Love is . . . an abstract word: the influence of phonological and semantic factors on verbal short-term memory in Williams syndrome

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LOVE IS… AN ABSTRACT WORD: THE INFLUENCE OF LEXICAL SEMANTICS ON VERBAL SHORT-TERM MEMORY IN WILLIAMS SYNDROME

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Abstract

It has been claimed that verbal short-term memory in Williams syndrome is characterised by an over-use of phonological coding alongside a reduced contribution of lexical semantics. We critically examine this hypothesis and present results from a memory span task comparing performance on concrete and abstract words, together with a replication of a span task using phonologically similar and phonologically dissimilar words. Fourteen participants with Williams syndrome were individually matched to two groups of typically developing children. The first control group was matched on digit span and the second on vocabulary level. Significant effects were found for both the semantic and the phonological variables in the WS group as well as in the control groups, with no interaction between experimental variable and group in either experiment. The results demonstrate that, despite claims to the contrary, children and adults with WS are able to access and make use of lexical semantics in a verbal short-term memory task in a manner comparable to typically developing individuals.

Key words: Williams syndrome, short-term memory, language acquisition, phonology, semantics

Introduction

Williams syndrome (WS) is a rare genetic disorder resulting from a micro deletion on one copy of chromosome 7q11.23 (Ewart et al., 1993; Frangiskakis et al., 1996; Tassabehji et al., 1996; for up-to-date review, see Donnai and Karmiloff-Smith, 2002). It is characterised by specific physical anomalies including facial dysmorphology, and renal and cardiovascular anomalies. Abnormalities are also found in brain volume (Jernigan et al., 1993), brain structure (Galaburda et al., 1994) and brain biochemistry (Rae et al., 1998).

Williams syndrome is typically characterised by an uneven cognitive profile: despite low IQs (predominantly in the 50-65 range), language and face-processing capacities have been shown to be relative strengths while more serious deficits are found in visuo-spatial cognition, number, problem-solving and planning (Arnold et al., 1985; Udwin and Dennis, 1995; Bellugi et al., 1990). The surprising linguistic fluency of individuals with WS led initially to claims that language in WS is ‘selectively preserved’ (Bellugi et al., 1988). However, more recent studies have suggested that the WS language system is not only delayed but follows an atypical developmental pathway that impacts on all facets of language (Karmiloff-Smith, 1998; Karmiloff-Smith et al., 2003; Singer-Harris et al., 1997; Thomas and Karmiloff-Smith, 2003).

The present paper focuses on one particular aspect of the WS cognitive profile, verbal short-term memory. Verbal short-term memory has been considered a relative strength in WS and has been shown to be at the level of mental age (Udwin and Yule, 1990) or even higher than mental age (Mervis et al., 1999). In contrast, spatial short-term memory is severely impaired. Wang and Bellugi (1994) compared short-term memory in individuals with Williams syndrome and DS and found that while the WS group performed better than the DS group on a verbal short-term memory task, the Down syndrome group outperformed the WS group on a test of visual-spatial memory. Jarrold et al. (1999) extended these findings by demonstrating that this pattern holds even when differences in verbal and non-verbal skills are taken into account.

Vicari et al. (1996a) further examined the dissociation between verbal and visuo-spatial memory by considering both short- and long-term memory processing. As in previous studies, they found that when compared to typically developing controls, individuals with Williams syndrome had comparable verbal memory spans and significantly lower spatial memory. However, this pattern was not replicated in long-term memory, where verbal and spatial memory were both impaired. On the basis of these findings, Vicari et al. (1996a) argue for a further dissociation in WS memory, between normally developing verbal short-term memory and deficient long-term memory.

Other studies have considered possible patterns of strength and weakness in individuals with Williams syndrome within verbal short-term memory itself. Barisinikov et al. (1996) reported the single case study of CS, a patient with WS. On tasks of verbal short-term memory, CS displayed good phonological encoding and showed a phonological similarity effect (phonologically similar words were harder to remember than phonologically dissimilar words) and word length effect (a greater number of short words were recalled compared to long words) comparable to a group of controls matched on chronological age. Similar results were found by Vicari et al. (1996b) who compared a group of individuals with WS to a control group matched on non-verbal mental age. Vicari et al. (1996b) administered a word span task in which word length, phonological similarity and frequency were varied. As in the Barisinikov et al. (1996) study the participants with WS showed similarity and length effects similar to the typically developing controls. However, while control participants remembered more high frequency than low frequency words, this effect of frequency was reduced in the WS group. The authors interpreted these results as demonstrating a reduced contribution of lexical-semantic knowledge to short-term memory in WS. They argue that the reduced frequency effect in WS might be the result of a rigid use of a phonological encoding strategy for both high and low frequency words and propose that people with WS might be "hyper-phonological". The authors relate this pattern of results to WS linguistic abilities where there is some evidence for a pattern of well-preserved phonology coupled with impairments in lexical-semantics and syntax (Capirci et al., 1996; Pezzini et al., 1999; Karmiloff-Smith et al., 1997).

While the above study provides some evidence for a reduced contribution of lexical-semantic knowledge to word span in William syndrome, the evidence is limited in a number of important ways. Firstly, it is possible that the reduced frequency effect in WS memory span may have been a product of the particular control group used. In the Vicari et al. (1996b) study the WS group were broadly matched to typically developing controls on a general mental age measure, the Leiter Intelligence Performance Scales (Leiter, 1979). Given the discrepancy between verbal and non-verbal skills in WS, matching on overall mental age usually means that the WS group have better verbal and vocabulary skills that the control group (see for example Temple et al., 2002). It is therefore likely that the WS participants are not only older than the control group (and therefore have had exposure to many more low frequency words) but also have larger vocabularies. Given that the frequency measures in the Vicari et al. (1996b) study are based on young children, it may have been that the WS group were simply more familiar with the low frequency words than the control group. This fact may account for the reduced frequency effect in WS.

Indeed, when more appropriate control groups are used, normal frequency effects are found to affect performance on memory and language tasks in WS populations. Brock et al. (2002) examined the effects of frequency in WS on a probed serial recall task. Fourteen children with WS were compared to a group of typically developing children matched on level of vocabulary to a group of individuals with moderate learning difficulties matched on chronological age and vocabulary level. They found that all three groups recalled high frequency words better than low frequency words but, contrary to the findings of Vicari et al. (1996b), there was no evidence of a reduced frequency effect in the WS group.

A second problem with the Vicari et al. (1996b) study concerns the interpretation of the smaller frequency effect in WS as evidence of a reduced contribution of lexical-semantic knowledge to verbal short-term memory. Frequency has been shown to have a robust effect on memory span, with high-frequency words being recalled more easily than low-frequency words (Hulme et al., 1997). Hulme et al. (1995) argue that the effect of frequency provides evidence for a top-down influence of long-term memory on short-term memory task performance. In their model this is explained in terms of redintegration. Redintegration is a process whereby partially degraded memory traces can be 'cleaned up' or reconstructed at retrieval by matching them to representations of words held in long-term memory. According to this account, the influence of frequency comes primarily from the differential effectiveness of the phonological representations of high and low frequency words in long-term memory for 'cleaning up' the decaying phonological traces in short-term memory. A reduced word frequency effect in WS memory span, as found by Vicari et al. (1996b), would therefore indicate a reduced influence of lexical phonology rather than a reduced influence of lexical-semantic factors on WS verbal short-term memory.

A better variable with which to consider the possibility of a reduced lexical-semantic contribution in WS verbal short-term memory might be concreteness. Concreteness refers to the extent to which a word has a tangible referent. So, for example, *house* and *train* are considered to be highly concrete, whereas words such as *conscience* and *love* are abstract. Effects of concreteness on processing have been demonstrated in lexical decision tasks (James, 1975), naming (Strain et al., 1995) and sentence comprehension (Schwanenflugel and Shoben, 1983). There is also some evidence for differences in the processing of concrete and abstract items at the neurological level (Breedin et al., 1994; Weiss and Rappelsberger, 1996). Concrete words are thought to be 'richer' in terms of the number of features that define them (Plaut and Shallice, 1993) as well as in terms of the number of correlations between features (McRae et al., 1997).

This ‘richness’ may explain concreteness effects in short-term memory. Recent studies have demonstrated that both normal children (Nation et al., 1999) and adults (Walker and Hulme, 1999) recall concrete words more easily than abstract words. Like the effects of frequency, the effects of concreteness are redintegrative and thought to occur at retrieval in short-term memory tasks. Walker and Hulme (1999) argue that just as temporary phonological traces are compared with permanent phonological representations, temporary semantic traces are compared with permanent semantic representations. It is easier to match degraded *concrete* word traces to stored semantic representations than it is to match degraded *abstract* word traces to stored semantic representations. This is because the concrete word representations contain more unique information than do abstract representations. Concreteness is therefore an ideal variable with which to investigate the possibility of a reduced contribution of lexical-semantic knowledge to WS short-term memory.

The interpretation of Vicari et al.’s (1996b) findings as evidence for a reduced contribution from lexical-semantics in WS verbal short-term memory is problematic given the methodological concerns raised above. However, given that there is some evidence for semantic impairments in WS, the possibility of a reduced contribution from lexical-semantic knowledge in verbal short-term memory remains. Further, it is important because it may be symptomatic of an atypical semantic system in individuals with WS. A number of studies have suggested that, in spite of their often good vocabularies, individuals with WS do have abnormal lexical semantics. Several authors have proposed anomalous lexical processing in individuals with WS (Rossen et al., 1996; Temple et al., 2002). Temple et al. (2002) have also suggested that semantic networks may be more loosely organised in WS. However, others have argued that the underlying structure of the WS lexicon is normal. Tyler et al. (1997) demonstrated in WS the same taxonomic/category and thematic/functional priming effects as normal controls, but suggested that individuals with WS may still nonetheless have difficulties with integrating lexical knowledge with syntactic processing during on-line processing. In a speeded naming study, Thomas et al. (2002) found the same effects of frequency and semantic category in both WS and verbal-mental age controls. They noted, though, that lexical access may be slow and that semantic representations may sometimes be relatively shallow.

There is also evidence that language acquisition in WS follows an atypical path and is less constrained by semantics than in normal development. Stevens and Karmiloff-Smith (1997) showed that while children and adults with WS observe the fast mapping and mutual exclusivity constraints when learning new words, they were less constrained by the whole object or taxonomic constraints. A study by Mervis and Bertrand (1997) indicated that the usual co-occurrence of the onset of the vocabulary spurt and spontaneous exhaustive sorting (which is thought to appear when the child has acquired the insight that all objects belong to the same category, Gopnik and Melzoff, 1987) failed to emerge in their sample of toddlers with WS. Instead, the WS toddlers showed an unusual pattern: a vocabulary spurt prior to demonstrating spontaneous exhaustive sorting. It is also the case that while typically developing children begin to point referentially before producing referential labels, children with WS began naming before they either understood or produced referential pointing gestures (Mervis and Bertrand, 1997; Laing et al., 2002). Finally, Grant et al. (1997), reporting results from a study of nonword repetition, argue that vocabulary acquisition in WS adults retains a phonologically- based approach characteristic of normal four-year olds. Taken together, these findings suggest that during the word learning of individuals with WS phonology may be operating in the context of a less mature semantic system.

The present study investigates two aspects of verbal short-term memory in WS; semantic redintegration and the phonological input store. The role of lexical-semantic information and extent of semantic redintegration in memory processes is measured by the strength of the concreteness effect (Walker and Hulme, 1999) and this was examined in our first experiment. If, as Vicari et al. (1996b) suggested, there really is a reduced contribution from lexical-semantic knowledge to short-term memory in WS, we would expect to see a reduced concreteness effect in the WS group relative to typically developing control groups. However, if the organization of the WS lexicon is normal, as suggested by Tyler et al. (1997) and Thomas et al. (2002), we expect participants with WS to be as susceptible to the effect of concreteness on memory span as typical controls. The functioning of the phonological input store is measured by the strength of the phonological similarity effect (Vallar and Papagno, 2002). If the phonological input store is functioning relatively normally in WS as suggested by Vicari et al. (1996b) we would expect to replicate their finding of a phonological similarity effect on verbal short-term memory in this population. The second experiment aimed therefore to establish whether the findings of Vicari et al. regarding the effects of phonological similarity could be replicated in a different WS sample and a different language.

It was not a specific aim of the present study to examine differences in rehearsal processes in WS which we believe to be conceptually distinct to the main issues of our investigation, namely phonological storage and semantic redintegration.

Nevertheless, a measure of speech rate for the items to be remembered was included in order to check for the possible effect of speech rate as a confound across conditions. In the model of verbal short-term memory developed by Baddeley and Hitch (1974), speech rate is considered to be a measure of how quickly words can be rehearsed in the articulatory loop. The more items people can rehearse, the more they can remember. Although the hypothesis of covert rehearsal as a causal mechanism in verbal short-term memory is controversial (Cowan et al.,1994; Hulme et al., 1999), given the strong association between speech rate and performance in short-term memory tasks (Hulme et al., 1984) we wanted to ensure that any differences in the recall of words could not be accounted for by variations in speech rate.

Memory span performance in individuals with WS was compared to that of two different control groups. The first control group was individually matched to the WS group on the basis of vocabulary level. This enabled us to determine whether or not individuals with WS would be less influenced by semantic knowledge in a memory span task than those with similar semantic skills (at least in terms of comparable word knowledge). The second control group was matched on the basis of digit span. The use of this group enabled us to consider whether any group differences in effect size were due to differences in overall memory ability.

METHOD

Participants

Fourteen participants with WS, seven males and seven females, took part in the study. The participants were recruited through the Williams Syndrome Foundation, the UK support group for parents. All 14 participants had received a full clinical diagnosis of Williams syndrome and of these, 11 had the diagnosis confirmed genetically (genetic analyses for the remaining 3 were not available). The mean chronological age of the WS group was 21,7 (range 10,11 – 52,1). The participants had a mean General Cognitive Ability Score (GCA) of 47.6 (SD = 9.8, range 39-73). The GCA is an IQ equivalent score as assessed by the British Ability Scales II (BAS) (Elliott et al., 1996). Vocabulary knowledge was initially assessed for all participants by the British Picture Vocabulary Scale II (BPVS) (Dunn et al., 1997). Three individuals, whose age equivalent scores were at or near to ceiling, were later reassessed on the Peabody Picture Vocabulary Scale - Revised (PPVT) (Dunn and Dunn, 1981). Verbal short-term memory was measured using the BAS Recall of Digits Forward (Elliott et al., 1996).

Two comparison groups of typically developing participants were recruited for the study. In the digit span group, 13 children and one adult were individually matched to the participants with WS on the basis of gender and raw score on the BAS II Recall of Digits Forward subtest. The children in the digit span group were from primary schools in East Sussex and Hertfordshire. Participants in the vocabulary group were individually matched to the WS group on the basis of gender and BPVS or PPVT age equivalent score. The children in this group were from primary schools in London and Hertfordshire and a secondary school in Coventry.

Participant details are summarised in Table I.

Materials

Participants took part in two experiments. Experiment 1 compared memory span for concrete and abstract words. Experiment 2 compared memory span for phonologically similar and phonologically dissimilar words. For Experiment 1, two word lists were devised: a list of 8 concrete words (*key, lamp, brush, field, snake, girl, path, door*) and a list of 8 abstract words (*style, joke, wrong, age, fun, love, taste, help*). The word lists were matched for familiarity and frequency. For Experiment 2, two further word lists were devised: a list of 8 phonologically similar words (*bag, hat, rat, cap, tap, map, van, sad*) and 8 phonologically dissimilar words (*coat, leg, thief, fence, lamp, sack, fish, brave*). These lists were matched for frequency, familiarity and concreteness. The Kucera and Francis frequency values were taken from the Oxford Psycholinguistic Database (Quinlan, 1992). The familiarity and concreteness values were obtained by asking a group of adults, all of whom were professionals working with children, to rate a number of words. Seventeen people rated the words for concreteness. Concreteness was defined as the

TABLE I

Chronological ages (CA), BPVS/PPVT age equivalent scores and BAS Recall of Digits Forward raw scores

Group	Mean CA (range)	Mean (SD) BPVS/PPVT age equivalent scores	Mean (SD) BAS Recall of Digits Forward raw scores
WS	21.7 (10.11-52.1)	11.2 (6.9)	18.57 (4.07)
Digit span match	9.2 (5.1-40.5)	8.11 (7.4)	18.86 (4.52)
Vocabulary match	10.9 (6.1-40.5)	11.1 (6.9)	21.50 (6.56)

extent to which words referred to tangible objects, materials or persons. Raters were asked to judge the extent to which they felt a word to be concrete on a scale of 1 (very abstract) to 7 (highly concrete). Fifteen adults rated words for familiarity. They were asked to rate words on a scale of 1-5 for the extent to which they felt an average 5 year-old child would have heard a word and would know its meaning. The reliability of these ratings was high (for concreteness μ = .97 and for familiarity μ = .90). The words used and their frequency, familiarity and concreteness values are shown in Appendices 1 and 2.

For each of the conditions, four lists were created at each list length - from two to eight items – by sampling at random without replacement.

Procedure

The participants with WS were seen individually in a single session at the Neurocognitive Development Unit, Institute of Child Health, in London. Testing lasted approximately two hours, and breaks were given as needed. The children in the control group were seen at school and tested individually in a quiet area outside their classroom. Due to the practical difficulty of seeing school children for one long session, testing was broken up into a number of shorter sessions.

Before taking part in the span tasks, all participants were asked to repeat a list of all the words across both experiments in order to ensure that they were able to hear the words correctly. All participants repeated the list correctly. The order of presentation of Experiments 1 and 2 was counterbalanced across participants. Further, within each experiment the order of presentation of word conditions (concrete vs. abstract words and phonologically similar vs. dissimilar items) was counterbalanced.

To measure memory span for the word lists in each of the experiments, participants were presented with lists beginning with sequences of two items and then increasing in length until errors were made. There were four lists at each length. Initially two lists were presented at each length and, if both were repeated correctly, the list length was increased by one. Once an error was made, an additional two lists were presented at that and every subsequent length. When all lists at a certain level were repeated incorrectly, no further lists were given. The lists were read to the subjects at a rate of one item per second in an even monotone, dropping the voice slightly on the last item. After hearing each list, participants were asked to repeat the list in the correct order.

Memory span was calculated as the maximum list length at which the participant recalled both lists correctly, plus 0.25 for every subsequent correct list. This scoring method was used by Hulme et al. (1991) who found it to be a more sensitive measure than alternatives which take span as the longest list length repeated without error. This degree of sensitivity is particularly important when investigating the verbal memory of very young children and of individuals with learning disability, and ensures that there are no floor effects to limit the analysis of results.

After each word span task a measure of speech rate was recorded. Participants were asked to say each word ten times, as quickly but as carefully as possible. The time taken for the participants to repeat each word ten times was averaged and converted into a mean speech rate in words per second for each of the word conditions.

Results

The span scores obtained in each of the conditions of the two experiments are shown in Figures 1 and 2.

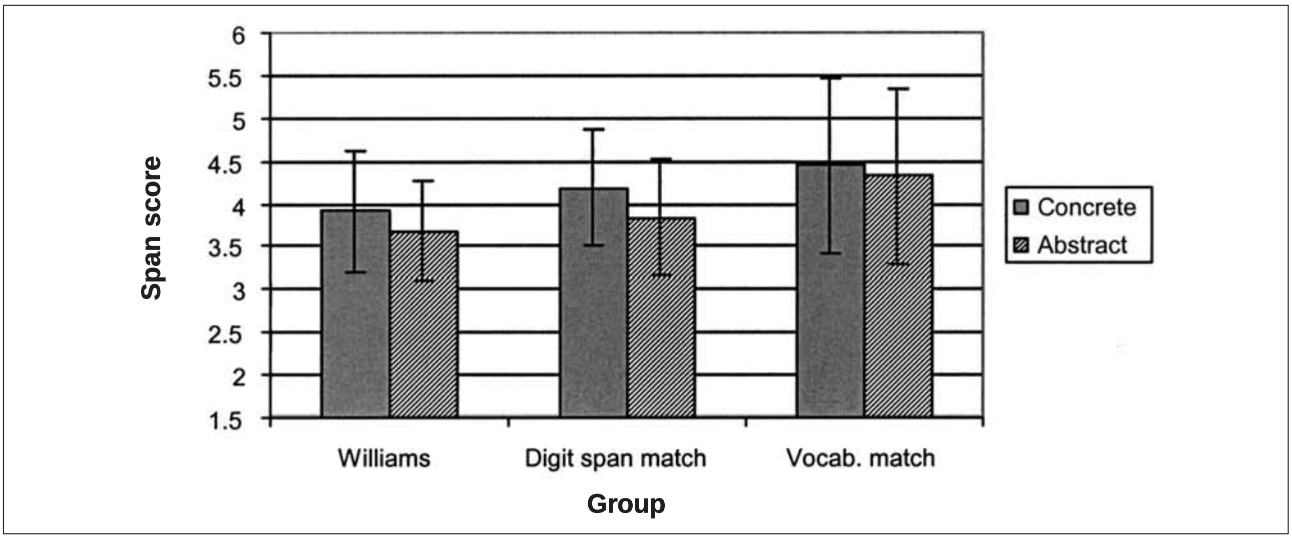

Fig. 1 - *Memory span scores (means and standard deviations) for concrete and abstract words for the WS and control groups.*

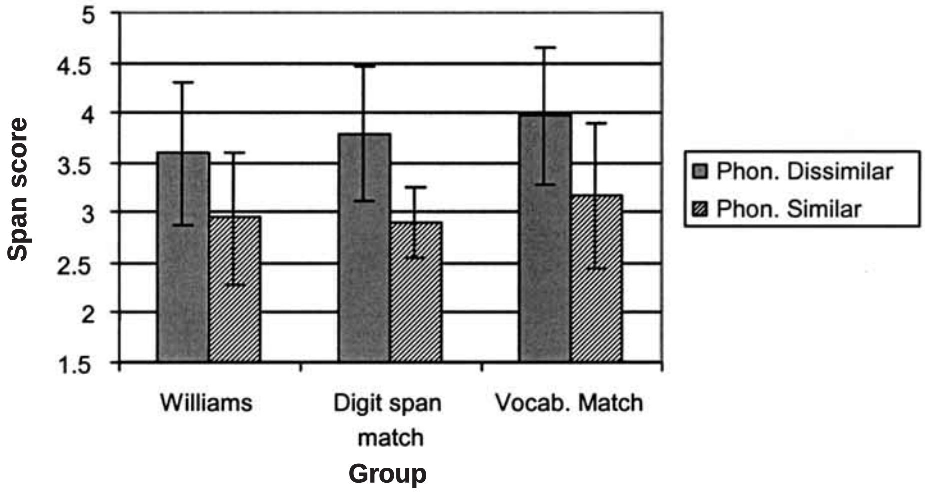

Fig. 2 - *Memory span scores (means and standard deviations) for phonologically similar and dissimilar words for the WS and control groups.*

Firstly, the effect of concreteness was examined. As Figure 1 illustrates, span scores for concrete words were higher than for abstract words. A two-way mixed analysis of variance was carried out in which the repeated measures variable was concreteness and the between subjects factor was group. There was a significant effect of concreteness [F (1, 39) = 6.49, p = .02], confirming the difference between scores seen in the graph.

Figure 1 shows the concreteness effect is strongest in the digit span group, followed by the WS group and was smallest in the vocabulary group. However, the overall effect of group on span scores was nonsignificant [F (2, 39) = 2.26, p = .12], and that there was no interaction between concreteness and group [F (2, 39) = .46, p = .63]. One-way ANOVAs were then carried out on the difference scores (span scores for concrete words minus scores for abstract words) to check further for group effects. WS difference scores did not differ from either those of the digit span group [F (1, 27) = .36, p = .57] or from those of the vocabulary group [F (1, 27) = .20, p = .66].

The effect of phonological similarity was next examined, in a set of parallel analyses to those above. Phonologically similar words were harder to recall than phonologically dissimilar words [F (1, 39) = 89.92, p = < .001]. There was again no overall effect of group on span scores [F (2, 39) = .95, p = .39] and no interaction between group and phonological similarity [F (2, 39) = .79, p = .46]. One-way ANOVAs performed on difference scores confirmed that participants with WS were as sensitive to the effect of phonological similarity on their memory span for words as both the digit span group [F (1, 27) = 1.74, p = .20] and the vocabulary group [F (1, 267) = .57, p = .46].

The span scores were then re-examined to check that the effects of concreteness and phonological similarity were not due to any differences in the rate at which the words could be spoken. The mean speech rate data for each condition in the two experiments are presented in Table II.

An analysis of covariance (ANCOVA) was first carried out on the span scores for concrete and abstract words, with speech rate (words per second) for each of these word types as covariates. The effect of concreteness remained significant [F (1, 38) = 6.54, p = .02]. The effects of group and the concreteness by group interaction were nonsignificant [group: F (2, 38) = 1.04, p = .36; group by concreteness: F (2, 38) = 0.41, p = .66].

A second ANCOVA with speech rate for each word type as covariates was carried out on span scores for phonologically dissimilar and similar words. The effect of phonological similarity remained significant [F (1, 38) = 67.22, p = < .001]. Group and the interaction of group by phonological similarity were nonsignificant [group: F (2, 38) =

TABLE II

Mean number of words per second (SD) for concrete, abstract, phonologically dissimilar and phonologically similar word used in span tasks

Group	Concrete	Abstract	Phonologically dissimilar	Phonologically similar
WS	2.30 (0.51)	2.44 (0.54)	2.36 (0.60)	2.51 (0.55)
Digit span	2.45 (0.40)	2.54 (0.40)	2.49 (0.38)	2.60 (0.41)
Vocabulary	2.72 (0.38)	2.86 (0.58)	2.87 (0.75)	3.16 (0.80)

.11, p = .90; group by phonological similarity: F (2, 38) = 0.77, p = .47].

Mixed analyses of variance were carried out on speech rate scores for each experiment. Concreteness was entered as a repeated measures variable in the first analysis, and phonological similarity in the second. Group was entered as a between subjects variable in both analyses. Somewhat surprisingly, given that rate of articulation is typically positively correlated with memory span (Hulme et al., 1983), participants in all three groups said more abstract words per second than concrete words [F (1, 39) = 5.85, p = .02], and more phonologically similar words than phonologically dissimilar words [F (1, 39) = 12.71, p = .001]. There was a significant effect of group in each case [concreteness: F (2, 39) = 3.25, p = .05; phonological similarity: F (2, 39) = 3.90, p = .03], reflecting the fact that scores were somewhat lower in the WS group than in the other two groups. Participants in the vocabulary group, who were older than those in the digit span group, had the highest scores. The group by concreteness interaction was nonsignificant [F (1, 39) = 0.12, p = .88], indicating that the participants with WS showed the same pattern as controls. Similarly, the group by phonological similarity interaction was not significant [F (2, 39) = 1.18, p = .32].

While the finding that word categories that were harder to remember were faster to say was unexpected, it is worth pointing out that if the two sets of words in each experiment had been matched for speech rate, the effects of the experimental variables would have been stronger.

Discussion

The present study aimed to investigate claims that lexical-semantic factors make a reduced contribution to verbal short-term memory in WS. This claim is important for two reasons. Firstly, verbal short-term memory is considered to be an area of relative strength in WS (Jarrold et al., 1999) and one which has been claimed to underpin WS language development (Bishop, 1999). Indeed there is evidence that in typical development verbal short-term memory is a strong predictor of early vocabulary development (Gathercole, 1995). Understanding more about the nature of verbal short-term memory in WS therefore has important implications for our understanding of language acquisition in this population. Secondly, it has been suggested that phonology and semantics operate somewhat differently in relation to one another in WS language (Capirci et al., 1996; Pezzini et al., 1999; Karmiloff-Smith et al., 1997; Thomas and Karmiloff-Smith, 2003). Investigating the relative influence of phonology and semantics in verbal short-term memory has the potential to further inform this aspect of WS language functioning.

The results of this study show that both semantic and phonological factors affect the performance of individuals with WS in verbal short-term memory tasks. For participants with WS, as for controls, concrete words were easier to remember than abstract words and phonologically dissimilar words were easier to remember than phonologically similar words. The Vicari et al. (1996b) study showed that while people with WS and controls showed comparable phonological similarity effects on short-term memory for words, participants with WS showed reduced effects of frequency in their recall. On the basis of these findings, they concluded that individuals with WS are overly dependent on phonological processing and could be described as 'hyper-phonological'. However, we have demonstrated that individuals with WS are as able as controls matched on memory level or vocabulary to make use of lexical-semantic information stored in long-term memory in the performance of a verbal word span task. The suggestion that individuals with WS are 'hyper-phonological' therefore needs to be reviewed.

It could perhaps be argued that differences between the two studies, other than the use of the concreteness rather than frequency as a variable, might account for the different pattern of results obtained. Participants with WS in the present study had a vocabulary age of 11,2 while those in Vicari et al.'s study had a mean mental age of 5,6. Perhaps differences in results between the two studies were due to the different mental ages investigated. However, given that a discrepancy between verbal and non-verbal functioning is a key feature of the WS cognitive phenotype it is likely that Vicari's participants had vocabulary skills in advance of their overall mental age. It is therefore not clear whether, or to what extent, the two WS samples differed in their level of language development. This leads on to a further difference between the two studies, namely the control groups used in the two studies. In our experiment examining the effect of concreteness on memory span, the participants with WS were individually matched to typically developing children on a measure of vocabulary ability, while in the Vicari et al. (1996b) study participants with WS were compared to a group of typically developing children whose chronological age was equivalent to the overall mental age of the WS group. We argued in the introduction that the use of a control group matched on overall mental age is problematic given the uneven cognitive profile found in WS. We suggested that in order to assess whether there really is a reduced contribution from lexical-semantics in WS, we needed to compare them with a group of typically developing children with the same level of language skill. Nonetheless, it would be interesting to include a mental age match control group in future work as this would allow discussion of the relative importance of overall mental ability versus language ability in determining effect size.

The demonstration of a phonological similarity effect in an English-speaking sample with WS replicates and extends the findings of Vicari et al. (1996b) with Italian participants with WS. In the present study phonological similarity had a comparable effect on recall for the WS group as it had on typically developing children matched on overall memory level and vocabulary. These findings therefore confirm that phonological similarity has a robust effect on the verbal short-term memory of individuals with WS. In terms of the Baddeley and Hitch (1974) model of verbal short-term memory, one part of working memory, the phonological loop, appears to function normally in individuals with WS. A number of studies have suggested that this aspect of phonological short-term memory is localized in the left supramarginal gyrus (see Vallar and Papagno, 2002 for a review).

The present study also confirmed that the effects of phonological similarity and concreteness were not due to any variation in speech rate for these items. Both effects on verbal short-term memory remained significant after differences in speech rate were taken into account. Further, although we did find some differences in speech rate between conditions, these differences were in the opposite direction to that expected if variations in speech rate were responsible for the effects in the span task. Abstract words were repeated slightly faster than concrete words but the concrete words were remembered more easily than the abstract words. Similarly, phonologically dissimilar words were repeated faster than the phonologically similar words but the dissimilar words were recalled more easily than the similar words. We can therefore conclude that the effects of phonological similarity and concreteness were not due to differences in speech rate for these items. Indeed, it could be argued that the fact that differences in speech rate turned out to be in the opposite direction to the effect sizes means that the effect sizes were smaller than they might otherwise have been. Had speech rate been controlled across items, it is likely that both effects would have increased in size. The present study therefore provides a particularly conservative test of the effects of concreteness and phonological similarity on verbal short-term memory.

While this study demonstrates that individuals with WS access their lexical-semantics when asked to recall lists of words, the findings do not preclude the possibility of a semantic impairment in individuals with WS. It is unlikely that fine-grained semantic representations are needed or indeed accessed in this kind of task. Even if semantic representations of words are poorly specified (Temple et al., 2002) or shallow (Thomas et al., 2002), representations of concrete words may still be richer than abstract words in terms of the numbers of features that define them.

The results of this study also do not rule out a possible imbalance between phonology and semantics in WS language. This imbalance between phonology and semantics may be an important feature of WS language development, but it is not necessarily manifested in all language processing tasks in later development. When a task mimics the language learning process or stretches the language system, then in WS processing may begin to rely more heavily on phonology than semantics. Studies of typically developing children have suggested that phonological short-term memory has a strong influence on word learning but that this influence decreases with language development as the size of the lexicon increases and other factors come into play (Gathercole, 1995). Others have suggested that the direction of causality is reversed and that vocabulary skill predicts performance in phonological short-term memory task because both are dependent on the quality of the underlying phonological system (Snowling et al., 1991). Either way it could be argued that this dependence on phonology in language learning is extended in the case of WS. This would account for the fact that concreteness effects were found in the present study but were absent in a study of WS reading development. Laing et al. (2001) taught a group of people with WS to associate printed words with their spoken form. The printed words were more or less related to the phonological form of the spoken words. Like the control group, people with WS learned to associate printed words with their spoken words more easily than the non-phonetic print. However, while the control group was strongly influenced by the concreteness of the words that they were learning to read, the WS group was not. We argue that in this kind of task, where the system is being pushed to establish new mappings, the imbalance will fall in favour of phonological processing. In another learning task, Majerus et al. (2001) demonstrated that people with WS learn to associate word-nonword pairs just as easily as word-word pairs, again suggesting a reduced semantic constraint in the learning process. Finally, as mentioned in the Introduction there is also good evidence now to suggest that in early language development individuals with WS may rely more heavily on a phonological than a semantic system (Mervis and Bertrand, 1997). In our view, the degree of imbalance between phonology and semantics in WS is likely to be dependent on the demands made on the language system both during early acquisition and during real-time processing. Further investigation of this imbalance, and of our hypothesis that it may be restricted to certain points in development, is likely to provide important clues to the process of WS language acquisition. Investigating this question may require the use of more direct language measures, however, rather than measures of verbal short-term memory. Nevertheless, the present study in which, unlike previous research, we carefully controlled for memory span, vocabulary level and speech rate, has enabled us to rule out claims of a phonology/semantics imbalance in the domain of verbal memory in WS. In light of the present findings, there is no basis on which to claim either a reduced contribution from semantics or an over-dependence on phonology in WS verbal short-term memory.

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Appendix 1

Properties of the phonologically similar and dissimilar word sets

Property	Mean (SD) rating phonologically similar words	Mean (SD) rating phonologically dissimilar words	t value
Concreteness	6.00 (1.51)	6.10 (1.62)	–.12
Familiarity	3.88 (0.68)	3.70 (0.92)	.46
Frequency	28.63 (16.27)	28.00 (17.30)	.07

Appendix 2

Properties of the concrete and abstract word sets used in the verbal short-term memory task

Property	Mean (SD) rating concrete words	Mean (SD) rating abstract words	t value
Concreteness	6.34 (0.60)	2.51 (0.56)	– 13.21**
Familiarity	4.21 (0.58)	4.13 (0.62)	– .25
Frequency	130.50 (118.60)	130.00 (109.93)	– .01

** $p < .001$