STANDARDISATION AND ADAPTATION OF THE DENVER DEVELOPMENTAL SCREENING TEST (DDST) AND DENVER II FOR USE IN SINGAPORE CHILDREN

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ABSTRACT

Objective – To modify and standardise the Denver Developmental Screening Test (DDST) and Denver II for developmental screening of children in Singapore.

Method – The study used a quota sample of 2,194 Singapore children aged 4 weeks to 6 years. Logistic regression analysis established the 25th, 50th, 75th, and 90th percentile passing age for achieving the test tasks. Subgroup differences in Sex, Ethnicity, Social Class and Mother's Education were analysed by stepwise logistic regression; the composite norms for items with statistically significant subgroup differences ($p \leq 0.10$), were then adjusted by weighting based on the composition of Singapore children. The study protocol was based on the DDST (1975) and Denver II (1990), the latest version of the DDST. Modifications were introduced to improve on the sensitivity of the test and to make the test more suited to Singapore culture.

Main Findings – Out of the 215 items studied, 115 items were selected to form the new test, DDST, Singapore. DDST, Singapore shares 63% of the items with DDST (1975) and 67% of the items with Denver II. Among the comparable items, differences between the norms of Singapore and Denver children greater than 10% were demonstrated in more than 30 items, and differences of greater than 20% in 10 items. Within the study sample of Singapore children, there were relatively smaller differences among the subgroups studied. Only 10 items had clinically significant subgroup differences of more than 10%. None had more than 20% difference.

Conclusion – DDST, Singapore is substantially different from the DDST (1975) and Denver II (1990). The use of the local standardised version for developmental screening of Singapore children is justified.

Keywords: *developmental screening, Denver Developmental Screening Test, Denver II, standardisation*

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INTRODUCTION

Developmental screening has become an established component of child health surveillance programmes in many developed countries[1]. While the efficacy of developmental screening remains controversial, its value as an integrated part of a total health surveillance programme for young children is well accepted[1-3]. In Singapore, the 17 government Maternal and Child Health (MCH) Clinics are the main providers of developmental screening, screening approximately 50% of each year's birth cohort of children. Checklists of developmental items based on the tests of Mary Sheridan[4] and Egan et al[5], were used for development screening prior to the study. The lack of clearly defined guidelines for the interpretation of these developmental checklists and of normative data on child development in Singapore necessitated the development of a structured, standardised developmental screening test based on local norms.

The objective of this study was to adapt and standardise the Denver Developmental Screening Test (DDST) for use in Singapore for developmental screening of children aged 4 weeks to 6 years.

The DDST[6] was chosen because it met our needs for a test that is standardised in administration and objectively scored, referenced to a norm, reliable, valid[7-9] and broadly focussed on all areas of development from 2 weeks to 6 years. It is suitable for use by nurses[10] and primary health care doctors who do not have extensive training in child development. It is also widely used in many countries in the world including Asia[11-13].

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METHOD AND SUBJECTS

The data for the study were collected between May 1988 and February 1989. Besides the authors, a psychologist, a paediatrician and statisticians were involved in the protocol planning and statistical analysis of the study.

Study Design

The sample consisted of 2,194 Singapore children aged 4 weeks to 6 years 11 months.

The sample was drawn from 3 sources:

1. Children attending 6 Maternal and Child Health (MCH) Clinics – 85%.
2. Postal invitations to a random sample of children, who had not previously attended MCH Clinics. The sample was randomly drawn from the Preliminary Birth Report – 12%.
3. Children attending 5 child care centres, kindergartens mostly in the older preschool age group – 3%.

Similar to the Denver II study, a quota sample was used. Children were recruited to meet the quota proportions in terms of age, sex (male 50%, female 50%), ethnic group (Chinese 50%, Malay 25%, Indian 25%) and social class (Class 1 & 2, 3 & 4, 5 & 6, 7 in equal proportions of 25% each). The social classification was based on the father's occupation as defined in the 1980 Singapore Population Census. Because developmental change in younger children proceed at a more rapid rate than in older children, the sample consisted of a larger proportion of younger children.

Children with conditions which are known to be associated with delayed development were excluded from the sample.

Selection of Items

Data for 215 test items were collected and analysed. The items

were taken from DDST (1975), the study protocol of Denver II and the developmental checklist used for developmental screening in MCH Clinics. One hundred and fifteen test items were selected to form the new test, DDST, Singapore. The selection of an item for inclusion in the DDST, Singapore was based on whether it was (a) common to DDST (1975) or Denver II (1990)[14]; (b) easy to administer and score; (c) well liked by the testers and children; (d) low in the scores for "No Opportunity, Refusal"; and (e) had minimal difference between the subgroup and the composite norm.

Modifications

Twenty-two items were deleted and 11 items from the DDST (1975) were modified and of the 29 items not present in DDST (1975), 16 of them were taken from Denver II (1990) and 13 were new items. Table I shows the proportion of items in DDST, Singapore that are common with DDST (1975) and Denver II (1990). DDST, Singapore shares 63% of the items with DDST (1975) and shared slightly more (67%) items with Denver II. Most of the modifications introduced are in the Personal-Social and the Language Sectors.

Table I – The proportion (%) of items in DDST, Singapore that are common with DDST (1975) and Denver II (1990)

	Gross Motor	Fine Motor	Personal Social	Language	All Sectors
DDST	91	83	38	39	63
DENVER II	81	85	53	49	67

Data Collection

Six MCH staff nurses were trained in data collection. Data collection commenced only after the testers had achieved intertester reliability scores of more than 90%. The test items were also translated into the Chinese, Malay and Tamil languages and the test administered in the language in which the child was most proficient (according to the caregiver). The result of the PASS/FAIL outcome for each item was then used in the computation for the normative data. An average of 884 children (range 282 – 1,438) were tested for each item.

Statistical Analysis

Logistic regression analysis was used to determine the 25th, 50th, 75th and 90th percentile passing ages for all the items. Several statistical processes, including the goodness of fit statistics suggested by Lemeshow and Hosmer[15] were used to obtain the best fitting of the regression lines.

To determine if significant differences existed between subgroups, the statistically significant subgroup variables were identified by running a backward stepwise logistic regression analysis. The ancillary variables included Sex, Ethnicity, Social Class and Mother's Educational Level. For the "composite" percentiles, all subgroups showing statistically significant differences at the 10% level (ie $p \leq 0.10$), were weighted to correspond with the prevalence of the subgroups in the Singapore population (based on the 1988 Labour Force Survey of Singapore).

An item was said to have clinically significant subgroup difference when the difference between any of the subgroups and its composite 90th percentile norm was greater than 10%. For example, for the item "Comb doll's hair", the 90th percentile norm for female children was 22 months while the norm for males was 26.9 months. The composite norm for both sexes was 24.5 months resulting in a 10.2% difference between the female and composite norm. Therefore, it is an item with clinically significant difference in the Sex subgroup.

RESULTS

Profile of Subjects

A profile of the subjects by Sex, Ethnicity, Social Class and Mother's Education is presented in Table II. The population statistics of Singapore are taken from the Labour Force Survey, 1988.

The frequency distribution for Age, Sex, Ethnicity, Social Class were the direct result of the quota sampling method. The proportion of the minority groups in Social Class and Ethnic groups was increased to enable analysis of subgroup differences. There was a higher proportion of mothers in the sample with secondary education and a lower proportion of mothers with no or primary education when compared to that of the Singapore female population, aged 15 years and above ($p < 0.01$).

Table II – Profile characteristics of subjects

		No. in Sample	% in Sample	*% in Population
Sex				
Male		1,086	49.8	51.1
Female		1,108	50.5	48.9
Ethnic Group				
Chinese		1,113	50.7	76.6
Malay		603	27.5	14.9
Indian		471	21.5	6.4
Others		7	0.3	2.2
Social Class				
I	1. Professional/Technical	340	26.7	18.5
	2. Managerial	247		
II	3. Clerical	296	29.3	27.7
	4. Sales	347		
III	5. Services	440	20.1	13.2
	6. Agricultural	7		
IV	7. Production	511	23.6	36.0
	8. Others	6	0.3	0.7
Mother's Education				
Nil/Primary		897	40.9	59.9
Secondary		1,200	54.7	36.7
Tertiary		86	3.9	3.3
Not Stated		11	0.5	
Total		2,194	100.0	100.0

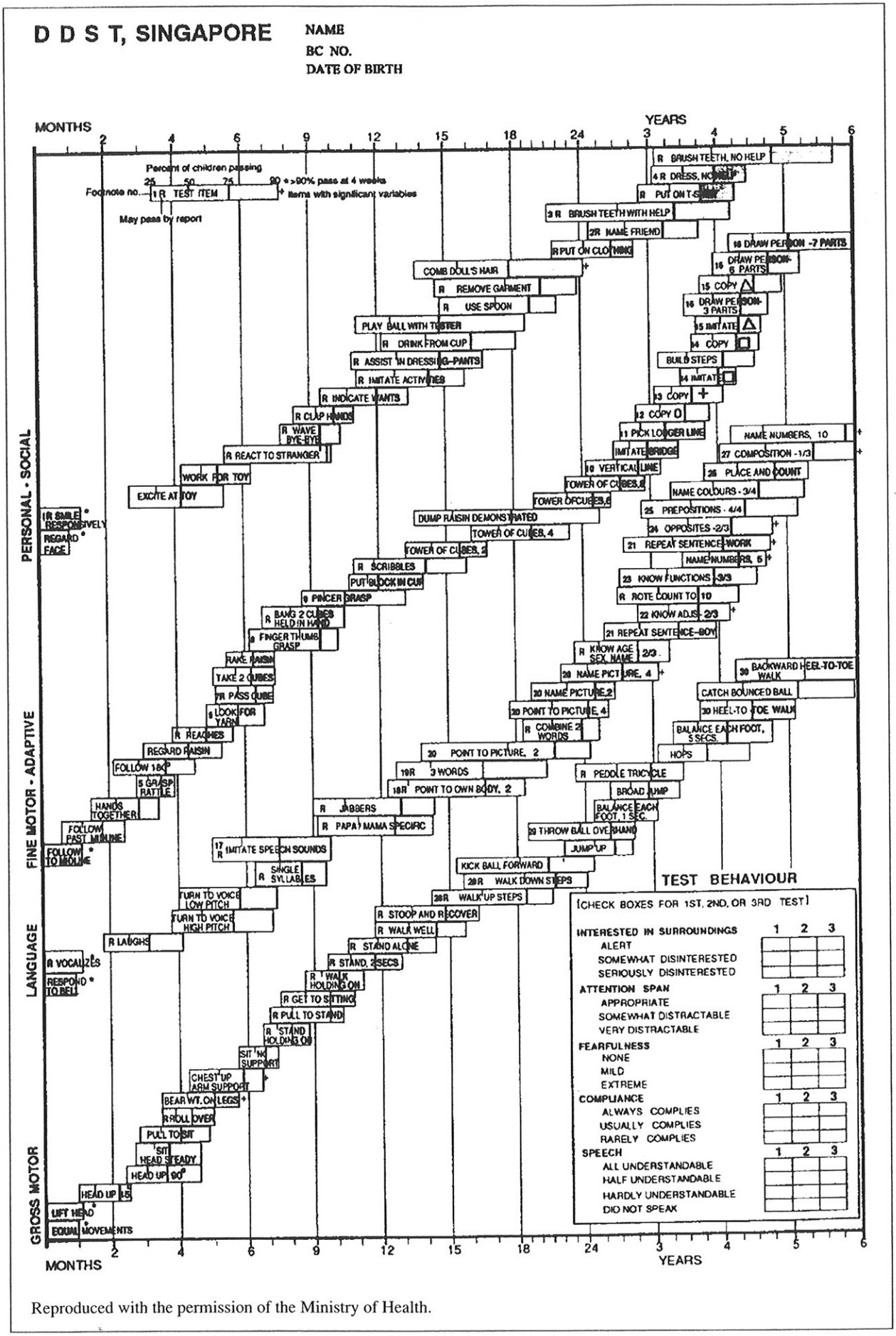
*Based on Labour Force Survey, Singapore 1988

The Construction of the DDST, Singapore Test Form and Test Manual

The main outcome of the study was the production of the DDST, Singapore Test Form (Appendix 1) and the Test Manual. The format of presentation closely resembles that of Denver II (1990). Each item is presented as a bar. Each of the four areas of development, Personal-Social, Fine Motor-Adaptive, Language and Gross Motor was represented by a set of item bars. Reading against the age scale, each bar depicts the 25th, 50th, 75th and 90th percentile passing ages for the test item. The items that can be passed by "Report" are preceded by "R". Subject behaviour during the test is recorded in the window at the lower right hand corner of the form.

The Test Manual contains instructions for the test administration and interpretation of the test, and recommendations for follow up.

Appendix 1 – The DDST, Singapore Test Form



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Subgroup Differences

The 4 variables studied were: Sex, Ethnicity, Mother's Education and Social Class.

Two hundred and fifteen potential items were analysed for subgroup differences at the 90th percentile passing age. Only 36 items had subgroups with clinically significant differences. "Ethnicity" and "Mother's Education" were the variables that had the most number of items with clinically significant differences among the subgroups. Among the four developmental sectors, the Language sector had the most number of items with significant differences among the subgroups. In the final DDST, Singapore Test Form, only 10 items (8.7%) of the total 115 items had clinically significant subgroup differences at the 90th percentile passing age (see footnote). These items are distinguished by a "+" sign at the end of the item bars in the Test Form. The data are presented in the Test Manual for reference by users of the test.

None of the items in DDST, Singapore has subgroup differences greater than 20%.

Comparison with DDST (1975) and Denver II (1990)

Because of the modifications, only 73 items can be compared with DDST (1975) and 81 items with Denver II (1990).

The differences were examined by calculating the percent differences between the 50th and 90th percentile passing ages for every comparable item for DDST, Singapore and DDST (1975) (see footnote). The same was done for the comparison with Denver II.

Comparison with DDST (1975)

At the 90th percentile passing age, there were 32 items (44% of the comparable items) with more than 10% differences between DDST, Singapore and DDST (1975). Ten items had more than 20% differences.

At the 50th percentile passing age, for 64% of the tests, Singapore children achieved the test tasks at a later age than Denver children. The trend was reversed at the 90th percentile passing age where for 58% of the tests, Singapore children achieved the test tasks at an earlier age than Denver children. However, most of those items that Singapore children achieved earlier were in the Fine Motor sector.

Comparison with Denver II (1990)

At the 90th percentile passing age, there were 33 items (41% of the comparable items) with more than 10% differences between DDST, Singapore and Denver II (1990). Fourteen of them had more than 20% differences.

In more than half of the tests (63% at the 50th percentile, 57% at the 90th percentile passing age), Singapore children achieved the test tasks at a later age than Denver children. The exception to this trend was in the Fine Motor sector where Singapore children achieved the test tasks earlier in 59% of the tests at the 50th percentile and 74% of the tests at the 90th percentile.

DISCUSSION

Sampling Method

Although a stratified random sample of children from all parts of the country is ideal, the quota sample was used instead in order to ensure adequate numbers in each subgroup for studying subgroup differences.

The bias introduced by the quota sampling was partially overcome by taking the weighted average of the passing ages for subgroups based on their proportions in the Singapore population.

Another reason that would make the random sampling method impractical was illustrated by the high non-response rate from children invited to join the study. The poor response (32%) to the random postal call up of children for the study could have been improved by testing these non-respondent children at home, but this method was beyond our resources.

The test developed will mainly be used for children attending the Maternal and Child Health (MCH) Clinics and for those who will respond to call up letters. As more than 80% of children born each year in Singapore attend the MCH Clinics, this sampling method is adequate for our needs.

Validity

No attempt was made to determine the validity of DDST, Singapore against established developmental scales or psychological tests as it is not our intention to use it to diagnose developmental abnormalities. Based on local standardised norms the test is adequate for our purpose to screen for developmental deviations from the norms.

Modification

The modifications introduced have resulted in a test which is substantially different from both the DDST (1975) and Denver II (1990). The modifications were necessary as the social habits, child rearing practices and language of Singapore children are different from the Denver children. Singapore parents and children also react differently to test situations. These differences were reflected most obviously in the Language and Personal Social sectors.

Some items were deleted because they were irrelevant to the languages and culture of Singapore people eg "Use plurals", "Play pat-a-cake" and "Give first and last name". Items that were deleted because they were difficult to administer or interpret included "Play peek-a-boo" and "Define words". Two items "Wash and dry hands" and "Feed self crackers" were deleted because a high proportion of children had not been given the opportunity to carry out these tasks. Some of the items were modified without changing the basic task, eg the pictures in the item "Name pictures" were replaced with a set of pictures that was more suitable to Singapore children. Other items were made more precise eg "Turn to voice" was replaced with 2 items testing high and low pitch sounds using more refined, sound making instruments.

The modifications were also made in order to improve the sensitivity of the test as the DDST had been criticised for lacking in sensitivity in picking out less severe handicaps[3,16] and for its weakness in the Language sector[17].

The new items were for testing preschoolers with the exception of one item, "Jabber" which was added for infants.

The testers generally experienced great difficulty in getting the children to converse freely during testing. Our local children are relatively shy and reticent with strangers, making it difficult to test expressive language items other than those requiring very few syllable answers. These similar characteristics were described by Miller and Onotera in their study on the use of DDST in Southeast Asian immigrant children in Minnesota, USA[18]. The items "Rote count to 10", "Repeat sentences" enabled testers to hear the children articulate the important sounds in the 3 main languages and to test their attention to sounds, as well as short term memory.

Tests of abstract mathematical concepts, "Place and count" and early reading and symbol recognition "Name numbers" were introduced to enhance the test in screening out children with mild mental deficiency and those at risk for school failure.

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* Footnote

The following tables are obtainable on request from the authors:

* The 25th, 50th, 75th and 90th percentile norms for all the 115 items – S-Tables 1-4

* The norms for the individual subgroups with more than 10% differences from the composite norm – S-Table 5

* Comparison of the 50th and 90th percentile passing ages between DDST, Singapore and DDST (1975) – S-Tables 6-7

* Comparison of the 50th and 90th percentile passing ages between DDST, Singapore and Denver II (1990) – S-Tables 8-9

A new Behaviour sector was added to record the child's behaviour during the test, eg his alertness, compliance to tester's instructions, to assist the tester in the interpretation of the child's performance and to improve these sensitivity of the test.

The sensitivity of DDST, Singapore was also increased by lowering the failing criteria. An item was scored as "Delay" when a child older than the 90th percentile passing age, failed the item. It was scored as "Caution" if the child who failed, was between the 75th and 90th percentile passing ages. If a child scored two or more "Caution" or up to one "Delay" in the entire set, his development was classified as "Questionable". Development was "Abnormal" if there were two or more "Delays". This scoring criteria may have to be adjusted pending the results of the evaluation study.

Differences in Development Among Subgroups

Ethnicity and Mother's Education were the two most important co-variables of clinical importance. In our study, although male and female children performed differently in many test items, the magnitude of the differences did not reach clinical significance (ie with >10% differences between subgroup norms and the composite norm).

Subgroups differed the most in language development. One reason for this could be the intrinsic differences in the languages used eg some test items like "Know Name/Age/Sex", "Repeat Sentences" consist of more syllables in the Malay and Indian languages than the Chinese language. The difference in the degree of difficulty for the same item in different languages may account for the Chinese children attaining earlier passes for these items.

In Gross Motor development, Chinese children were slower than Malay and Indian children particularly in the item "Bear weight on leg" and "Chest up, arm support" when in the prone position. Besides true genetic differences, child rearing factors may have contributed to the differences among the various races. Chinese parents tend to be over protective and do not allow their children to move freely for fear of injury.

CONCLUSION

Although there were a number of differences among the subgroups, they were not significant enough to justify the use of different sets of norms for each subgroup.

The test was modified to suit the Singapore culture. Other modifications were also introduced with the aim to improve the sensitivity of the test. The differences in the norms between Singapore and Denver children were shown to be greater than the differences demonstrated between the composite norms and the norms of the different subgroups in the local population. Based on these reasons, the use of DDST, Singapore as the preferred test for screening children in Singapore is justified.

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