

# The Relationship Between MHC Stage and WAIS-IV IQ Scores

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# What is the WAIS Test?

- Adult intelligence is most often measured by the Wechsler Adult Intelligence Scale (WAIS)
- The Current fourth edition (WAIS-IV) Includes (Wechsler, 2008) :
  - Verbal Comprehension
    - Similarities
    - Vocabulary
    - Information
    - Comprehension
  - Perceptual Reasoning
  - Working Memory
  - Processing Speed
- The verbal test score has been shown to strongly predict the WAIS full scale score (Wildman & Wildman, 1977)

# Limitations of IQ Tests

- IQ tests are developed using norms and *psychometric analysis*
  - Responses are analyzed in psychometrics using factor analysis
  - It is not known why some items are more difficult than others a priori
- To a large extent, intelligence tests only test surface information (McClelland, 1973)
- These tests have been shown to have cultural and education level biases
- Intelligence tests may mainly predict testing-taking and symbol-manipulation competencies (McClelland, 1973)

# Theoretical and Empirical Relationships between Psychometric and Piagetian Conceptions of Intelligence

- Piaget's definition about IQ is an individual's place in a universal sequence of development toward formal operational reasoning (McClelland, 1973)
- Piagetian's cognitive stage measures provide a rational standard for educational intervention (Kohlberg & Mayer, 1973)
- Piaget's definition of intelligence is not limited to school-type success (Devries, 1974)
  - It takes the long-range perspective of the evolution of knowledge and intelligence in the individual
  - It describes changes with age in the structure of knowledge
  - It describes changes in reasoning about reality

# Correlation Between IQ Tests and Piaget-Type Tasks

Paper	Test Used	Correlation	<i>N</i>	Age
Devries, 1974	Fifteen Piaget-type Tasks and Stanford-Binet IQ Test	$r = 0.34$	143	Age 5-7
Humphreys and Parsons, 1979	Twenty Seven Heterogeneous Piagetian Tasks and 11 Wechsler Subtests	$r = 0.837$	150	Age Range: Age 6-10, 10-14 and 14-18
Dudek, Lester, Goldberg and Dyer, 1969	Nine Piaget test and Wechsler intelligence scale for children	$r(\text{kindergarten}) = 0.48$ $r(\text{Grade 1}) = 0.52$ $r(\text{Grade 2}) = 0.56$	100	Age 5-8

- $r_{\text{Average}} = 0.578$

# The Model of Hierarchical Complexity

- **The Model of Hierarchical Complexity (MHC)** (Bernholt, Parchmann, & Commons, 2009; Commons, Goodheart, Pekker, Dawson, Draney, & Adams, 2008; Commons, Goodheart, Pekker, A., Dawson-Tunik, Cyr, E., Rodriguez, et al., 2005; Dawson, 2002; Skoe, (in press))
- Is a non-mentalistic, neo-Piagetian and quantitative behavioral development theory
- It offers a **standard method** of examining the universal pattern of development
- A fundamental assumption is that development proceeds across a large number of general **sequences** of behavior
- These sequences exist in every domain including
  - Mathematical, logical, scientific, moral, social, and interpersonal domains
- The stages of the MHC have been shown to predict human's “smartness” in the colloquial sense using the Laundry and the Balance Beam instruments (Commons, Goodheart, Pekker, Dawson, Draney, & Adams, 2008)

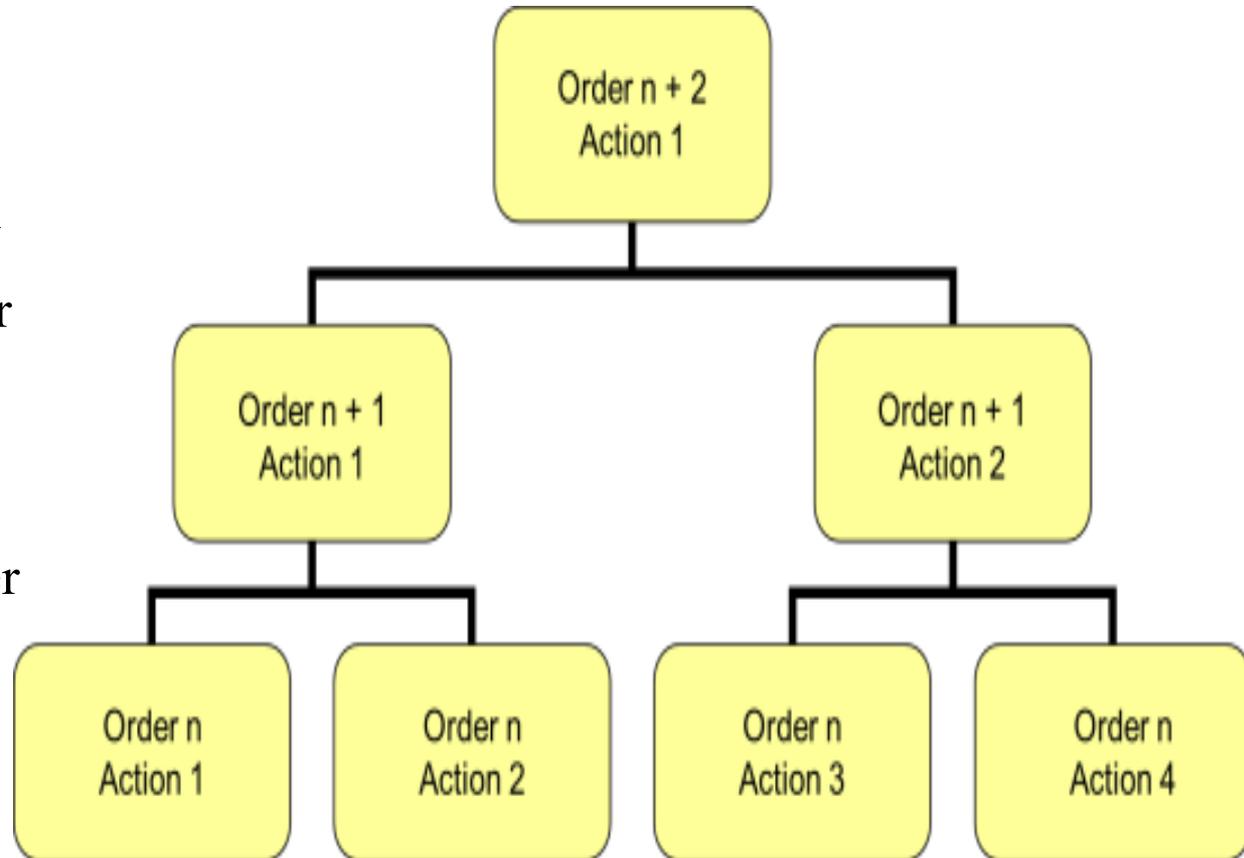
# The Model of Hierarchical Complexity: What Does It Consist Of ?

- ***Orders***
  - The different layers in a hierarchical sequence of task complexity are referred to as “orders”
- ***Stages***
  - The **successful completion** of a task of a given order is referred to as “stage”
- ***Orders of Hierarchical Complexity (OHC)***
  - Assess the predicted difficulty of behavior tasks (Commons & Miller, 1998; Commons & Pekker, 2008; Commons & Richards, 1984a, 1984b; Commons, Trudeau, Stein, Richards, & Krause, 1998, Commons, Gane-Mcalla, Barker, Li, in press)
  - The OHC is a equally-spaced unidimensional ordinal scale
  - The OHC measures difficulty independent of domain and content
- The higher the order of hierarchical complexity, the more the difficulty of the task

# Three Axioms of The Model of Hierarchical Complexity

## Higher Order Action Is:

- a) Defined in terms of tasks actions from the **next lower** order of hierarchical complexity
- b) Defined as the higher order task action that **organizes** two or more less complex actions
- c) The ordering of lower task actions have to be carried out **non – arbitrarily** way



# The Model of Hierarchical Complexity Generates 16 Known Orders

- MHC Generates 16 Orders or Hierarchical Complexity

Order Number	Order Name	Order Number	Order Name
0	Computational	8	Concrete
1	Sensory Or Motor	9	Abstract
2	Circular Sensory Motor	10	Formal
3	Sensory-Motor	11	Systematic
4	Nominal	12	Metasystematic
5	Sentential	13	Paradigmatic
6	Preoperational	14	Crossparadigmatic
7	Primary	15	Meta- Crossparadigmatic

# Why Use the Model of Hierarchical Complexity to Score IQ Test?

- The *Model of Hierarchical Complexity* is cultural, content and education free
  - It is just mathematical
- Assessments based on the Model Of Hierarchical Complexity may be a better measurement of intelligence than contemporary IQ tests
- The MHC does a better job measuring intelligence because
  - It does not rely on psychometrical analyzed norms
  - It based on a simple, clear mathematical model
    - They are based on what order of hierarchical complexity of test items that are correctly done

# The Hierarchical Complexity Scoring System

- The Hierarchical Complexity Scoring System (HCSS) was used to score (Commons, Miller, Goodheart, & Danaher-Gilpin, 2005) the tasks in the Verbal Comprehension Section of WAIS-IV
- The HCSS is an application to score difficulty of tasks based on the Order of Hierarchical Complexity
  - It entails several steps for assessing performance on a task

# WAIS-IV Scoring System Limitations

- The WAIS-IV scoring is incomplete
  - The score 0 can be expanded into many lower order stages as shown by HCSS scoring
  - The 0 point also includes unscorable somewhat randomly appearing answer
  - These are not probed as would be done in a Piagetian type interview
- In some cases, the WAIS-IV Scoring System is also inconsistent based on HCSS scoring
  - Each question has more than one order within the same point answer
  - This restricts the range and therefore lowers the predictability and validity
- The information subsubsection of the verbal subsection to a large extent depends on culture, experience and knowledge
  - People in other culture may not understand the specific facts the WAIS-IV mentioned in the test, which may lower their scores

# Why Is Stage A Better Measure of “Smartness”?

- It does not rely on norms and *psychometrics* for which
  - Only responses are analyzed in psychometrics
  - It is not known a priori why the items are more difficult
- The order of hierarchical complexity is based on 3 axioms
- There is no corresponding analytic a priori mathematical analysis of items on IQ tests
- No such measure is available with IQ because it is *psychometric* and not *psychophysically* tested
  - In psychophysics, stimulus characteristics are used to predict response characteristics
  - Task difficulty is scored using HCSS
  - ***Order Of Hierarchical Complexity*** predicts Rasch performance difficulty with  $r$ 's of over 0.9

# Current Study With Cross-cultural Data

- Clinicians in Belgium agreed to record individual item scores using the WAIS-IV
  - Participants are “high-IQ” population

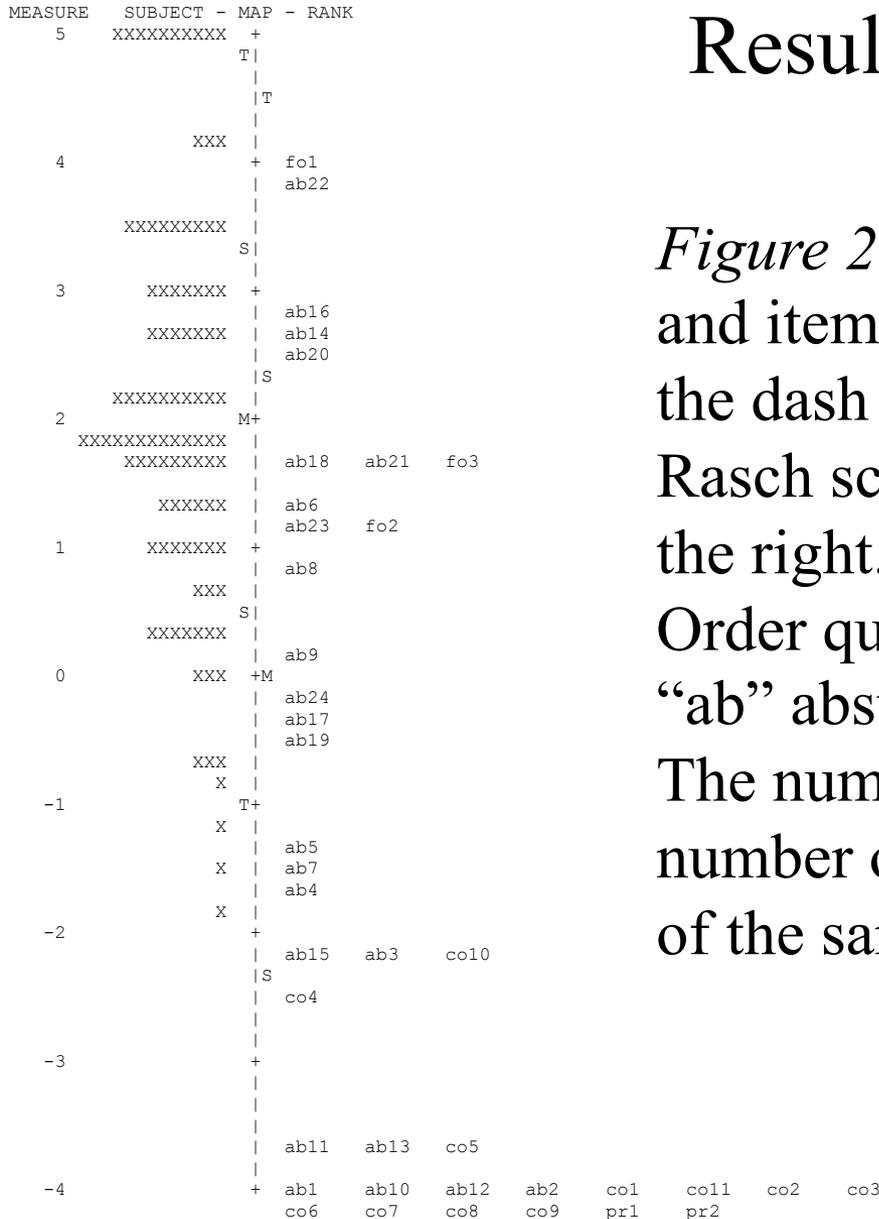
# Method

- With actual data on individuals this study will answer
  - What is the relationship between Rasch person scores and WAIS-IV verbal scores
- To answer this there are a number of steps
  - OHC of items have been obtained as we demonstrated in this presentation
  - Rasch Scores for Items & persons were obtained
  - Rasch items scores were predicted from the OHC scores
  - Their WAIS-IV scores were predicted from the Rasch Person Scores
- Therefore, we will know how well Rasch person predict IQ

# Results

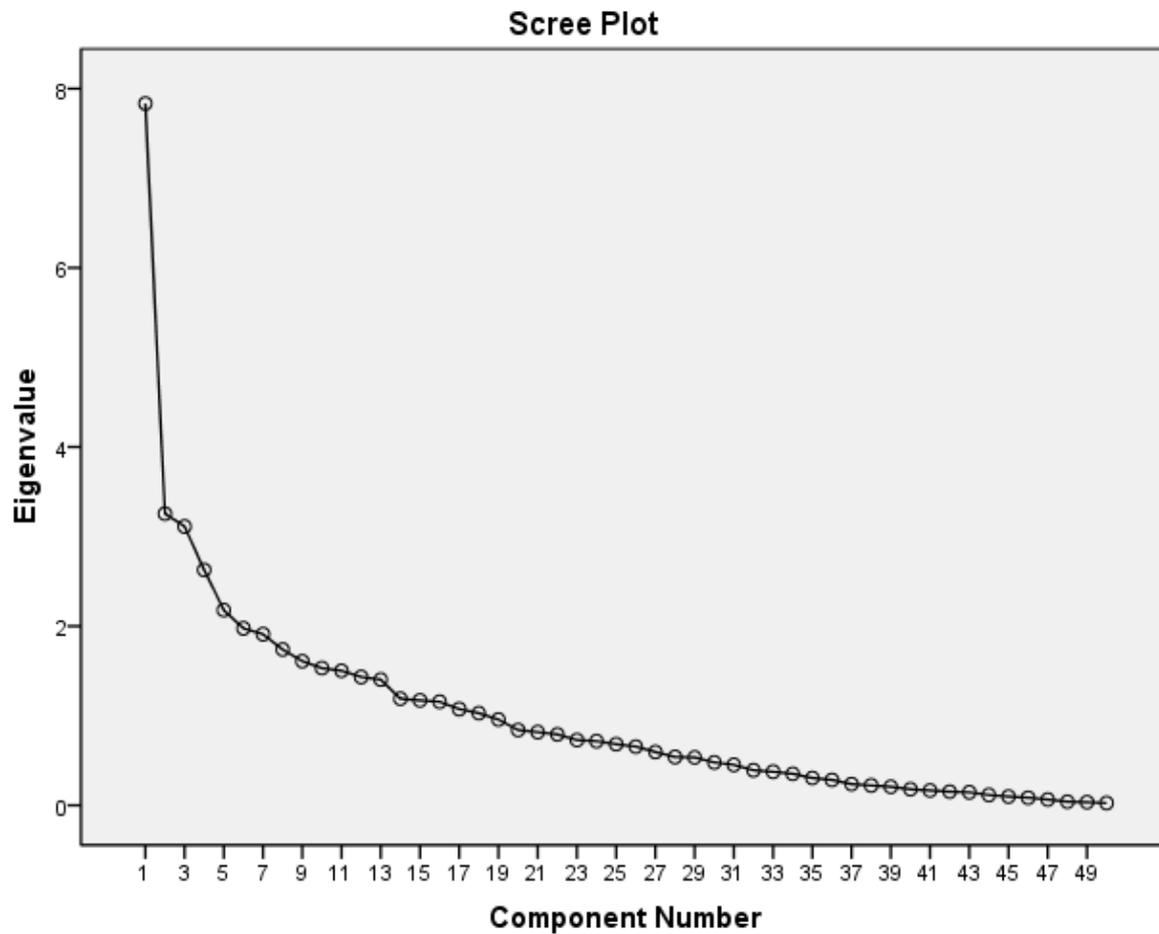
- The mean IQ of the sample was 121.34 ( $SD = 12.497$ )
  - well above the population mean of 100
- On the items analyzed, the participants scored a range of 61 to a perfect score of 80 out of 80, with an extremely high mean of 72.87( $SD = 4.237$ )
- Of the 40 items, 24 were scored as abstract, 11 were scored concrete, 3 formal, and 2 primary
  - It was clear that there was not a great range in the Orders of the items

# Results



*Figure 2.* Rasch map of persons and items. The X’s to the left of the dash line mark the person Rasch scores and the items are on the right. The “pr” marks primary Order questions, “co” concrete, “ab” abstract, and “fo” formal. The number marks the sequential number of that item among items of the same order.

*Figure 3.*



Scree plot of factors affecting all IQ items. The first component had by far the largest Eigenvalue, and we propose that this is OHC.

# Results

- A simple linear regression was calculated to predict Rasch item scores based on OHC of items
- An  $r = .666$  ( $R^2 = .443$ ) was found ( $F(1,38) = 30.275, p < .001$ ).
  - Rasch item difficulty was equal to  $-30.163 + 2.93$  (OHC).
- A multiple linear regression was calculated, where Rasch item difficulty =  $a_0 + a_1\text{OHC} + a_2\text{Rarity}$
- An  $r = .778$  was found,  $F(2,37) = 28.831, p < .001; R^2 = .605$ 
  - An item's Rasch difficulty score was equal to  $-25.199 + 2.323$  (OHC) +  $2.633$  (Rarity)

# Discussion

- There was not a large range of stages tested by the Verbal Comprehension Index (VCI) of the WAIS-IV test
- Just two variables OHC and rarity, predicted Rasch IQ item difficulty with an  $r = .778$
- An additional finding of this study was that there was a correlation ( $r = .456$ ) between Rasch person scores and IQ

# Discussion- Criticisms of IQ

- The IQ has an extremely limited range of Order of Hierarchical Complexity
  - Almost all of the items were scored at abstract or concrete
  - Meanwhile, the entire Information section of the test asked the participants to recall facts,
    - Which was determined to be entirely concrete and was not used in the analysis.
- Does not test complexity at highest or lowest levels
- If the test was designed with sequentially more complex items, it would be possible to see what Order of Hierarchical Complexity with which a participant was struggling
- Rarity was also determined to be a major factor, which was a factor that is based on likelihood of exposure
  - Not inherent ability

# Limitations and Difficulties of Our Study

- Stage of participants could not be assessed completely accurately
  - Because IQ was not designed with OHC in mind
  - Did not give participants an independent stage instrument, such as the laundry problem
  - This means correlations between stage and IQ are only estimates
- The participants were all “high IQ” further decreasing the variance
  - Due to availability of data sets with more range of IQs
- Only those questions that were identical to the English version of the WAIS-IV were used in analysis
- Only used VCI and not entire WAIS-IV test
  - Rest of the test was too difficult to score for OHC

# Conclusion

- This study demonstrates a systematic stage ceiling effect of the Verbal Comprehension Index of WAIS-IV test
- Two things predicted which items would be most difficult
  - The Order of Hierarchical Complexity predicted the most
  - Word rarity was second
- This demonstrates how OHC is a successful indicator of task difficulty
- A person's Stage, measured by their successfully completing tasks of a certain Order, is a strong indicator of intelligence

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