing using the model of hierarchical complexity. *Behavioral Development Bulletin*, *19* (4).

Most theories and studies of decision making are a-developmental. However, there is ample evidence that there are differences in behavior on many decision-making tasks between children and adults. This paper asserts that within adults there are differences in behavior on many decision-making tasks and discusses investment as a decision-making task where differences in adult behavior can be analyzed. It presents an argument that stage theory can determine investment behavior. The major properties of investment behavior are ***a)*** how many variables a person can look at and ***b)*** whether a person can compare systems and understand that regulations are incomplete and not consistent. We propose that the rational theories of investing fail because most economic theories assume perfectly rational players in the market place. One of the major reasons that private investors do terribly in managing and investing money is the inadequate stage development of the investors on the task of investing.

36. Alves, J. (2014). Depression, the loss of value and its relationship to stage. *Behavioral Development Bulletin*, *19* (4).

Depression is almost always accompanied by the loss of value for previously salient reinforcement. But do the sources of reinforcement value change with stage? At every stage, punishment

produces depression is some fashion. Punishment has two effects. First is during acquisition, punishment strengthens competing behaviors by being paired with the elicitor of the operant behavior that interferes with the punished behavior. Second during allocation it changes the value of the punished behavior relative to the other competing behaviors. For example, primary stage 8 performing people think only about themselves. At that primary stage, people receive a lot of punishment because they do not take other people's perspectives and integrate those perspectives with their own. They are the second lowest stage criminals. Non-psychotic rapists are an example. They are not severely depressed but moderately depressed. They are nasty and there is a tendency toward aggression. If you ask them, they say that the world sucks. They see themselves as victims.

37. Commons-Miller, L. A. H., Commons, M. L., Li, E. Y., Miller, P. M., Golino, H. F. & Tuladhar, C. T. (in press). Stage of pricing strategy predicts earnings: a study of informal economics.

The study examined the relationship between stages of development on economic tasks and income of the people being studied. It shows that the order of hierarchical complexity was a better predictor of income and indicates that social stratification will continue to persist as differences in individual's developmental stages will persist.

38. Harrigan, W. J. (in press), November. Replacing Maslow's needs hierarchy with an account based on stage and value.

An all-encompassing model of value and stage was applied to interpret Maslow's "needs" hierarchy model. The model of hierarchical complexity was used to expand the understanding of Maslow's model. It was suggested that Maslow's hierarchy of needs be interpreted from the perspective of stage and value.

39. Commons, M. L., Grotzer, T. A. & Davidson, M. N. (in press). The sufficiency of reinforcing problem solutions for transition to formal operations.

A racially and socio-economically integrated population of fifth and sixth grade students was repeatedly presented with formal-operational causality problems. With problem presentation alone and with problem presentation and feedback, no significant change occurred. The transition to the formal stage performance accelerated significantly only when correct answers were reinforced. There were 75% of the participants reaching the formal stage on the problem they were trained. This finding supports the sufficiency of reinforcement for producing formal stage performance.

40. Commons-Miller, L. A. H, Commons, M. L, Miller, P. M., Golino, H. F., & Li, E. Y. (in Press). Stage of pricing strategy predicts earnings: a study of informal economics.

Social stratification is a significant moral issue mostly driven by high levels of income disparity. A common notion is that such income disparity can be reduced by creating equal opportunity of education for all individuals. However, this study shows that developmental stage is a better predictor of income and indicates that social stratification will continue to persist as differences in individuals' developmental stages will persist. This cross-cultural study examines the relationship between stages of development on economic tasks and income of the people being studied. Two groups of people were studied: people who sell things on the sidewalks (peddlers) and people who transport goods (carters). Participants were from Brazil and the United States. Studying informal economies across cultures allowed us to test the stage of pricing strategies used by people of varying education levels and at different behavioral stages of development ranging from primary to metasystematic. The purpose of this study was to determine the extent to which the behavioral developmental stage of economic reasoning affected income obtained. Three quasi-independent variables were examined: the behavioral stage of the person's economic behavior, the country in which they lived, and how much schooling they had. It was found that the developmental stage of participants' pricing strategies, correlated most with how much they earned. The developmental stage was a better predictor of income than education.

41. Day. J, (in press). On cognitive complexity, stage, and value, in religious cognition.

This study examined whether level of cognitive complexity in religious cognition, using measures rooted in the model of hierarchical complexity, mediates the relationship between level of general cognitive development, and religious judgment, in children and adolescents. The study was conducted with 189 children and adolescents drawn from Catholic schools in France. General cognitive development level was measured using the WISC and WAIS. Level of cognitive complexity in religious cognition was measured using the *Religious Cognition Questionnaire: Pastor-Parishioner Scenario* (RCQ). Religious judgment levels were measured using the *Religious Cognition Questionnaire: Pastor-Parishioner Scenario* (RCQ). Results indicate that the relationship between IQ and religious judgment is mediated by level of complexity in religious cognition. The results provide further empirical evidence for the conceptual validity and research utility of the model of hierarchical complexity in the domain of religious cognition, and the power of the concept of complexity in religious cognition for explaining relationships between general cognitive development using IQ measures and other domains where the judgment of social, moral, and philosophical issues are concerned. The results also provide further empirical evidence for the distinctive, and relatively advanced, capacity of "gifted" young people to think critically about religious and philosophical issues.

42. Görtz, D. P., & Commons, M. L. (in press). The stage-value model: implications for the changing standards of care.

The standard of care is a legal and professional notion against which doctors and other medical personnel are held liable. The standard of care changes as new scientific findings and technological innovations within medicine, pharmacology, nursing

Table 5. the correlation coefficients of the model of hierarchical complexity and each instrument's Rasch data

study names	measures	*r* for predicting Rasch difficulty	factor loading	
			1	2
there is only one stage domain	helper person	$r(40) = 0.977$	0.969	0.087
there is only one stage domain	laundry	$r(111) = 0.964$	0.999	0.028
there is only one stage domain	empathy	$r(22) = 0.910$	0.939	–0.321
there is only one stage domain	counselor patient	$r(30) = 0.934$	0.952	–0.158
there is only one stage domain	breakup dilemma	$r(21) = 0.835$	0.954	–0.239
there is only one stage domain	caregiver	$r(42) = 0.711$	0.964	–0.107
there is only one stage domain	algebra	$r(40) = 0.966$	0.975	0.143
there is only one stage domain	balance beam	$r(51) = 0.980$	0.919	0.433
there is only one stage domain	infinity [reference]	$r(52) = 0.912$	0.966	0.137
developmental task action sequence in the development of communication	autism developmental task sequence (ADTS)	$r(42) = 0.893$	—	
why there are upper limits to the stage of development on one's best task and best domain	$\log_2$(age) predicted moral maturity score	$r(225) = 0.764$ $p = 0.000$	—	
the stage of development of a species predicts the number of neurons	stage of development predicts number of neurons	linear: $R^2 = 0.580$ power function: $R^2 = 0.764$	—	
forensic experts' perceptions of expert bias	the Rasch scores of the items in the instrument and the orders of hierarchical complexity of the items	$r(16)=0.698$	—	

and public health are developed and adopted. This study consists of four parts. Part 1 describes the problem and gives concrete examples of its occurrence. The second part discusses the application of the model of hierarchical complexity on the field, giving examples of how standards of care are understood at different behavioral developmental stage. It presents the solution to the problem of standards of care at a paradigmatic stage 14. The solution at this stage is a deliberative, communicative process based around why certain norms should or should not apply in each specific case, by the use of so-called meta-norms. Part 3 proposes a cross-paradigmatic stage 15 view of how the problem of changing standards of care can be solved. The proposed solution is to found the legal procedure in each case on well-established behavioral laws. We maintain that such a behavioristic, scientifically based justice would be much more proficient at effecting restorative legal interventions that create desired behaviors. The forth part address a chaos theory of why parts one, two and three will occur. Simply stated, it sets forth that the change is driven by attractors that produce short and long term reinforcing benefits. These attractors select the behaviors that obtain them even in a noisy environment where is are ups and down in policy.

43. Görtz, D. P. & Commons, M. L. (in press). The societal attractors towards flatter organization in the 21st century in medicine, law, business, public administration and politics.

Organizations in general are likely to become flatter in the 21st century, which also affects the future of institutions of medical care, psychiatric care and forensics. This trend can be seen already today. This paper suggests eight long-term "attractors" (rather than linear short-terms trends) that lead to flatter organizations. Organizations and the need for management and bureaucracy are discussed from an informational perspective. It is argued that management and hierarchical bureaucracy are necessary because information about specific behaviors needs to be processed by organizations, but that informational efficiency simultaneously implies the striving towards the lowest possible number of layers. Then the eight attractors (long-term trends) are presented: ***a)*** the cultural evolution of information management; ***b)*** scientific support for new forms of management; ***c)*** social media technology; ***d)*** social innovation of new management forms; ***e)*** new production and distribution chains; ***f)*** the strong growth of the world market; ***g)*** the radically disruptive technological development; ***h)*** the re-integration of business, politics and civil sphere. Some consequences in medicine, psychiatry and forensics are presented, including the new forms of treatment in psychiatry where psychiatric treatment is likely to become increasingly merged with the real everyday life situations of the patients.

» TASK DIFFICULTY PREDICTION

The model of hierarchical complexity (MHC) measures stage of development within and across domains, allowing comparison between domains. The table below illustrates the *r* scores for predicting Rasch difficulty and it corresponding factor loadings by using the model of hierarchical complexity as scale. The data shows that the model of hierarchical complexity successfully predicted task difficulties.

» DISCUSSION

The list of advances shows how the model of hierarchical complexity has been developing. It also shows how the theory has been applied to numerous topics. The model of hierarchical complexity is now being used in all inhabited continents of the world except Africa. Because the model is so simple and is based on analysis of tasks and not just performances, it is dynamic. This has been shown by the addition of the new orders of hierarchical complexity and the revision of scoring of examples to illustrate other orders. Where might the model of hierarchical complexity go? There seem to be two branches of investigation. One is the construction of instruments in an ever widening set of domains. Because much of the work so far has been done in adulthood, the 'new frontier' has been to conduct similar kinds of studies with children and adolescents and also with non-human animals. Another is the scoring of interviews, speeches and text, also in an expanding variety of domains.

The application of the model of hierarchical complexity has added, along with other stage approaches, to the understanding of the interaction of value and stage; to organizational development, education, and the development of science and culture. Each of these areas will be briefly discussed next.

Organizational development

For understanding organizational development, the model of hierarchical complexity is used to analyze the structure of organizations and to match employees' stage of performance with the stages required to perform the tasks demands in their job descriptions. The degree of the match is used to select such employees for organizations. This work is ongoing. In the newest work, stage of performance is being combined with six factor loadings of interest.in the Holland scale (Holland, 1973) Interest constitutes the "value" part of the consequences of task engagement and completion. When using interest's factor loadings combined with stage of performance, a match between the position demands in and organization is enhanced greatly over just using personality matching. The squared differences between each variable are minimized by choosing the right person. The process can also be used to find the right date for people seeking relationships

Education

One of the exciting applications has been to the area of computer run education. An example would be the use of computer run education to teach the model of hierarchical complexity. Another use has been to understand how to arrange items in a computer run curriculum so that they have a higher chance of being ordered properly by increasing difficulty. Using adaptive means, and using age as a predictor of stage of performance on an item, one would have the program start at the appropriate age, as a first approximation. If the person preformed correctly, the next item in the developmental task sequence would be presented. If they did not get the item predicted by age, a less difficult item in the sequence would be chosen. The adaptive way would maximize the rate of acquisition of material from the next stage.

Terrorisms and politics

Currently, as Commons (Commons & Goodheart, 2007) has argued, government-building in troubled areas has simply proceeded by one country (often the United States) attempting to impose the current system of government as is in the United States on another country. Commons has argued that the types of governmental structures that countries have are stage-related, and that to impose a system that is not a good match on a country will inevitably fail. Instead, government-building would have the tasks match the same stage at which enough of the powerful part of the society is operating at, or perhaps just slightly above that stage. The unrealistic expectations of helper governments would be replaced by successful interventions at each progressive stage.

Table 6. societal developmental periods and their correspondence to developmental stages

societal development periods	corresponding stages
ultra-traditionalism	transition to concrete
traditionalism	concrete
transition to modernism	abstract
early modernism	formal
modernism	systematic
transition to ultra-modernism	metasystematic
ultra modernism	paradigmatic
advanced ultra-modernism	cross paradigmatic

Development of science

There are a number of applications to the development of science. One of the applications to science that proceeds rather directly out of the model of hierarchical complexity is the proposal for stacked neural networks. One of reasons to propose such stacked neural networks is that existing neural network models are not articulated enough to take on complex learning. The only ones that exist now have two layers, not counting the internal layers within a network. Networks that are more multilayered can address issues at each developmental stage and should therefore be able to better model intelligence of a variety of animals and of humans. For example, in a nominal order 5 task, a four layered stack could ***understand*** single words. It could respond to the ***meaning*** of such words.

Stacked neural networks use the model of hierarchical complexity (Commons & Chen, 2008) to accomplish the following tasks: model human development and learning; reproduce the rich repertoire of behaviors exhibited by humans; allow computers to mimic higher order human cognitive processes and make sophisticated distinctions between stimuli; and allow computers to solve more complex problems.

Development of culture

In very condensed form, the societal developmental periods have been analyzed as to their corresponding stage of development. Remember stage change can only take place one stage at a time. There cannot be any skipping of stages because the higher stage always requires proficient next lower stage behavior. The suggested correspondence between type of societal development, and stage are shown in Table 5.

Above, we outline some of the current work using the model of hierarchical complexity. Because the model of hierarchical complexity is an open system, there is no way to predict what the future applications will be. ■

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