ORIGINAL ARTICLE

NUMERICAL ACUITY OF AMERICAN AND PAKISTANI FIRST-GRADE CHILDREN: A CROSS-CULTURAL COMPARISON

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ABSTRACT

OBJECTIVE
Specific purpose of present study was to investigate any possible cross cultural differences on acuity of approximate number system (ANS).

DESIGN
Cross sectional study

PLACE AND DURATION
The study was conducted in Pakistan and America in duration of two and a half years. 144 American children were tested in Harvard lab for developmental studies in first one and a half year of the study; while 120 Pakistani children were tested in Government schools of Islamabad in last in one year of the study.

SUBJECTS AND METHODS
Sample consisted of 264 first grade children from America (N =144) and Pakistan (N= 120). Panamath task was used in order to measure children's numerical acuity.

RESULTS
Results revealed that there was no significant difference between two populations on numerical acuity thus suggesting that children from both cultures have equally promising cognitive capacity for numbers to learn mathematics and excel in it.

CONCLUSION
Results have important implications for delayed mathematics learning and assessment of mathematic learning disabilities.

KEY WORDS
Weber fraction, approximate number system, numerical acuity.

INTRODUCTION

Human beings share primitive number abilities with non-human animals [1]. They can process numerical quantities approximately with any educational exposure. Even newborn infants have been shown to discriminate quantities approximately.[2,3,4,5] Research has shown that newborn infants can discriminate the quantities differed by ratio of 3 (4 vs. 12, 6 vs. 18) across modalities, but cannot discriminate the quantities differed by ratio of 2 (4 vs. 8) [6]. Six month old can discriminate numbers differed by ratio of 2:1 but unable to discriminate numerosities in 3:2 ratio [4].

At 9-10 month of age ratio even drops to 3:2 7. Acuity of this system increases throughout childhood and adult like acuity is gained late in development. 3 years old can discriminate quantities differed by ratio of 4:3, 6 year old can discriminate by ratio 6:5 and adults by 11:10[8,9].
Developmental change in acuity continues to increase thought life and adult like acuity is gained in preteen years[9]. Studies show that without formal education humans can process numbers approximately[11].

Approximate number system is very helpful throughout the life. Research evidence shows that the ANS plays a foundational role in learning later mathematics. Research shows that preschool children's acuity of approximate number system correlate with their school math ability 13. Research has also shown that this approximate number system is correlated and predictive of later math achievement[14].

Research on children with dyscalculia has shown that dyscalculic children have impaired ANS representation as compare to their peers.[15,16]

The research evidence indicates that numerical acuity increases with age and experience and is very important for later mathematics learning. There is no research evidence documenting the trend of numerical acuity of Pakistani population. So an important question to figure out was whether children from Pakistan would also exhibit similar pattern of numerical acuity as children from any other cultures? Or they might have differences on numerical acuity because of belonging to a developing country, less technology exposure and lack of sophisticated learning technology. We addressed this question by testing American and Pakistani first grade children with panamath task to delineate the above mentioned question.

METHODS

SAMPLE

264 children (123 girls and 141 boys) participated in the study. American sample comprised of 68 girls and 76 boys (mean age = 7 years 41 days) and they were tested at Harvard Lab for developmental studies. Pakistani sample comprised of 55 girls and 65 boys (mean age = 6 years, 165 days) and they conducted the experiment in a quiet room at Government schools of Islamabad. Children were willing to participate and

children's parents, teachers and authorities gave permission for data collection.

STIMULI AND APPARATUS

Approximate Number System Assessment

The ANS acuity of each participant was assessed using an approximate number comparison task implemented in the Panamath computer game[14]. This task comprise of 6 training trials followed by 60 test trials presented on fixed trial order based on 4 ratios. There are 15 trials for each ratio. Ratio bin are 2:1, 3:2, 4:3, 6:5.

Two characters, one blue (Grover) attached to right side of computer screen and one yellow (Big Bird) attached to the left side of screen were used. On each trial, child saw two separate boxes of equal size on the screen one of yellow character and the other of the blue character. Two arrays of colorful dots, yellow dots in box of yellow character and blue dots in the box of blue character appeared ranging from 4-15 dots across trials. Each trial required children to judge who has more dots (yellow or blue) and to hit the corresponding key of character on the keyboard. Comparison array of dots appeared for 2000ms on the screen. Children responded through the keys, and got feedback by beeps (ping) corresponding to right and (basso) to wrong response. As an estimate ANS acuity, the Weber fraction (w) was calculated on the basis of children's performance in accord with the algorithms given at www.panamath.org. Further details can be found at www.panamath.org.

PROCEDURE AND DESIGN

Children were contacted one by one and experiment was done individually with each participant in a noise free room. Children were given instruction about the procedure of playing the game. Children from both countries carried out the experiment following same instructions, procedures except the fact that instruction to American children were given in English and for Pakistani children in Urdu language. Children attempted 60 test trials of the Panamath game after 6 practice trails to assess their numerical acuity.

RESULTS

Results show that there were significant differences in the ages of American and Pakistani samples. t-test has found the difference statistically significant, $t = 16.196$ ($df = 262$), $p = 0.00$. American first grade children were older than the Pakistani first grade children (see table 1).

As the numerical acuity is concerned, there was no significant difference on numerical acuity (w) between Pakistani population and American population. t-test has found the difference statistically significant, $t = -1.530$ ($df = 262$), $p = 0.127$ (see table 2).

Discussion

Results showed that there was no significant difference on Weber fraction (w) between two populations. However, children from America showed lower value of Weber fraction (which is good as low Weber fraction means more sophisticated acuity) as compare to Pakistani children. At the outset both population are very different in terms of educational, developmental, technological and socioeconomic factors. These factors contribute a lot towards the cognitive development of children and in turn to math learning abilities as well. Although there were vast differences between the two populations in terms of exposure but results showed that both group were not significantly different than each other in terms of numerical acuity.

TABLE 1

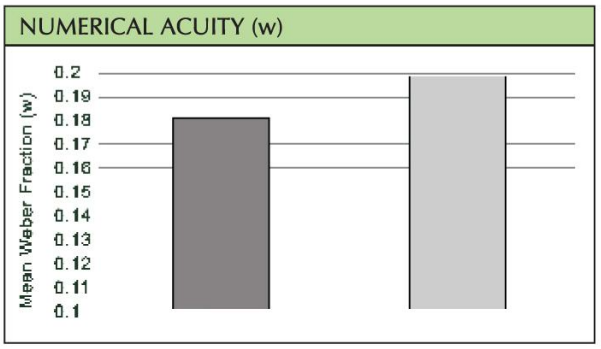
t-test results comparing American and Pakistani children on age

Group	*N*	*M*	*SD*	*t*	*df*	*P*
American	144	7 years 41 days	138	16.196	262	0.000
Pakistani	120	6 years 165 days	91			

TABLE 2

t-test results comparing American and Pakistani children on Weber Fraction (w)

Group	*N*	*M*	*SD*	*t*	*df*	*p*
American	144	.18	.09	-1.530	262	0.127
Pakistani	120	.20	.09			



One factor that might be contributing somehow towards the low fraction of American sample might be the mean age as American children were older than Pakistani sample and there was significant difference on age between two groups. Previous research agrees with this explanation.[6,7,8,9,10]

However results have important implications for mathematical learning and instruction. As initial learning and mature performance of symbolic arithmetic depend on the ANS[17]. Since children in Pakistan are also similar in terms of their approximate number abilities so at the outset they can learn mathematics with similar competence and expertise as children from any other culture. Belonging to a developing country does not incline them to perform in mathematics inadequately. Rather they can learn and accelerate like children belonging to any other culture provided that similar effective teaching strategies may apply in educational practices. Moreover, results indicate the favorable outcome as Pakistani children can learn mathematics with equal competence as children from any developed country. Since they performed equally well on numerical acuity.

CONCLUSION

Panamath task children can be assessed to figure out at earlier stages if they might have math learning difficulties. Educational interventions can be implemented in order to enhance children's learning in mathematics.

LIMITATIONS & SUGGESTIONS

Children from other age groups (younger or older) were not tested in this study. It might be the case that different age groups would add further clarity about competence on mathematic learning and could reflect on cross-cultural differences between two populations. Future research can be carried out to further address this question; how children from other age group perform cross culturally. Moreover, future researcher can use Panamath task to assess children's math learning difficulties so that these children can get some intervention to learn later mathematics.

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