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Commentary on a new model for strategy development for strategy development combining categorical data analysis with growth modeling

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ABSTRACT

There have been a number of steps in the evolution of modeling cognitive strategy for development. While the older stage models such as Piaget's and Kohlberg's did not have much information regarding the processes that take place between stages, Boom's new model for strategy development is 12 times as dense. It is as dense as the model of hierarchical complexity (MHC). Boom's model and MHC include substages which explain what happens between each stage of development. Existence of substages is also confirmed indirectly by Hautamaki, Marjanen, Kupiainen, and Vainikainen (2012). In the current paper, it is argued that MHC and Boom's model should be combined to have a complete model of stage development. Reasons for this proposal are discussed along with tests that can be done. Finally, few unanswered questions are posed.

KEYWORDS: cognitive strategy, strategy development, model of hierarchical complexity, sub-stages, Boom's model, latent growth modeling, item response theory, overlapping waves model

There have been a number of steps in the evolution of modeling cognitive strategy for development. First, there are staircase steps which are half stage in Kohlberg (Colby & Kohlberg, 1987), Piaget (Inhelder & Piaget, 1958), levels in Fischer (1980) and stages in Commons, Trudeau, Stein, Richards and Krause (1998). Second, there is Guttman scaling (1944, 1950) appropriate for non-probabilistic stair case models. Third steps include, Siegler's (1996) Overlapping Waves Model (OWM) which is a system (Siegler, Rest's is an earlier version of that system (Rest, 1999). Within Boom (2012), there is an implicit comparison of stages versus within stage strategies.

"Density" of a stage model

It is important to put into perspective that older stage models such as Piaget's or Kohlberg's were not very dense. They did not contain much if any explicit information filling in what happens between one stage and the next (e.g. see Colby & Kohlberg, 1987; Inhelder & Piaget, 1958). Boom's New Model for Strategy Development is 12 times as dense as Kohlberg or Piaget (Boom 2012; Commons, Commons-Miller and Miller, 2012). It has the same density as the Model of Hierarchical Complexity (MHC). MHC heavily borrows from it. Boom's model and MHC include subtasks and subsubtask which fill in information about what happens between one stage and the next which older stage models such as Piaget's or Kohlberg's did not. For example, in primary stage of arithmetic there are three subtask actions, each containing five subsubtask actions. Subsubtasks are necessary for acquisition of subtask action (Boom, 2012). However, subsubtasks do not persist after acquisition whereas subtasks persist even upon completion of the next stage.

More indirect confirmation of sub-stages

Hautamäki, et. al. (2012) also gave indirect confirmation of the existence of subtasks. They do so by showing that different comparisons within the Water Level Task (WLT) vary in difficulty. It is important to note that this work is a very unusual task for a human to do. It is one that does not appear to have a great deal of evolutionary significance. The WLT is like the formal balance beam task of the MHC, but even one stage more difficult. It combines understanding volume and the tilt level. That is, motorically it is easily solved, but understanding how it works is much more difficult (probably systematic order).

» WHAT IS NEEDED TO HAVE A COMPLETE MODEL OF STAGE DEVELOPMENT?

We argue that the model of hierarchical complexity is a metasystem. Boom's new model for strategy development is a metasystem as well. They need to be combined.

Boom's model is a metasystem stage 12

Boom's model is a metasystem stage 12 because it combines two systems and applies them to the OWM. Latent growth model (LGM) is the first system and item response theory (IRT) is a second system. The IRT provides the means to relate the use of such strategies to an underlying developmental dimension and the movement

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of individuals along this dimension can be modeled using LGM (Boom, in press). To combine the systems, Rasch latent scores for group data is required. Learning how to characterize individual scores as to slope and intercept to be compared is required as well. All these are combined in Boom's model which fully coordinates the systems yielding a metasystem.

The transition to the paradigmatic stage 13: Why using both Boom's new model for strategic development and an analysis of the tasks using MHC is necessary

Neither of the two metasystems is sufficient alone because psychometric systems do not have a priori predictive systems. Without Boom's model we cannot check those predictions. What is needed is to combine two metasystems: Boom's new model for strategic development and Common's three layer model of hierarchical complexity. The one of Boom is a psychometric model of performance. This would also apply to Hautamäki. Common's three layer model of hierarchical complexity is one of orders of hierarchical complexity, it is one of subtasks required actions and sub-subtasks required actions.

The MHC is a metasystem. Boom's model is a metasystem. Combining two metasystems is paradigmatic. However, because the combination has not been tested predictively, it is the last subtask in the transition to paradigmatic stage.

Towards a psychophysics of development

On the stimulus side there are required subsubtask actions. This is what is captured by the MHC. These required sub-subtask actions are task-stimulus for the strategies which are the behaviors. This is what is captured by the OWM. When the two models, the MHC and the psychometrics, combine they produce the new paradigm which is the psychophysical paradigm of development.

Tests

One proper test is showing that the priori subtasks are complete and predict the strategies between stages and the orderings of the stages themselves. The latter has been done with the stages showing that there are gaps between stages and that they are equally spaced (Commons et al., 2014). Likewise, we might predict that the spacing between subtasks within an order are equally spaced. This can be tested using Boom's model. The subtask numbers and a combination index combining order tasks and subtasks, as well as within stage strategies across many stages can be used to predict stage strategies.

Unanswered questions

With distinctions between stage strategies on one hand and micro developmental strategies between stages on the other, there may be some confusion. In the MHC there are 17 stages. Within each stage, are there always the same number of subtasks? Do they vary with task sequence, domain and order? Does the OVM help us identify missing subtask and sub-subtask actions? Does it help us identify superfluous subtask and sub-subtask actions? Can it help us distinguish between sufficient and necessary sub-subtask actions? What would be the expected *r*'s between sub-subtask action number, order number and Rasch score? ■

REFERENCES

Boom, J. (2012, July). *New Model for Strategy Development: Combining Categorical Data Analysis with Growth Modeling*. Paper presented at Biennial Meeting of the International Society for the Study of Behavioral Development, Edmonton, Canada.

Colby, A. & Kohlberg, L. (1987). *The measurement of moral judgment*. NY: Cambridge University Press.

Commons M. L., Commons-Miller L. A. H., & Miller P. M. (2012, July). *Boom's Overlapping Wave Model, Rasch Analysis and Subtasks in Transition Between Primary and Concrete Stage Arithmetic.* In N. Galambos (Chair), Quantitative Analysis of Qualitative Developmental Progress: Modeling Cognitive Strategy Development. Symposium conducted at the meeting of International Society for the Study of Behavioral Development, Edmonton, Alberta, Canada

Commons M. L., Li, E. Y., Richardson, A. M, 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).

Commons, M. L., Trudeau, E. J., Stein, S. A., Richards, F. A., & Krause, S. R. (1998). The existence of developmental stages as shown by the hierarchical complexity of tasks. *Developmental Review, 8*(3), 237-278. doi: 10.1006/drev.1998.0467

Fischer, K. W. (1980). A theory of cognitive development: The control and construction of hierarchies of skills. *Psychological Review*, *87*(6), 477-531. doi:10.1037/0033-295X.87.6.477

Guttman, L.A. (1944). A basis for scaling qualitative data. *American Sociological Review, 91*, 139-150.

Guttman, L.A. (1950). *The basis for scalogram analysis*. In Stouffer, S.A., Guttman, L.A., & Schuman, E.A., Measurement and prediction. Volume 4 of Studies in social psychology in world war II. Princeton: Princeton University Press

Hautamaki, J., Marjanen, J., Kupiainen, S., & Vainikainen, M.P. (2012, July). *Old wine in a new bottle - Modelling the development of co-ordination of horizontal and vertical planes using WLT-task*. In N. Galambos (Chair), Quantitative Analysis of Qualitative Developmental Progress: Modeling Cognitive Strategy Development. Symposium conducted at the meeting of International Society for the Study of Behavioral Development, Edmonton, Alberta, Canada

Inhelder, B. and Piaget, J. (1958). *The Growth of Logical Thinking from Childhood to Adolescence*. Basic Books, New York, NY.

Siegler, R. S. (1996). *Emerging minds: The process of change in children's thinking*. New York, NY US: Oxford University Press.

Rest, J.R., Narvaez, D., Bebeau, M. & Thoma, S. (1999). *Postconventional Moral Thinking: A Neo-Kohlbergian Approach*. Mahweh, NJ: Lawrence Erlbaum Associates.

Van der Ven, S. H. G., Boom, J., Kroesbergen, E. H., & Leseman, P. M. (2011). Relations between the development of strategy selection in learning single-digit multiplication and working memory: A microgenetic study. *Journal of Experimental Child Psychology*, under revision.

Van der Ven, S.H.G., Boom, J., Kroesbergen, E., & Leseman P.P.M. (2012). Microgenetic patterns of children's multiplication learning: Confirming the Overlapping Waves model by latent growth modeling. *Journal of Experimental Child Psychology*,*113*(1), 1-19. doi:10.1016/j.jecp.2012.02.001