

**Brief report**

## Neuropsychological effects of second language exposure in Down syndrome

J. O. Edgin, A. Kumar, G. Spanò & L. Nadel

*Department of Psychology, University of Arizona, Tucson, AZ, USA*

**Abstract**

**Background** While it has been common practice to discourage second language learning in neurodevelopmental disorders involving language impairment, little is known about the effects of second language exposure (SLE) on broader cognitive function in these children. Past studies have not found differences on language tasks in children with Down syndrome (DS) and SLE. We expand on this work to determine the effects on the broader cognitive profile, including tests tapping deficits on neuropsychological measures of prefrontal and hippocampal function.

**Method** This study examined the specific cognitive effects of SLE in children with DS (aged 7–18 years). Children with SLE ( $n = 13$ ; SLE predominantly Spanish) and children from monolingual homes ( $n = 28$ ) were assessed on a standardised battery of neuropsychological tests developed for DS, the Arizona Cognitive Test Battery. The current exposure level to a language other than English in the SLE group was greater than 4 h per day on average.

**Results** No group differences were observed for any outcome, and level of exposure was also not linearly related to neuropsychological outcomes, several of which have been shown to be impaired in past work.

**Conclusion** There were no measurable effects of SLE on neuropsychological function in this sample of children with DS. Potential clinical implications of these findings are discussed.

**Keywords** Down syndrome, executive function, intellectual disability, memory, neuropsychology, second language exposure

**Introduction**

As noted by Kay-Raining Bird *et al.* (2005), Kay-Raining Bird (2009) and others, exposure to a second language has often been discouraged in individuals with intellectual disabilities (ID), including Down syndrome (DS), given the cognitive and language difficulties often faced by these individuals. In individuals with DS, language difficulties emerge from a very early age, including gaps between production and comprehension noticeable in the toddler years (Miller 1992; Chapman 1995; Roberts *et al.* 2007). There is also a wide body of

Correspondence: Dr Jamie Edgin, 1503 East University Boulevard, Tucson, AZ 85748, USA (e-mail: jedgin@email.arizona.edu).

evidence suggesting non-verbal learning deficits in this population, including difficulties in executive function and memory (Nadel 2003; Pennington *et al.* 2003; Rowe *et al.* 2006). For instance, in a recent study employing a large sample of individuals with DS ( $n = 74$ ), we found evidence for impairments on a battery of neuropsychological measures, including measures of set-shifting and associative memory (i.e. the Arizona Cognitive Test Battery for DS; Edgin *et al.* 2010a). Despite evidence for group deficits in these domains, there are few studies that examine the broader cognitive outcomes in children with ID exposed to a second language.

The research that has been conducted has not found any differences in language impairments in monolingual and bilingual children with DS (Kay-Raining Bird *et al.* 2005; Feltmate & Kay-Raining Bird 2008). Two case studies have been conducted addressing the effects of second language learning on the broader cognitive profile of DS. Woll & Grove (1996) examined visual memory in twins with DS bilingual in British Sign Language, and Vallar & Papagno (1993) showed enhanced working memory in a bilingual individual with DS. To our knowledge, no other studies have examined the effect of second language exposure (SLE) on neuropsychological function in this population or in any other ID. Previous studies have indicated that bilingual typically developing children sometimes show cognitive advantages, including greater working memory capacity (Bialystok 1999; Bialystok & Martin 2004; Bialystok & Shapero 2005; Bialystok 2007). Given the findings in the general population, there is a possibility that SLE could be beneficial to those with DS.

Therefore, it is important to determine if learning two languages creates a special problem in a neurodevelopmental disorder such as DS. Does exposure to two languages crowd out the resources available for developing skills in the broader cognitive profile, does it enhance neuropsychological function as sometimes found in typically developing children, or is there no effect at all (for a discussion, see Bialystok 2007; Kay-Raining Bird 2009)? Given these questions, we evaluated the effects of SLE on neuropsychological outcomes in children with DS. Past studies of SLE in this population have not examined the broader cognitive profile and have been conducted with fairly small samples

[ $n = 8$  in Kay-Raining Bird *et al.* (2005)]. The null findings of this work require replication. There is also evidence that effects of SLE are mediated by socio-economic status (Morton & Harper 2007). Therefore, in this report we present data from individuals with DS with and without SLE who were similar in socio-economic status as well as IQ, gender and age.

## Methods

### Participants

Forty-one individuals medically diagnosed with DS (trisomy 21), aged 7–18 years were recruited at the University of Arizona through local support groups and advertisement. The participants were recruited for a comprehensive neuropsychological study of DS and were not specifically recruited based on their exposure to a second language. Exclusion criteria were the presence of Robertsonian translocation, mosaicism and past head injury. Via questionnaire, parents were asked about their child's first language, whether or not they were exposed to another language in addition to English and the extent of the exposure. Thirteen parents reported frequent current exposure to another language than English (greater than 1 h per day) with the amount of reported time of the other language ranging 1–11 h per day (mean 4.80 h per day). This amount of time was significantly different from sample without SLE, for which parents reported rare exposure to another language (Table 1,  $P < 0.001$ ). Twelve families spoke Spanish in addition to English, and one family spoke Italian. Of the 13 families reporting SLE, six parents/caregivers reported that their child's first language (i.e. language of first communication) was Spanish, five reported English, and two families reported both Spanish and English. All children were able to function well enough in English to complete the assessment with English administration and attended English-speaking schools. The language exposure was predominantly from family members or caregivers who spoke another language in the home.

Table 1 shows that the monolingual ( $n = 28$ ) and SLE groups ( $n = 13$ ) were equivalent on mean age ( $P = 0.95$ ), gender ( $P = 0.25$ ), mean KBIT-II IQ ( $P = 0.69$ ) and social background factors, including

**Table 1** Participant characteristics of individuals with Down syndrome with and without second language exposure (SLE)

Measure	Monolingual <i>n</i> = 28	SLE <i>n</i> = 13	<i>F</i> / $\chi^2$	<i>P</i>
Child background factors				
Mean (SD) age in years	12.94 (3.66)	13.01 (3.16)	0.003	0.95
% Male	50.0	69.2	1.33	0.25
Mean (SD) IQ	45.53 (7.08)	44.54 (7.68)	0.17	0.69
Mean (SD) hours of second language exposure per day	0.00	4.80 (3.97)	42.13	<0.001
Family background factors				
% Income <\$25 000	12.5	4.3	0.65	0.42
Mean (SD) mother's education level in years	14.59 (2.48)	15.40 (1.90)	0.85	0.36

the percentage of families with income <\$25 000 ( $P = 0.42$ ) and mother's mean level of education ( $P = 0.36$ ). It should be noted that the matches between these groups naturally resulted from the split between these two groups, and were not constructed.

## Measures

### *The Arizona Cognitive Test Battery*

Measures included a validated battery of neuropsychological tests for use in children and adults with DS, the Arizona Cognitive Test Battery for DS (Edgin *et al.* 2010a). The majority of the measures reported here, with the exception of the Dimensional Change Card Sort task, were drawn from this battery. Edgin *et al.* (2010a) found deficits in individuals with DS in comparison with a group of typically developing mental age-matched controls on some measures of the Arizona Cognitive Test Battery, including the Behavior Rating Inventory of Executive Function (BRIEF) – School Age, CANTAB Intra-Extra Dimensional Set Shift (IED), Dots task and the CANTAB Paired-Associates Learning (PAL), with most of the measures showing medium-large effect sizes for between-group differences (i.e. Cohen's *d*). Given a total number of 41 individuals, the study had 80% power to detect medium-large effect sizes for between-group differences in ANOVA (Cohen 1992). However, tests of bilingual advantages have shown a range of effect sizes, ranging from small to large (e.g. Bialystok & Martin 2004; Bialystok & Shapero 2005), so this sample may be somewhat underpow-

ered to detect any advantages in the SLE group. All tests and procedures were approved by the Human Subjects Committee at the University of Arizona.

### *IQ and language measures*

Kaufman Brief Intelligence Test – Second Edition (KBIT-II) is a brief, individually administered measure of both verbal and non-verbal intelligence appropriate for individuals from 4 to 90 years old (Kaufman & Kaufman 2004). The KBIT-II English language measures include verbal knowledge, a vocabulary test in which children point to pictures matching words, and riddles, a test in which children respond to a question with one word.

The Scales of Independent Behavior – Revised (SIB-R) (Bruininks *et al.* 1997) is a caregiver-completed checklist-style rating scale designed to assess adaptive functioning and everyday skills. The SIB-R measures Motor, Social and Communication, Personal Living and Community Living Skills. The SIB-R includes a parent report of overall language skills, including language comprehension and expression (i.e. specific language was not specified).

### *Tests of neuropsychological function*

These tests tap domains found to be important to the cognitive profile of DS in the past literature (Pennington *et al.* 2003; Visu-Petra *et al.* 2007), including tests of prefrontal and hippocampal function. These tests and their application to DS are described in more detail elsewhere (Edgin *et al.* 2010a). Hippocampal measures included the CANTAB PAL task, a measure of spatial paired

**Table 2** Comparison of the neuropsychological outcomes of individuals with Down syndrome with and without second language exposure (SLE)

Mean (SD) measure	Monolingual <i>n</i> = 28	SLE <i>n</i> = 13	<i>F</i>	<i>P</i>	Effect size ( <i>d</i> )
Language tasks					
KBIT verbal knowledge raw score	12.64 (8.11)	11.15 (5.97)	0.35	0.56	0.21
KBIT riddles raw score	9.61 (5.04)	7.46 (4.05)	1.80	0.19	0.41
SIB-R language expression age equivalent	5.75 (3.57)	4.51 (3.86)	0.76	0.39	0.33
SIB-R language comprehension age equivalent	6.52 (1.93)	5.11 (2.69)	2.75	0.11	0.60
Prefrontal tasks					
CANTAB IED errors per stage	6.19 (5.84)	4.64 (1.76)	0.80	0.38	0.36
Modified Dots task inhibitory control phase proportion correct	0.68 (0.29)	0.58 (0.29)	1.07	0.31	0.35
Modified Dots task combined phase proportion correct	0.56 (0.21)	0.51 (0.16)	0.49	0.49	0.27
Dimensional Change Card Sort task, post-switch correct	3.70 (2.03)	3.61 (2.00)	0.02	0.90	0.04
BRIEF inhibitory control raw score	18.50 (4.38)	17.25 (5.07)	0.62	0.43	0.26
BRIEF set shifting raw score	15.71 (3.40)	16.00 (2.76)	0.07	0.80	-0.09
BRIEF working memory raw score	20.79 (4.26)	20.33 (4.33)	0.09	0.76	0.11
Hippocampal tasks					
C-g arena proportion search time in target quadrant	0.26 (0.22)	0.25 (0.15)	0.01	0.91	0.05
CANTAB PAL errors	5.63 (3.73)	5.32 (3.32)	0.07	0.80	0.09

KBIT, Kaufman Brief Intelligence Test; SIB-R, Scales of Independent Behavior – Revised; IED, Intra-Extra Dimensional Set Shift; BRIEF, Behavior Rating Inventory of Executive Function; c-g arena, computer-generated arena; PAL, Paired-Associates Learning.

associates and the computer-generated arena (c-g arena) (Thomas *et al.* 2001), a test of spatial memory and navigation. Tests of prefrontal function included the CANTAB IED task, a measure of rule and reversal learning, the Modified Dots task, a measure of inhibitory control and working memory (Davidson *et al.* 2006), the Behavior Rating Inventory of Executive Function (BRIEF) – School Age (Gioia *et al.* 2000), a widely used caregiver questionnaire of everyday skills reflective of abilities in the executive domain, and the Dimensional Change Card Sort task (Zelazo *et al.* 1996), widely used to measure executive abilities in pre-school children and found to be enhanced in typically developing bilingual children (Bialystok & Martin 2004).

## Results

Table 2 shows the relation between SLE and neuropsychological outcome. Between-group differences were assessed with ANOVA. Consistent with past findings (Kay-Raining Bird *et al.* 2005; Feltmate & Kay-Raining Bird 2008), we did not find any differences in English language skill in children

with DS and SLE. While there was a trend toward lower parent-reported language comprehension in the SLE group on the SIB-R ( $P = 0.11$ ), these results did not extend to language skills as assessed on the KBIT-II tests.

Moreover, no differences were found on any neuropsychological measure. The measured effect sizes for each difference were small. In an additional analysis examining the linear relationship between hours of language exposure per day and each neuropsychological outcome in linear regression, there were no significant effects of exposure level ( $P > 0.15$  for each outcome). Therefore, in this sample of individuals with DS with and without SLE, there were no measurable differences in cognitive outcome across this battery.

## Discussion

The present study examined the effects of SLE on the profile of neuropsychological function in children with DS. Second language exposure was substantial: over 4 h per day on average. The study examined the effects of SLE on performance on a

validated battery of neuropsychological tests (i.e. the Arizona Cognitive Test Battery). The SLE and monolingual groups had equivalent IQ, age, gender and socio-economic status. There were no significant differences between the groups on any measure, and measured effect sizes on the neuropsychological measures were consistently small. While the current study could have been underpowered to detect the small effects for bilingual advantages found in the past literature, power was significant to detect any disadvantages from SLE of a medium-large effect size.

These findings have clinical and educational implications for individuals with DS and their families. Often, it is suggested that children with DS should be limited to learning one language. However, our results, in combination with the findings of Kay-Raining Bird *et al.* (2005) and Kay-Raining Bird (2009), suggest that there are no differences in important cognitive outcomes between children exposed to a significant amount of another language versus those who are raised in monolingual households. Given the absence of any detectable costs associated with SLE, the social benefits of learning to communicate with all members of the family and community may be well worth the effort to expose children with DS to a second language.

However, this study is somewhat limited by the measures employed. While we have included some measures of verbal and linguistic intelligence, a full battery of language measures was not used and we do not have data regarding competence in each language specifically. Furthermore, while it is clearly important to examine the impact of SLE on memory and executive function, additional skills could be affected. Past reports have suggested that metalinguistic skills (i.e. verbal working memory or phonological processing) may be enhanced by SLE (Kay-Raining Bird 2009). Future work should explore the effects of SLE on verbal short-term memory in DS, a cognitive deficit affecting cognitive development across domains (Edgin *et al.* 2010b).

Despite these limitations, the current study's findings are consistent with other work suggesting no significant effect of SLE in children with DS. Given the cognitive profile of DS, which involves significant cognitive difficulties shared with other

neurodevelopmental disorders, these findings may be applicable to other intellectual disabilities. However, more research is required before we can be certain that SLE will be an appropriate course of action in each individual child. Buckley (2002) suggests monitoring the language progress of each child with SLE as individual differences are likely. However, the present study expands on past research to provide some evidence that SLE does not cause any greater problems to the broader cognitive profile of those with DS on average, including important areas of neuropsychological function.

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### References

- Bialystok E. (1999) Cognitive complexity and attentional control in the bilingual mind. *Child Development* **70**, 636–44.
- Bialystok E. (2007) Acquisition of literacy in bilingual children: a framework for research. *Language Learning* **57**, 45–77.
- Bialystok E. & Martin M. M. (2004) Attention and inhibition in bilingual children: evidence from the Dimensional Change Card Sort task. *Developmental Science* **7**, 325–39.
- Bialystok E. & Shapero D. (2005) Ambiguous benefits: the effect of bilingualism on reversing ambiguous figures. *Developmental Science* **8**, 595–604.
- Bruininks R. K., Woodcock R. W., Weatherman R. F. & Hill B. K. (1997) *Scales of Independent Behavior – Revised (SIB-R)*. The Riverside Publishing Company, Itasca, IL.
- Buckley S. (2002) Can children with Down syndrome learn more than one language? *Down Syndrome News and Update* **2**, 100–2.
- Chapman R. S. (1995) Language development in children and adolescents with Down syndrome. In: *The Hand-*

- book of *Child Language* (eds P. Fletcher & B. MacWhinney), pp. 641–63. Blackwell, Oxford.
- Cohen J. (1992) A power primer. *Psychological Bulletin* **112**, 155–9.
- Davidson M. C., Amso D., Anderson L. C. & Diamond A. (2006) Development of cognitive control and executive functions from 4 to 13 years: evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia* **44**, 2037–78.
- Edgin J. O., Mason G., Allman M., Capone G., DeLeon I., Maslen C. *et al.* (2010a) Development and validation of the Arizona Cognitive Test Battery for Down syndrome. *Journal of Neurodevelopmental Disorders* **2**, 149–64.
- Edgin J. O., Pennington B. F. & Mervis C. B. (2010b) Neuropsychological components of intellectual disability: the role of immediate, working and associative memory. *Journal of Intellectual Disability Research* **54**, 406–17.
- Feltmate K. & Kay-Raining Bird E. (2008) Language learning in four bilingual children with Down syndrome: a detailed analysis of vocabulary and morphosyntax. *Canadian Journal of Speech-Language Pathology and Audiology* **32**, 6–20.
- Gioia G. A., Isquith P. K., Guy S. C. & Kenworthy L. (2000) *Behavior Rating Inventory of Executive Function*. Psychological Assessment Resources, Odessa, FL.
- Kaufman A. S. & Kaufman N. L. (2004) *Kaufmann Brief Intelligence Test – Second Edition*. AGS Publishing, Circle Pines, MN.
- Kay-Raining Bird E. (2009) Bilingualism in children with Down syndrome. *Perspectives on Language Learning and Education* **16**, 90–6.
- Kay-Raining Bird E., Cleave P., Trudeau N., Thordardottir E., Sutton A. & Thorpe A. (2005) The language abilities of bilingual children with Down syndrome. *American Journal of Speech-Language Pathology* **14**, 187–99.
- Miller J. F. (1992) Lexical development in young children with Down syndrome. In: *Processes in Language Acquisition and Disorder* (ed. R. S. Chapman), pp. 202–16. Mosby, St. Louis, MO.
- Morton J. B. & Harper S. N. (2007) What did Simon say? Revisiting the bilingual advantage. *Developmental Science* **10**, 719–26.
- Nadel L. (2003) Down's syndrome: a genetic disorder in biobehavioral perspective. *Genes Brain and Behavior* **2**, 156–66.
- Pennington B. F., Moon J., Edgin J., Stedron J. & Nadel L. (2003) The neuropsychology of Down syndrome: evidence of hippocampal dysfunction. *Child Development* **74**, 75–93.
- Roberts J. E., Price J. & Malkin C. (2007) Language and communication development in Down syndrome. *Mental Retardation and Developmental Disabilities Research Reviews* **13**, 26–35.
- Rowe J., Lavender A. & Turk V. (2006) Cognitive executive function in Down's syndrome. *British Journal of Clinical Psychology* **45**, 5–17.
- Thomas K. G. F., Hsu M., Laurance H. E., Nadel L. & Jacobs W. W. (2001) Place learning in virtual space III: investigation of spatial navigation training procedures and their application to fMRI and clinical neuropsychology. *Behavioral Research Methods, Instruments & Computers* **33**, 21.
- Vallar G. & Papagno C. (1993) Preserved vocabulary acquisition in Down's syndrome. The role of phonological short-term memory. *Cortex* **14**, 89–101.
- Visu-Petra L., Benga O., Tincas I. & Miclea M. (2007) Visual-spatial processing in children and adolescents with Down's syndrome: a computerized assessment of memory skills. *Journal of Intellectual Disability Research* **51**, 942–52.
- Woll B. & Grove N. (1996) On language deficits and modality in children with Down syndrome: a case study of twins bilingual in BSL and English. *Journal of Deaf Studies and Deaf Education* **1**, 271–8.
- Zelazo P. D., Frye D. & Rapus T. (1996) An age-related dissociation between knowing rules and using them. *Cognitive Development* **11**, 37–63.

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