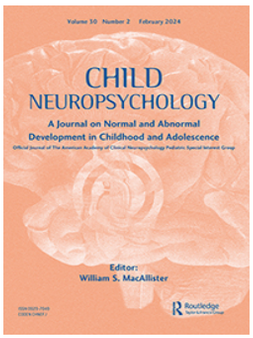

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Child Neuropsychology

A Journal on Normal and Abnormal Development in Childhood and Adolescence

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/ncny20

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To cite this article: Rebecca Ward & Eirini Sanoudaki (03 Nov 2023): Predicting language outcomes in bilingual children with Down syndrome, Child Neuropsychology, DOI: 10.1080/09297049.2023.2275331

To link to this article: https://doi.org/10.1080/09297049.2023.2275331

Published online: 03 Nov 2023.

CHILD NEUROPSYCHOLOGY
https://doi.org/10.1080/09297049.2023.2275331

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Predicting language outcomes in bilingual children with Down syndrome

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ABSTRACT

Continuous approaches to measuring bilingualism have recently emerged as a means of understanding individual variation in language abilities. To date, limited information is available to assist in understanding the language abilities of bilingual children with Down syndrome (DS), who are specifically known to have a large variation in linguistic outcomes. Group studies in this population report that children exposed to two languages do not differ from their monolingual counterparts after considering age and non-verbal cognitive abilities, although no study to date has examined the relationship between the amount of exposure to one language and the linguistic abilities in the other language within this population. This study sought to identify whether exposure to an additional language, specifically Welsh, predicted linguistic abilities in the majority language, in this case, English. Sixty-five children between the ages of 5;5–16;9 who had varied linguistic experiences completed a range of cognitive and linguistic assessments. Results from hierarchical regression analyses show that the amount of exposure to Welsh had no impact on language abilities in English, after controlling for non-verbal cognitive abilities, short-term memory and socioeconomic status. This demonstrates that exposure to an additional language does not have a negative impact on language development, a finding that has important clinical and educational implications.

ARTICLE HISTORY
Received 26 May 2023
Accepted 19 October 2023

KEYWORDS
Down syndrome; bilingual; language acquisition; developmental disability; language disorders

The impact of exposure to more than one language on linguistic outcomes is highly variable due to the heterogeneous nature of bilingual experiences. These experiences not only vary from individual to individual but are also dynamic and changeable during an individual's lifespan. Conceptualizing bilingual experiences has consequently posed a substantial challenge to researchers, although current measures often consider the degree of exposure to each language as being a key factor in language outcomes (Gathercole & Thomas, 2009; Hammer et al., 2012; Thordardottir, 2019), particularly when considering children in dual-language learning environments. Although several well-designed and validated tools exist that aim to determine what contributes to an

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individual's bilingual status (such as the Quantifying Bilingual Experiences Questionnaire and the Language Experience and Proficiency Questionnaire; De Cat et al., 2022; Marian et al., 2007), methodological challenges exist due to the indirect measures that are needed to quantify or determine bilingual experiences. As Kremin and Byers-Heinlein (2021) note, the requirement of multiple measures which include a number of factors, in itself, suggests that researchers are evidently aware of the multi-dimensional nature of bilingualism. Furthermore, comparing and contrasting the findings of studies in the field can be onerous due to the diversity of samples and the varying approaches in defining what constitutes as bilingual.

As a result of viewing bilingualism as a complex interplay of various factors, recent research has redefined and reconceptualized the notion of this concept. Previously, a bilingual speaker was defined as an individual with complete native-like control of both of their languages, or being perfectly balanced in each language (Lambert et al., 1959). Although this view has been challenged and refined in more recent studies, traditionally researchers have employed categorical research designs which aim to compare groups, most often bilinguals and monolinguals, on specific aspects of linguistic or cognitive development. With quantity of language exposure being considered as a key factor in accounting for variation in performance, alongside various other factors such as the age and order of acquisition and the quality of parent-child interactions (Bylund et al., 2019; Siller & Sigman, 2002), more recent approaches to researching bilingualism have instead proposed that viewing bilingualism on a continuum as a continuous variable may be more appropriate (Kremin & Byers-Heinlein, 2021; Marian & Hayakawa, 2021). In doing so, researchers can evaluate the impact that numerous factors have on language outcomes, which may also help to explain individual variation in linguistic outcomes and identify subtle differences between individuals or populations.

One population in which this approach might be particularly beneficial is when researching children with a higher degree of variability in language outcomes, such as autistic children (Kjelgaard & Tager-Flusberg, 2001) or even more notably children with Down syndrome (DS), with individual differences being described as a "hallmark of Down syndrome" (Feltmate & Kay-Raining Bird, 2008, p. 16). DS is the most common chromosomal disability which is reported to occur in around one in every 700–1000 live births (Morris & Alberman, 2009; Parker et al., 2010), and frequently results in cognitive and linguistic challenges, notably difficulties with the development of phonology (Martin et al., 2009; Roberts et al., 2007) and expressive morphosyntax (Andreou & Katsarou, 2013; Ypsilanti & Grouios, 2008). Relative strengths include semantic, pragmatic (Martin et al., 2009) and social development with some individuals with DS having a tendency to have fairly strong skills in engaging with others and orienting attention (Fidler, 2005).

Developmental disabilities and bilingualism

As children with developmental disorders such as DS often have delays and difficulties with several aspects of language, some have expressed concerns about how these children would acquire two (or more) languages. The developmental trajectory for children with DS is not only delayed, but some aspects may be more challenging than others, alongside the aforementioned and well-documented variability in cognitive and linguistic abilities (Feltmate & Kay-Raining Bird, 2008; Tsao & Kindelberger, 2009). Although group design

research studies to date provide concurring evidence that bilingualism does not exacerbate these delays and difficulties compared to monolingual control groups (Drysdale et al., 2015; Kay-Raining Bird et al., 2005, Ward & Sanoudaki, 2021a; Zhou et al., 2019), clinicians' advice to parents may not align with the current evidence base. For example, studies have reported that parents have been advised to limit their language input to a single language to avoid confusion (Howard et al., 2020; Kay-Raining Bird et al., 2012; Ware et al., 2015). In some circumstances, parents have even been directed toward the view that the use of more than one language in the home may even have caused, or contributed toward their child's language difficulties with one professional stating that a child 'has these problems because he hears so many different languages' (Jegatheesan, 2011, p. 195).

Not only are these views unsupported by current evidence, but they may inadvertently have a negative impact on children's language outcomes. As Drysdale et al. (2015) proposed, the use of a non-native language in the home may be less successful if parents lack fluency in that language and are not as proficient in modeling the language appropriately. Moreover, bilingualism is often a natural and necessary feature of some families and societies. Thus the proposal that parents should abandon or reduce the use of a native language in the home, may not be practical (Yu, 2016). In contrast, when parents interact with their children using their native language, research suggests that they are better able to convey emotions, resulting in increased engagement and potentially more meaningful interactions (Wharton et al., 2000). This is clearly an area of growing clinical importance and some recent policies reflect this approach, however, de Valenzuela et al. (2016) notes that "practice does not always follow policy."

Researchers investigating the impact of bilingualism on language development in children with DS specifically report that bilingual children exhibit similar language profiles as monolingual children with DS when appropriate matching paradigms are employed (i.e., considering non-verbal IQ and age; Kay-Raining Bird et al., 2005; Ward & Sanoudaki, 2021b). Earlier case studies also demonstrate that children with DS are capable of acquiring more than one language, including spoken and signed languages (Vallar & Papagno, 1993; Woll & Grove, 1996). However, when it comes to children with developmental disabilities such as DS, quantifying bilingualism might be even more difficult as standardized assessments are often inappropriate for bilingual children and it may be difficult to account for bilingual experiences in considering proficiency in each language. Faced with these challenges, a more appropriate approach to evaluating the impact of bilingualism on linguistic outcomes may be to consider exposure to an additional language as a continuous variable. As a result, children's language abilities in their additional language can then be examined in relation to the age of first bilingual exposure (AoE) and degree of exposure (i.e., the frequency and duration of exposure) to that language.

Accounting for variability in language outcomes

When it comes to understanding the individual differences on children's language abilities, Paradis (2023) notes that that are a number of variables internal and external to the child themselves that are important to consider. For typically developing (TD) children, studies suggest that relative exposure to each language predicts linguistic

abilities in that language, particularly in the case of minority languages (Gathercole & Thomas, 2009; Hoff et al., 2012; Thordardottir, 2011). Although some individuals may have concerns that minority language exposure would negatively affect children's abilities in the majority language, studies with TD populations report that this is not the case and that the use of a home language that differs from the majority language has little impact on language outcomes in the majority language (Cattani et al., 2014; De Cat, 2020; Papastergiou & Sanoudaki, 2021).

In addition, Thordardottir (2019) investigated how variation in the quantity of language input and the AoE to each language impacted language outcomes. Findings from this study demonstrated that differences between simultaneous (children acquiring two languages from birth) and sequential (children acquiring one language prior to the introduction of a second) bilinguals were mediated by variations observed in the amount of exposure that children received in each language. This relationship was not found for the timing of exposure, suggesting that quantity of exposure, not the age of exposure, has more of an impact on language outcomes in TD children. However, in a recent review by Paradis (2023), it was highlighted that the relationship between AoE and language development is more complex. Here it was suggested that older bilingual children acquiring a language may be afforded faster initial gains in development. In other words, children who have a higher AoE often display language gains more quickly than children with a lower AoE. Additionally, Paradis (2011) noted that child internal factors overall (such as language aptitude and cognitive maturity) explain more variance in language outcomes.

Similarly, Bohman et al. (2010) investigated the factors that influence language outcomes in Spanish-English bilinguals. The authors report that performance in both the L1 (first language) and L2 (second language) were explained by variations in language input and output, socioeconomic status and age. As a result, this study also suggests that the amount of exposure to both the L1 and L2 are influential in explaining variation in language abilities, particularly during the early stages of language acquisition.

Far fewer studies have investigated the impact of bilingual exposure in children with varying developmental trajectories (Gonzalez-Barrero & Nadig, 2018; Hambly & Fombonne, 2014), a population in which these apprehensions may be even greater. One such study that has been conducted in this area specifically explored vocabulary sizes and morphological abilities in autistic children and found that current language exposure accounted for a similar degree of variability as it did for TD children (49–62% of the variance; Gonzalez-Barrero & Nadig, 2018).

For children with DS specifically, a parent-report study suggested that there was a relationship between vocabulary size and mental age as well as a relationship between exposure to a second language and language outcomes in that language (Trudeau et al., 2011). No relationship was found for exposure to a second language (French) and expressive or receptive language outcomes in the first language (English). Interestingly, in Kay-Raining Bird et al. (2005) group study of bilingual children with DS, a series of follow up correlations were conducted which suggested that the duration of exposure to a second language was not significantly related to first language abilities in children with DS. The authors caution that the lack of variability seen in the amount and duration of exposure to a second language in the bilingual children may explain this finding as the bilingual children may have received "adequate" exposure in their second language, such

that the amount of exposure was no longer related to performance in the second language.

Finally, a preliminary study of twelve children (four of whom had DS and were considered bilingual), involved the examination of individual differences in linguistic outcomes (Feltmate & Kay-Raining Bird, 2008). The authors reported that measures of current language input were related to the variability in each of the languages, in this case English and French (i.e., children with more exposure to French performed higher on the French language assessments). Due to the very small sample size, no statistical comparisons were made, and so caution is needed in interpreting these findings. As a result, very limited research is available concerning the relationship between exposure to a minority language with linguistic abilities in the majority language in children with DS. The aim of the current study will therefore be to expand current understanding of the role of language input and the AoE on language outcomes in children with DS. This study will take a novel approach by using continuous measures of language exposure to investigate any relationship with language outcomes.

Concurrently, utilizing continuous measures in quantifying bilingual experiences is arguably more suitable for linguistic contexts where two languages are frequently used alongside each other. The UK is an increasingly multilingual country, but Wales more specifically has two official languages, meaning that the whole population has some degree of exposure to an additional language, albeit limited for some individuals. Welsh is considered a minority language as only around 19% of the population speak the language fluently according to the latest self-report census (Office for National Statistics, 2011). English is the majority language and is widely spoken in most communities. For educational settings, over a quarter of schools in Wales are Welsh-medium (26.4%) with Welsh being the primary language of instruction. A further 5.4% provide bilingual instruction, and an additional 2.1% have a dual-stream option meaning that parents are able to opt for Welsh-medium or English-medium education (Welsh Government, 2020). Welsh-medium schools are available across the country and children from all backgrounds (i.e., homes with English, Welsh or another home language) are able to access Welsh-medium provisions. As a result, Wales provides a natural bilingual platform, though the degree of exposure to each language is highly variable dependent on geographical, cultural and individual factors. Resultingly, this linguistic setting provides an opportune environment for evaluating the role of language input on linguistic variability.

Additional predictors of language variation

Several further factors need to be considered when estimating linguistic variability and will be controlled for in the current study. Firstly, non-verbal cognitive abilities (NVCA) have been described as being "intertwined" with language outcomes in TD children and children with "idiopathic intellectual disabilities" (Slušná et al., 2021, p. 2). Furthermore, NVCA has also been found to predict language gains in young autistic children who had limited productive vocabulary (Ellis Weismer & Kover, 2015), though similar studies report a more complex interaction between NVCA and language in autistic children (Stevens et al., 2000). As children with DS are known to have a lower NVCA compared to

TD children, along with a high degree of variability (Tsao & Kindelberger, 2009), individual differences in this domain need to be taken into account.

A second predictor which relates to language variability is parental socioeconomic status (SES). Although conflicting findings have emerged as to how SES might impact language abilities, it has been suggested that SES impacts both the quality and quantity of language input that children receive, resulting in reduced language skills (Paradis, 2023). More specifically, vocabulary development in particular seems to be impacted by lower parental SES, for both monolingual and bilingual TD children (Biemiller & Slonim, 2001; Pungello et al., 2009).

This also seems to be the case for children with DS, with studies suggesting that elevated language abilities are found in children from higher SES backgrounds (Arango et al., 2018). The final variable that will be controlled for in the present study which is reported to be associated with language development is phonological short-term memory (STM). This has been strongly linked to several aspects of linguistic abilities, including sentence comprehension (Willis & Gathercole, 2001) and phonological awareness, which in turn also has a mediating effect on word reading skills (Knoop van Campen et al., 2018). These three key predictors will therefore be controlled for in the present study.

Study aims and research questions

The quantity and breadth of research investigating bilingualism in diverse populations, including those with developmental disabilities, has increased in recent years, although to date it is still unclear whether the degree of exposure to an additional or minority language specially impacts language outcomes in the majority language. In the case of children with DS, very limited information is available with regards to the variability that exists in language outcomes and what the role of language input and the AoE has on language outcomes within a bilingual context. Generally, research consistently reports that exposure to one language predicts language proficiency in that language (Hurtado et al., 2014), including for children with neurodevelopmental conditions such as autism (Gonzalez-Barrero & Nadig, 2018), however, less research has focused on whether the quantity of exposure to a minority language is directly related to proficiency in the majority language.

The primary aim of this study is to identify whether there is a relationship between exposure to a minority language (in this case Welsh) and language proficiency in the majority language (in this case English). More specifically, we aim to observe whether the degree of current exposure and the AoE to Welsh predicts English language skills after controlling for a number of factors identified earlier, that are known to influence language development. The research questions that will be addressed are:

(1) Does the percentage of current exposure to a minority language (Welsh) predict language proficiency in the majority language (English) for TD children and children with DS after controlling for NVCA, STM & SES?
(2) What impact does the AoE to a minority language (Welsh) have on language proficiency in the majority language (English) for TD children and children with DS after controlling for NVCA, STM & SES?

Methods

For this study, both children with a diagnosis of DS and TD children were recruited. Within these two populations, children were recruited from a variety of linguistic backgrounds including those with substantial Welsh-language input such as those attending Welsh-medium schools, alongside children with predominantly English-language exposure attending English-medium schools. As participants were recruited from Wales, the majority of children received at least a small degree of exposure to Welsh, with Welsh-medium lessons being a statutory requirement for all public schools in Wales, and with Welsh being fairly widely used within the public domain (e.g., such as bilingual television and radio programs). As a result, the aim was to include a sample of children with diverse language experiences and a varied degree of exposure to both English and Welsh (see participants section below). Full ethical approval for the study was received from the University departmental ethical review board.

Participants

A total of 77 children were recruited for the study. The inclusion criteria stipulated that children with DS should be between five and 16 years of age at the time of data collection, with the TD children being between three and seven years of age. This meant that the TD children would be of a similar developmental age to the children with DS. As children with a dual diagnosis of both DS and ASD often display a differing linguistic and cognitive profile to children with DS, four bilingual children with both DS and ASD were excluded from the subsequent analysis but are reported on separately in Ward & Sanoudaki (2021a). One participant was removed due to being trilingual, with another removed due to being bilingual in languages other than English and Welsh. A further six participants were removed as they did not complete all of the assessments, which left a final sample of 65 children (see Table 1).

The final sample included 25 participants with DS, who were between 5;5–16;9 (mean = 9;6, *SD* = 2.98) and there were 40 TD participants who were between 2;11 and 7;10 (mean = 4;3, *SD* = 1.34). No significant between-group difference was observed between TD children and children with DS for gender ($p = .60$) or parental SES ($p = .34$). Parental

Table 1. Group characteristics of TD participants, participants with DS and the between-group comparison.

	Down Syndrome	Typically Developing	Group Comparison (*p* value)	Combined Sample
Age in months *	114.60 (35.67)	5.98 (16.13)	<.001*	75.45 (4.11)
Gender (% Male)	36.00	42.50	.609	40.00
SES	10.64 (2.12)	11.24 (2.46)	.335	1.98 (2.32)
Non-verbal cognitive ability	10.36 (5.68)	11.73 (5.23)	.326	11.20 (5.40)
Current Welsh exposure (%)	18.92 (25.41)	28.50 (26.12)	.165	24.44 (26.04)
Lifetime Welshexposure (%)	21.28 (28.22)	24.54 (23.42)	.628	23.19 (25.34)
Age of exposure (months)	7.64 (15.44)	5.00 (1.23)	.552	5.83 (11.94)

Mean scores are reported with standard deviations in parenthesis. Non-verbal cognitive ability represent raw scores on the non-verbal matrices subtest of the KBIT-II (Kaufman & Kaufman, 2004). Socioeconomic status (SES) was obtained via parent report in terms of parental education and occupation (scale from 2–14). *Indicates a between-group effect with $p < .05$.

SES was calculated as a composite score of parental occupation and education level by combining Likert scale scores regarding parental occupation and education obtained from the parental background questionnaire (see below). None of the TD children displayed any evidence of an intellectual disability, according to their performance on the cognitive measure (defined as a Z-score within ± 2). Parents of the TD children also confirmed that their child did not have any known or suspected language impairment or developmental disorder.

Of the parents/guardians of children with DS, none specified that their child had mosaic or translocation DS subtypes and children were included if they had no more than mild hearing loss as determined by parental report. This would subsequently be representative of children with DS who frequently have mild or corrected hearing loss. As the design of the study included TD children at the same developmental age as the children with DS, the TD children were younger than the children with DS ($p < .001$). There was no significant difference between the TD children and the children with DS on their non-verbal cognitive ability ($p = .33$). Most of the children with DS were attending mainstream schools ($n = 19$, 76%), with a further three (12%) attending a special educational needs school. One was placed within a specialist unit in a mainstream school (4%), and two were attending both a special educational needs and a mainstream school on different days (8%). All TD children were attending mainstream schools or nurseries.

In terms of language exposure, as aforementioned, English is the majority community language in Wales, meaning that all children received substantial input in English regardless of home language or the language of schooling. At the same time, the majority of children received at least a small degree of exposure to Welsh, with Welsh-medium lessons being a statutory requirement for all public schools in Wales. The amount of current exposure to Welsh for the TD children varied from 0%-90%. Five children with DS had a statement of educational need (an official legal document that outlines the child's needs and how the education authority will meet these needs within educational settings), which stipulated that they were exempt from this legal requirement to have Welsh language lessons, with parental reports indicating that their child received no exposure to Welsh. Of all participants with DS, current exposure to Welsh ranged from 0% to 90%. Forty-nine percent of participants (10 DS, 22 TD) were attending Welsh-medium or bilingual schools/nurseries, and 35.4% (8 DS, 15 TD) received Welsh language input in at least one other setting (e.g., spoken at home by at least one parent).

The AoE to a second language varied from birth to 48 months. The vast majority of parents who reported that their children had received input in both Welsh and English stated that they had been exposed to both languages from the outset (71.4%). For the children with DS, of the parents who reported that their children were exposed to both languages, 72.7% were exposed from birth. Similarly, 70.8% of typically developing children received input in both languages from birth.

Materials and procedure

Two organizations who support children with DS and learning difficulties disseminated information about the research project in order to recruit participants with DS. Typically developing children were recruited by contacting local Welsh and English-medium schools and nurseries. Parents or caregivers were provided with an information leaflet,

consent form and background questionnaire to complete (see below). Once informed consent was received, children were assessed in either their homes, schools, or a combination of both, depending on the suitability of these environments. A series of one-to-one sessions were conducted by the first author on the cognitive and linguistic measures described below, with the number of sessions varying according to the age and needs of each child. Assessments were completed in the same pre-defined order. Only the language of testing was used during each respective session, with the Welsh language assessments taking place on a different day to the English language assessments. Children were also administered a Welsh receptive vocabulary assessment and phonological awareness assessments in English and Welsh, but these are not reported on further here as they are not relevant for the present study (see Ward & Sanoudaki, 2021b). All data was stored securely in line with general data protection regulations as both hard copies and electronically. Participants were assigned a unique ID number so that the data was anonymous from the point of data collection.

Background questionnaire

Parents or guardians were asked to complete a background questionnaire, which was provided in their language of choice (Welsh/English or both) and completed either before or during one-to-one testing sessions with the children. The first section of the questionnaire aimed to gather essential demographic information about their child (i.e., age, hearing status etc.). This included two questions to gather information about parental socioeconomic status (SES) which included parents' highest level of education and occupation. These scales were combined to create a single composite measure of SES. The next section related to the child's language background and experiences, which included parental report of the percentage of time their child was currently exposed to each language, the percentage of lifetime exposure to each language and the percentage of time that the child responded in each language. Although direct observations of children's language environment are believed to provide the most accurate representation of their exposure, parental reports are widely used in the literature and considered to be an accurate estimate of children's linguistic exposure (Byers-Heinlein et al., 2020). Further information regarding home language use, AoE to each language, the consistency of exposure and any gaps in exposure was obtained, as well as a parent report of their child's receptive and expressive language abilities. Measures of current language exposure and AoE used for the subsequent analyses were calculated based on parent-report estimations provided in the background questionnaire.

Cognitive measures

In order to assess phonological short-term memory (STM), a forward digit span measure was used with an increasing length of digits from two upwards. After piloting, a reverse digit span was deemed too difficult for the children under study, resulting in the decision to employ a forward digit span measure. Previous research has deemed STM as being fundamental to language outcomes (Baddeley, 2003), particularly phonological working memory in the case of children with DS (Baddeley & Jarrold, 2007; Witecy & Penke, 2017). Two trials of each digit length were presented until the participant was no longer able to recall either sequence within a trial. Prior to the assessment, the children were asked to count to 10 to ensure that they recognized and could say all the digits and served

as a warm-up to the task. A measure of non-verbal cognitive ability was administered to ascertain the cognitive development level of each participant. The Kaufman's Brief Intelligence Test (KBIT-II; Kaufman & Kaufman, 2004) was utilized for this purpose as it is a short, standardized assessment with a non-verbal matrices subtest, suitable for the target populations. Furthermore, the KBIT-II has a high level of internal consistency with a coefficient of .93 across all ages and a coefficient of .88 for the nonverbal subtest specifically.

Expressive and receptive language measures

Parent-report instruments can be effective in measuring language production, however, they may not be as reliable in assessing language comprehension (Feldman et al., 2005; Tomasello & Mervis, 1994), may be less reliable for those from lower SES (Feldman et al., 2000) and are also unable to evaluate children's abilities in everyday contexts (e.g., within sentences). As a result, a standardized assessment was used to assess expressive, receptive language abilities in English, the Clinical Evaluation of Language Fundamentals – Preschool Version (CELF-P, Second Edition; Wiig et al., 2006). This is a clinical diagnostic tool that is specifically designed and standardized for children between 3–7 years old. The core eight subtests were administered: Concepts and Following Directions, Word Structure, Expressive Vocabulary, Recalling Sentences, Sentence Structure, Basic Concepts, Recalling Sentences in Context, Word Classes. The CELF-P provides three main outcome measures: Core, Receptive and Expressive Language, which are calculated by combining scores on various sub-tests. Core language is calculated by combining sentence structure, word structure and expressive vocabulary subtests. Receptive language is comprised of sentence structure, concepts and following directions, and basic concepts subtests. The word structure, expressive vocabulary and recalling sentences subtests are combined to calculate expressive language. Note that there is some overlap in the subtests which comprise of each language area. As a result, receptive and expressive language components are the focus of the subsequent analyses. Performance did not indicate a ceiling effect for expressive or receptive language skills. The internal consistency across all ages is within acceptable standards of between .79 and .97. Internal consistency is also high for children from clinical groups such as autistic children, children with hearing disorders and language disorders (alpha coefficients between .87 and .97). As children with DS have developmental ages that do not correspond to their chronological age, instead the children with DS in the study had developmental ages within the range specified for the CELF-P (3–7). Raw scores were converted to z-scores which were used in the subsequent analyses due to the lack of standardized scores available for children outside of this age range.

Data analysis

As mentioned above, standardized scores from the measures used were not appropriate, as the participants were outside of the age range for the assessments. Instead, raw scores were converted to Z scores for all of the English language measures. This also enabled comparisons between participants with DS and TD participants, as well as comparison between the different components of language being assessed here: receptive, expressive language.

A two-step hierarchical linear regression was conducted using the enter method to identify whether exposure to Welsh predicted English language abilities, whilst considering the influence of the covariates specified earlier which have been identified as influencing language abilities: NVCA, STM and SES. These are expected to have an impact on language abilities but are not the focus of this research, and so were included in the first step of the model. Exposure to Welsh was entered in the second step. Statistical analyses were conducted using JASP and SPSS.

Results

For a summary of the descriptive statistics for both TD and DS groups on the linguistic and cognitive measures described above, see Table 2.

In order to satisfy multicollinearity assumptions, the percentage of current and lifetime exposure could not both be entered into the regression model as these were highly correlated (r = 0.86, $p < .001$). Preliminary analyses suggested that both the percentage of current and lifetime exposure to Welsh explained a similar degree of variability in English language outcomes. As current language exposure to Welsh ($r = 0.32$) was slightly more predictive of language abilities compared to lifetime exposure ($r = 0.28$), current language exposure to Welsh was used in subsequent analyses. This aligns with previous research which has also shown that current exposure is more predictive of language outcomes than lifetime exposure (Cohen, 2016; Hambly & Fombonne, 2014). There were no outliers, residuals were normally distributed, and inspection of the residuals indicated that the residuals were homoscedastic.

Does the percentage of current exposure to a minority language (Welsh) predict language proficiency in the majority language (English) for TD children and children with DS after controlling for NVCA, STM & SES?

To answer to our first research question, we investigated whether current exposure to Welsh predicted the variance in English receptive language abilities for TD participants after controlling for NVCA, STM and SES (see Figure 1). Results from the first step of this model which included the control variables was significant $F(3, 27) = 16.563$, $p < .001$, $R^2 = 0.65$, R^2 Adjusted = 0.61, ƒ2 = 1.56. This suggested that NVCA, STM and SES explained a significant amount of variation (61%) in participants' English receptive language. The

Table 2. Descriptive statistics for linguistic and cognitive measures for both TD participants and the participants with DS.

	Down Syndrome	Typically Developing
Core Language	35.88 (17.74)	46.6 (17.62)
Receptive Language*	30.68 (12.34)	39.71 (13.86)
Expressive Language**	32.48 (19.95)	51.22 (22.15)
Short-Term Memory	2.88 (0.83)	3.25 (.71)

Mean raw scores for each of the measures are presented with SD in parenthesis. Measures for Core, Receptive and Expressive language were obtained using the Clinical Evaluation of Language Fundamentals – Preschool Edition II (Wiig et al., 2006). Measures of non-verbal cognitive ability are represented by raw scores on the non-verbal matrices subtest of the KBIT-II (Kaufman & Kaufman, 2004). Short-term memory is reported as digit span. *Missing data for two children. ** Missing data for four children.

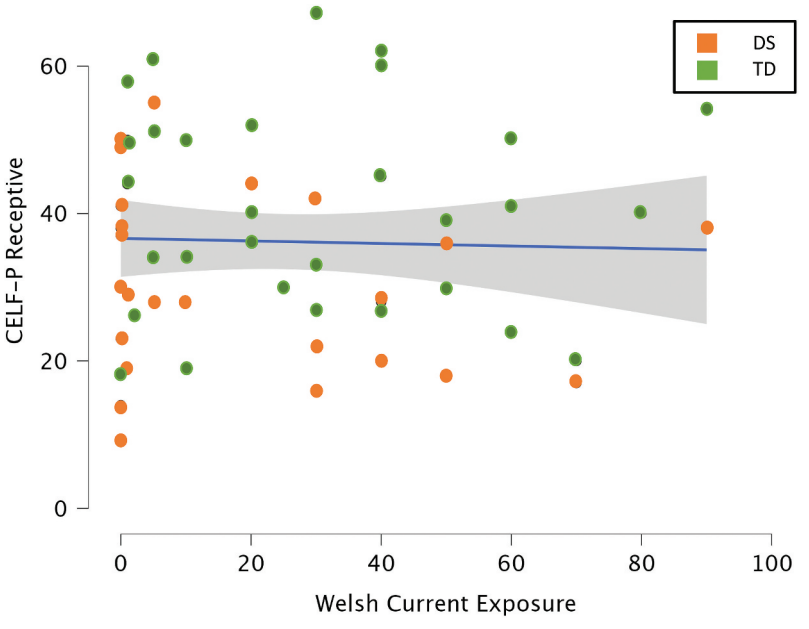

Figure 1. Relationship between current exposure to Welsh and receptive language abilities in English as measured by the CELF-P for children with DS (Down syndrome) and TD (typical development).

addition of the predictor variable (Welsh current exposure) from block 2 did not significantly improve the model F change (1, 26) = 0.237, $p = .630$, R^2 Change = 0.003, R^2 Adjusted = 0.60, ƒ2 = 1.50, which suggests that the amount of exposure to Welsh did not have an impact on receptive skills in English and did not improve the prediction. The results from this model are presented in Table 3, which indicate that NVCA had the largest influence on English receptive language abilities, followed by STM.

The same finding was observed for the children with DS, where the first step of the model accounted for a significant amount of variation in English receptive language abilities F(3, 21) = 32.697, $p < .001$, $R^2 = 0.82$ R^2 Adjusted = 0.79, ƒ2 = 3.76. The addition of current Welsh exposure in step 2 again did not improve the prediction change (1, 20) = 0.147, $p = .706$, R^2 Change = 0.001, R^2 Adjusted = 0.79, ƒ2 = 3.76. This suggests that there was no relationship between current exposure to Welsh and receptive language abilities in English for children with DS or TD participants. For the participants with DS,

Table 3. Regression results for the impact of percentage of current exposure on English receptive language abilities.

	DS Group			TD Group		
Variable	Standardized β	t	p	Standardized β	t	*p*
NVCA	0.364	3.100	.006	0.716	5.071	<.001
SES	0.036	0.359	.723	0.043	0.371	.713
STM	0.634	5.217	<.001	0.147	1.043	.306
Current Welsh exposure	−0.037	−0.383	.706	−0.057	−0.487	.630

STM was the strongest predictor of English receptive language abilities, whereas for the TD participants NVCA was the strongest predictor.

A second regression model was run to answer the first research question, this time to identify whether current exposure to Welsh predicted the variance in English expressive language abilities (see Figure 2). For the TD group, the first step of this model was significant F(3, 25) = 39.160, $p < .001$, $R^2 = 0.83$, R^2 Adjusted = 0.80, ƒ2 = 4.00, suggesting that NVCA, STM and SES, accounted for a significant amount of variation in participants' English expressive language abilities. In block 2, the addition of the predictor variables (Welsh current exposure) did not significantly improve the model, F change (1, 24) = 2.453, $p = .130$, R^2 Change = 0.016, R^2 Adjusted = 0.814, ƒ2 = 4.26. The results for this regression model are presented in Table 4. These findings show that NVCA had the largest influence on English expressive language abilities.

To explore whether this relationship between English expressive language abilities and current Welsh language exposure was the same for children with DS, a further regression model was conducted. The first step of this model was significant F(3, 21 = 6.912, $p = .002$, $R^2 = 0.50$, R^2 Adjusted = 0.43, ƒ2 = 0.75. The addition of Welsh current exposure as a predictor in step 2 did not improve the prediction, again suggesting that there was no relationship between current exposure to Welsh and English expressive language abilities

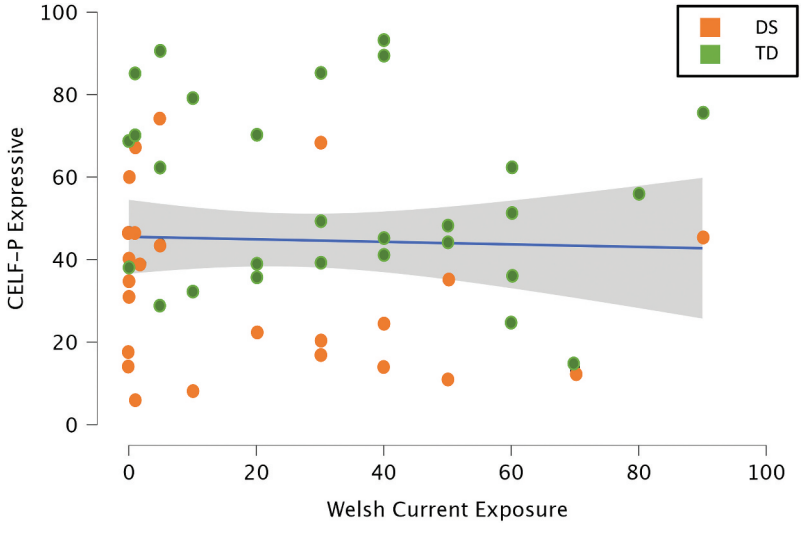

Figure 2. Relationship between current exposure to Welsh and expressive language abilities in English as measured by the CELF-P for children with DS (Down syndrome) and TD (typical development).

Table 4. Regression results for the impact of percentage of current exposure on English expressive language abilities.

	DS Group			TD Group		
Variable	Standardized β	t	p	Standardized β	t	*p*
NVCA	0.288	1.454	.161	0.744	7.185	<.001
SES	0.145	0.868	.368	0.090	1.061	.299
STM	0.446	2.175	.042	0.254	2.465	.021
Current Welsh exposure	−0.067	−0.417	.681	−0.128	−1.566	.130

(F change (1, 20) = 0.174, $p = .681$, R^2 Change = 0.004, R^2 Adjusted = 0.401, ƒ2 = 0.67). For the participants with DS, STM was the strongest predictor of English expressive language (see Tables 3 and 4).

Does the AoE to a minority language (Welsh) predict expressive and receptive language proficiency in the majority language (English) for TD children and children with DS after controlling for NVCA, STM & SES?

To investigate whether the AoE to Welsh specifically impacted children's linguistic abilities in English, a regression model was undertaken to explore this in relation to receptive language abilities in English specifically, again after controlling for NVCA, STM and SES. The aim of this analysis was to identify whether the relationship between AoE to Welsh and English receptive language abilities mirrored that of TD children and children with DS, and as a result, this regression model was split by DS status. For the TD group, the first block of this model with the control variables was significant F(3, 19) = 12.257, $p < .001$, $R^2 = 0.66$, R^2 Adjusted = 0.61, ƒ2 = 1.56. Within this model, only NVCA significantly contributed to this mode, suggesting that only NVCA explained the variation in English receptive language abilities. Block two which included the AoE to Welsh did not significantly improve this model F change (1, 18) = 0.006, $p = .941$, R^2 Change = 0.00, R^2 Adjusted = 0.58, ƒ2 = 1.38, suggesting that AoE to Welsh was not related to English receptive language skills (see Table 5).

Similar findings were found for expressive language abilities for the TD group where the first block with the control variables was significant F(3, 17) = 31.98, $p < .001$, $R^2 = 0.92$, R^2 Adjusted = 0.82, ƒ2 = 4.56. The addition of the AoE to Welsh as an additional variable in block two did not significantly improve this model F change (1, 16) = 0.350, $p = .562$, R^2 Change = 0.003, R^2 Adjusted = 0.82, ƒ2 = 4.56 (see Table 6). This showed that AoE to Welsh was not related to English receptive language skills for TD participants.

A further analysis was conducted to see if this relationship was the same for the DS group. For receptive language, the first block of this model with the control variables was significant F(3, 7) = 28.533, $p < .001$, $R^2 = 0.92$, R^2 Adjusted = 0.89, ƒ2 = 8.09. Adding AoE

Table 5. Regression results for the impact of age of exposure on English receptive language abilities.

	DS Group			TD Group		
Variable	Standardized β	t	p	Standardized β	t	*p*
NVCA	0.668	3.512	.013	0.559	3.015	.007
SES	0.175	0.890	.408	−0.019	−0.136	.893
STM	0.350	1.738	.133	0.325	1.784	.091
Welsh age of exposure	0.221	1.250	.258	0.011	0.075	.941

Table 6. Regression results for the impact of age of exposure on English expressive language abilities.

	DS Group			TD Group		
Variable	Standardized β	t	p	Standardized β	t	*p*
NVCA	0.486	1.095	.315	0.686	5.291	<.001
SES	0.028	0.061	.954	0.149	1.552.	.140
STM	0.282	0.599	.571	0.280	2.197	.043
Welsh age of exposure	0.365	0.886	.410	0.058	0.592	.562

to Welsh into the model did not improve the prediction, F change (1, 6) = 1.562, $p = .258$, R^2 Change = 0.016, R^2 Adjusted = 0.90, ƒ2 = 9.00. This showed that AoE to Welsh was not related to English receptive language skills for those with DS. Finally, an analysis was conducted in relation to AoE to Welsh and expressive language abilities. The first block of this model with the control variables was not significant (though note the p value indicated that this was approaching significance) F(3, 7) = 3.977, $p = .06$, $R^2 = 0.63$, R^2 Adjusted = 0.47, ƒ2 = 0.89. The AoE to Welsh did not improve the model for those with DS, F change (1, 6) = 0.785, $p = .410$, R^2 Change = 0.043, R^2 Adjusted = 0.46, ƒ2 = 0.85. This showed that AoE to Welsh was not related to English receptive language skills for participants with DS either.

Discussion

The focus of this study was to explore the extent to which variation among children in their exposure to a minority language predicts language abilities in the majority language, after controlling for several variables which have been associated with linguistic abilities. More specifically, the study aimed to identify if there was a relationship between the degree of current exposure and AoE to Welsh on the one hand and receptive and expressive language abilities in English on the other hand for both TD children and children with DS. In answering the first research question, the results demonstrate that the current amount of exposure to Welsh did not have an impact on receptive or expressive language abilities in English, after controlling for STM, SES and NVCA. No significant relationship was observed between the degree of current exposure to Welsh and performance on the combined sub-components of the CELF-P.

These findings coincide with prior literature that reports that the use of a home language which differs from the majority language does not have a negative impact on language outcomes (Cattani et al., 2014; De Cat, 2020; López & Tashakkori, 2004). For many of the children in the present study, using Welsh at home did not appear to impact development of the majority language (English). Although the linguistic situation in Wales is fairly unique with the availability of immersive Welsh-medium education, findings from previous studies with children who have English as an additional language seem to also be transferable to this context. For example, studies report that children attending bilingual educational programs do not have any additional difficulties in developing English language skills or English literacy skills, when this language is the majority language (López & Tashakkori, 2004). This view is also supported by the conclusion proposed by Poarch and Bialystok (2017, p. 187) that "not only is there ample evidence for the cognitive benefits of bilingualism, but also is there no indication that the acquisition of the majority language is jeopardized through maintaining a home language."

In comparing the TD participants and the participants with DS, findings demonstrate that there was no evidence to suggest that increased exposure to Welsh had any impact on English language abilities for TD children, and more importantly, increased exposure to Welsh had no impact on English language abilities for children with DS in this study either. These findings substantiate earlier parent-report findings by Trudeau et al. (2011) as well as an earlier study by Kay-Raining Bird et al. (2005) who reported that the rate or

duration of exposure to a second language did not negatively impact vocabulary sizes in the first language.

These findings also support the results of studies which report that the amount of current language exposure account for a similar degree of variability in language outcomes for autistic children as it does in TD children (Gonzalez-Barrero & Nadig, 2018). These findings also substantiate the preliminary findings reported by Hambly and Fombonne (2014), who suggested that current input in each language was related to the variability in each language in four bilingual children with DS, although their study did not report the relationship between the impact of exposure of one language on language outcomes in the alternative language.

Our final research question aimed to identify whether the AoE to Welsh had any impact on the participants' linguistic abilities in English. Results suggest that the AoE to Welsh had no bearing for participants' English receptive or expressive language abilities. These findings were found for the TD participants, as well as the participants with DS. To date, no other study has examined the impact of AoE to an additional language in bilingual children with DS. These findings coincide with recent findings for TD children reported by Thordardottir (2019) who also reported that performance on language measures was not related to the AoE to a second language, although Thordardottir did report that the amount of input was more strongly related to language abilities. Similarly, Bedore et al. (2012) also reported that current language exposure was more closely associated with variation in language outcomes compared to AoE in Spanish-English bilinguals.

These findings have important implications as they suggest that the use of an additional language or the AoE to an additional language, specifically a language that differs to the majority community language, does not negatively impact language outcomes. Using a continuous measure, these findings suggest that the amount of exposure to an additional language has no bearing on key abilities in the majority language. These results extend previous group-design studies which report that children with DS who are categorized as being bilingual do not have any additional difficulties compared to monolinguals with DS (Kay-Raining Bird et al., 2005; Ward & Sanoudaki, 2021b). There are several clinical applications of these findings, for example in relation to advice provided to parents or caregivers regarding bilingualism. In line with previous studies, the findings of the present research suggest that parents of children with developmental disabilities from bilingual backgrounds, or those who desire that their child be raised bilingually should not be discouraged from doing so. As this study did not find that the degree or AoE to Welsh was related to language abilities in English for children with DS, parents or caregivers should not be encouraged to discontinue or even reduce input to an additional language. An intervention study with this population has found that children receiving a narrative intervention in both of their languages leads to gains in both languages as well as cross-language transfer effects (Gorman et al., 2021). This suggests that speech and language therapy delivery would also benefit from implementing an approach which includes both languages.

In the present study, three control variables were used to help account for the variation in language outcomes in English, which were NVCA, SES and STM. Including these factors as control variables resulted in being able to account for a large degree variability in English language abilities for both children with DS and TD children (accounting for

up to 67% of the variance). Therefore, these variables appear to be important in influencing language development in these populations, although SES did not contribute to any these models. This suggests that the role of SES in these circumstances is limited, or at least when compared to the influence of NVCA and STM. Interestingly, for the participants with DS, STM was the strongest predictor of English expressive and receptive language abilities, whereas for TD participants NVCA was the strongest predictor in each model. Although NVCA did significantly predict language outcomes in English for the participants with DS (with the exception of expressive language), this suggests that the role of STM is more influential for children with DS. This finding is also supported by previous studies that have investigated language outcomes in monolinguals (Abbeduto et al., 2003) and bilinguals with DS (Kay-Raining Bird et al., 2005). This suggests that the mechanisms underpinning language development may differ for children with DS compared to TD children, and a focus on developing STM abilities in children with DS may be successful in enhancing linguistic abilities also.

Strengths and limitations

There are several strengths of this research to highlight. Firstly, the participant recruitment employed a very stringent approach to ensuring that participants had a wide range of linguistic experiences. This meant that, although there is a relatively small sample size, the sample was fairly representative of the diverse populations that exist in Wales, and within bilingual settings more generally. In addition, the approach to data collection was comprehensive and several measures were used to collect data on cognitive and linguistic abilities. Although this resulted in a small number of participants being excluded as they did not complete enough assessments, this provided a thorough understanding of the participants language abilities and non-verbal cognitive ability, enhancing the validity of the findings.

There are however several limitations that are also important to note. With regards to the population size, as noted above there was a fairly small sample size in the current study, and this is particularly true when conducting analyses on the different populations here (children with DS and TD children). Although this sample was fairly limited in size, this is one of the largest studies of bilingual children with DS to date and challenges exist in recruiting very specialist populations. Nevertheless, further studies with larger sample sizes in future are needed to substantiate these findings. In considering the sample of the present study, participants were exposed to English and Welsh specifically. Therefore, caution is warranted in applying these findings to different contexts, especially contexts where the additional language may not receive as much support as Welsh and English do in Wales (i.e., official language status, Welsh-medium immersion nurseries, governmental policies, and legislation). Future research should endeavor to conduct research in diverse linguistic contexts to identify whether these findings are transferable to different circumstances.

Finally, one further limitation to consider is that conceptualizing bilingualism and attempting to ascertain the degree of exposure that children have to each language is a challenging task. Due to the ages and developmental abilities of the children in the current study, it was necessary to obtain this information via the parental-report questionnaire. As a result, the accuracy of this information may be limited as some parents

may underestimate exposure to a language, whereas others may overestimate this factor. To further strengthen these findings, a composite score consisting of a number of bilingual experiences (e.g., from both parents and teachers) may be more appropriate when using continuous approaches to bilingualism in future studies. Nevertheless, studies utilizing parent-report methods are widely used and accepted (Byers-Heinlein et al., 2020).

Conclusion

Challenges arise in conceptualizing bilingual experiences, with more recent approaches opting for continuous measures of bilingualism such as the degree of exposure to each language. This approach may help our understanding of individual variability in linguistic outcomes and may be particularly useful in heterogeneous populations, such as children with DS who display a large degree of variability in language and cognitive profiles. This study is the first to date to use continuous measures of bilingual experience to ascertain whether the amount and AoE to a minority language (Welsh) impacted majority language (English) proficiency in children with DS. In summary, findings demonstrate that the amount of current exposure and the age of first exposure to Welsh did not have an impact on receptive or expressive language abilities in English, after controlling for NVCA, STM and SES. Importantly, this relationship was found not only for TD children, but children with DS also. The implications arising from these findings mean that exposure to an additional language (no matter how large or small), does not seem to impact the development of a majority language. In practice, this means that clinicians should adopt an evidence-based approach when advising parents and making decisions around language use in the home, community and clinic, and that educational provisions should be inclusive when it comes to bilingual opportunities.

Acknowledgments

The authors are very grateful to the funders of this research, the ESRC Wales-DTP studentship (grant number 1790820) secured by the second author in collaboration with the UK Down's Syndrome Association and awarded to the first author. We are very thankful to all the children, schools and families that participated in this project. We are very grateful to the UK Down's Syndrome Association for collaborating and promoting this research with their networks.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The work was supported by the Economic and Social Research Council [1790820].

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Data availability statement

The study materials which include information about the study, the consent form, and the questionnaires are provided in the supplementary materials and are available on the OSF (https://osf.io/kywgf/). The analysis code is also available on the OSF (https://osf.io/aj93m). As the data relates to a very specialist population, the data relating to this study is not publicly available to ensure participants' anonymity and privacy.

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