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The role of necessity in cognitive development

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Abstract

There seem to be two kinds of nonconservers—those who think their response might change on another occasion and those who think their response would *always* be the same. After training in conservation, the former (called nonconservers without necessity) show no detectable gains in conservation, while the latter (called nonconservers with necessity), surprisingly, show significant gains in conservation.

In the present study, nonconservers with necessity were more likely than the nonconservers without necessity to think the classic conservation arguments (e.g., identity, negation, and compensation) were good and correct reasons and that the typical nonconservation reasons were poor and wrong.

In sum, the nonconservers who can support their conclusions with the deductive force of necessity, even though they are wrong in their conclusion, appear to be more developmentally advanced than other nonconservers who do not offer necessity as part of the justification for their nonconservation conclusion.

Keywords: Conservation; Cognitive development; Necessity; Conservation training

It is one thing to know that something is true, but quite another thing to know that it *must be* true, that is *would always be* true, that it *had to be* true, that it *could not be different*, and so forth. Many things are true, but some small subset of them are also *necessarily* true, and the subject of this study is whether knowing that something that is true is also necessarily true confers a developmental advantage on the child and whether such knowledge is itself a sign of cognitive development.

According to Piaget (1971, 1986, 1987), concepts like conservation and transitivity are experienced as logically necessary truths, and such feelings of necessity constitute evidence

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of the underlying cognitive structures postulated in his theories. In other words, the feeling of logical necessity is one of the defining characteristics of *operativity* (Inhelder, Sinclair, & Bovet, 1974; Smith, 1993).

It seems, however, that there are two kinds of nonconservers, some who hold their mistaken view by necessity (*it must weigh* more) and some who do not (*it could sometimes weigh less*). The question naturally arises whether these two kinds of nonconservers differ in other ways that are related to cognitive development. Would, for example, one be easier to teach to conserve than the other?

Murray and Armstrong (1976) found that nearly all conservers feel their conservation judgments are necessary in the sense that they assert that the two quantities in question will always equal each other no matter how many times one is transformed into a different shape, etc. Surprisingly, they also found that about half the nonconservers also saw their judgments as necessary. Thus, it seems that both conservers and some nonconservers may have equivalent levels of logical competence. Similar results were found subsequently with adult conservers and nonconservers (Murray & Armstrong, 1978).

On the face of it, there are two plausible but competing views of the role of necessity in cognitive development. On one view, the nonconserver with necessity should resist any training regime that seeks to convince this nonconserver that, for example, the weight of a flattened clay ball is unchanged because, not only does the child believe that the flattened ball weighs more, but the child also believes that it *must* weigh more, would *always* weigh more, *had to* weigh more, could not weigh less, and so forth. On another view, more closely aligned with Piagetian theory, the nonconserver with necessity has already acquired the underlying and defining attribute of the operativity structure and should be fairly easily convinced that the ball's weight, despite the misleading appearances, must really be constant (or that has to be conserved). There is some evidence to support the latter view that those nonconservers with necessity are more easily and successfully trained to conserve than those without necessity (Murray & Zhang, 2000).

The present study takes up the question of whether there are other developmental correlates of the association of necessity with nonconservation; in particular, whether nonconservers with necessity will be more likely than those without necessity to evaluate correctly some classic operativity reasons (identity, negation, and reciprocity) and some traditional nonconservation reasons (appearance and action).

1. Method

Twenty-six first-graders, 23 second-graders, and 22 third-graders from a suburban public elementary school were given a liquid amount conservation task in which an equal amount of liquid from one of two identical glasses was poured into a tall and narrow vase and from the other glass into a short and wide bowel. The children were asked to judge whether the amounts of liquid were still equal, or if they were not, which receptacle had more (or less). Conservers of course, were those who held that the amount was still the same in the vase and in bowel, and the others were nonconservers.

The children were then asked whether they thought the result of the pouring transformation was "*always like that*" (e.g., the vase has more) or was "*just sometimes like that*". For example, those who answered, the vase *always* had more, were classified as those with necessity; and those who answered the vase *sometimes* had more were those without necessity.

The children were divided into four groups: nonconservers without necessity (NC−), nonconservers with necessity (NC+), conservers without necessity (C−), and conservers with necessity (C+).

Each child was then presented with 12 episodes in which the reasoning of another child about the liquid conservation task was portrayed. There were four types of episodes—those in which both the conservation judgment and reason showed operativity (episodes1, 5, and 10), those in which a nonconservation judgment was coupled with a nonoperativity reason (episodes 2–4 and 6–8), those where conservation judgment was coupled with a nonoperativity reason (episode 9), and those where a nonconservation judgment was coupled with an operativity reason (episodes 11 and 12).

In these episodes, the other child was described as giving the classic operativity reasons for a decision about liquid amount (identity, negation, and compensation) as well as classic nonconservation reasons (e.g., *appearance*—the vase has more because it looks like there is more; *action*—the bowel has less because the pouring makes it less). The children were told that the other child when shown the task had said, for example, that the reason the amount of water was the same in the vase (*tall glass*) and bowel (*short glass*) was because the water could be poured back into the first glasses and they would be the same amount (negation). They were asked whether they thought this child was right or wrong in what he or she said in the episode, and the number of their correct responses to the 12 episodes was recorded as their operativity score (0–12). To be scored as correct the children had to respond that the other child in episodes 1, 5, and 10 was right and that in all other episodes that the other child was wrong.

The text descriptions of the 12 episodes were as follows and were prefaced with the following introduction:

> Here are the first glasses with the same amount of water. I pour the water into the second glasses, just like before. Then I asked some kids if they thought there was the same amount of water in both glasses.
>
> 1. One kid told me that there was the same amount of water in both glasses because no water has been added or taken away. All I did was pour from one glass to another glass. Do you think he is right? If you think he is right, circle the letter Y, if you think he is wrong, circle the letter N.
> 2. I talked to another kid and she said the tall glass has more water because pouring makes it more. Do you think she is right? If you think she is right, circle the letter Y, if you think she is wrong, circle the letter N.
> 3. Another kid told me that the short glass now has less because pouring makes it less. Do you think she is right? If you think she is right, circle the letter Y, if you think she is wrong, circle the letter N.
> 4. Then I talked to some other kids and one told me that there was less water in the tall glass because pouring makes it less. Do you think he is right? If you think he is right, circle the letter Y, if you think he is wrong, circle the letter N.
> 5. Another kid told me that there is the same amount of water in each glass because if you poured the water back into the first glasses, it would be the same amount. Do you

think he is right? If you think he is right, circle the letter Y, if you think he is wrong, circle the letter N.

6. One kid told me that there would be more water in the short glass because pouring makes it more. Do you think he is right? If you think he is right, circle the letter Y, if you think he is wrong, circle the letter N.
7. I was getting confused by these answers, so I talked to some more kids. One told me that the short glass has less water because it looks like it has less water in it. Do you think she is right? If you think she is right, circle the letter Y, if you think she is wrong, circle the letter N.
8. Another kid told me that the tall glass has more because it looks like it has more in it. Do you think she is right? If you think she is right, circle the letter Y, if you think she is wrong, circle the letter N.
9. A third kid told me that she thought both glasses have the same amount of water in them because it looks like the same amount. Do you think she is right? If you think she is right, circle the letter Y, if you think she is wrong, circle the letter N.
10. I still don't know what to think. I asked a kid what he thought and he told me the two glasses have the same amount of water in them because even though one glass is lower, it is also much wider. Do you think he is right? If you think he is right, circle the letter Y, if you think he is wrong, circle the letter N.
11. Another kid said no, the tall glass has more because it is much taller than it is wider. Do you think he is right? If you think he is right, circle the letter Y, if you think he is wrong, circle the letter N.
12. Another kid said the short glass has less water because it is a lot lower than it is wider. Do you think she is right? If you think she is right, circle the letter Y, if you think she is wrong, circle the letter N.

In episodes 1, 5, and 10, the other child's judgment and reasoning was correct in all respects (conservation judgment and operativity reason). In all other episodes the other child's reasoning was incorrect in some respect. In episodes 2–4 and 6–8, the other child gave a nonconservation judgment and a nonoperativity reason. In episode 9, the other child displayed a conservation judgment but a nonoperativity reason, and in episodes 11 and 12, the other child displayed a nonconservation judgment coupled with an operativity reason.

2. Results

The number of subjects in each grade falling in different categories of conservation and necessity are displayed in Table 1.

The 71 subjects from the three grades were equally distributed between conservers ($n = 35$) and nonconservers ($n = 36$) based on their judgment of the liquid amount conservation task. As expected, nonconservers outnumbered conservers in Grade 1, and the opposite was found in both Grades 2 and 3. Also as expected, there was a significant difference in the number of conservers between Grades 1 and 2 ($\chi^2_{(1)} = 7.22$, $p < .01$) and between

Table 1
Numbers of conservers and nonconservers with (+) and without (−) necessity at each grade

Grades	Conserver			Nonconserver			With	Without	Total
	C+	C−	Total	NC+	NC−	Total	C+, NC+	C−, NC−	
Grade 1	4	2	6	7	13	20	11	15	26
Grade 2	7	7	14	5	4	9	12	11	23
Grade 3	10	6	16	4	2	6	14	8	22
Total	21	15	36	16	19	35	37	34	71

Grades 1 and 3 ($\chi^2_{(1)} = 11.83$, $p < .01$), but not between Grades 2 and 3 ($\chi^2_{(1)} = .711$, $p > .40$). Among the 71 subjects, 34 children did not show necessity, and 37 children did. Chi-square tests showed there was no significant difference, however, between the grades in terms of numbers of children exhibiting necessity.

Table 2 displays the average number of correct responses to the 12 episodes made by four groups of subjects (C+, C−, NC+, and NC−). Univariate analysis of variance (ANOVA) showed that there was a significant difference ($F_{(3,67)} = 6.74$, $p < .001$) across the groups in their correct responses to the 12 classical conservation and nonconservation arguments about the liquid task. Tukey HSD and Bonferroni pair-by-pair comparisons showed that the mean number of correct evaluations by conservers, with necessity (C+) or without necessity (C−), was significantly higher ($p < .001$ for C+ and $p < .01$ for C−) than that by nonconservers without necessity (NC−). The mean number of correct evaluations by conservers with necessity (C+) was significantly higher ($p < .01$) than that by nonconservers with necessity (NC+). No significant differences in the mean numbers of correct evaluations were found between any other groups.

With one exception, conservers and nonconservers with necessity were significantly more accurate evaluators of other children' conservation reasons than those without necessity. The exception was that conservers without necessity were not significantly more accurate than nonconservers with necessity (Table 3).

Overall, the children with necessity (whether conservers or nonconservers) were significantly more able to evaluate all the episodes correctly in each type of episode than those children without necessity (see Table 4, $\chi^2_{(3)} = 9.73$, $p < .02$). This finding held for each type of episode except one (conservation with nonoperativity reason episode, $\chi^2_{(1)} = 1.59$, $p > .20$). The other episodes showed significant differences between those with and without necessity—conservation plus operativity reason episode, $\chi^2_{(1)} = .7.65$, $p < .006$; nonconser-

Table 2
Mean number of correct evaluations (0–12) and (standard deviations) by conservers and nonconservers with and without necessity

Conservation	Necessity	
	Without	With
Nonconservers	7.53 (2.95)	9.19 (2.59)
Conservers	10.07 (2.38)	11.67 (0.66)

Table 3
Number of correct evaluations out of 12 on which the mean score of the row group excelled the column group

Row group	Column group		
	C−	NC+	NC−
C+	11*	12*	11*
C−		7	10*
NC+			10*

* Sign test significant at .05 level.

Table 4
Numbers of children with and without necessity who correctly evaluated each type of episode

Necessity	Type of episode (judgment and reason) and episode numbers			
	Con/Op*, 1, 5, and 10	NonC/NonOp*, 2–4 and 6–7	Con/NonOp, 9	NonC/Op*, 11 and 12
With ($n = 37$)	30	24	27	34
Without ($n = 34$)	17	9	20	24

Type of episode: Con/Op: conservation/operativity, NonC/NonOp: nonconservation/nonoperativity, Con/NonOp: conservation/nonoperativity, NonC/Op: nonconservation/operativity.
* Chi-square between with and without necessity significant at .05 level.

vation plus nonoperativity reason episode, $\chi^2_{(1)} = 10.30$, $p < .001$; and nonconservation with operativity reason episode, $\chi^2_{(1)} = 5.38$, $p < .02$. The one exception, the conservation with nonoperativity episode, was either the most, or nearly the most, difficult for all kinds of children, but still more children with necessity than without it successfully evaluated it.

There were significant differences in mean numbers of correct evaluations across the three grades ($F_{(2,68)} = 13.32$, $p < .001$). The mean number for Grade 1 students was lower ($p < .001$) than the mean in Grade 2 and in Grade 3 ($p < .001$), while there were no significant differences between Grades 2 and 3 in the mean numbers of correct evaluations of another child's responses ($p > .60$).

3. Discussion

Piaget (1987) suggested that children construct the two realms, what is possible and what is necessary, side-by-side in their construction of reality. Initially anything which happens represents all of what is possible and it is necessary simply because it happens. Later the child begins to see the real as only a subset of the possible. Similarly, the necessary comes to be seen as only a subset of what happens. Following this line of reasoning, one may characterize the children in the non-necessity group as those who consider most of the alternatives to be possible but none of them to be necessary. For this group, the search for underlying reasons for their judgment, a process Piaget calls "excavations", has not proceeded far enough to generate reasons why some possibilities might be more expected than others. For the nonconservers with necessity, on the other hand, there may be already reasons why some of the possibilities cannot be true and only one possibility carries the force of necessity and must be true. Put differently, the availability of such reasons leading to a necessary judgment may signal the existence of a deductive principle or operativity so that the nonconservers with necessity appear to be more developmentally advanced.

The results support the role of necessity in cognitive development. On the whole, necessity was significantly correlated with recognizing the truth or falsity of classic operativity reasons and nonconservation reasons, with conservers as a group also performing significantly better than nonconservers. The nonconservers with necessity are more likely than the nonconservers without necessity to give correct responses in such an episode task, and the same pattern can be found among the conservers with different degrees of necessity.

Nonconservers with necessity were not significantly different from conservers without necessity in their performance on the episode tasks of this study. Such a finding indicates that nonconservers with necessity may share an equivalent level of operativity with conservers, which supports the view that necessity is implicated in the cognitive gains these nonconservers make in the training process. It also suggests that there may be a developmental scale of the following progression: nonconservation without necessity, nonconservation with necessity, conservation without necessity, and conservation with necessity.

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