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Accelerated Cognitive Development—Piaget's Conservation Concept

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Abstract

Piaget's ideas have significantly influenced education and psychology, particularly the concept of conservation, which he had proposed as being acquired during the concrete operational stage. However, research conducted after Piaget found that children under the age of 6 are unable to understand his concept of conservation. However, more recent studies have found that three-year-olds may be able to acquire this concept, even when tested using the same tasks. But, this study addresses the issues of "fixity" and "reliability" for the concept of conservation. Then, the robustness (fixity and reliability) of Piaget's concept of conservation (numbers/length) was examined by observing a four-year-old child who demonstrated the possible acquisition of this concept at the age 3, in this study. It was found that the child was able to robustly maintain the concept. Therefore, the study shows the possibility of accelerated cognitive development for Piaget's concept of conservation. The reason may be that younger children have higher intelligence than those in previous generations. And, the grounds may be that of the influence of gene-environment interaction.

Keywords: accelerated cognitive development, conservation of numbers/length, gene-environment interaction, Jean Piaget

1. Introduction

Piaget's ideas have significantly influenced education and psychology, particularly the concept of conservation, which he had proposed as being acquired during the concrete operational stage. The conservation concept, which relates to the understanding of the equivalence of numbers, length, weight, mass, area, and volume requires abstract logical thought (transitive relations). The acquisition stage for numbers and length is generally determined using the following general Piagetian tasks and the stage has been clarified (Piaget, 1952; Ginsburg & Opper, 1969; Goswami, 1998; Siegler, DeLoache, & Eisenberg, 2003; Hetherington & Parke, 2003; Pastorino & Doyle-Portillo, 2013).

In the numbers task, two rows (R1, L1) with the same number of marbles are shown to children, who are then asked to show that the number of marbles in each row is the same. Subsequently, the distance between the marbles in one of the rows is increased or decreased, after which the children are asked if the modified row has the same number of marbles as the other row. After they answer, they are asked to show that the number of marbles in both rows is the same. The acquisition stage for this task is estimated to be 6–7 years old.

In the length task, two straight sticks of the same length are aligned in parallel (R1, L1). The children are then asked to show that the stick lengths are the same. Then, one stick is shifted from its parallel position, after which the children are asked again if the stick is the same length as the other. After the children answer, they again show whether the two sticks are of the same length. The acquisition stage for this task is also estimated to be 6–7 years. The conservation of mass has been found to occur around 7 years of age, the conservation of weight around 9 years of age, the conservation of area around 8–9 years of age, and the conservation of volume around 11 years of age.

Supplementary tests following Piaget's designs have demonstrated that acquiring the conservation of length and number before the age of 6 is rare (Goswami, 1998), with very little changes being found in the past 70 years, indicating that perception acquisition in children is relatively static. However, a "development acceleration phenomenon" has been observed in children's mental and physical development, for example, for cognitive development, it has been found that the ability of infants to read and write "hiragana" in Japanese has been accelerating (Shimamura & Mikami, 1994); therefore, it is reasonable to surmise that there is a possibility of accelerated development in other specific areas.

The latest research suggests that even when the Piagetian design (tasks) has not changed, three-year-old children are also able to acquire the concept of conservation if the tasks are employed through play (daily life) (Watanabe, 2017).

However, this study addresses the issues of "fixity" and "reliability" for the conservation concept. As a child at a very young age might not fully remember the concept each time, it is necessary to continue conceptual testing as they age to verify conceptual fixity. In addition, because the correct answer for general Piagetian tasks is "the same" for all questions, when examining reliability, researchers have expressed a concern that children provide the correct answers in follow-up studies because of memorization or the "practice effect". Therefore, when conducting subsequent studies, it is necessary to devise a suitable method to demonstrate conservation acquisition robustness among children between the age of 4 and 6 years. If this can be identified, cognitive development acceleration for conservation could be concluded.

Therefore, this study investigated the fixity and reliability of the conservation concept in a four-year-old who had demonstrated the potential to acquire this concept at the age of three. Based on the results, this study suggests the possibility of accelerated cognitive development for the conservation concept.

2. Methods

To verify "fixation" and "reliability" for the conservation of numbers and length, the following procedure was enacted.

Research design: Single-case research methods were employed (Barlow, Nock, & Hersen, 2009) so as to continue the work from a previous study (there was also an issue regarding the physical difficulties of studying several people). The treatment variable (main variable) was the Piagetian task linked to play, including ordinary conversations. An A-B design was adopted because withdrawal procedures are naturally difficult.

Target: A four-year-old child (female) (from 4 years, 0 months to 4 years, 11 months), as in Watanabe (2017).

Characteristics of the subject child: She had not yet learned any special arithmetic. However, she had experienced mathematics in her ordinary conversations and during play in areas such as fractions, 3-D puzzles, a multiplication table song, and number and calculation quizzes. At 3, the child had been answering one item in the mathematics awareness survey (which has approximately 70 mathematical items) about once a month as part of her play (in a quiz or play format).

Stages by age in months: 4 years, 0 months was considered to be any day in the 1-month period from day zero of turning four until the day before turning 4 years, 1 month old. The study timing was arbitrary (cf., Watanabe, 2015).

Reliability Verification: This was the same as for Piagetian tasks; however, the child was not asked why the lengths and numbers were the same or different and, as a general rule, the final question was only asked once. All tasks were undertaken each month until the child was 4 years, 11 months old.

(1) Numbers

Five spheres were aligned in two rows (A1, A2) and the child was asked to show whether the number of spheres was the same in each row. Then, A2 was either lengthened or shortened (changed at least twice), after which the child was asked "which one is bigger" or "which one is larger" (Figure 1).

Figure 1. Numbers

(2) Length

・Two pens of the same length (A1, A2) were aligned and the child was asked to say whether they were the same length. Then, the position of A2 was offset or rotated up or down or left or right, after which the child was asked "which one is longer" (Figure 2).

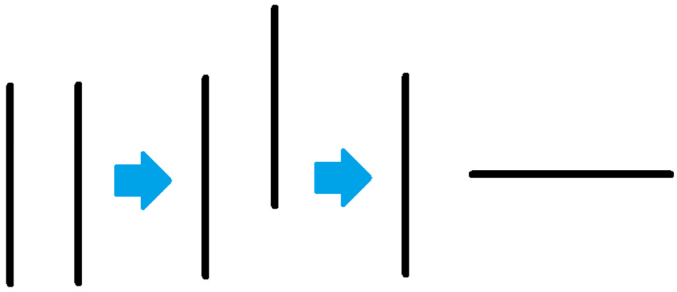

Figure 2. Length

Reliability Verification: The following changes were added to the Piagetian tasks (at 4 years, 4 months and 4 years, 10 months).

(1) Numbers

Five spheres were aligned in two rows (A1, A2) and the child was asked to show whether the number of spheres was the same in both rows. Then, A2 was lengthened or shortened (at least two times), after which the child was asked “which one is bigger” or “which one is larger”. In the task progression, the number of spheres in one line was increased or decreased, after which the same question was asked again (Figure 3).

Figure 3. Numbers

(2) Length

Two pens of the same length (A1, A2) were aligned and the child was asked whether they were the same length. Then, A2’s position was offset or rotated up or down or left or right and the child was asked “which one is longer?” In the task progression, the length of one pen was changed, after which the same question was asked again (Figure 4).

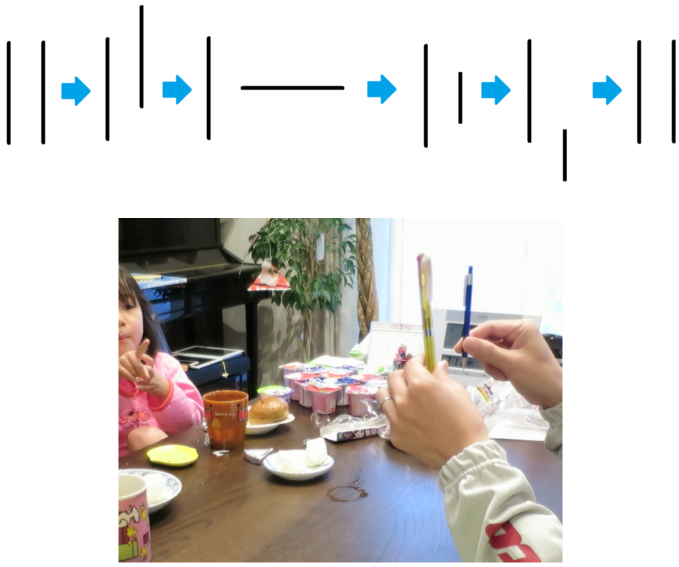

Figure 4. Length

3. Results

3.1 Fixity Results

Based on the results, the child attained a value of 1 (indicating a correct answer) at 3 years, 6 months of age for length and at 3 years, 7 months of age for numbers. Because this value was maintained at 1 for the subsequent 4–5 months, the concept seemed internalized until at least 4 years, 11 months (as it was clear, statistical analysis was not conducted). In other words, after the concept was acquired, it was maintained and internalized (Figures 5 and 6).

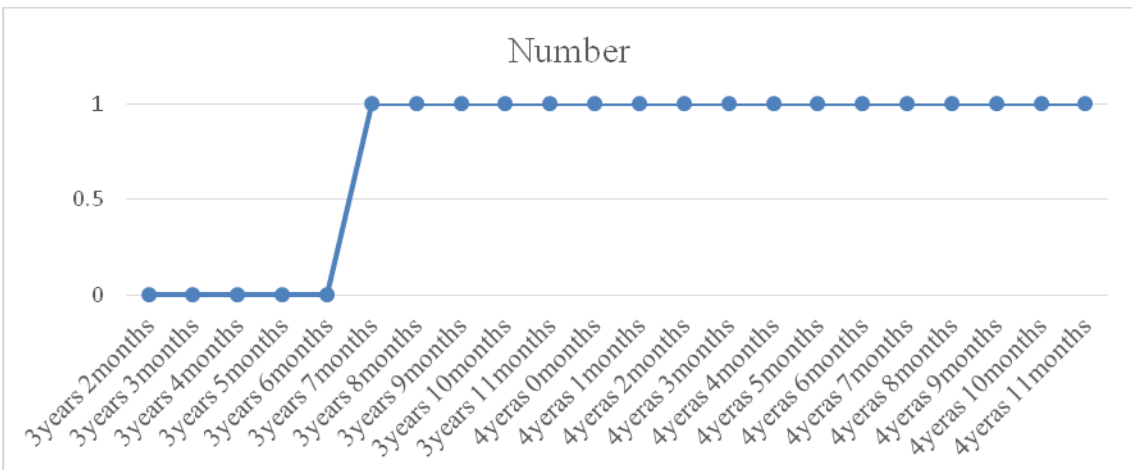

Figure 5. Numbers

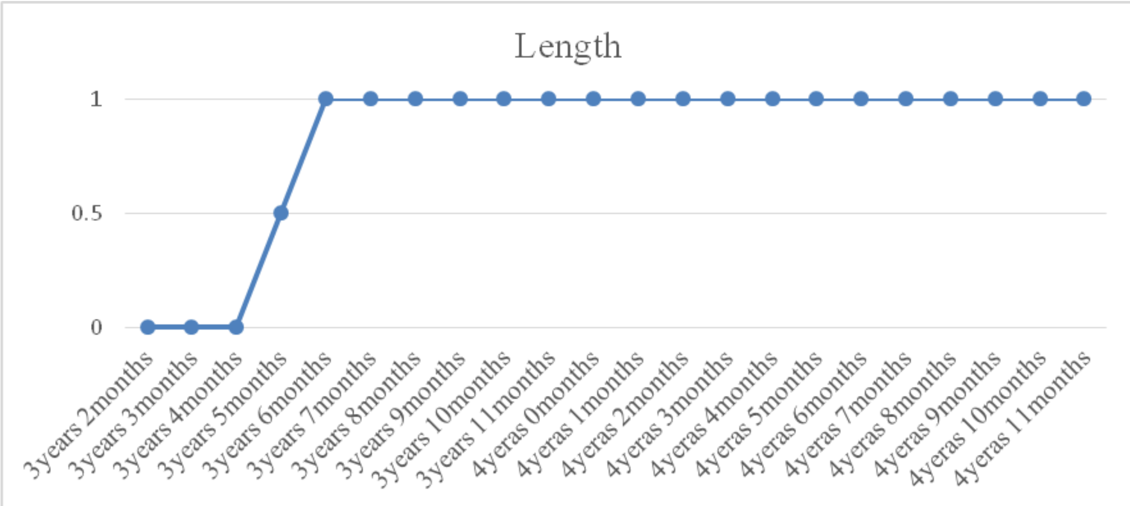

Figure 6. Length

3.2 Reliability Results

The child correctly answered all questions in the second survey for both length and numbers. Surveys were conducted once at age 4 years 4 months and again 6 months later at age 4 years, 10 months. In addition, a "size comparison" for which "the same" was not always the correct answer was incorporated in the middle of each of the surveys. Therefore, the possibility for the child to answer "the same" due to memorization was quite low; in other words, the responses indicated that the child had reliably acquired the conservation concept.

The above results showed that a four-year-old was able to maintain the conservation concept for both numbers and length.

4. Discussion

Prior research has found that children under the age of 6 are unable to understand Piaget's conservation concept (Goswami, 1998). However, more recent studies have found that three-year-olds may be able to acquire this concept, even when tested using the same tasks (Watanabe, 2017). Through regular surveys and scaffold testing, this study found that a four-year-old was able to robustly acquire the conservation concept for numbers and length, indicating acceleration in cognitive development from the previously presumed cut-off point of six years of age. Since the phenomenon was accepted by the investigation, we will discuss the theoretical factors of the possibility below.

The results from this study, therefore, serve to strengthen the proof for accelerated cognitive development for Piaget's conservation of numbers and length. It has been recently observed that younger children have higher intelligence than those in previous generations. For example, the finding of this study complies with Flynn's (2012) finding that the Intelligence Quotient (IQ) for children had increased. From around 1950 to 2000, both the Wechsler Intelligence Scale for Children (an intelligence test for 6-15-year-olds) and the Wechsler Adult Intelligence Scale (an intelligence test for 16-89-year-olds) showed a 15-point increase (Flynn, 2012). As Piaget's original research was conducted 70 years ago in 1940, if the IQ of younger children has increased since then, it is possible that the ability to acquire the conservation concept may have also shifted to a younger age. However, this study supports Flynn's (2013) analysis of the data on IQ tests and found that the IQ related to abstract problems had also increased significantly over the last century (Flynn, 2013). As Piagetian tasks generally assess logical thinking, it also seems valid that an increase in IQ could positively affect the ability to correctly solve the Piagetian tasks. This study agrees with Flynn's (2013) view that as the society has developed a more scientific attitude, there has been a commensurate increase in basic IQ, which he explained using "individual multipliers" and "social multipliers". Hence, aligning with Flynn's (2013) view, this study observes that individual multipliers alone, which are related to an individual's environment, are not sufficient to lead to an increase in IQ; however, because social multipliers, which are related to an individual's social environment, also affect analytical reasoning, these two together could have led to the increase in IQ with each generation. Overall, however, there is little support by Flynn and other researchers for the postulation that environments alone affect IQ.

On this point, Heckman, after an extensive literature review, speculated that “gene-environment interactions may be central to explaining human and animal development” (Heckman, 2013, p. 16), an idea that was also supported by Rutter, a child psychiatrist, who claimed that as many psychological traits and mental disorders are multifactorial, this provides evidence that there are both genetic and environmental influences (Rutter, 2006). Behavioral geneticists, Asbury and Plomin also believe that people’s environments operate in conjunction with genes, as genes are unable to activate without experience (Asbury & Plomin, 2014), which was in agreement with an earlier statement by behavioral geneticist, Spector, who claimed that “There are few if any examples of environmental factors without a genetic component, and conversely genes do not work alone and are usually dependent on the cells they live in and their environments. So, in a world where hundreds of genes are working together to influence a trait or disease, the old distinction between nature and nurture is simply no longer relevant” (Spector, 2012, p. 20).

Neuroscience studies have concluded that genes do not activate behavior; rather, they consist of a DNA sequence that contains all the relevant information necessary to produce a certain protein, and that the expression of the gene varies because of numerous factors, including environmental factors.

As research advances, the belief that there is a frontier between the innate and the acquired is disappearing, giving way to an understanding that there is interdependence between genetic and environmental factors in brain development (OECD, 2007). Medical scientist, Moalem, stated that advancements in scientific research have showed that genetic inheritance “can change and be changed by what we experience” (Moalem, 2014, p. 223). Further, one of the more important findings in 20th-century biology was the transfer of traits across generations and that the materialization of these traits in the complex development process involved interactions among genes as well as interactions between genes and the environment (Deutsch, 2012).

Epigenetics, a recent field of study, has been found to be the basis for these processes as environmental conditions may result in genes being turned off or on. While epigenetics does not consider certain phenomena, studies have shown that there is probably no separation between the impact of genetics and that of the environment (Asbury & Plomin, 2014; Rutter, 2006; Heckman, 2013; Spector, 2012), as exemplified by Shenk (2010) who claimed that “Everything we know about epigenetics so far fits perfectly with the dynamic system model of human ability. Genes do not dictate what we are to become, but instead are actors in a dynamic process” (p. 163).

Because of these new developments, it could be predicted that a child’s phenotype significantly transforms when the three elements of genetics, individual environment, and (long-term) social environment are favorable. For future research into Piaget’s conservation concepts and long-term social environments, it has been shown that the overall abstract IQ has significantly increased since Piaget’s initial research. Further, a new and effective individual environment has been established, in which children have been “elevated to doing ordinary play with Piaget tasks” (Watanabe, 2017). Although gaining scientific evidence for changes in child genetics is quite difficult and should be a topic for future study, we know that the subject child’s family lineage is prone to a phenotype that “excels at scientific subjects” because the father’s maternal line has produced several science teachers. The child’s father teaches university mathematics, her father’s male cousin [mother’s younger brother’s child] teaches middle school mathematics, her father’s other male cousin [mother’s older brother’s child] teaches middle school science, and her maternal grandfather is an elementary school teacher (specializing in science). In other words, the subject seems to have a genotype prone to this form of expression.

Considering all this information, it could safely be concluded that this study both practically and theoretically indicates the possibility of accelerated cognitive development related to Piaget’s conservation concept. If the gene-environment interaction is at work, it is possible that individuals will have different abilities. Therefore, this single-case study seems to be an effective departure point for an exploration of the possibilities of acquisition of abilities.

As a first step in proving or validating strong hypotheses, single-case research methods can be effective; however, to validate the findings in this study, it is planned to increase the number of subjects in future research and to examine any acquisition changes in the other Piaget conservation concepts.

Acknowledgments

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