Lexical Conflict Resolution in Children with Specific Language Impairment

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ABSTRACT

The aim of our study is to examine the effect of conflict on naming latencies in children with specific language impairment (SLI) and typically developing (TD) children and to explore whether deficits in conflict resolution contribute to lexical problems in SLI. In light of previous results showing difficulties with inhibitory functions in SLI, we expected higher semantic conflict effect in the SLI than in the TD group. To investigate this question 13 children with SLI and 13 age- and gender-matched TD children performed a picture naming task in which the level of conflict was manipulated and naming latencies were measured. Children took longer to name pictures in high conflict conditions than in low conflict conditions. This effect was equally present in the SLI and TD groups. Our results suggest that word production is more effortful for children when conflict resolution is required but children with SLI manage competing lexical representations as efficiently as TD children. This result contradicts studies, which found difficulties with inhibitory functions and is in line with findings of intact inhibitory abilities in children with SLI. Further studies should rule out the possibility that in SLI lower level of conflict resulting from weaker lexical representations masks impairments in inhibition, and investigate the effect of linguistic conflict in other areas.

1. Introduction

1.1. Lexical impairments in specific language impairment

Children with specific language impairment (SLI) show linguistic deficits that are not accounted for by obvious impairments in other cognitive domains. Usually morphosyntactic and syntactic problems are emphasized (e.g.: Bishop, 1997; Leonard, 1998/2014) but lexical impairments are reported as well. Several studies show that first words appear later in children with SLI than in typically developing children (TD) and their vocabulary size lags behind age-based expectations at older ages too (Bishop, 1997; Watkins, Kelly, Harbers, & Hollis, 1995; Trauner, Wulfeck, Tallal, & Hesselink, 1995). SLI can also appear later without early vocabulary deficits, and early vocabulary problems do not always lead to language impairment later (Henrichs et al., 2011; Poll & Miller, 2013; Rescorla, 2011; see Ellis Weismer, 2007 and Leonard, 1998/2014 for a review).

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Children with SLI are less efficient than TD peers in experimental word learning tasks as well (e.g. Rice, Buhr, & Nemeth, 1990; Rice, Buhr, & Oetting, 1992; Rice, Oetting, Marquis, Bode, & Pae, 1994). Word retrieval seems problematic in picture naming tasks: they make more errors than TD children even when they know the word (Kail & Leonard, 1986; McGregor & Leonard, 1995), and they have longer naming latencies (Anderson, 1965; Ceci, 1983; Kail & Leonard, 1986; Katz, Curtiss, & Tallal, 1992; Lahey & Edwards, 1996; Leonard, Nippold, Kail, & Hale, 1983; Miller et al., 2001; Wiig, Semel, & Nystrom, 1982; Windsor & Hwang, 1999a). Difficulties with lexical processing also appear: children with SLI show more errors (Crosbie, Howard, & Dodd, 2004) and longer reaction times in lexical decision (Edwards & Lahey, 1996; Windsor & Hwang, 1999b) and in word monitoring tasks (Montgomery & Leonard, 1998; Montgomery, Scudder, & Moore, 1990; Stark & Montgomery, 1995). Taken together, these findings show that the acquisition, production and processing of words are slower and more error-prone in SLI than in typical development (see also Leonard & Deevy, 2004).

1.2. Accounts of lexical impairments in SLI

As the above review suggests, lexical deficits are present in various forms in the language of children with SLI, and there is no agreement in the literature on the potential causes of these impairments. A possible explanation is that lexical problems are caused by differences in the features of lexical representations. Several studies argue that in language impairment, less information is available about lexical items and the items are not as well-organized as they are in the mental lexicons of typically developing children (Kail & Leonard, 1986; Lahey & Edwards, 1999; McGregor, Newman, Reilly, & Capone, 2002; Sheng & McGregor, 2010). McMurray, Samelson, Lee and Tomblin (2010) attributes language impairments to faster lexical decay after word retrieval in these populations.

Others relate lexical problems to non-linguistic impairments: several earlier studies suggest that a generally slower processing contributes to lexical impairments as well (Kail, 1994; Leonard et al., 2007; Miller et al., 2001; Windsor & Hwang, 1999c). Lahey and Edwards (1996) argue that children name pictures more slowly because their non-linguistic response processes are impaired. Non-linguistic problems are suggested to contribute to the processing of ambiguous words by Norbury (2005), who proposes that less effective suppression mechanisms can contribute to weaker performance of children with SLI and she also emphasizes deficits of memory and attention skills as likely factors at play. Mainela-Arnold, Evans and Coady (2008) and Mainela-Arnold, Evans and Coady (2010) argue, based on findings from a gating task, that top-down attentional processes are impaired in children with SLI. In a gating task participants are presented with increasingly longer chunks of words starting from their beginning, and they are asked to guess the word after each trial. Children with SLI showed similar performance as TD children with one difference: they produced competing alternatives even after they found the appropriate word. According to the authors, this pattern is the result of weaker representations that are more vulnerable to lexical competition or, alternatively, it is caused by the deficit of top-down competition-resolving processes, or by a combination of the two (Mainela-Arnold et al., 2008).

Mainela-Arnold et al., (2010) also showed that performance of children with SLI lags behind TD children both in a word definition task and in a delayed word repetition task, with positive correlations between the two performance measures. They propose that because of reduced attentional capacity – reflected by impaired performance on the delayed repetition task – children with SLI have weak phonological representations which have a negative effect on semantic representations as well. Impairments of higher order top-down processes in word retrieval can also be linked to a new line of research in the psycholinguistic literature that emphasizes the role of cognitive control functions in linguistic processes, which we review below.

1.3. Competition and the role of cognitive control in word retrieval

According to recent studies, cognitive control, i.e. the ability to orchestrate our actions and thoughts with our internal goals (Miller & Cohen, 2001) is necessary for language use in many areas including syntactic ambiguity resolution (January, Trueswell, & Thompson-Schill, 2009; Novick, Trueswell, & Thompson-Schill, 2005; Novick, Trueswell, & Thomspon-Schill, 2010), lexical ambiguity resolution (Bedny, Hulbert, & Thompson-Schill, 2007), the assessment of common ground (i.e. the set of shared beliefs by the interlocutors; Brown-Schmidt, 2009), and, most importantly from the point of view of our research question, in word production as well (Kan & Thompson-Schill, 2004; Schnur, Schwartz, Brecher, & Hodson, 2006; Schnur et al., 2009). When a word is retrieved several other words are activated and for successful production of the target word, the activation level of its lexical representation has to be higher than that of the competing words. When the difference between the activation level of the target word and the other words is not big enough, word retrieval difficulties may appear.

The blocked cyclic naming paradigm is a widely used paradigm to investigate word production under competition (e.g. Belke, Meyer, & Damian, 2005; Damian, Vigliocco, & Levelt, 2001; Kroll & Stewart, 1994; Schnur et al., 2006, 2009). In this task participants are asked to name pictures in the context of other pictures either from the same category (homogeneous block, e.g. *pear, apple, melon . . .*) or from different categories (mixed block, e.g., *pear, chair, blouse . . .*). Sets of items are repeated in succession multiple times in various orders. For example, six fruits are presented after each other and then they are repeated several times in different orders. A robust finding is that adults name pictures in the homogeneous blocks significantly slower than pictures in the mixed blocks. This effect is usually not present in the first cycle (or first homogeneous cycles are named even faster than first mixed cycles), in the second cycle there is a large drop in reaction times for the mixed block and a smaller drop for homogeneous blocks and this pattern remains similar in the third and the fourth cycles (e.g., Belke et al., 2005; Biegler, Crowther, & Martin, 2008; Navarrete, Del Prato, & Mahon, 2012; Schnur et al., 2006).

Several explanations have been proposed to account for the patterns found in the blocked cyclic naming task. Selection-by-competition accounts (e.g.: Belke et al., 2005) state that in mixed blocks, reaction times become lower from the second cycle because of the activation of the same word representations during the previous cycle(s) (repetition priming) and this effect is smaller in homogeneous blocks because of the co-activation of several semantically similar representations. In the homogeneous condition, the target word requires extra time to reach the critical difference threshold, which leads to longer naming latencies. Schnur et al. (2006) suggest that cognitive control might also have a role in the process. They argue that a high level of competition leads to conflict between the target word and competing words, constituting a signal that engages cognitive control mechanisms. Longer reaction times from the second cycle result, at least partly, from the time needed for this control mechanism to take effect. The formulation of hypotheses and the experimental design in the current study was motivated by the findings and theoretical framework of Schnur et al. (2006); following their terminology, we will use the word 'conflict' to refer to situations when multiple representations are expected to be activated to a similar degree. We will refer to the increase in naming latencies in conditions with high level of competition relative to low level of competition as the 'conflict effect' throughout the paper.

Oppenheim, Dell, and Schwartz (2010), on the other hand, suggest a different account of the semantic blocking effect. They take word production to be an error-based implicit learning process resulting in incremental changes in the connection weights between semantic features and word representations. Due to this process, semantic-lexical connections are strengthened for the selected word and weakened for non-selected but related words during word production. For instance, the selection of *table* for naming the picture of a table strengthens the links between the semantic features of a table (e.g. made of wood, has four legs, used for eating or working) and the word *table*, but also leads to a parallel weakening of links between those same semantic features and other semantically related words which were not selected (e.g. *chair,tablecloth*). Therefore it yields a decrease in reaction times from the second cycle due to the strengthened connections but in semantically mixed blocks reaction times should show a smaller decrease because of the continuous weakening of connection strengths of every word except the actual target word. For instances of high interference, the theory propose a booster mechanism which amplifies the activation of each word until a winner can be selected. The model would predict the presence of a semantic blocking effect already in the first cycle, the lack of which is explained by conscious strategies applied by the participant, according to Oppenheim et al. (2010). Crowther and Martin (2014) argues (following the proposition of Belke (2013) and Belke and Stielow (2013)) that the model should be supplemented by a top-down control mechanism biasing the activation of items within the response set. This idea is supported by their results showing correlations between the size of the semantic blocking and Stroop effects (Crowther & Martin, 2014). Thus we can conclude that both of these theories are compatible with the idea of cognitive control processes involved during the naming of homogeneous blocks of the semantic blocking paradigm.

The most popular picture naming paradigm for the manipulation of semantic competition is the abovementioned semantic blocking paradigm, but important results were found with a task in which participants are required to name pictures with low vs. high name agreement (Kan & Thompson-Schill, 2004; Novick, Kan, Trueswell, & Thompson-Schill, 2009). Name agreement is determined by the number of names available for describing a picture. High name agreement pictures can be named with one word only, or even when there are multiple available names, one of them is used a lot more frequently than the others (a picture of an apple is usually named as an *apple*). In the case of low agreement pictures there are more than one available names, with similar probabilities of use (a picture of a stove can be named as *stove*, *oven* or *range*). In the latter case conflict is expected to be higher while the alternatives are still competing with the target word for selection. Kan and Thompson-Schill (2004) as well as Novick et al. (2009) assumes that a cognitive control mechanism is responsible for biasing the selection in these cases.

In sum, studies with healthy adults showed that pictures with high conflict are named significantly slower than pictures with low conflict. The involvement of cognitive control in these conflict effects are supported by correlations between word retrieval and cognitive control measures and an association of higher conflict with an increased level of activation in the left inferior frontal gyrus, an area usually active during other tasks involving cognitive control (Kan and Thompson-Schill, 2004; Schnur et al., 2006). Furthermore, patients with aphasia with a left inferior frontal gyrus impairment take longer or even fail to produce pictures with high conflict (Biegler et al., 2008; Novick et al., 2009; Schnur et al., 2006, 2009). These results suggest that cognitive control has a critical role in successful word selection when more representations are activated in healthy adults, and impairments of cognitive control can contribute to word retrieval difficulties in patients with aphasia.

To our knowledge, no studies explored the effect of conflict manipulations during picture naming either in typically developing children, or in children with language impairment so far. Beyond its theoretical importance, the question has potential clinical relevance as well: shedding light on the specific sources of lexical problems in children with SLI enables the development of targeted trainings. If general cognitive control abilities are impaired in children with SLI, contributing to deficits in the language domain, these abilities should also be the focus of therapy beyond language abilities.

1.4. The current study

Motivated by the above findings on the role of cognitive control in word retrieval in healthy adults and in patients with aphasia, our aim in the current study employing a picture naming task was to test the hypothesis that cognitive control problems in children with SLI contribute to their word retrieval difficulties. Since we have not found any developmental results on this question in the literature, we also aimed to explore the relationship between cognitive control and lexical conflict resolution in TD children. Our hypothesis regarding the role of cognitive control impairments in SLI was motivated by three sets of previous findings: 1) word retrieval problems observed in SLI (as reviewed above) 2) cognitive control impairments contributing to word retrieval difficulties in adults (also reviewed above) and 3) problems with cognitive control observed in children with SLI (e.g. Finneran, Francis & Leonard, 2009; Henry, Messer, & Nash, 2012; Lum & Bavin, 2007; Seiger-Gardner & Brooks, 2008; Spaulding, 2010).

Based on earlier results from adults and patients with aphasia, we expected a decrease in reaction times through cycles both in homogeneous and mixed blocks because of the repetition priming effect, with a smaller decrease in the homogeneous blocks due to the conflict effects. Considering the name agreement manipulation, we expected longer reaction times in the case of pictures with low name agreement than with high name agreement. Overall, generally higher reaction times were expected in the case of high conflict conditions (homogeneous blocks, low name agreement) than low conflict conditions (mixed blocks, high name agreement). Since cognitive control develops well into adolescence (Davidson, Amso, Anderson, & Diamond, 2006), these effects of conflict could be even stronger in children than in adults. Also, we expected that if children with SLI have problems with cognitive control, conflict effects are going to be stronger and manifest in longer reaction times for high conflict conditions in SLI than in TD.

The last prediction, however, can be modulated by differences of facilitatory and inhibitory processes in children with SLI relative to TD children. As it was mentioned in the introduction, the organization of the lexicon and the connections between lexical representations can be different in children with SLI and TD children. These differences can be conceptualized in different ways by the selection-by-competition and the incremental learning accounts.

On the basis of the selection-by-competition account, a relevant difference is expected in the connections between elements of the mental lexicon. First, as it was discussed in the first section of the paper, these connections between semantic nodes and word representations can be weaker in children with SLI leading to generally slower reaction times during all conditions. Second, connections between semantically related elements can be weaker resulting in slower spreading activation which would lead to smaller conflict effects, i.e. smaller difference between homogeneous and mixed conditions as well as smaller increase in the effect through the cycles of homogeneous blocks. Therefore even if cognitive control abilities are impaired, the smaller level of conflict could be handled by the weaker cognitive control abilities leading to conflict effects comparable to those observed in TD children. Third, the difference between connections both between semantic nodes and word representations on the one hand and between semantically related elements on the other can have consequences on the name agreement manipulations as well in the SLI group. When a picture with multiple potential names is named for the first time with the target word, competing names are activated due to their relationships with the semantic nodes as well as to their relationships with the target word. But once the target word is selected, the competing alternatives do not activate to a high degree again due to the weaker connections, which would yield smaller or missing name agreement effects through the later cycles. And fourth, effects caused by name agreement differences can be generally smaller in children with SLI because they do not have strong relationships between semantic nodes and alternative names (they use the word *couch* for naming the couch, competing alternatives, like *squab* or *settee* might be less activated than in TD children).

The incremental learning account also predicts differences between the TD and SLI groups in lexical organization and in the connections between lexical representations that are expected to manifest in the blocked cyclic naming paradigm. Weight adjustments may not be as efficient in children with SLI as in TD children, predicting similar patterns as the selection-by-competition account by proposing weaker relationships between elements. It is also possible that the booster mechanism is less efficient in children with SLI, which would lead to longer reaction times in the case of semantically homogeneous blocks in that group relative to the TD group. The incremental learning account, however, does not have explicit theoretical predictions for the name agreement manipulations.

Table 1
Means (and standard deviations) for demographic data and scores for screening tests in the SLI and TD groups. Results from one-way ANOVAs are shown for group differences.

	TD		SLI		F	Sig	η_p^2
	Mean	SD	Mean	SD			
Age	8;9	1;4	8;10	1;4	0.16	0.901	0.001
Raven IQ (standardized scores)	108.54	9.71	100.54	5.83	6.473	0.018	0.212
Nonword repetition (raw scores)	6.23	1.01	3	1.47	42.506	0.000	0.639
PPVT (raw scores)	124.5	13.75	97	20.86	15.792	0.001	0.397
TROG blocks (raw scores)	18.38	1.45	13.15	2.67	38.533	0.000	0.616
Sentence repetition (raw scores)	37.38	3.23	19.76	8.21	51.862	0.000	0.684

2. Methods

2.1. Participants

Twenty-six Hungarian-speaking children participated in our study. The SLI group consisted of thirteen children (4 girls, 9 boys) who were selected from a special school for children with language impairments. Their mean age was 8;10 with a standard deviation of 1;3. Only children without hearing or neurological impairments and with normal intelligence (performance above 85 scores on Raven Colored Progressive Matrices; Raven, Court, & Raven, 1987) were screened for inclusion in the SLI group. All children were included based on criteria that are commonly used and represent accepted practice in selecting children with SLI in research (see e.g. Leonard, 1998/2014, Tager-Flusberg & Cooper, 1999): linguistic abilities were assessed with four tests and children who performed at least 1.5 SD below age-based expectations on at least two out of the four tests were included in the SLI group. These four tests consisted of two receptive and two expressive tests. The receptive tests were the Hungarian versions of the Peabody Picture Vocabulary Test (PPVT: Csányi, 1974; Dunn & Dunn, 1981) and the Test for Reception of Grammar (TROG: Bishop, 1983; Lukács, Győri, & Rózsa, 2012). The expressive tests were the Hungarian Sentence Repetition Test (Kas & Lukács, in preparation), and a nonword repetition test (Racsmány, Lukács, Németh, & Pléh, 2005). All children meeting these criteria were included in the study. No eligible children declined participation.

Typically developing children were matched individually to children in the SLI group on chronological age and gender. Demographic and screening data for the two groups are shown in Table 1. All children were tested with the informed consent of their parents, in accordance with the principles set out in the Declaration of Helsinki and the stipulations of the local institutional review board.

2.2. Stimuli

We used 36 line drawings of common objects well-known to children at this age from the picture set used by the norming study of Bates et al. (2003). Bates and her colleagues selected 520 pictures from various databases for their study. The pictures were comparable in picture quality, visual complexity, and potential cross-cultural validity of the depicted item. The pictures were normed in a picture naming study with adults in seven languages (also in Hungarian) measuring naming latency, name agreement (defined as the proportion of using one dominant name from all valid names) and various features of the dominant response (frequency, length, complexity – monomorphemic vs. plural/compound . . .) (Bates et al., 2003). The 36 pictures were selected for the study to manipulate competition during naming both with varying the semantic context (based on Schnur et al., 2006) of the pictures and the name agreement of a picture (based on Kan & Thompson-Schill, 2004).

Pictures were taken from six semantic categories with six exemplars in each; half of these pictures had low name agreement (i.e. had more than one similarly plausible names) and the other half had high name agreement (i.e. had one dominant name). Data for name agreement for the pictures were available in Hungarian from the study of Bates et al. (2003) who published their data online (http://crl.ucsd.edu/experiments/ipnp/1database.html). (The design that determined picture selection is shown in Fig. 1.). Frequencies of the target names were similar in the high and low name agreement conditions ($F(1,34) = 0.001$, $p = 0.97$, $\eta_p^2 = 0.000$; log frequencies ranged from 2.26 to 5.35 (mean 4.39, SD 4.7)); based on a Hungarian frequency dictionary (http://szotar.mokk.bme.hu/szoszablya/searchq.php; Halácsy et al., 2004; Kornai, Halácsy, Nagy, Trón, & Varga, 2006). The length of words varied between one and four syllables in each condition. Because of having to control several factors at the same time, we ended up with a word set containing words with higher mean length in the low agreement condition (mean: 2.5 syllables, SD: 0.99) than in the high agreement condition (mean: 1.9 syllables, SD: 0.8). We decided to loosen this specific criteria instead of other ones because according to Bates et al. (2003), in naming, word length effects on naming latency are confounded with other factors (with word frequency or name agreement) and length has very small or no effect independently. Kawamoto, Liu, Mura, and Sanchez (2008) found longer naming latencies for words starting

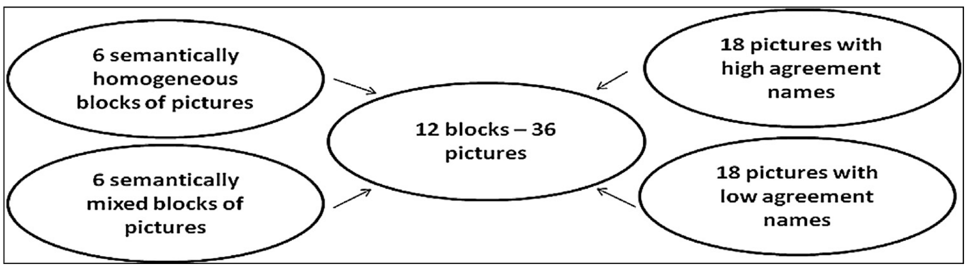

Fig. 1. Pictures were selected from six semantic categories with six pictures from each category, therefore 36 pictures were used in the task. These pictures were presented in two blocks: once together with members of the same category and once with members of other categories. Therefore altogether 12 blocks of pictures were presented. Half of the 36 pictures had a name with low name agreement and the other half had a name with high name agreement.

with a plosive than for other initial phonemes; in the current study number words starting with a plosive was equal in the low and high name agreement conditions.

Each picture was presented once together with pictures from the same semantic category (semantically homogeneous blocks) and once together with pictures from various semantic categories (semantically mixed blocks). One block consisted of six pictures, which were repeated four times (in four *cycles*) each time with a different order of pictures yielding 24 items in each block (Examples of target answers for the pictures in a homogeneous and a mixed block are given in the Appendix, together with the names of categories from which homogeneous blocks were generated). Four cycles were included to raise the level of conflict during homogeneous cycles. Altogether six homogeneous and six mixed blocks were presented for the children. Due to the name agreement manipulations, half of the pictures belonged to the *low agreement* condition with several equally plausible names (e.g. a picture of a couch can be named in Hungarian with the following words: *szófa* 'sofa', *kanapé* 'couch', *dívány* 'divan', *ágy* 'bed') and the other half was a *high agreement* picture with only one plausible name (e.g. a picture of an apple in Hungarian is almost always named with the word *alma* 'apple').

2.3. Procedure

We used the E-Prime 2.0 software (Schneider, Eschman, & Zuccolotto, 2012) for presenting the stimuli and for collecting data. Reaction times were measured with a microphone that triggered a voice key. Answers were coded as 'correct', 'incorrect' or 'technical error' by the experimenter on paper. Before the experiment, children were instructed to name each picture and asked not to say anything else except the names of the pictures. Pictures were presented on a computer screen and remained on the screen until the child gave a response. Within a block, pictures followed each other with a one second pause between them; between blocks, children could take a break as long as they needed. The order of the 12 blocks was randomized across participants. The task lasted for approximately 20 min.

3. Results

Results were analyzed using SPSS (SPSS, 2009), version 18.0. We conducted a $2 \times 2 \times 2 \times 2$ repeated measures analysis of variance with Group (SLI vs. TD) as between-subject variable and Homogeneity (Homogeneous vs. Mixed), Agreement (Low vs. High) and Cycle (1 vs. 4) as within-subject variables. Note that for investigating the effect of Cycle we included reaction times only for the first and the fourth cycles in the analysis (Means and standard deviations for reaction times for the four cycles by Group and conditions are shown in Table 2.). Only reaction times for correct answers (names which are plausible for the picture) were included; trials where the voice key was triggered inappropriately or was not triggered because the answer was too quiet were also excluded, as well as reaction times under 300 ms and above 3000 ms. After the exclusion of RTs based on these criteria, 87% of all trials were included in the analysis.

The ANOVA showed a significant main effect of Agreement ($F(1, 24) = 13.845$, $p < 0.001$, $\eta_p^2 = 0.366$): low agreement pictures took longer to name than high agreement pictures. All other main effects were nonsignificant (Homogeneity: $F(1, 24) = 1.162$, $p = 0.242$ $\eta_p^2 = 0.046$; Cycle: $F(1, 24) = 0.28$, $p = 0.867$ $\eta_p^2 = 0.001$; Group: $F(1, 24) = 0.105$, $p = 0.794$ $\eta_p^2 = 0.004$). A significant interaction appeared between Homogeneity, Agreement and Group ($F(1, 24) = 8.841$, $p = 0.007$, $\eta_p^2 = 0.269$), Homogeneity and Cycle ($F(1, 24) = 27.079$, $p < 0.001$, $\eta_p^2 = 0.530$), and Agreement, Cycle and Group ($F(1, 24) = 5.092$, $p = 0.033$, $\eta_p^2 = 0.175$). All other interactions were nonsignificant (Homogeneity x Group: $F(1, 24) = 0.364$, $p = 0.552$, $\eta_p^2 = 0.015$; Agreement x Group: $F(1, 24) = 0.157$, $p = 0.695$, $\eta_p^2 = 0.007$, Cycle x Group: $F(1, 24) = 1.112$, $p = 0.302$, $\eta_p^2 = 0.044$; Homogeneity x Agreement: $F(1, 24) = 0.906$, $p = 0.351$, $\eta_p^2 = 0.036$; Homogeneity x Cycle x Group: $F(1, 24) = 1.038$, $p = 0.318$, $\eta_p^2 = 0.041$; Agreement x Cycle: $F(1, 24) = 3.349$, $p = 0.080$, $\eta_p^2 = 0.122$).

For breaking down the Homogeneity x Agreement x Group interaction, we analyzed the effect of Homogeneity and Agreement in 2×2 repeated measures ANOVAs separately for the two groups. In the SLI group the main effect of Agreement was significant ($F(1,12) = 5.076$, $p = 0.044$, $\eta_p^2 = 0.297$): low agreement pictures were named significantly slower than high

Table 2
Mean reaction times (and standard deviations) in milliseconds in the picture naming task by Group and by conditions.

	High name agreement		Low name agreement	
	SLI	TD	SLI	TD
Homogeneous cycles				
1.	1095 (165)	1087 (146)	1186 (166)	1163 (192)
2.	1089 (179)	1183 (211)	1288 (223)	1197 (173)
3.	1274 (209)	1165 (249)	1370 (193)	1309 (261)
4.	1249 (231)	1170 (182)	1222 (203)	1302 (237)
Mixed cycles				
1.	1167 (191)	1126 (176)	1329 (198)	1208 (280)
2.	1114 (174)	1062 (156)	1278 (174)	1241 (332)
3.	1130 (192)	1163 (263)	1153 (190)	1111 (235)
4.	1083 (286)	1094 (241)	1131 (267)	1144 (279)

agreement pictures. The main effect of Homogeneity was nonsignificant ($F(1,12) = 0.160$, *n.s.*). A significant interaction appeared between Homogeneity and Agreement ($F(1.12) = 5.832$, $p = 0.033$, $\eta_p^2 = 0.327$). After investigating the effect of Agreement in homogeneous and mixed blocks separately, we found that Agreement did not have a significant effect on homogeneous blocks ($F(1, 12) = 1.804$, *n. s.*) but low agreement pictures were named significantly slower in mixed blocks: $F(1, 12) = 6.305$, $p = 0.027$, $\eta_p^2 = 0.344$. In the TD group the main effect of Agreement was significant ($F(1, 12) = 9.219$, $p = 0.010$, $\eta_p^2 = 0.434$): low agreement pictures were named significantly slower than high agreement pictures. The main effect of Homogeneity was not significant ($F(1, 12) = 1.069$, *n.s.*), neither was the Homogeneity x Agreement interaction ($F(1, 12) = 2.937$, *n.s.*) (Results for the SLI and TD groups are shown in Fig. 2).

To investigate the significant Homogeneity x Cycle interaction further, we examined the effect of Homogeneity in the first and fourth cycles separately (collapsing mean reaction times over Agreement and Group). We found that in the first cycle naming pictures in the mixed condition took significantly longer than in the homogeneous condition ($F(1, 25) = 8.546$, $p = 0.007$, $\eta_p^2 = 0.255$). We observed the opposite pattern in the fourth cycle: reaction times were significantly higher for pictures from the homogeneous condition ($F(1, 25) = 14.579$, $p = 0.001$, $\eta_p^2 = 0.368$). (Mean reaction times by Homogeneity and Cycle are shown in Fig. 3).

The Agreement x Cycle x Group interaction was further investigated by examining the effect of Agreement and Cycle in the two groups separately. In the SLI group the main effect of Agreement was significant ($F(1, 12) = 5.085$ $p = 0.044$, $\eta_p^2 = 0.298$): low agreement pictures were named significantly slower than high agreement pictures. The main effect of Cycle was not significant ($F(1, 12) = 0.346$, *n.s.*) while the Agreement x Cycle interaction was significant ($F(1, 12) = 20.625$, $p = 0.001$, $\eta_p^2 = 0.632$). After investigating the effect of Agreement separately in the first and fourth cycles, we found a significant effect only in the case of the first cycle where low agreement pictures were named significantly slower than high agreement pictures (first cycle: $F(1, 12) = 11.066$, $p = 0.006$ $\eta_p^2 = 0.480$, fourth cycle: $F(1, 12) = 0.153$, *n.s.*). In the TD group the main effect of Agreement was significant ($F(1, 12) = 9.226$, $p = 0.010$, $\eta_p^2 = 0.435$): low agreement pictures were named significantly slower than high agreement pictures. But the main effect of Cycle ($F(1, 23) = 0.866$, *n.s.*) and the Agreement x Cycle interaction ($F(1,12) = 0.57$, *n.s.*) was not significant (Mean reaction times in the SLI and TD groups by Cycle and Agreement are shown in Fig. 4).

We also tested whether conflict resolution abilities (the size of the conflict effect) were associated with individual differences in PIQ and language measures (performance on the screening tests). No significant correlations were observed either with PIQ, or with language measures (all ps > 0.1).

4. Discussion

Our aim in the current study was to investigate the effect of lexical conflict on word production in children with SLI compared to age-matched TD children. For this aim we manipulated the level of conflict in three ways in a picture naming task. Pictures were presented either in a 1) semantically homogeneous or in a semantically mixed context, they appeared in both contexts 2) four times across the task resulting in increasingly higher level of conflict in the homogeneous blocks and 3) pictures had either low name agreement with multiple plausible names or high name agreement with one dominant name. Results show a very similar pattern for the two groups. We found that pictures with lower name agreement, i.e. with multiple equally plausible names took longer to name for both children with SLI and for TD children. Furthermore, when pictures appeared for the first time in the block both groups named them faster in a semantically homogeneous context than in a mixed context but this pattern was reversed after three repetitions: in the fourth cycle, pictures in the semantically mixed context were named faster. Name agreement affected the two groups differently in the fourth cycle: TD children named pictures with multiple available names slower than pictures with one dominant name but no such difference appeared in children with SLI. The same difference appeared between the two groups when only the homogeneous blocks were

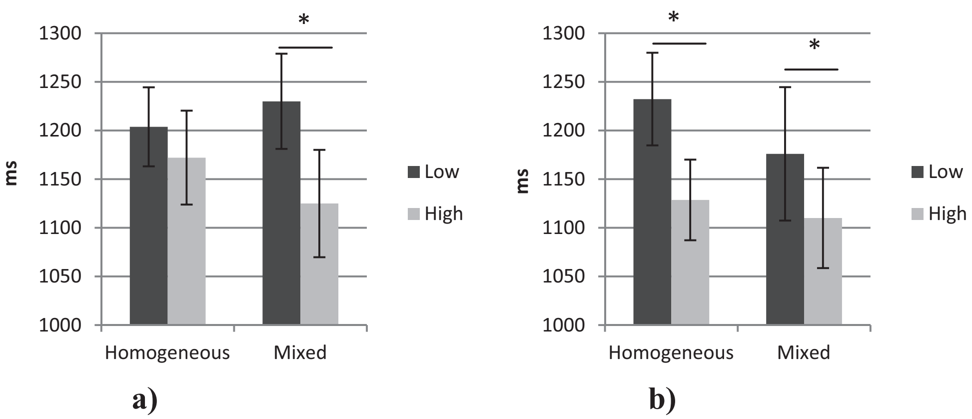

Fig. 2. Mean reaction times by Homogeneity and Agreement in the a) SLI and b) TD groups. Differences marked by * are significant at $p < 0.05$.

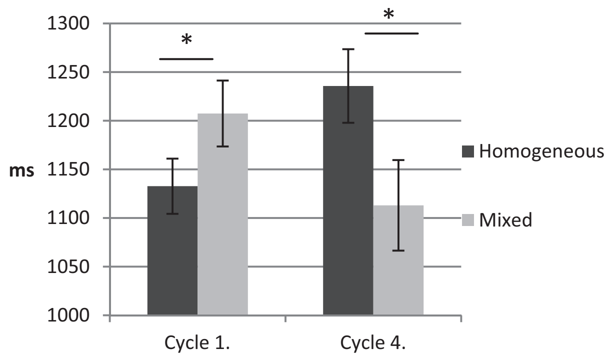

Fig. 3. Mean reaction times by Homogeneity and Cycle. Differences marked by * are significant at $p < 0.05$.

considered: pictures with multiple possible names were named slower than pictures with one dominant name by TD children but reaction times of children with SLI were similar for these two types of pictures in homogeneous semantic contexts.

Arguably, different effects of name agreement in the two groups can be partly accounted for by differences in the organization of the mental lexicons of children with SLI and TD children that might lead to different priming and conflict effects. We summarized some of these potential differences at the end of the *Introduction* both in line with the competition-by-selection and the incremental learning accounts. One of these potential differences based on the competition-by-selection theory was that competition can be smaller in children with SLI in the fourth cycle of the low agreement condition because competing alternatives of the target name are reactivated to a smaller degree than in TD children after once the word was selected successfully. The lack of reactivation can be the result of weaker relationships between semantic nodes and word representations and between semantically related word representations.

The lack of an agreement effect in the homogeneous semantic context in children with SLI is difficult to interpret. The finding that a conflict effect is not present in the case of low agreement pictures appearing in the fourth cycle in children with SLI as well as other differences between the mental lexicon of TD and SLI children are likely contributions. Lexical conflict has two different sources in the low agreement homogeneous condition: multiple available names on the one hand and homogeneous semantic context on the other hand. As discussed above, children with SLI were relatively quick to name low agreement pictures in the fourth cycle, probably resulting from the lack of strong reactivation of alternative names. Lower reaction times overall in the low agreement condition in the SLI group are thus mainly accounted for by this group difference in the fourth cycle. The effect of the homogeneous context might also be reduced in SLI. As it was discussed among the potential differences between SLI and TD lexicons predicted by the selection-by-competition account the *Introduction*, children with SLI might have fewer and weaker connections between semantically related word representations. While conflict in a homogeneous semantic context originates from strong relationships between representations of one semantic category that raise the activation level of all category members when one member is retrieved through spreading activation, weaker associations yield smaller competition and a reduced conflict effect.

The potential differences predicted by the selection-by-competition account between the lexicons of children with SLI and TD children are party supported by our data. Generally weaker relationships between semantic nodes and word representations in the SLI group would predict generally higher reaction times which we did not find. The hypothesis about

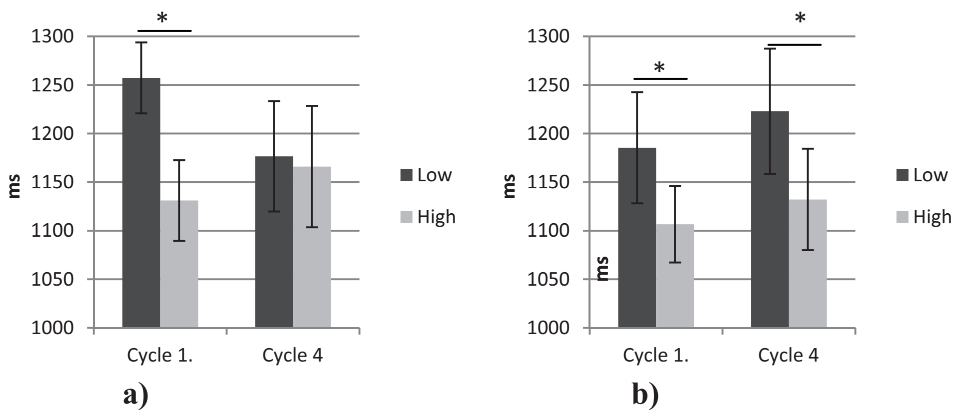

Fig. 4. Mean reaction times by Cycle and Agreement in the a) SLI and b) TD groups. Differences marked by * are significant at $p < 0.05$.

less dominant alternative names of the object which would result in generally smaller name agreement was not supported either. In contrast, weaker relationships between semantically related word representations potentially leading to weaker reactivation of alternative names after the target was once selected (points two and three in the *Introduction*) can account for the RT differences between the two groups. The predictions of the incremental learning account would only apply for semantic blocking effects but our results show differences more related to name agreement manipulations for which the theory does not have clear predictions.

Overall, our results show that children, both with and without SLI exhibit some, but not all lexical conflict effects found in previous adult studies. The number of available names for a picture affected reaction times in children in a similar way as it affected adults in the study of Kan and Thompson-Schill (2004): just like adults, children were slower in naming pictures with multiple available names than pictures with one dominant name. Overall reaction times were higher for children (with a mean of 830 ms in adults and 1170 ms in children) but the magnitude of the effect of name agreement was comparable in the two studies (100 ms in adults and 80 ms in children).

The manipulation of semantic context and number of presentations resulted in a different pattern in our study than in a previous adult study with the same design (Schnur et al., 2006). Adults named pictures with a similar speed when they appeared for the first time in the block independently of the semantic context and reaction times grew faster with repetitions. This priming effect on naming latencies was smaller when pictures appeared in a homogeneous semantic context, yielding generally slower reaction times in the semantically homogeneous than in the semantically mixed context. In contrast, in our study semantic context of the pictures had different effects at the beginning and at the end of the blocks and the number of presentations had different effects on semantically homogeneous and mixed blocks. Homogeneous context facilitated the naming in the beginning of the blocks relative to mixed context and while reaction times increased with cycles in homogeneous blocks, they decreased in mixed blocks. Because of reverse effects of the semantic context at the beginning and at the end of the blocks, semantic context did not have an overall effect on naming latencies. Based on the framework of Schnur et al. (2006) discussed in the *Introduction* of our paper, we can state that activation of the semantically similar names facilitated naming speed in children relative to the semantically mixed context in the beginning of the blocks, when names appeared only once and thus competition was low. At later stages of the block, after producing the semantically similar names three times, competition became higher, demanding cognitive control mechanisms for successful retrieval, which led to higher reaction times than in the first cycle. The different pattern of results in children and adults can be attributed to the facilitatory effect of homogeneous semantic context in the first cycle in children but not in adults. This can probably be accounted by the faster reaction times of the adult population which allow less space for further facilitation by the priming effect of semantically similar names.

Results can be interpreted in the frame of the incremental learning account (Oppenheim et al., 2010) supplemented by cognitive control mechanisms (Crowther & Martin, 2014) as well. We suggested at the end of our introduction that weight adjustments might be less efficient in children with SLI than in TD children. This consideration can be applied for the difference between children and adults as well (although the theory does not have clear predictions for the developmental apects of incremental learning during word production). Due to slower weight adjustments in children than in adults, weight decrease between semantic nodes and competing word representations might take longer therefore the spreading activation between semantically related nodes can have a facilitatory effect. This effect is not expected to appear in adults because it is suppressed by the faster weight decreases resulting in comparable reaction times to the first cycle of the mixed condition.

Although we did not find an overall effect of semantic context in children, the effect of semantic context appeared both in children and adults at the end of blocks. Reaction times of adults were generally faster in Schnur et al. (2006) study (mean reaction times of adults is ∼800 ms and the mean reaction time of children is ∼1170 ms). Our study showed a more pronounced effect of semantic context in children, shown by bigger difference between reaction times for homogeneous vs. mixed semantic context in the case of the fourth appearance (∼60 ms for adults in the Schnur et al. (2006) study and 122 ms for children in our study).

In sum, we found generally higher naming latencies in children than did previous studies in adults with similar manipulations. This is not surprising based on developmental research about word retrieval showing that retrieval speed reaches its plateau after age 10 (Wiegel-Crump & Dennis, 1986). Lexical conflict had similar effects in children and in adults, although the effect of semantic context was modulated in children by the priming effect of homogeneous semantic context when a picture appeared for the first time in the block. An age-related difference also appeared in the size of the effects of name agreement and semantic context manipulations. In adults, several factors were associated with a lexical conflict effect reflected by an increase in reaction times in picture naming: multiple available names (versus just one available name, Kan & Thompson-Schill, 2004) and homogeneous semantic context (i.e. names from the same category, versus mixed semantic context, i.e. names from different categories, Schnur et al., 2006). Children in our study showed a higher conflict effect than adults for the semantic context manipulation and a similar or even smaller effect for the name agreement manipulation. The higher conflict effect for the context manipulation was expected based on earlier results showing protracted development of cognitive control abilities until adolescence (Davidson et al., 2006) and it can be accounted for by less effective cognitive control abilities of children. The smaller effect of name agreement manipulation in children was an unexpected finding. A potential explanation for the small name agreement effect lies in the differences between the mental lexicons of children and adults. We suggested at the end of our *Introduction* that children with SLI might have weaker connections between semantic nodes and subdominant words leading to weaker competition in the case of low agreement pictures. Our data did not support this prediction – as the effect of name agreement manipulation was comparable in children with SLI and in TD children – but this difference might be present between the lexicons of children and adults. Multiple available names might generate a smaller degree of conflict in children because the alternatives might have weaker connections with the semantic nodes: if a child uses *couch* for naming the couch, competing alternatives, like *squab* or *settee* might get less activation in children than in adults. This smaller level of conflict can be resolved even with less developed cognitive control abilities.

Although we cannot draw strong conclusions based on the comparison of conflict effects in different studies, these results suggest that conflict resolution processes are similar in children between 7;1 and 10;7 years and adults, although their efficiency might be different. Adult imaging studies with the same manipulations in picture naming tasks showed that brain areas associated with cognitive control are recruited for conflict resolution during word retrieval (Kan & Thompson-Schill, 2004; Schnur et al., 2006). Similarities between adult and child results in lexical conflict resolution suggest that general cognitive control processes are recruited in lexical conflict resolution of children as well. Systematic comparison of effects of name agreement and homogeneity on children and adults would be necessary to explore this question further, together with testing associations between general cognitive control abilities and lexical conflict resolution in children directly.

Our main aim in the current study was to explore the possibility that conflict resolution is especially difficult for children with SLI and their word retrieval problems can be partly accounted for by the impairments of conflict resolution processes. We expected that conflict manipulations will have a bigger effect in children with SLI than in TD children. Contrary to our expectations, conflict effects were similar in the SLI and TD groups, suggesting that lexical conflict resolution, at least when it involves semantic conflict, is not impaired in children with SLI, and thus lexical problems in SLI probably have other sources. This finding is in accordance with studies finding intact cognitive control abilities in children with SLI (e.g. Henry et al., 2012; Lukács, Ladányi, Fazekas, & Kemény, 2015; Noterdaeme, Amorosa, Mildenberger, Sitter, & Minow, 2001). Nevertheless, it should also be taken into consideration that the mental lexicons of children with SLI and TD children might be different leading to different levels of semantic conflict. If in SLI connections are weaker between semantic nodes and word representations as well as between semantically related word representations then the degree of conflict will be also smaller. Successful resolution of a smaller level of conflict might be achieved even if conflict resolution is impaired yielding similar performance patterns in SLI and TD.

Further studies are needed to investigate lexical processes and conflict resolution in SLI. The comparison of children with SLI with a vocabulary matched control group would be a fruitful line of future research: it would control for group differences in the present study potentially originating from differences between lexicon sizes of children with SLI and TD children. Previous work (Mainela-Arnold et al., 2008, 2010) found problems related to the inhibition of phonological representations in SLI, therefore the effect of phonological conflict on word retrieval should also be further investigated systematically. Another promising line of future research would be to study the effect of lexical conflict with a design or with a set of experiments that allows the investigation of facilitatory and inhibitory effects in a more targeted way together with directly examining the relationship between lexical conflict resolution and cognitive control.

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Appendix A.

Required answers for pictures of a mixed block: thumb, lemon, wardrobe, glass, doll, fan, wardrobe, thumb, doll, fan, glass, lemon, thumb, doll, fan, wardrobe, lemon, glass, lemon, fan, doll, wardrobe, thumb, glass.

Required answers pictures of a homogeneous block: lemon, strawberry, peach, cherry, apple, pear, apple, peach, pear, cherry, lemon, strawberry, peach, pear, cherry, lemon, strawberry, apple, cherry, peach, strawberry, apple, lemon, pear.

The categories of the homogeneous blocks: fruits, parts of the human body, electrical devices, furniture, toys, kitchen utensils.

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