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Brief report

A modified version of the Bayley Scales of Infant Development-II for cognitive matching of infants with and without Down syndrome

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Abstract

Background Many measures of infants' early cognitive development, including the BSID-II (The Bayley Scales of Infant Development), mix together test items that assess a number of different developmental domains including language, attention, motor functioning and social abilities, and some items contribute to the assessment of more than one domain. Consequently, the scales may lead to under- or over-estimates of cognitive abilities in some clinical samples and may not be the best measure to use for matching purposes.
Method To address this issue we created a modified form of the BSID-II (the BSID-M) to provide a 'purer' assessment of the general cognitive capacities in infants with Down syndrome (DS) from 6 to 18 months of age. We excluded a number of items that implicated language, motor, attentional and social functioning from the original measure. This modified form was administered to 17 infants with Down syndrome when 6, 12 and 18 months old and to 41 typically developing infants at 4, 7 and 10 months old.
Results The results suggested that the modified form continued to provide a meaningful and stable measure of cognitive functioning and revealed that DS infants may score marginally higher in terms of general cognitive abilities when using this modified form than they might when using the standard BSID-II scales.
Conclusions This modified form may be useful for researchers who need a 'purer' measure with which to match infants with DS and other infants with intellectual disabilities on cognitive functioning.

Keywords Bayley scales, BSID-M, cognition, Down syndrome, infants, matching

Introduction

The Bayley Scales of Infant Development (BSID & BSID-II, Bayley 1969, 1993) provide a mental development index or 'facet', comprised of items which are intended to have predominantly cognitive

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Table 1 Age of participants at each comparison point

	n	Age in Months	Age in days		
			M	SD	Range
Comparison one					
Infants with Down syndrome	10	6	197.8	9.4	189–220
Infants with typical development	22	4	133.2	9.7	116–152
Comparison two					
Infants with Down syndrome	13	12	381.5	23.7	353–429
Infants with typical development	25	7	219.2	8.9	206–252
Comparison three					
Infants with Down syndrome	17	18	568.5	25.1	550–652
Infants with typical development	35	10	314.4	11.8	299–354

content. If we are to explore potential dissociations between cognitive development and other domains of functioning in infants with intellectual disabilities (IDs), it is essential that we develop relatively 'pure' measures of cognitive abilities that we can use for matching purposes. Unfortunately, many measures of infants' early cognitive development, including the BSID-II, mix together test items that assess a number of different developmental domains including language, attention, motor functioning and social abilities, and some items contribute to the assessment of more than one domain.

Specifically, some items which are included in the cognitive subscale are also used to assess social engagement, and success on some cognitive items may be constrained by an infant's fine tuned motor functioning or by abilities to attend to the task rather than their general abilities for planned action or representation, which may be the area on which researchers wish to match. Thus, while these scales give useful indications of the general developmental level of an infant, it is not always clear that the cognitive subscale score that emerges is a 'pure' enough index of cognitive functioning to be safely employed as a matching measure (Moore *et al.* 2002).

Another problem when using the BSID-II scales with infants with developmental difficulties is in knowing at which point in the scales to start (Gauthier *et al.* 1999). This can sometimes mean that infants with IDs are administered more items than typically developing (TD) children, which may lead to particular problems for infants with Down syndrome (DS) when considered in light of mastery motivation problems (Wishart & Duffy 1990; Gilmore *et al.* 2003).

This paper reports our initial attempt to develop a modified version of the Bayley II that is simpler to administer and that might provide a less confounded assessment of cognitive level when being used as a matching measure. We refer to this as the BSID-M. The intention was to develop a measure of cognitive functioning that would be familiar to researchers in administration, and retain its coherent structure, but would specifically focus on cognitive capacities, and allow researchers to be more confident when matching infants with and without DS on cognitive abilities. This may then allow researchers to reveal with more clarity those areas of functioning that are spared or impaired relative to cognitive level (Rast & Meltzoff 1995; Chapman & Hesketh 2000; Fidler 2005).

To explore these issues we administered this BSID-M longitudinally to a group of infants with DS when aged 6, 12 and 18 months. To select our comparison ages, we used norms from Table 1 in Rauh *et al.* (1996). Their data indicated that: 6-month-old infants with DS would be expected to have mental ages equivalent to a 4-month-old TD infant; 12-month-old infants with DS have mental ages around 7 months; and 18-month-old infants would be expected to perform at the level of a 10-month-old infant.

Our first question was whether we would get a meaningful profile of responses that would allow us to compare groups. Our second question was whether the levels of stability of the measure were

comparable with the BSID-II. Our third question was whether we would obtain levels of performance in the infants with DS that were similar to the TD infants.

Method

Participants

Seventeen children with DS and 41 TD infants took part in the study. The infants with DS were tested when aged 6, 12 and 18 months and the TD infants were tested when aged 4, 7 and 10 months. Ten infants with DS and 15 TD infants comprised a fully longitudinal sample and were tested at all three comparison points. Details of the sample are provided in Table 1.

Participants were recruited through health professionals and by advertisements. The demographics of the two groups were very similar (see Table 2).

Selection of items

Only items that contributed to the cognitive facet of the BSID-II up to 12 months developmental age (DA) were considered for administration. We excluded all items that also contributed to the social facet, apart from five social items[1] which we retained to facilitate engagement with the task. Also we excluded items from the cognitive scale if they also contributed to the language facet and any item for which the motor demands might be particularly taxing. In addition, we excluded items that assessed attentional control such as habituation or the tracking of objects (in light of Zelazo & Stack 1997). We also excluded items that depended on hearing. Other selected items were also excluded after consultation with experienced colleagues in the field. Concerns were raised about the BSID-II object concept tasks involving the heavy plastic cups provided, which we have repeatedly found difficult for young infants to manipulate, and that may act as an unnecessary constraint on infants' planned action abilities.

The items we excluded and retained are listed in Table 3.

[1] These items were not used in the calculation of the final cognitive scores.

Table 3 groups the items according to the DA at which they would be expected to be passed on the full BSID-II scales. Note that many items on the BSID-II are derived from the administration of a single structured task. For example, by presenting the red cubes one allocates scores for a number of items that relate to this presentation, even those items that are below the DA tested. Thus, for the older infants reported here, we are able to report their success rates on items that relate to the level at which they were being assessed and also at younger levels. Importantly, while this gives the impression that the older infants were administered a longer test, this was not in fact the case, and the procedure did not take much longer for the older than the younger infants.

We were left with a battery of items that examined infant's abilities to use planned meaningful actions but that did not depend on hearing, language production, require overly precise motor coordination, or require changes in attentional focus.

Procedure

The BSID-M took up to 15 min to administer. Infants were typically seated on the mother's lap or in a high chair. The whole session was recorded on video for later 'off-line' confirmation of the coding. As with the administration of the full BSID-II, an element of discretion was allowed in how items should be administered. For example, items could be omitted if the experimenter judged that failure on earlier items showed that further testing on that set would be unproductive.

Results

Table 4 shows the success rates achieved by infants with and without DS on each item at each of the age comparison points. Examination of Table 4 shows that there was considerable consistency in levels of performance across items from within each developmental level for each age group. The only item that appeared to be out of line with items in the developmental bracket was item 40 – carries ring to mouth which for the two older comparison points showed far lower levels of 'success'. This may

Table 2 Characteristics of infants and their families

	Infant		**Family**					
Group	***n* (first born)**	**Gender**	**Mother's Mean age in years (SD)**	**Mothers' Ethnicity**	**Mothers' Qualifications**[†]	**Relationship status**	**Father's Mean age in years (SD)**	**Best SES of Father or mother***
Down syndrome	17 (9)	11 male 6 female	31.94 (5.5)	12 = white 1 = Indian-Asian 1 = afro-carribean 3 = mixed race	None = 1 GCSE = 4 Vocational = 9 A' level = 1 Degree = 2	Married/Partner = 14 Single = 3	31.06 (4.4)	II = 9 IIIN = 7 IIIM = 1
Typically developing	41 (24)	24 male 17 female	30.4 (6.0)	28 = white 7 = Indian-Asian 5 = afro-carribean 1 = mixed race	None = 0 GCSE = 7 Vocational = 19 A' level = 5 Degree = 10	Married/Partner = 35 Single = 6	31.45 (5.11)	I = 1 II = 25 IIIN = 9 IIIM = 5 Other = 1

* SES = Socio-economic status; I = Professional; II = managerial/technical; IIIN = skilled non-manual; IIIM = skilled manual.

† GCSE: UK age 16 school leaving qualifications; Vocational: school or post-school semi-skilled vocational training; A' level: UK advanced, age 18, school/college qualification; Degree: Bachelors level or above UK university degree qualification.

Table 3 Items retained and excluded from the BSID-II (The Bayley Scales of Infant Development) cognitive facet together with reason for exclusion

Developmental age (months)	Items retained		Cognitive facet items excluded		Reason for exclusion
2	15	Eyes follow ring	17–18	Eyes follow ring in circle/arc	Attention
	24	Head follows ring	20	React to disappearance of face	Social
	25	Regards cube for 3 s	23	Glances from bell to rattle	Motor
			26–28	Habituation to visual stimulus	Attention
			30	Turns head to sound	Hearing
			32	Eyes follow rolling ball	Attention
3	37	Manipulates ring	29	Novelty after habituation	Attention
	38	Reaches for suspended ring	34	Inspects own hands	Motor
	39	Grasps suspended ring	35	Plays with rattle	Motor/hearing
	40	Carries ring to mouth	36	Eyes follow rod	Motor/attention
	42	Reaches for cube	41	Approaches mirror*	Social
			47	Display awareness of surroundings	Attention/social
4	43	Reaches persistently	46	Fixates on disappearance of ball	Attention
	44	Uses hand-eye in reaching	49	Smiles at mirror image*	Social
	45	Picks up cube	50	Responds playfully to mirror image*	Social
	48	Plays with string	51	Regards pellet	Motor/accommodation
			52	Bangs in play	Pers. comm./motor
			55	Lifts inverted cup	Motor
5	53	Reaches for 2nd cube	54	Transfers object to hand	Motor
	57	Picks up cube deftly	56	Looks for fallen spoon	Pers. comm.
	58	Retains 2 cubes for 3 s	59	Manipulates bell	Motor
	60	Attends to scribbling			
6	62	Pulls string adaptively	64	Cooperates in game*	Social
	65	Retains 2 of 3 cubes for 3 s	66	Rings bell purposely	Hearing
			67	Lifts cup by handle	Motor
			69	Looks at pictures in book	Attention
7	74	Puts 1 cube in cup	72	Looks for contents of box	Motor
8	75	Attempts to secure 3 cubes	73	Turns pages of book	Motor
	79	Fingers hole in pegboard	77	Pushes car	Motor
			80	Removes lid from box	Motor
9	82	Suspends ring by string	83	Pats toy in imitation*	Motor/social
	86	Puts 3 cubes in cup	84	Finds one object	Motor
			85	Removes pellet from bottle	Motor
10	88	Retrieves toy from clear box	89	Puts six beads in box	Motor
11	91	Scribbles spontaneously			
	92	Closes round container			
	95	Puts 9 cubes in cup			
12	87	Places 1 peg repeatedly	96	Finds toy under reversed cups	Motor-heavy cups
	93	Places circle in pink form board			
	97	Builds tower of 2 cubes			
	98	Places pegs in 70 s			

* These items were retained to facilitate social engagement but did not contribute to the total score.

reflect the different strategies for exploring objects that are adopted by younger and older infants, and suggests that this item is only appropriate as an indicator of cognitive level for younger infants.

In order to examine stability over time in individual differences we examined the profiles of the longitudinal subsample and correlated the number of successful items at comparison point one with

Table 4 Showing number of infants administered each item and success rate on each item at each comparison point

			Comparison one (DS = 6 months; TD = 4 months)				Comparison two (DS = 12 months; TD = 7 months)				Comparison three (DS = 19 months; TD = 10 months)			
			DS		TD		DS		TD		DS		TD	
Developmental age (months)		Item	*n*	% pass	*n*	% pass	*n*	% pass	*n*	% pass	*n*	% pass	*n*	% pass
2	15	Eyes follow ring	8	100	11	100	–	–	–	–	–	–	–	–
	24	Head follows ring	9	100	12	100	–	–	–	–	–	–	–	–
	25	Regards cube for 3 s	10	100	21	86	–	–	–	–	–	–	–	–
3	37	Manipulates ring	10	90	18	50	13	100	21	95	17	94	32	97
	38	Reaches for suspended ring	10	60	21	38	13	100	23	96	17	94	29	100
	39	Grasps suspended ring	10	40	21	24	13	100	23	96	16	94	29	100
	40	Carries ring to mouth	10	70	18	39	13	23	22	41	16	31	29	34
	42	Reaches for cube	10	60	21	48	13	100	23	96	17	100	32	97
4	43	Reaches persistently	10	50	21	29	13	100	22	96	17	100	32	97
	44	Uses hand-eye reaching	10	40	21	14	13	92	23	91	17	100	33	97
	45	Picks up cube	10	40	21	24	13	100	23	91	17	94	33	97
	48	Plays with string	8	50	21	24	13	92	23	96	16	88	32	91
5	53	Reaches for 2nd cube	10	10	21	10	13	83	22	69	16	81	31	74
	57	Picks up cube deftly	10	0	21	0	13	85	22	50	17	94	33	97
	58	Retains 2 cubes for 3 s	10	10	21	5	12	83	24	61	16	63	31	68
	60	Attends to scribbling	–	–	–	–	10	70	24	79	11	73	29	93
6	62	Pulls string adaptively	–	–	–	–	12	50	22	36	15	80	28	61
	65	Retains 2 of 3 cubes for 3 s	–	–	–	–	11	46	23	52	14	14	28	54*
7	74	Puts 1 cube in cup	–	–	–	–	10	70*	23	22	16	75	32	66
8	75	Secures 3 cubes	–	–	–	–	11	36	23	22	14	7	28	17
	79	Fingers hole in pegboard	–	–	–	–	12	17	20	10	17	47	33	18
9	82	Suspends ring by string	–	–	–	–	11	46	16	38	15	73*	26	39
	86	Puts 3 cubes in cup	–	–	–	–	10	20	22	5	16	56	31	23
10	88	Retrieves from clear box 1	–	–	–	–	11	0	11	9	16	38	32	38
11	91	Scribbles spontaneously	–	–	–	–	–	–	–	–	17	36	34	24
	92	Closes round container	–	–	–	–	–	–	–	–	16	18	28	32
	95	Puts 9 cubes in cup	–	–	–	–	–	–	–	–	16	25	31	7
12	87	Places 1 peg repeatedly	–	–	–	–	–	–	–	–	16	31	28	10
	93	Places circle in board	–	–	–	–	–	–	–	–	14	36	23	9
	97	Builds tower of 2 cubes	–	–	–	–	–	–	–	–	17	36	28	7
	98	Places pegs in 70 s	–	–	–	–	–	–	–	–	16	6	28	0

* Significant association with group (Chi-square $p < 0.05$).
DS, Down syndrome; TD, typically developing.

that at time two, and total items at comparison two with total at comparison three. For comparison one vs. two, the correlations were for DS, Spearman's Rho = 0.41, NS; for TD infants, Spearman's Rho = 0.54, $p < 0.05$. For comparison two vs. three, the correlations were for DS, Spearman's Rho = 0.40, NS; for TD infants, Spearman's Rho = 0.65, $p < 0.01$. Thus both groups of infants showed reasonable stability over time.

The 6-month-old infants with DS and the TD infants achieved a similarly high level of success on the items from the 2-month developmental period. However, for items from the 3- and 4-month developmental period, 6-month-old infants with DS

tended to show higher levels of performance than the 4-month-old TD infants. In terms of the total number of items passed at comparison one (DS = 6 months; TD = 4 months), DS infants passed between 3 and 13 items administered, Mean = 7.9, SD = 3.3. TD infants showed a similar range of items passed (0–13) with Mean = 4.6, SD = 3.3. A *t*-test showed there to be a significant difference in the number of items passed by the two groups, $t = 2.59$, d.f. = 30, $p = 0.016$, 2-tailed).

For comparison two (DS = 12 months; TD = 7 months) the majority of infants in both groups passed items in the 3- and 4-month sets. DS infants passed between 8 and 18 of the items administered, Mean = 12.7, SD = 2.5. TD infants showed a wider range of items passed (range 3–16) with Mean = 10.9, SD = 3.4. A *t*-test showed there to be no significant overall difference between the groups ($t = 1.68$, d.f. = 35, $p = 0.1$, 2-tailed), although on item 74 (puts one cube in cup) there was a significant association between diagnosis and success with more infants with DS succeeding on this item (Chi-square = 7.01, d.f. = 1, $p = 0.008$).

For comparison three (DS = 18 months; TD = 10 months), DS infants passed between 7 and 24 of the relevant items administered, Mean = 15.3, SD = 4.8. TD infants showed a similar range of items passed (range 5–19) with Mean = 13.5, SD = 3.2. A *t*-test showed there to be no significant difference between the groups ($t = 1.59$, d.f. = 49, $p = 0.12$, 2-tailed). There were significant associations of diagnosis and performance on two items at this comparison point. Item 65 where more TD infants were successful (Chi-square = 5.97, d.f. = 1, $p = 0.014$) and item 82 where more infants with DS were successful (Chi-square = 4.63, d.f. = 1, $p = 0.031$).

Discussion

The data suggest that the modified version of the BSID-II is a meaningful measure of cognitive level with reasonable consistency within groups. Furthermore, correlations between the first comparison point and subsequent points, ranging from 0.40 to 0.65, while not significant for the small sample of infants with DS, were comparable with previous reports. Specifically, Harris *et al.* (2005) reported for the full BSID, in an at-risk sample, a correlation across administrations of 0.49. Similarly, Niccols & Latchman (2002) reported stability correlations in at-risk samples of 0.37 and 0.65. Thus our data suggest that this modified scale is comparable in stability to the full BSID-II.

In terms of use for matching the findings indicate that young infants with DS may have higher cognitive levels than suggested from international norms derived from the BSID published by Rauh *et al.* (1996). The 6-month-old infants with DS in particular performed significantly better than the 4-month-old TD control infants. The data suggest that if we wish to match on DA on the basis of our BSID-M, we might wish to match 6-month-old infants with DS with 5-month-old TD infants. With the two older comparisons the DS infants did not do significantly better than the TD infants. However, the DS infants tended to show higher scores, and it might be recommended that for matching purposes 12-month-old infants with DS would be matched with 8-month-old TD infants and 18-month-old DS infants with 12-month-old TD infants.

Of course until a subsequent study is performed in which the same infants are administered both the BSID-II and BSID-M in counterbalanced order we cannot conclude that the BSID-II significantly underestimates the cognitive abilities of infants with DS. However, this initial study at least suggests there is some mileage in using a modified version for detailed matching purposes.

The development of simple measures that more clearly assess cognitive level may facilitate the more efficient collection of data in large scale longitudinal studies in infancy and allow developmental relations between domains to be tested with more precision. Matching on this new measure would allow researchers to confidently investigate attention, language, motor and social development in infants with DS without fear that their matching procedure has been confounded. While this paper presents only a preliminary attempt to modify the BSID-II to be used as a better matching measure, it highlights the importance of adopting an approach that recognises the limitations of all tests that were designed to assess general developmental levels for matching purposes. It remains to be seen whether this scale will prove useful for matching cognitive

abilities with other infants at developmental risk as part of wider comparison studies (Hodapp 2004).

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