A Scoring System for Evaluating Infant Cognitive Performance

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1. Tasks and modified passing criteria
To compare infant linguistic and cognitive development in the U.S. and Japan, we selected 16 tasks from the developmental intelligence tests in each country. All of the 16 tasks were administered to each subject in both countries. The scoring system described here incorporates a modification of the original tests’ passing criteria and a new 2-1-0 rank scoring system we developed.

1) Tasks for evaluating an infant’s understanding of object permanence
We chose the following 6 object permanence tasks.

OP 1: Cover with cloth (1 trial)
OP 2: Wrap with cloth (1 trial)
OP 3: Hide under one of two blue cups, no movement (3 trials)
OP 4: Hide under red or blue cup, switching cups (3 trials)
OP 5: Hide under one of three blue cups, 5-sec delay (3 trials)
OP 6: Hide under one of two blue cups, switching cups (3 trials)
OP1, OP2, OP4, and OP5 are part of the Kyoto Scale of Psychological Development (Shimazu et al., 1985). OP1 is included in the tests of Bühl er & Hetzer (1932), Ushizima et al. (1949), Cattel (1947), Koga (1967), Bayley (1969), and Knobloch (1980). OP2 is included in the tests of Cattel (1947), Koga (1967), Bayley (1969), and Knobloch (1980). OP4 was developed by Ushizima et al. (1949). Tests similar to OP5 have been reported by Cattel (1947) and Koga (1967). These tasks use a 10-sec delay with 3 obstacles.

OP3 was reported by Uzgiris & Hunt (1975) and Dunst (1980), and OP6 was reported by Bühl er & Hetzer (1932) and Wishart & Bower (1984).

The passing criterion in single-obstacle tasks such as OP1 and OP2 is commonly the perfect appearance of a hidden object. The passing criterion with multiple obstacles is commonly a high probability of finding the hidden object in multiple trials:

OP 3 : Uzgiris & Hunt (1975) Success in each of the two locations in 3 to 5 trials
Dunst (1980) The same as Uzgiris & Hunt (1975)

OP 4 : Ushizima et al. (1949) Two consecutive successes in 3 trials
Shimazu et al. (1985) Two successes in 3 trials

OP 5 : Shimazu et al. (1985) Two successes in 3 trials
Cattel (1947) and Koga (1967) Two successes in 3 trials

OP 6 : Bühl er & Hetzer (1932) At least 3 successes
Wishart & Bower (1984) Four successes in 4 trials or 4 successes in 5 trials

None of the previous studies has used a discrete numerical probability as a passing criterion in object permanence tasks. We distinguished between imperfect passing, such as 2/3 success, and perfect passing; i.e., 3/3 success. Based on the distinction, we created 3 new performance categories: Failure, Weak Passing, and Strong Passing. Task score 0, 1, and 2 were applied to these 3 categories.

Miller et al. (1970) also used a 2-1-0 rank scoring system in the methodological examination of object permanence tasks of Uzgiris & Hunt (1966). They applied score 0 to perfect failure, score 2 to perfect passing, and score 1 to anything in-between. Their system is different from ours in the following two points. First, we focused on perfection of passing criterion in previous studies, and created the two passing categories: Weak Passing and Strong Passing. Task score 1 of our system is not including failure such as 1/3 success. Second, we did not consider cases in which 2/3 success was achieved by searching in only one location (such as searching only the right position when the target was consecutively hidden in the right, left, and right positions) as passing. This new 2-1-0 rank scoring system is described in Chapter 2.

2) Tasks for evaluating an infant’s understanding of means to an end

We chose the following 10 means-end tasks.

ME 1 : Letting go of an object to reach for another (3 trials)
ME 2 : Use of locomotion as a means (3 trials)
ME 3 : Use of the relationship of a support (2 trials, and 1 trial after a demonstration)
ME 4 : Use of string horizontally (2 trials, and 1 trial after a demonstration)
ME 5 : Use of string vertically (2 trials, and 1 trial after a demonstration)
ME 6 : Use of stick as a means (2 trials, and 1 trial after a demonstration)
ME 7: The problem of a matchbox and a cookie (1 trial)
ME 8: The problem of a chain and a container (1 trial)
ME 9: The problem of a solid block and a peg (1 trial)
ME10: The problem of a tube, its contents, and a stick (1 trial)

These tasks are mainly drawn from the Ordinal Scale of Psychological Development (Uzgiris & Hunt, 1975) Scale II. ME7 was used by Miller et al. (1980), and ME10 was described by Dunst (1980). ME7, ME8, and ME10 were used as assessment tools in stage theory by Casati & Lézine (1968).

In the case of the tool-using tasks ME3 to ME6, Uzgiris & Hunt (1975) adopted passing criteria which included success after a demonstration. They used this demonstration to lead the infant's action. We divided performance into three levels and considered success after a demonstration as scoring less than spontaneous success, based on the notion that imitative tool-use is distinct from spontaneous tool-use (Köhler, 1917). The new 2–1–0 scoring system for tool-using tasks is described in Chapter 3, and there we quoted the description of infant actions from Uzgiris & Hunt (1975).

In tasks that correspond to ME8 and ME9, Uzgiris & Hunt (1975) considered that only immediate success should be taken as passing. However, based on the findings of Casati & Lézine (1968) and Piaget's original observation (1936), spontaneous and constructive success after failure can be treated as the attainment of stage 6. For example, in Piaget's original observation #182, he considered the action of turning a pencil over after about thirty failures as invention; i.e., a sudden solution by deductive means. We considered the sequential success which showed constructive new means as Weak Passing in our criteria. Immediate success was considered Strong Passing. That is, in our quantified 2–1–0 scoring system, subjects acquires a score according to how quickly they become aware of a task situation and succeed.

The difference between our passing categories and those of Uzgiris & Hunt (1975) can be explained by the difference in the procedures. They prepared two kinds of foresight tasks and provided multiple opportunities for the infant to solve the task. Their ordinal scale was designed to check the regularity of the infant's repetitive action. On the other hand, we prepared four kinds of tasks and observed the infant's action in each task without repetition. We observed many cases in which initial failure was switched off to constructive new means in a trial. The subjects may have succeeded immediately and regularly in additional trials, if they had been offered multiple trials as in the procedure of Uzgiris & Hunt (1975).

We needed to define concretely performance which is success through inventive means in a trial in each task. To form an operational definition, we considered a specific action and its continuation until success as evidence of an inventive solution.

The specific actions that were to be continued until success consisted of

ME 7: Either pushes or pulls the box to get it open (to get the cookie)
ME 8: Rolls up or dangles the chain, with/without holding the container (to put the chain in at once). Or holds the container (to put the chain in at once).
ME10: Uses the stick to push the contents out of the tube (to get the contents).

The actions in parentheses are the ends of the solutions. The so-called specific actions are not directly related to the ends, and appear before the ends. We considered these actions and their continuation until success as intermediate and inventive means in infant problem solving.

It is difficult to define the constructive new means in ME9. In this task, the infant needs to stop stack-
ing the blocks based on an understanding of solidity. We considered the overt action of awareness as evidence of understanding, and included the infant’s gesture and/or verbal communication of solidity with the passing criteria of ME9.

We described the operational definitions that we created to define the inventive means in the italic text in Chapter 3.

2. Scoring System for Object Permanence Tasks

In the following system, UH refers to the response categories of Uzgiris & Hunt (1975), and Ush refers to the categories of Ushizima et al. (1949). The categories with asterisks indicate passing criteria in these previous studies. We created 3 new performance categories and a 2–1–0 rank scoring system as follows.

Performance categories:

- FA = Failure
- WP = Weak Passing
- SP = Strong Passing

Score: [0], [1], and [2]

OP 1. Cover with cloth (1 trial)

UH.a  FA [0] Loses interest in the object once it is completely covered.

UH.b  FA [0] Reacts to the loss of the object. For example, looks at the cloth with eyes wide open, or looks around. However, does not search or obtain it under the cloth.

UH.c  FA [0] Pulls the cloth, but not enough to uncover the object, and does not obtain the object.

UH.d* Pass [2] Removes the cloth with visual attentiveness and obtains the object under the cloth.

OP 2. Wrap with cloth (1 trial)

FA [0] Loses interest in the object once it is completely wrapped.

FA [0] Reacts to the loss of the object. For example, looks at the cloth with eyes wide open, or looks around. However, does not open the cloth or obtain the object.

FA [0] Pulls the cloth, but not enough to uncover the object, and does not obtain the object.

Pass [2] Opens the cloth with visual attentiveness and obtains the object.

OP 3. Hide under one of two blue cups, no movement (3 trials)

FA [0] Loses interest, does not search.

FA [0] Searches for the object, but fails every time. \((- - -\)}

FA [0] Searches for the object only with the hand on one side (right or left), and obtains it once or twice in 3 trials. \((- + - , + + -\)}

FA [0] Searches for the object and obtains it once in 3 trials. \((- - + , + - -\)}

WP [1] Searches for the object and obtains it twice in succession in 3 trials. \((+ + - , - + +\)}

SP [2] Searches for the object and obtains it each time. \((+ + +\)}
3. Scoring System for Means-End tasks

In the following system, UH refers to the response categories of Uzgiris & Hunt (1975). The categories with asterisks indicate passing criteria in this previous study. We created 3 new performance categories and a 2-1-0 rank scoring system as follows.

Performance categories:
- FA = Failure
- WP = Weak Passing
- SP = Strong Passing

Score: [0], [1], and [2]

ME 1. Letting go of an object to reach for another (3 trials)
- FA [0] Can not hold a block in each hand simultaneously.
UH.a  FA [0]  Reaches toward the third object while still holding the others, and can not grasp the third.

UH.b  FA [0]  Reaches for the third object with a filled hand, but in the process of reaching, the first object slips out from the hand.

Pass[2]  Drops both of the objects already being held and then reaches for the third object with an empty hand. (1st, 2nd, or 3rd trial)

UH.c*  Pass[2]  Drops one of the objects, or passes one of the objects to another hand, and then reaches for the third object with an empty hand. (1st, 2nd, or 3rd trial)

Pass[2]  Can grasp the third block without dropping any blocks (1st, 2nd, or 3rd trial)

Pass[2]  Can not hold the blocks which a tester offers due to fear of a stranger. If the subject passes two consecutive tasks from ME3 to ME5, ME1 is considered passed.

ME 2. Use of locomotion as a means (3 trials)

UH.a  FA [0]  Continues play and makes no attempt to retrieve the object.

UH.b  FA [0]  Indicates desire for the object (looks at it repeatedly, innerspers), but does not try to retrieve it.

UH.c*  Pass[2]  Moves to regain the object and resumes play using it. (1st, 2nd, or 3rd trial)

Pass[2]  Can not play in front of a tester due to fear of a stranger. If the subject passes two consecutive tasks from ME3 to ME5, ME2 is considered passed.

ME 3. Use of the relationship of a support (3 trials)

FA [0]  Loses interest in the object.

UH.a  FA [0]  Reaches for the object on the support and indicates desire for it.

UH.b  FA [0]  Tries to climb and reach the object.

UH.c  FA [0]  Appeals to another person to get the object.

FA [0]  Touches the support, but does not pull it enough.

UH.d*  WP [1]  Pulls the support and obtains the object after a demonstration (3rd trial).

UH.e*  SP [2]  Pulls the support and obtains the object without a demonstration (1st or 2nd trial).

ME 4. Use of string horizontally (3 trials)

FA [0]  Loses interest in the object.

UH.a  FA [0]  Reaches for the object and indicates a desire for it.

FA [0]  Tries to climb and reach the object.

FA [0]  Plays with the string itself mouthing or holding.

UH.b  FA [0]  Manipulates the string, but does not pull it enough to obtain the object.

UH.c*  WP [1]  Obtains the object by pulling the string after a demonstration (3rd trial).

UH.d*  SP [2]  Obtains the object by pulling the string without a demonstration (1st or 2nd trial).

ME 5. Use of string vertically (3 trials)

FA [0]  Loses interest in the object.

UH.a  FA [0]  Indicates desire for the object by leaning to look at it, reaching toward it, and so on, but does not use the string to obtain it.

UH.b  FA [0]  Drops the string on the floor and becomes unhappy.

UH.c  FA [0]  Plays with the string itself mouthing or holding.
UH.d  FA [0] Pulls the string, but not enough to get the object.
UH.e* WP [1] Obtains the object by pulling the string after a demonstration (3rd trial).
UH.f* SP [2] Obtains the object by pulling the string without a demonstration (1st or 2nd trial).

ME 6. Use of a stick as a means (3 trials)
UH.a  FA [0] Plays with the stick and loses interest in the object.
UH.b  FA [0] Reaches for or attempts to climb toward object, disregarding the stick.
UH.c  FA [0] Plays with the stick and object, without getting the object any closer (hits object with stick, knocks it off table, etc.).
UH.d* WP [1] Obtains the object with the stick after a demonstration (3rd trial).
UH.e* SP [2] Obtains the object with the stick without a demonstration (1st or 2nd trial).

In the following system, the italic text indicates a specific action, the continuation of which is interpreted as an inventive means.

ME 7. The problem of a matchbox and a cookie (1 trial)
   FA [0] Loses interest in the object.
   FA [0] Simply applies various types of simple actions to the box (shaking the box and hearing the sound of the cookies; exploring the box, sometimes by turning it over; touching the side of the box that opens; asking for help), without trying to discover any novel property.
   FA [0] There is no evidence of any of the following actions in the italic text, but the subject is successful in obtaining the cookie.
   WP [1] Applies the various above-mentioned simple actions to the box, and then either pushes or pulls the box to get it open, and removes the object. The subject continues to watch the side that opens, and either pushes or pulls until the object is removed.
   SP [2] Immediately either pushes or pulls the box to get it open, and removes the object. The subject continues to watch the side that opens, and either pushes or pulls until the object is removed.

ME 8. The problem of a chain and a container (1 trial)
   FA [0] Does not attempt to put the chain into the container even after a demonstration.
   FA [0] Simply applies various types of simple actions resulting in failure (tumbling the container while holding it; tumbling the container by touching it with the chain; tumbling the container by hanging the chain on it; the chain slides down outside the container after it hangs on the container; asking for help), without trying to discover any novel properties.
   FA [0] There is no evidence of any of the following actions in the italic text, but the subject is successful in putting the chain in the container.
   WP [1] Applies the above-mentioned simple actions to the container and the chain, and then, while concentrating on the chain, rolls it up or dangles it, before trying to put it in, with/without holding the container. The subject continues watching and putting the chain inside until success is certain.
   WP [1] Applies the above-mentioned simple actions to the container and the chain, and then,
while concentrating on the container, holds it and puts the chain inside in one motion.

SP [2] Immediately, while concentrating on the chain, rolls it up or dangles it, before trying to put it in, with/without holding the container. The subject continues watching and putting the chain inside until success is certain.

SP [2] Immediately, while concentrating on the container, holds it and puts the chain inside in one motion.

ME 9. The problem of a solid block and a peg (1 trial)
FA [0] Plays with blocks, but does not stack them.
FA [0] Simply applies various types of simple actions resulting in failure (placing the solid block without watching it, placing the solid block while/after watching it, asking for help), without trying to discover any novel properties.
WP [1] Applies the above-mentioned simple actions, resulting in failure, and then communicates awareness of its solidity (such as by saying "no hole", "can’t", or "it’s strange", or by gesturing to show solidity) and stops placing the solid block.
WP [1] Applies the above-mentioned simple actions, resulting in failure, and then becomes aware of the solidity with visual regard and stops placing the solid block without any communication.
SP [2] Immediately communicates awareness of its solidity as above and stops placing the solid block.
SP [2] Immediately becomes aware of the solidity with visual regard and stops placing the solid block without any communication.

ME10. The problem of a tube and a stick (1 trial)
FA [0] Loses interest in the object.
FA [0] Simply applies various types of simple actions, resulting in failure (putting a finger into the tube; shaking the tube, sometimes while watching the toy; tapping the table with the tube, sometimes while watching the toy; asking for help), without trying to discover any novel properties.
FA [0] There is no evidence of any of the following actions in the italic text, but the subject is successful in getting the contents.
WP [1] Applies the above-mentioned simple actions to the tube, and then uses the stick to push the contents out of the tube. The subject continues to watch the contents and/or push the stick until the contents are obtained. The action of obtaining the contents at the end of the tube by hand, after the specific action and continuation, is considered success.
SP [2] Immediately uses the stick to push the contents out of the tube. The subject continues to watch the contents and/or push the stick until the contents are obtained. The action of obtaining the contents at the end of the tube by hand, after the specific action and continuation, is considered success.

4. Methodological advantages of the present scoring system in a comparative study

In a comparative study of linguistic and cognitive development, it is important to prepare neutral quantitative measures to be applicable to each country. For example, intelligence quotient (IQ) or devel-
opmental quotient (DQ) of a specific test can only be used in cases where the norm study was done along
the same procedures in each country before the comparative study. It is impossible to compare
cognitive development among different countries by depending on a specific stage theory or an ordinal
scale without any positive proofs that the stage or the scale is equally suitable for each country.

When we set about the comparative study, we found that there was no specific test for sensory-motor
intelligence commonly standardized and used in the U.S. and Japan. We could not depend on the existing
test scales in each country. This situation led us to choose an experimental research method to evaluate
the infant cognitive performance. We selected the above-mentioned 16 tasks which are used as development
al tests in the U.S. and/or Japan, and had to create a new scoring system. We didn’t adopt a
stopping rule in tasks which is generally used in developmental test methods. We administered all of the
tasks to each subject in both countries. On the basis of the quantitative scoring procedures which we
have developed here, we will analyze generality and differences between the two countries in infant cognitive
performance. We can analyze the infant cognition by using experimental design including a country
variable.

Another advantage of the scoring system is the possibility of a study based on the correlational analysis
among different behavioral measures. For example, we can analyze the relational strength between
a specific score in cognitive measures and a specific score in linguistic measures on the basis of their corre-
lation. The final total results of the correlational analysis shows us the relationship factors between sen-
sory-motor intelligence and language acquisition in each country. The quantitative rank scoring system
for infant cognition will be indispensable to the structural analysis of correlation in our research.

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