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Orthographic analysis of words during fluency training promotes reading of new similar words

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Remediation of a serious lack in reading fluency often takes the form of repeated reading exercises. The present study examines whether transfer of training effects to untrained (neighbour) words can be enhanced by training with an orthographic focus as compared with emphasising semantics. The effect of oral versus silent reading during training is studied as well. Two groups of reading-disabled children (mean age = 7 years, 11 months) were given repeated reading training with limited exposure duration (350 ms) in which 15 target words were repeated 20 times in exercises focused on either orthography ($N = 26$) or semantics ($N = 25$). The children were required to either read the target words aloud or perform the exercises silently, but this requirement appeared to have no effect on the training results. The results show that untrained neighbour words benefited more from training targets with an orthographic focus than from exercises with a semantic emphasis.

Repeated reading is an effective technique for improving reading fluency (for an overview, see Chard, Vaughn & Tyler, 2002; Kuhn & Stahl, 2003). The positive training effects on reading speed and accuracy are hypothesised to be the result of either increased specification of the orthographic characteristics of a word or improved general decoding skills (van den Bosch, van Bon & Schreuder, 1995). Repeated reading training effects are claimed to be further enhanced by combining repeated reading with the use of limited exposure duration (Breznitz, 1997; Tan & Nicholson, 1997). The short presentation time may prevent the child from using an elaborate decoding reading style, promotes whole word reading and ultimately leads to improved reading fluency. Type of instruction can have an additional effect on training and transfer effects. For instance, high levels of fluency and large word-specific effects have been found when reading exercises were focused on the semantic properties of a word (Norbury & Chiat, 2000; Sandak, Mencl, Frost & Pugh, 2004). On the other hand, an explicit focus on the orthographic characteristics of a word might lead to higher levels of transfer compared with mere visual presentation of words (Benson, Lovett & Kroeber, 1997). Another factor that could influence repeated reading training effects is the type of response that the child is required to give. Instructing the child to read orally during repeated reading training could provide the reader with much-needed practice in relating orthography and phonology. The present study will examine whether repeated reading training and transfer effects can be enhanced by focusing specifically on orthography or semantics during training and whether reading aloud during training can have additional beneficial effects.

Frequency of repetition has been found to be related to increased fluency in reading (Meyer & Felton, 1999). As claimed by the self-teaching hypothesis (Share, 1995, 1999), each successful decoding opportunity will increase the likelihood of future successful reading of that particular word. Unfortunately, this means that the effects of simple repeated reading appear to be word specific (Lemoine, Levy & Hutchinson, 1993; Young, Bowers & MacKinnon, 1996; for an overview, see Wolf & Katzir-Cohen, 2001). The practical value of a training programme can be evaluated more positively if both word-specific training effects as well as generalisation occur. The question then remains as to how transfer of repeated reading training effects can be enhanced. Several experiments have pointed to the possibility that amount of transfer to untrained words is dependent on the focus of instruction (Benson et al., 1997; Lovett et al., 1994). An explicit focus on either the orthographic, semantic or phonological properties of a word during fluency training might have a positive influence on generalisation of effects. For instance, if the orthographic characteristics of a word are specifically trained and therefore highly recognisable to a child, generalisation could occur when an untrained word has similar orthographic features. Indeed, this hypothesis is confirmed by the results of Reitsma (1997), who demonstrated that repeated reading of neighbour words, which focuses children on orthographic similarities, improves reading of untrained but similar neighbour words in beginning readers. In this case, transfer of training effects is assumed to be dependent on the ability to draw orthographic analogies, a skill that has been found to be somewhat impaired in reading-disabled children (Humphrey & Hanley, 2004). However, generalisation of repeated reading training effects does not have to be restricted to neighbour words. In fact, several fluency training programmes that have specifically focused on teaching orthographic characteristics of words have been able to generate transfer effects to untrained and unfamiliar material (Benson et al., 1997; Lovett et al., 1994). These results lead to the hypothesis that reading training focused on orthographic characteristics of words improves general decoding skill.

Alternatively, previous experiments have demonstrated that intervention programmes addressing the semantic properties of words can have substantial word-specific training effects (Norbury & Chiat, 2000; Sandak et al., 2004). It could be expected that larger training effects would lead to larger transfer effects to similar neighbour words. In this case, semantic-based training should lead to more transfer to untrained neighbour words than training focused solely on orthography. However, this hypothesis again rests on the assumption that generalisation of training effects to untrained neighbour words by orthographic analogy is possible for reading-disabled children. Furthermore, the idea that semantic training could lead to better orthographic specifications than orthographic-based training appears counterintuitive. A study by Archer and Bryant (2001) demonstrated that training words in context does not lead to improved general word-reading skill, and thus generalisation, as compared with isolated word training. Finally, having knowledge about the meaning of a certain word does not support reading of unfamiliar words, simply because the orthography of a word is not consistently related to semantics. Thus, semantic training seems less likely to lead to larger transfer effects than orthographic-based training.

Children with dyslexia appear to have a general weakness in phonological skills, which causes the automatic decoding of words into phonemes to be poor (e.g. Georgiewa et al., 2002; Wesseling & Reitsma, 2001). Good phonological recoding is a prerequisite for creating word-specific orthographic representations (Dixon, Stuart & Masterson, 2002; Share, 1995, 1999; Sprenger-Charolles, Siegel, Béchennec & Serniclaes, 2003). Without well-specified orthographic representations, children with dyslexia remain dependent on elaborate and time-consuming decoding instead of a more efficient direct word-reading strategy. In other words, an inefficient ability to link orthographic and phonological material prevents reading-disabled children from reading fluently. Indeed, recent research has demonstrated that dyslexics are slow and inaccurate at learning a new relationship between spoken (pseudo) words and visually presented pictures (Mayringer & Wimmer, 2000; Messbauer, de Jong & van der Leij, 2002). Studies on rapid naming skills of children with dyslexia have also led to the idea that a subgroup of dyslexics are slow at linking visual and verbal material in general (Kirby, Parilla & Pfeiffer, 2003; Meyer & Wood, 1998; Wolf & Bowers, 2000). The disabilities of dyslexics in associating visual and verbal material are confirmed by fMRI studies that show reduced activation in posterior ventral and dorsal brain circuits during reading, areas that are critical in phonological and orthographic processing, respectively (Pugh et al., 2000; Shaywitz et al., 2002). Considering the evidence, it could be assumed that both the orthographic and phonological characteristics of a word can be underspecified to varying degrees in the mental lexicon of dyslexics, which in turn can lead to slow and inaccurate learning of the association between orthographic patterns and their phonological form. Exercises focused on improving the phonological and orthographic knowledge of words might therefore be an effective remediation tool for reading-disabled children.

One approach to activate explicitly orthography and phonology, and the link between them, is to require children to read out loud. The role of oral reading in remediation of reading disabilities is still questionable. Reading out loud demands active training in decoding from graphemes to phonemes, which is precisely the link that seems to be inefficient in children with dyslexia. Furthermore, reading out loud could be more effective than silent reading because two modalities are used during training, thereby increasing depth of processing (Elgart, 1978; McCallum, Sharp, Bell & George, 2004). Overall, it could be hypothesised that oral reading during training leads to increased ability in decoding from graphemes to phonemes and ultimately more specified orthographic and phonological representations of the words in the mental lexicon. Alternatively, especially in languages with a regular orthography, such as Dutch or German, the main task for dyslexics is to gain speed and not accuracy (Reitsma, 2004; Wimmer, Mayringer & Landerl, 1998). By focusing too much on articulation, less attention will be paid to the recognition of the orthographic pattern as such.

The American National Reading Panel (2000) concludes that reading out loud during training might not provide surplus value in the remediation of reading. No training studies have been reported in which an experimental contrast between oral and silent reading was made. However, it has been demonstrated that reading silently leads to faster reading times and can result in better comprehension of text compared with reading out loud (McCallum et al., 2004; Miller & Smith, 1990). On the other hand, this effect seems to be present only for poor readers. If reading silently is more efficient than oral reading in poor readers, it seems equally likely that the effects of word training could then also improve more. Apparently, the issue regarding the effects of type of verbal response is far from resolved.

To summarise, repeated reading training and transfer effects might be influenced by the type of training. Therefore, the present study will contrast the effects of semantic versus orthographic-based exercises. The hypothesis is that training orthography improves general decoding skill, whereas semantic training is mostly word specific. Additionally, a comparison will be made between the effects of oral versus silent reading during repeated reading training for poor readers. If oral reading leads to more efficient decoding from graphemes to phonemes, this type of training should lead to larger training effects of repeated reading for poor readers.

Method

Participants

Fifty-one grade 2 delayed readers from 13 regular elementary schools participated in the study (mean age = 7 years, 11 months, $SD = 4$ months). The children were selected according to their performance on a standard Dutch reading task, which required the participants to read as many separate words as possible within 1 minute (Een-Minuut-Test, Brus & Voeten, 1973). A child was included in the study if he or she were in the bottom 15% of their year group in terms of their performance on this test. As a result of this selection procedure, the children appeared to have an average reading lag of 7 months after 17 months of reading instruction. The participants did not have neurological or other physical difficulties (including problems in articulation) that could hinder the development of reading.

Four subject groups were created, while controlling for reading level ($F < 1$). Twenty-six participants performed the exercises focused on orthographic details either silently ($N = 13$) or by reading aloud ($N = 13$). The remaining children who trained with semantic-based exercises were also divided into two groups: silent training ($N = 12$) versus reading aloud ($N = 13$). Details on the performance of the subject groups on the standardised reading test are provided in Table 1.

Stimuli

The training consisted of the repeated reading of 15 target words. These one-syllable words consisted of a CVCC, CCVC, CCVCC or CCCVC structure and were of a reading level suitable for the reading skill of the participants. The words were concrete in meaning and part of the everyday vocabulary of the children at the start of the intervention. A list of 15 neighbour words was used as a control. These words were orthographically similar to the target words, but the first (10 words) or last letter (five words) was altered (e.g. *klas* and *glas*) to form a new word. A second control list was constructed, which consisted of words that had a structure similar to the target words

Table 1. Means and standard deviations for reading speed in seconds per word on the Dutch standardised reading test (Een-Minuut-Test, Brus & Voeten, 1973) for all four conditions.

	N	*M*	*SD*
Silent			
Orthographic	13	3.1	1.3
Semantic	12	3.1	1.2
Aloud			
Orthographic	13	3.3	1.6
Semantic	13	3.1	1.6

(e.g. CVCC), but did not resemble the target words orthographically or phonologically. All words were regular with respect to grapheme–phoneme correspondences. None of the neighbour or control words were used during training. An overview of the words used is given in Appendix A.

Procedure

After selection of the participants, a pre-test in paper format was performed. The children were asked to read a list of the 15 target words, neighbour words and control words, in alternating order. Accuracy and reading speed were registered by hand. Reading speed was recorded per list and thus not for each individual word.

Once the pre-training reading level of the words was established, the children used a computer to practise reading independently the 15 target words. Individualised instruction in using the programme was given in a practice session consisting of five items. The instruction was followed by 10 training sessions, with a frequency of three sessions a week. Each training session consisted of 30 items in which the target words were repeated twice per session. Therefore, the target words were repeated 20 times during the entire training.

Training of the target words was either focused on orthographic or semantic characteristics of the word. Two types of orthographic training were used. The children were presented either with a letter cluster (e.g. *nd*) or with two whole-word patterns (e.g. *hond hont*). Once the child finished inspecting the stimulus, they clicked a mouse button after which the first stimulus (the 'prompt') disappeared from screen. Subsequently, presentation of the target word (e.g. *hond*) followed. The child had to decide either whether the letter cluster was present in the target word or whether the target word was one of the two earlier presented word patterns. The incorrect orthographic prompt items were constructed by alternating the position of two letters in the target word or by substituting a letter with another visual or phonologically similar letter (v/f, s/z, etc.). The prompt items could be either existing words (e.g. *stok*), pseudo-words (*stor*) or non-words with illegal orthographic patterns (*sotk*). However, the prompt item was always orthographically similar to the target item. Thus, even the negative ('no') items had to be analysed carefully in order to give a correct answer. An important consideration is the fact that the initial prompt can also contain (parts of) the target word. For instance, children are presented with the target word twice in the correct whole-word pattern items (e.g. *hond hont* → *hond*). Thus, because a quarter of the exercises involved correct whole-word pattern items, the target word is actually seen 25 times during the entire orthographic training.

There were also two types of semantic training that were presented in varying order. As a first stimulus, either a question (e.g. *can it fly?*) or a word (e.g. *egg*) was presented on screen. Next, a mouse click caused the first stimulus to disappear and the target word (e.g. *bird*) to appear in the centre of the screen. Finally, the child was asked to answer the question or to indicate whether the first stimulus and the target word were semantically related by clicking with the mouse cursor on the correct answer on screen. The semantic relationship between the prompt and target word was either obvious or completely absent. Thus, although specific analysis of the orthography was necessary in order to identify the word, the exercises did not require excessive higher order reasoning.

For all forms of exercises, a response was given by using the mouse cursor to click on either the 'yes' or 'no' button that was displayed on screen. The type of trials and the order of 'yes' and 'no' answers was semi-randomised and balanced in the training sessions to prevent predictability in responding. Full randomisation was not considered suitable, because immediate repetition of a target word could then occur, possibly leading to priming effects. The target words were presented using a limited exposure duration of 350 ms and were followed by a visual mask consisting of non-letter symbols. The subject was instructed to read the target word either out loud or silently. Prior experience with the computer programme in our lab had demonstrated that the children normally do not read orally during the training. To ascertain oral reading, the experimenter monitored the children during the course of the training programme, and stimulated the children to read aloud when necessary. Accuracy feedback was given during training in the form of a picture of a smiling bear (correct answer) or a picture of a sad-looking bear (wrong answer).

After completion of the final session, the children received a post-test and, a month after training had finished, a retention test. On both occasions, the three word lists with the target, neighbour and control words were consecutively administered. The word order of the lists was mixed to prevent order effects in testing. Reading speed and accuracy were again registered by the experimenter.

Results

The average proportion correct and the mean reading speed per word in each condition on the pre-test, post-test and retention test are presented in Table 2.

As can be seen in this Table, the *accuracy* is overall relatively high: about 90%. An analysis of variance with repeated measures for Time of measurement (pre, post and retention) and Type of word (target, neighbour or control) as within-participants factors,

Table 2. Means and standard deviations (italics) for percentage accuracy and reading speed in seconds per word of the target, neighbour and control words on the pre-test (1), post-test (2) and retention test (3) for all four training groups (conditions).

Time	Semantic						Orthographic					
	Silent			Aloud			Silent			Aloud		
	1	2	3	1	2	3	1	2	3	1	2	3
Accuracy												
Target	88	94	91	90	95	95	91	93	94	90	96	94
	9.4	*6.9*	*9.2*	*14.6*	*7.9*	*4.8*	*8.8*	*8.2*	*10.0*	*8.9*	*4.4*	*7.6*
Neighbour	87	83	81	87	87	87	91	89	90	86	91	89
	12.2	*10.8*	*10.2*	*15.2*	*13.7*	*11.5*	*8.8*	*10.3*	*5.9*	*14.3*	*9.3*	*8.8*
Control	86	86	82	84	84	91	93	90	92	92	87	86
	13.0	*14.2*	*10.4*	*18.6*	*16.2*	*9.2*	*8.4*	*8.0*	*7.8*	*7.3*	*11.6*	*12.9*
Speed												
Target	2.0	1.2	1.2	2.1	1.1	1.1	2.0	1.2	1.2	1.9	1.3	1.4
	0.9	*0.6*	*0.7*	*1.2*	*0.7*	*0.7*	*0.9*	*0.7*	*0.7*	*1.0*	*0.6*	*0.8*
Neighbour	2.7	2.2	2.2	2.8	2.4	2.2	2.7	2.2	2.2	2.7	2.2	2.3
	1.0	*0.9*	*1.1*	*1.0*	*1.1*	*1.0*	*1.0*	*0.9*	*1.1*	*1.1*	*1.1*	*1.2*
Control	2.4	2.1	1.8	2.2	2.2	1.7	2.4	2.1	1.8	2.1	1.8	1.8
	1.5	*1.0*	*1.0*	*1.1*	*1.2*	*0.9*	*1.5*	*1.1*	*1.0*	*0.9*	*0.9*	*1.0*

and Type of training (orthographic or semantic focus) and Type of response (aloud or silent) as between-participants factors was conducted. The results of this analysis revealed a main effect for Type of word, $F(2, 94) = 19.18$, $p < .001$; $\eta_p^2 = .29$. Contrast analyses showed that target words were read more accurately than both the neighbour, $F(1, 47) = 31.00$, $p < .001$, $\eta_p^2 = .40$, and control words, $F(1, 47) = 20.3$, $p < .001$, $\eta_p^2 = .30$. The neighbour and control words do not differ with respect to accuracy ($F < 1$). Furthermore, an interaction effect appeared to be significant between Type of word and Time of measurement, $F(4, 188) = 3.17$, $p < .05$, $\eta_p^2 = .06$. Contrast analyses clarified that the improvement in accuracy on the target words is larger than the improvement on both neighbour words, $F(1, 47) = 6.02$, $p < .05$, $\eta_p^2 = .10$, and control words, $F(1, 47) = 9.46$, $p < .01$, $\eta_p^2 = .19$. The neighbour and control words do not differ with respect to improvement in accuracy. No further significant effects were obtained on analysing the accuracy data.

As the data in Table 2 indicate, the average *reading time* during the pre-test is generally well above the 2 seconds. For all types of words, a decrease in reading time is observed from pre to post and retention test, but it is clear that the decrease in reading times for the targets is substantial. An analysis of variance with repeated measures on Time of measurement (pre, post and retention), and Type of word (target, neighbour or control) as within-participants factors, and Type of training (orthographic or semantic focus) and Type of response (aloud or silent) as between-subjects factors was conducted on the reading times. A main effect of Time of measurement appeared, $F(2, 94) = 68.25$, $p < .001$; $\eta_p^2 = .59$, indicating that in general the children have improved their reading speed. Also, a main effect of Type of word was found to be significant, $F(2, 94) = 133.10$, $p < .001$; $\eta_p^2 = .74$, which was qualified by a significant interaction effect between Type of word and Time of measurement, $F(4, 188) = 9.55$, $p < .001$; $\eta_p^2 = .17$, and even a further interaction effect between Type of word, Time of measurement and Type of training, $F(4, 188) = 2.41$, $p = .05$; $\eta_p^2 = .05$. This latter interaction effect was explored with contrast analyses. First, an interaction effect between Type of word, Time of measurement and Type of training was only significant for the contrast between the pre- and post-test, $F(2, 98) = 3.21$, $p = .04$; $\eta_p^2 = .06$, and not between the post and retention test, $F(2, 98) = 1.54$, $p = .22$; $\eta_p^2 = .02$.

The decrease in reading time from pre- to post-test for each type of word and type of training is shown in Figure 1. Within-participants contrast analyses showed that targets and neighbour words in the orthographic condition showed a similar gain in reading speed, whereas the gain for neighbours was significantly higher than the gain for control words, $F(1, 25) = 7.64$, $p < .05$, $\eta_p^2 = .23$. In the semantic condition, a significant difference appeared between targets and neighbours, $F(1, 24) = 6.41$, $p < .05$, $\eta_p^2 = .21$, and also between neighbours and control words, $F(1, 24) = 6.09$, $p < .05$, $\eta_p^2 = .20$. Between groups, contrasts for each type of word revealed no significant effects.

Discussion

The present study examined the effects of orthographic versus semantic focus and type of verbal response during repeated reading training in order to improve fluency. The results indicate that repeated reading improves the reading skill of target words. Even though the children were already fairly accurate at the start of the intervention, the increase in reading skill was evident for both accuracy and reading speed of the target words. The

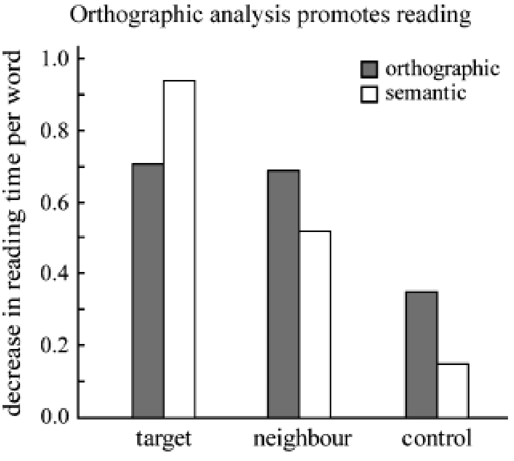

Figure 1. Difference in reading time from pre-test to post-test on the three word lists as a function of type of training.

decrease in reading times was the greatest when targets were practised in exercises with a semantic focus. Furthermore, when the exercises were focused on orthography, gains in reading speed on the target words were accompanied by a similar gain for untrained neighbour words. The significant training effect of repeated reading appears to be uninfluenced by verbal response: similar training effects are reached with oral compared with silent reading.

The results of the current study clearly indicate that repeated reading training effects could be influenced by focusing the child on orthographic or semantic properties of words. As was expected, orthographic training provided the children with the opportunity to generalise word-specific knowledge to untrained neighbour words. This finding suggests that the children in the current sample were able to benefit from drawing orthographic analogies, as long as the children were specifically focused on the orthographic characteristics of the target word. Humphrey and Hanley (2004) have demonstrated that children with dyslexia have difficulties with drawing orthographic analogies. These authors further hypothesise that this disability could be one of the main reasons why dyslexics find learning to read so difficult. However, our results suggest that the inability to draw orthographic analogies might only be a symptom of underspecified orthographic representations of words in the mental lexicon. Repeated reading of words helps to improve this specification and, as was demonstrated previously by Reitsma (1997), focusing children on specific orthographic elements of a word leads to more detailed word-specific orthographic representations in the mental lexicon. Because orthographic training yields more detailed word-specific orthographic knowledge compared with semantic training, there is a firm basis to mentally draw orthographic analogies to untrained neighbour words. Training and transfer effects might even be enlarged if groups of neighbour words were trained instead of single words. Not only would the child learn more detailed knowledge about the orthography of words, but a specific focus on similarities between words could promote further orthographic analogies.

The results of the present study further indicate that reading out loud during fluency training does not lead to larger improvements in reading fluency compared with silent reading. Oral reading is generally more accurate but slower than silent reading (McCallum et al., 2004). This slower reading speed during training, however, does not appear to hinder the establishment of increased fluency in reading. It was previously hypothesised that oral reading might be less effective for improving reading fluency, because too much attention would be directed at phonology and less resources would remain for the analysis of the orthographic pattern of a word. As increased fluency is the result of a more efficient reading strategy, focusing on the separate graphemes of a word instead of patterns of letters could be counterproductive. However, in order to access the phonology of a word in reading, the analysis of orthography of a word is mandatory. Thus, whether a child is reading orally or silently, the orthography of a word is always activated first and remains to be activated until a word is decoded completely and identification has occurred.

Some researchers claim that activation of phonology is automatic for more able readers, regardless of whether words are read aloud or silently (Booth, Perfetti & MacWhinney, 1999; Folk, 1999; Luo, Johnson & Gallo, 1998). This effect might explain the lack of difference in results between reading out loud or reading silently during training, because phonology would be activated regardless of vocalisation. Overall, the present study demonstrates that actively involving phonology by reading aloud is not necessary in gaining in fluency. Obviously, even though the present study did not find a difference in training effects following either oral or silent reading, these results do not indicate that remediation based on activation of phonology is ineffective. On the contrary, reading orally might be effective during the very early stages of learning to read (or for less regular languages) when grapheme–phoneme links still have to be established. Previous experiments have indeed found a positive effect of training phonology and phonological awareness on early reading (for an overview, see Ehri et al., 2001). However, although specification of the phonological characteristics of a word might be important in gaining accuracy in the beginning of learning to read, the current study shows that fluency in reading results from more frequent exposure to the orthographic pattern as such, irrespective of reading out loud or silently.

In conclusion, repeated reading is an effective and valuable method for increasing the fluency of word reading. A particular focus on the semantic characteristics during training will lead to large word-specific improvements in the reading speed of target words. On the other hand, training focused on orthographic properties of words seems to yield higher levels of generalisation to untrained orthographically similar words.

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Appendix A

Table A1. Overview of words.

Target	Neighbour	Control
kalf	half	kerk
brug	brul	trap
krant	krans	klomp
tong	long	hand
prik	pril	stil
wolf	golf	kust
drop	krop	pret
ring	ding	bank
klas	glas	fris
straat	straal	spreek
spons	slons	glans
jurk	kurk	lang
feest	beest	baard
woord	boord	buurt
bloem	bloed	spier