

**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 sectionalstudy

#### PLACE AND DURATION

The study wasconducted 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 120Pakistani children were tested in Government schools of Islamabad in last in oneyear 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 learnmathematics andexcelin it.

# CONCLUSION

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

# KEYWORDS

Weber fraction, approximate number system, numerical acuity.

#### INTRODUCTION

Human beings shareprimitive number abilities withnon-human animals'.They can process numerical quantities approximately with any educational exposure. Even newborn infants have been shown to discriminate quantities approximately.'·'"·' 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) '. Six month old can discriminate numbers differed by ratio of2:1 but unable to discriminate numerosities in 3:2ratio'.

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 candiscriminate by ratio6:5 andadults by11:10'·'.

Developmental change in acuity continues to increase thought life and adult like acuity is gained in preteen years'. Studies show that without formal education humans can process numbersapproximately 11•

Approximate number system is very helpful throughout the life.Research evidence shows thatthe ANSplays a foundational rolein 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 iscorrelated and predictiveof later mathachievement".

Research on children with dyscalculia has shown that dyscalculic children have impaired ANS representation ascompareto their peers."·"

The research evidence indicates that numerical acuity increases with age and experience and isvery important for later mathematics learning.Thereisno 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 gradechildren withpanamathtask to delineate the above mentioned question.

# METHODS SAMPLE

264 children (123 girls and 141 boys) participated in the study. American sample comprised of68girls and 76boys (mean age= 7 years41 days) and they were tested at Harvard Labfordevelopmental studies.Pakistani samplecomprised of 55girlsand 65boys(mean age=6years,165days) and theyconducted the experiment in aquiet room at Government schools of Islamabad.Children were willing to participate and



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

STIMULIAND 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". This task comprise of 6 training trials followed by 60 test trials presented on fixed trial order based on 4 ratios.Thereare 15 trialsfor eachratio.Ratiobin are2:1,3:2,4:3,6:5.

Twocharacters, 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, childsaw 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.](http://www.panamath.org/) Further details can be found at [www.panamath.org.](http://www.panamath.org/)

PROCEDURE AND DESIGN

Children were contacted one by one and experiment was done individually witheach participant in a noise free room.Children were given instruction about the procedure ofplaying 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 after6practice trailsto assess their numericalacuity.

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(seetable 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

## TABLE1

t-test results comparing American and Pakistani children on age

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Group | *N* | ***M*** | *SD* |  | *df* | *p* |
| **American** | 144 | 7years41 days | 138 | 16.196 | 262 | 0.000 |
| Pakistani | 120 | 6 years 165 days | 91 |  |  |  |

TABLE2

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

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

**NUMERICAL ACUITY (w)**

**0.2**

**0.19** I-

I

**0.18**

C

0 **0.17---** I------

i**m** i**0.16---** I------

u: **0.15**

ii; **0.14**

£>

**0.13**

C **0.1:2**

"' **0.11**

:":,;': **0.1**

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 thaneachother in terms of numericalacuity.

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 thisexplanation."·"·'·101

However results have important implications for mathematical learning and instruction. As initial learning and mature performance of symbolic arithmetic depend on the ANS". Since children in Pakistan are also similar in terms of their approximate number abilities so at the outset they can learn mathematics with similarcompetence andexpertise 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 numericalacuity.



## CONCLUSION

Panamath task childrencan beassessed to figure out atearlier 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 agegroups (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 someintervention to learnlatermathematics.

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