Colourless Ideas can still be Green:

The Mental Lexicon and Synaesthesia

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Table of Contents

1. Introduction

Words are a large part of a language. Speakers need them to be able to make themselves understood. The connection between a word, either spoken as a string of phonemes or written as a string of graphemes, and the mental concept it represents is often arbitrary. All the words people know are stored as mental representations in the brain, in the so-called mental lexicon. There are still many unanswered questions as to the exact structure of the mental lexicon. To date there has been little agreement on how words are stored in relation to one another and whether the mental lexicons of monolingual and bilingual speakers differ. In order to be able to speak an utterance, the speakers need to retrieve the desired words from that mental lexicon, but the underlying mechanism is still a mystery. Insight into the mechanism and structure of the mental lexicon can provide more information on language processing, language acquisition and also on suitable treatments for patients who suffer from language deficits. Therefore, research on the structure of the mental lexicon is important.

Language phenomena are often researched through participants in whom language is processed differently from the majority of the population, such as in aphasics. Another interesting phenomenon that may be useful for looking at language processing is synaesthesia. In people with synaesthesia, language does not only trigger the meaning of a word or concept when a word is perceived, but also triggers an external, non-standard concurrent, such as a colour or flavour. A pattern in a synaesthete's perception may reveal some details on the working of the mental lexicon. In this experiment we will aim to find patterns in perceptions of synaesthetes and try to formulate their implications for the structure of the mental lexicon.

2. Theoretical framework

2.1 The mental lexicon

Language is stored in the brain, but there is still much discussion about where and how exactly. In the majority of the population, language is located in the left hemisphere (Widmaier, Raff and Strang, 2008, p. 247). Different aspects of language are located in different parts of the brain and all have their own specific tasks, for example processing visual or audio input (Widmaier et al., 2008, p. 247). The exact area that is used to process language differs between men and women, which could indicate that they have a different approach to tackling language (Widmaier et al, 2008, p. 247). Our number of participants nor our method are sufficient to provide information about the exact area in the brain where the mental lexicon is located, but they may provide insights or suggestions for future research.

There are indications that there are several ways in which a brain can activate information, but research into the issue is still on-going (Widmaier et al, 2008, p. 245-6). One of the current theories on the mental lexicon is the neural network theory. In this theory, the mental lexicon is regarded as any other memory and is organised in neural networks. This means that the conceptual representation of words is located in a specific part of the brain and has neural connections to other areas of the brain, e.g. visual and audio processing areas. Neural networks are necessary to maintain memories in general, but their structure is different for long-term and short-term memories (Widmaier et al, 2008, p. 245-6). The type of memory that is important for the mental lexicon is "[the] declarative memory, which is the retention and recall of conscious experiences that can therefore be put into words" (Widmaier et al, 2008, p. 245-6). It is likely that in synaesthetes, the neural network has an extra link to an area that non-synaesthetes do not have a connection to. There are several theories on how the extra connection came into place and how it works exactly. Some researchers believe it has to do with a lack of disinhibition when a stimulus triggers a percept, but others believe it is caused by new activation by the percept itself (Hubbard, 2013, p. 477-9).The idea that the mental lexicon is part of a neural network is supported by neurologists, who usually discuss networks of activity, rather than areas of the brain. This activity can be visualised through imaging techniques such as fMRI (Aitchison, 2012, p. 48).

There are several theories on the structure of the mental lexicon, but linguists do not agree on which one is the most likely. Most earlier theories can be categorised as either "atomic globule theories" or "cobweb theories" (Aitchison, 2012, p. 90-1). In the atomic globule theory words are constructed by atoms that carry a part of a word's meaning or associations with the particular word. Some of these atoms may be shared with other words, and that is how words relate to each other (Aitchison, 2012, p. 91). For example, *lady-bug* may contain the atoms for *red* and *insect*, and share the *red* atom with *fire truck* and the *insect* atom with *fly*. In the cobweb theory, the mental lexicon is represented by a cobweb, and words are dots on the intersections of the threads. The links in between words are made up by the associations an individual has between the words (Aitchison, 2012, p. 91). In this theory, the word *lady-bug*, for example, would have threads connecting it to the words *fly* as a whole, but not necessarily with *fire truck*, because people do not associate *lady-bug* with this word. Supporters of this theory see words as single units, not as items with several features, which connect to other words (Aitchison, 2012, p. 91). Synaesthetes' perceptions could shed light on these theories if their perceptions are semantically based. If words that are semantically related, such as *lady-bug* and *insect*, are perceived with the same or similar colours, it would provide support for the cobweb theories. If words that only share a small part of their semantic content evoke similar colours for synaesthetes, such as *lady-bug* and *fire truck*, that would point into the direction of the atomic globule theories. This investigation will not look too deeply into the cobweb or atomic globule arguments, but may provide indications for further research into the matter using perceptions of synaesthetes.

The debate on whether the mental lexicons of the two languages of bilinguals are separate or overlapping is still ongoing. Marian, Spivey and Hirsch (2003) discuss the wide range of views and ideas by looking at the differences in methodologies and participants (p. 70-1). Researchers often use different imaging techniques to analyse brain processes and investigate language in participants with a wide range of language impairments, such as aphasia patients. Some research claims “distinct non-overlapping cortical representations of the two languages in bilinguals” (Marian et al. 2003, p. 71). Experiments that provide support for this claim involve language in multilingual aphasic patients, focussed on “cortical stimulation”, or observed “different Event Related Potential (ERP) patterns of first language processing of bilinguals and monolinguals” (Marian et al., 2003, p. 71). On the other hand, other research indicates overlap in cortical representations. Research supporting this vision of the location of the bilingual mental lexicon in the brain is carried out with bilingual participants and often involves PET or MRI imaging (Marian et al., 2003, p. 71). Yet other scientists have concluded that there is a mix of indications for overlapping and non-overlapping mental lexicons in their results when researching the lexicons of bilinguals (Marian et al., 2003). The tests used often required bilingual participants who were asked to perform tasks using both languages, either simultaneously or separately (Marian et al., 2003, p. 71). One of the latest models that espouse this last view is the Modified Hierarchical Model (Marian, 2009, p. 147-8). In this model there is a conceptual store that consists of three parts: L1-specific categories, shared categories, and L2-specific categories. The L1 words and L2 words are both connected to their respective parts of the store, but transfer from L1-specific categories to L2 words and from L2 specific categories to L1 words is also possible, as is transfer from L1 words to L2 words. The language specific parts of the conceptual store are included because there are concepts that are referred to by words that only exist in one of the languages, such as the Dutch word *gezellig* in Dutch-English bilinguals. The shared categories are added to accommodate concepts that are expressed by words in both languages. If this theory is correct, it is important to make sure that the test items chosen in the current study are all concepts that are shared by both languages and almost completely overlap, because if synaesthetes' perceptions are based on semantics, concepts for which one language has a single word and the other does not could influence participants' performance.

2.2 Synaesthesia

The investigation of synaesthesia is a relatively young discipline, although the first study on the subject was carried out in the early nineteenth century by Georg T. L. Sachs. Today, many disciplines of science, such as psychology and neuroscience, are interested in synaesthesia, which caused a renaissance of the research in the last decades. Synaesthesia is a condition of which 61 different variants have been established so far and there are perhaps more variants still undiscovered. The variant that is most common is grapheme-coloured synaesthesia, in which colours are evoked by visual stimuli of written words, letters and numbers. The stimulus by which a synaesthetic experience is evoked is called the trigger, or inducer. The experience itself is called the concurrent.

Simner (2012) states that there is no universal definition for synaesthesia. However, she proposes that synaesthesia is not always a sensory condition. She proposes that although in many cases the synaesthetic concurrent is experienced after visual input, the actual trigger for the experience is the cognitive representation of the input. The form of synaesthesia we are focussing on includes colours, tastes and scents which are perceived due to a linguistic trigger. Simner notices that in most grapheme-colour variants of synaesthesia, letters recall the same colour regardless of visual features such as font, boldfaced or not, uppercase or lowercase (Simner, 2012). This shows that it is not the actual visual input that determines the synaesthetic experience, but the mental representation of that input (Simner, 2012).

A thing all forms of synaesthesia share is invariability. This means that every trigger evokes one and only one concurrent that is consistent every time the trigger is processed (Simner, 2012). According to Simner (2012), if any variability is detected in a person's concurrents, this person cannot be diagnosed with synaesthesia, and therefore cannot participate in experiments investigating this phenomenon. Genuine synaesthesia can be determined by so-called "consistency tests" (Simner, 2012, p. 7), which usually exist of two sessions. In the first session of the consistency test, the participants are asked for their experienced concurrents evoked by various triggers. The second session, which usually takes place after a few months, includes the same triggers that were used in the first session, which enables the experimenter or the computer program to see how the responses relate to each other. In most studies, a control group is involved in order to establish whether the outcomes of the presumed synaesthetes are significantly different. Asher et al. (2006) investigated consistency scores for both synaesthetes and non-synaesthetes. The synaesthetes involved were 57.2-85.3% consistent with a mean of 71.3%, and the non-synaesthetes were 14-52.3% consistent with a mean of 33% (p. 143).

Simner, Glover and Mowat (2006) state that grapheme-colour synaesthesia is thought to be the most common form of synaesthesia (p. 281). They investigated what linguistic aspect of a word is the actual trigger for the synaesthetic experience, and propose that "[s]ynaesthetes often report that the colour of each grapheme is apparent in the word overall, but that the word's colour is dominated by a particular grapheme (or graphemes) whose colour appears as the most prevailing" (p. 281). In the grapheme-colour variant, the first consonant or vowel in a word is often said to contribute most to the induced sensation. In addition, stress might be a factor in the involuntary determination of which colour is perceived. A distinction that can be made is between consonants and vowels as triggers. A synaesthete either perceives colours triggered by consonants or by vowels. Then, the influence of the stress pattern can be estimated for both subtypes. Simner, Glover and Mowat found that stress is important mostly when the induced word colour is evoked by vowels. In this case, the stressed vowel is the most important one in the word, followed by the vowel that appears first. If the stressed vowel is also the first vowel of the word, it is extremely dominant. When the synaesthetic colour is triggered by consonants, the initial consonant is particularly dominant and stress plays a less important role. As Simner, Glover and Mowat (2006) point out, “the influence of stress on word colouring holds equally with written and spoken stimuli, but (…) colour naming proceeds more quickly in the former” (p. 286). This suggests that even in the processing of written stimuli, stress patterns play a role. Therefore, it can be taken into account as affecting the synaesthetic concurrent experienced.

2.3 Reaction time in visual word presentation

In order to be able to comprehend language, people need to access words, or lexical entries, in the mental lexicon. The rate with which people make decisions about whether the presented string of letters represents a word is often measured by a lexical decision task (Harley, 2010, p. 146). In a lexical decision task, people have to press one button as fast as possible when they believe the presented word represents a word in their language, and another button when they believe the presented word does not exist in their language (Harley, 2010, p. 146).

Whaley (1978) studied the time it takes to identify a string of letters as a word or a nonword. He found that the average classification time for words was 597 ms and for nonwords 689 ms (p. 148). Harley (2010) states that the average time required to recognise a word is 333 ms (p. 151). However, this is solely the time to recognise a word, and it does not incorporate the additional time needed to react to it. According to McLeod (1987), average visual reaction times are approximately 200 ms. When the visual reaction time is added to the word recognition time, the outcome of Whaley's investigation of 597 ms is approached. Swinney (1979) measured reaction times in the range from 641 to 664 ms (p. 649).

Whaley proposed that multiple factors could influence the time which appeared to be necessary for the identification of a word or a nonword. For words, these factors include "word length in letters (…) and the frequency of first and last letters of the word", and for nonwords these factors include "the presence of vowels in the non-word string (…) and by whether or not the phonological representation of the nonword approximates that of a real word" (p. 144). In addition, according to Rubin, Becker and Freeman (1979), morphological structure may affect reaction times in a lexical decision task (p. 764). Pyllkänen and Marantz (2003) claim that there is an effect due to the number of words that sound and/or look like the stimulus, which is called the "neighbourhood density" (p. 186). They found that "high probability/high density stimuli elicited significantly longer reaction times than low probability/low density stimuli" (p. 187). Due to limitations of time and materials, only a selection of the above effects could be investigated in the current study. The stimuli used in the lexical decision task in the present study consist of monosyllabic and monomorphemic words. The nonwords all approximate existing words with respect to their form. They all contain vowels and were formed accordingly to the rules of English syllable formation.

Monosyllabic and monomorphemic words facilitate the recognition process with respect to polysyllabic and polymorphemic words. We hypothesise that synaesthesia can facilitate the recognition process as well. Shams and Seitz (2008) state that "multisensory exposure can result in superior recognition of objects compared to unisensory exposure" and that some forms of "synaesthesia can provide a superior memory capacity" (p. 414). One of our participants mentioned that she could easily memorise long wordlists in secondary school because of the synaesthetic concurrents she experienced, which functioned as a mnemonic aid. If synaesthesia can help people remember things more easily, then perhaps it can help them to access lexical entries, which essentially are part of the memory system, more easily as well. We hypothesised that in the lexical decision task, the reaction time required to identify a word as an existing one will be shorter for synaesthetes when that particular word is presented in the congruent colour.

3. Method

3.1 Participants

Our experiment involved a test group consisting of three synaesthetes and a control group consisting of five people who did not have synaesthesia. All participants are named by their initials, for privacy reasons. The three synaesthetes participated in our pilot study in September 2013 and agreed to participate a second time. Two of them were male and one was female. The males were 25 and 64 years old and the female was 24 years old. All three synaesthetes have a degree in higher education and claim to use English daily. One of the participants is a retired secondary school teacher of English.

The control group consisted of two males and three females. The male participants were 22 and 27 years old and the female participants were 21, 22 and 52 years old. All control group participants are native speakers of Dutch who claimed to have come into contact with English for the first time at an early age: participant C1 was two or three years old and C4 was 12 years old, the others were in between these ages, as shown in Table 1. All control group participants are either studying at university or have graduated from a university of applied sciences. Additionally, they all claimed to use English every day, or at least often. This has led us to believe that they can be considered bilingual speakers of both Dutch and English at least an intermediate level.

Participant	Age	Age of first contact with English	Education	Frequency of use of English in everyday life	Gender
C1	21	2-3	Higher education	Daily	Female
C2	52	6	Higher education	Daily	Female
C3	22	8	Higher education	Daily	Male
C4	22	12	Higher education	Daily	Female
C5	27	10-11	Higher education	Daily	Male
S1	25	7	Higher education	Often	Male
S2	64	Unknown	Higher education	Daily	Male
S3	24	11	Higher education	Often	Female

Table 1. Basic information about all participants.

To establish consistency of their perceptions, all participants filled in a questionnaire. This questionnaire can be found in Appendix A. The three synaesthetes first filled in this questionnaire in September 2013 when we were conducting the pilot study for this investigation. Their second time was in February 2014. The participants who were part of the control group filled in the questionnaire for the first time in early February and for the second time in March 2014. The questionnaires were sent by email and we requested that they would be returned by email as well. One of the participants, S3, has both grapheme-colour synaesthesia and lexical gustatory synaesthesia. Therefore, we have two separate data sets for S3. As expected, the control group scored very low on consistency. Only 10 to 50 per cent of the Dutch words and 6.7 to 66.7 per cent of the English words received the same perception responses on both tests. The synaesthetes had higher scores on average. S1 scored 56.7 per cent full matches and 20 per cent broad matches for his English words and 45 per cent matches and 35 per cent broad matches for his Dutch words. Participant S2 did not hand in a second questionnaire due to personal circumstances. Therefore his scores could not be calculated, but we concluded from the interview we conducted before he took the computer tests that his synaesthesia was most likely genuine. Participant S3 was more consistent in her lexical-gustatory perceptions than in her grapheme-colour ones. Her lower scores for grapheme-colour consistency is due to the fact that in most cases her flavour perception is more prominent and therefore she only filled out her flavour perceptions, because we asked the participants to fill out their initial perceptions. For 60 per cent of the Dutch words and 66.7 per cent of the English words she perceived the exact same flavours. For 25 per cent of the Dutch words and 23.3 per cent of the English words she experienced the same colours, and for respectively 20 per cent and 0 percent her perceptions broadly matched. Information about all participants and their perceptions can be found in Table 2.

Participant	Dutch Words n=20				English words n=30			
	Match	Broad Match	Mismatch	No percepion	Match	Broad Match	Mismatch	No percepion
C1	15	15	30	40	10	10	23.3	56.7
C2	50	15	35	0	66.7	10	23.3	0
C3	40	25	30	5	33.3	20	46.7	0
C4	20	10	35	35	6.7	0	6.7	86.7
C5	10	0	55	35	13.3	0	20	66.7
S1	45	35	15	5	56.7	20	16.7	6.7
S2	-	-	-	-	-	-	-	-
S3a	25	20	25	30	23.3	0	6.7	70
S3b	60	20	5	15	66.7	3.3	10	20

Table 2. Results for the synaesthesia test in percentages. There were 20 Dutch words and 30 English words involved. S3a represents the results gathered with the grapheme-colour variant and S3b represents the results gathered with the lexical gustatory variant.

3.2 Materials

Three tests were developed in the Phonetics Lab of the UiL OTS at Utrecht University. All participants except S2 took their tests on a computer at the UiL OTS using the computer program Zep (Veenker 2014). Participant S2 could not come to the laboratory in Utrecht due to physical conditions, so we visited him at his house. With the exception of participants S2 and S3, the tests were taken in two sittings. During the first sitting, participants performed the first task and during the second sitting they performed the other two. The participants were not paid for their participation, but they did receive a small present worth a few euros afterwards, which they did not know about beforehand.

3.3 Experiments

3.3.1 Primary synaesthetic experiences

In the first experiment, the participants were presented with 100 test items. These items were shown individually and sequentially. At the bottom of the screen, 16 colours were presented. For each item, the participants had to pick the colour that matched their synaesthetic experience or the colour that approached their experience the nearest. There was also a comment box in which participants could elaborate on their picked colour. Participant S3 has both grapheme-colour synaesthesia and lexical-gustatory synaesthesia, so she wrote down the flavours she experiences in a comment box as well as choosing a colour from the colour picker.

3.3.2 Priming task

The second experiment had the same design as the first experiment. However, the test items only partly corresponded to the test items used in the first experiment. We wanted to investigate whether the colours synaesthetes experience for certain words could be manipulated when a primed item is shown directly prior to these words. The test item KING, for example, primes the semantic related word QUEEN and the phonological related word RING. These three words then form two pairs, QUEEN-KING and RING-KING. For both pairs, the participants had to pick the colour they perceived for KING. When the participant sees the QUEEN-KING pair, the semantic meaning of king will be more prominent and when the participant reads the RING-KING pair, they will focus more on the phonetic and orthographic features of KING. We hypothesised that KING in the different pairs would evoke different shades or perhaps even different colours. If there is a clear pattern in the matching or mismatching of the colours, that could indicate the relation between semantic and phonetic/orthography and synaesthetic perceptions. During the test, the pairs were randomly presented, so words containing the same word of focus did not succeed each other.

3.3.3 Lexical decision task

The third experiment had the form and layout of a Stroop test (Stroop, 1935). Usually, the presented words in a Stroop test are colour names which are printed in a congruent or incongruent colour. In most Stroop tests, with non-synaesthetic participants, the used colours are only red, green and blue, so, for example, the presented word red could be printed in red, green or blue. The participant needs to name the colour in which the word is printed. Sometimes, the words are other words than colour names, but the words have a natural association with a particular colour, for example, grass has a strong natural connection with the colour green. That colour is then the congruent colour. It has been shown that participants were faster in naming the print colour when it was a congruent colour than an incongruent one (Schmidt et al, 2013, p.130-131).

In a previous Stroop test case study concerning a synaesthete, Bergfield Mills, Boteler and Oliver (2010) used a Stroop test on a synaesthete because "only the [synaesthetic] experience itself, the end result of the process is a conscious experience, therefore they do not seem to interfere [with normal language processing]. A Stroop test could cause this interference". This study by Bergfield Mills et al. (2010) involved only one participant with a very strong and specific type of synaesthesia that was especially strong for digits zero through nine. She was asked to perform two tasks on two separate occasions. In the first task, print colours had to be named. These colours either matched or mismatched the colours of synaesthesia for this specific participant. In the second task, the participant uttered the word that corresponded with a given digit and these digits were presented in either the synaesthetic colour, or a mismatching colour. The experiment had four conditions: mismatched, matched, black digits, and coloured circles instead of digits. Bergfield Mills et al. (2010) proposed and confirmed three hypotheses: the first is that the participant would be slower in naming colours that do not match her synaesthesia than those that do. The second hypothesis is that participant's naming time for matching print and synaesthesia colours the reaction time should be the same as the Black Digit condition and the Circles condition. The last hypothesis states that she would be slower for naming the digits corresponding with the colours of the circles, because synaesthesia only works one way.

In our third experiment, we asked participants to perform a similar kind of Stroop test combined with a lexical decision task. Both non-words and existing words were presented and the participants had to make a decision as fast as possible about whether the presented string of letters represented an existing English word or not. One third of the data acquired in the first task were used in this experiment. The words were presented in three conditions: congruent, incongruent or black coloured print. In the congruent condition, the colour presented matched the colour that the participant had reported to experience during the first task. The incongruent colour was the colour opposite in the colour spectrum to the congruent colour. The black colour print served as a neutral condition. Our interest was if the reaction time necessary for recognising the test items and making the lexical decision was affected when a test item was presented in the colour the participant picked earlier in the experiment. We hypothesised that congruent colours reduce the reaction time, incongruent colours would increase the reaction time and reaction for words printed in black would fall in between the other two.

3.4. Analysis

The analysis of the results consisted of two parts. Firstly, we looked at patterns within the perceptions of individual participants and secondly we looked at patterns in the perceptions of all participants for single words. We were looking for matches or broad-matches in the perceptions. In the first experiment, results were categorised as a match when at least four out of five control group participants or two out of three synaesthetes perceived the same colours for a word or when a participant perceived two out of three words that start with the same phoneme in the same colour. In the second experiment, we only looked at matches within the data sets of each participant. When the colours were not the same but very similar, the perceptions were categorised as broad-matches. Similar colours were defined as colours that would be close to each other on a pencil case, as the design of the colour picker was a pencil case design. This means that different shades of one colour are similar, e.g. denim blue and light blue, but also colours that would be next to each other on the box, such as shades of green and blue, orange and yellow, and pink and red. All data were processed manually, as our data were not sufficient to produce significant results when using MANOVA. All test items were categorised by their initial letter, or phoneme in the case of category Y. A full list of all categories and they items they contain can be found in Appendix B. In the first experiment we looked at perceptions of participants per category, but we also looked at the test items themselves, because some test items evoked the same or similar colours across participants. The results of the third experiment were analysed in the program SPSS through linear regression. The program provided us with separate significance numbers for the reaction times measured for words printed in a congruent colour, an incongruent colour, a neutral colour, and nonwords. We used these significance numbers in addition to the actual reaction times to speculate about the implications of the data.

4. Results

4.1 Primary synaesthetic experiences

The results gathered in this experiment were analysed both per individual participant and per test item. The data were analysed through MANOVA, which did not lead to any significant results because ($P \geq 0.05$). The data set we gathered was too small for analysis through MANOVA to discover and recognise significance. Therefore, the results were analysed manually. The number of categories, which are groups of words with the same initial phoneme, for which each of the participants perceived matching or broadly matching colours were manually analysed and counted. The colours perceived could vary across participants and only had to match within a participant. The percentages of matches for both groups were calculated and are shown in Table 3 and 4. The percentages of matches for the control group participants are on average lower than those for the synaesthetes.

Control group participants	Matches (n=24)
C1	0.0%
C2	0.0%
C3	16.7%
C4	0.0%
C5	4.2%
Synaesthete group participants	
S1	37.5%
S2	8.3%
S3	12.5%

Table 3. Percentage of categories with matching or broadly matching perceptions within word groups for all participants. The total number of word groups was twenty-four.

When we compared all participants' perceptions per test item, we discovered that the perceptions across the control group matched more often than across the synaesthetes, respectively 42.9% and 25.4%, as shown in Table 4.

Group	Matches (n=63)
Control	42.9%
Synaesthetes	25.4%

Table 4. Percentage of matches within individual test items. There were sixty three test items in total.

The control group had similar colour perceptions for twenty-seven out of sixty three test items. The group of synaesthetes only perceived similar colours for sixteen test items, of which fourteen also evoked matches for the control group.

4.2 Priming task

The results gathered in this experiment were analysed per individual participant. First, the percentage of matches with the results from the first experiment was calculated. As shown in Table 5, the extremes fall within a relatively small range. The perceptions of the participants of the control group matched less often than those of the synaesthetes, but there is no wide gap between the results. The resemblances measured for the participants of the control group and the synaesthetes varied respectively from 43.3% to 50.6% and 56.6% to 87.8%. The results of participant S3 are divided into S3a and S3b, since this participant has two forms of synaesthesia, the grapheme-colour and lexical gustatory variants. S3a represents the results gathered with the grapheme-colour variant and S3b represents the results gathered with the lexical gustatory variant.

Participant	Matches (n=82)
C1	43.4%
C2	49.4%
C3	46.4%
C4	50.6%
C5	43.9%
S1	56.6%
S2	58.5%
S3a	64.6%
S3b	87.8%

Table 5. The participants' matches between the first and second experiment in percentages. There were 82 test items.

Second, the pairs of words presented in this experiment were formed on the basis of phonological priming and semantic priming. We investigated if the type of priming could account for, if any, manipulation of concurrents. However, the perceptions for test items in the different types of priming did not differ significantly with respect to the number of matches with the first experiment.

4.3 Lexical decision task

The results of the lexical decision task did not support our hypothesis. We expected the reaction times the synaesthetes needed to identify a word presented in the colour congruent with their choice in the first test would be shorter than the words presented in the incongruent and neutral colours. However, none of the participants' reaction times showed a significant difference with respect to congruency, as can be seen below in Table 6.

						Significance	
Participant	CON	INCON	NEUT	MEAN	NON	Congruency	Word type
C1	621.3	620.4	618.5	620.1	614.0	.886	.338
C2	613.6	617.9	618.8	616.4	624.8	.591	.174
C3	635.0	635.9	640.0	636.4	667.1	.747	.000
C4	622.6	613.4	617.9	618.0	628.3	.272	.023
C5	614.9	619.6	617.6	617.6	626.0	.816	.156
S1	638.5	641.5	635.5	638.5	660.8	.766	.000
S2	639.8	644.2	641.6	641.9	673.8	.881	.000
S3	612.9	612.8	603.4	609.7	622.4	.354	.002

Table 6. The reaction times in milliseconds measured for each participant.

The reaction times with respect to word type, word or a nonword, differed significantly for five of the eight participants. Since it is made clear in the literature that it takes longer to identify a string of letters as a nonword than a word, we expected the results of all participants to differ significantly for word type. All three synaesthetes were significantly faster in identifying words than nonwords. Although four out of five participants of the control group were faster in identifying words than nonwords, the differences were significant for only two participants. Surprisingly, for control group participant C1, the mean reaction time measured for the identification of words was higher than that of nonwords, respectively

620.1ms and 614.0ms. Although this is not a significant difference, it forms a contrast with the literature.

Participant C3, S1 and S2 were slower than the other participants. C3 and S2 are the two older participants, so ageing might account for this outcome. In addition, participant S2 had suffered from a minor stroke a few years ago, so this might have influenced the results as well. Although he pointed out that the incongruent colours confused him, this confusion did not show in his results. Participant C3 pointed out afterwards that she is not used to working with computers, and told us that she felt she needed time to adjust to the setting. Participant S1 mentioned that the second experiment was very exhausting for him, so it might be the case that he reacted more slowly in the third experiment than he normally would because he was less concentrated than he might have been if this experiment was conducted in isolation.

5. Discussion

5.1 Primary synaesthetic experiences

As pointed out in section 4.1, the control group had fewer colour matches within groups of words that started with the same grapheme than the group of synaesthetes. This can be explained by the observation that the control group has no consistent perceptions and that they are mostly based on semantics. These perceptions are often linked to the colour an item has in the real world, as outlined previously. The colours the control group participants experience are therefore often similar to one another or, when they differ, are predictable semantically, as shown in Table 7.

Test item	Perceptions
Beach	Shades of blue or beige or yellow
Face	Ballet pink, beige or white
Fire	Red
Garden	Dark or Light green
Heart	Shades of red and pink
Jail	Grey, black or dark green
Jeans	Denim blue or royal blue
Kiss	Shades of red and pink
Lamp	Yellow or white
Leaf	Dark or Light green
Milk	White or royal blue (milk cartons are royal blue in the Netherlands)
Mouth	Shades of red and pink
Mother	Shades of red and pink
Pleasure	Red and orange
Pool	Light blue and white
Rice	White or beige
Rose	Red, pink or magenta
Sleep	Shades of blue or white
Snake	Dark and light green
Snow	White
Test	Black, white or grey
Thief	Grey and black
Tooth	White or beige
Waste	Grey or black
Year	Black or grey
Zipper	Grey or denim blue

Table 7. List of test items that evoked similar colours in at least four out of five control group participants and/or for which the colours matched the test item semantically.

For the group of synaesthetes, participant S1 has told us and mentioned in the textbox of experiment one that the initial letter of a word usually determines the colour he perceives for a word. This explains his high rate of matches within the word groups. Groups of test items with the initial grapheme F, G, K, L, P, SH, S, TH and W all evoke similar colours within their respective groups. These graphemes make up 37,5 per cent of all groups. The initial letter is more important than the semantics of a word, which can be seen in words such as

FIRE, KISS and RICE. The colours perceived by S1 for these words are respectively *yellow*, *orange* and *red*. The control group picked the colours the concepts of these words usually are associated with in the real world, which are respectively *red*, *red* or *pink*, and *white* or *beige*. The colour S1 perceived for these test items matched the other test items that started with the same phoneme, but that colour had semantically no relation to the specific test item.

Participant S2 told us that his synaesthetic perceptions are mostly semantically based. His own judgement is reflected in his test results: only 8.3 per cent of all grapheme groups evoke similar colours. His perception often matched those of the control group. For example, his perceptions for the words FIRE, KISS, LAMP, LEAF, MILK, MOUTH, POOL, SNOW and TOOTH are similar to the control group's perceptions and correspond with the colours these items are associated with in the real world.

Participant S3 is the most complex case, as she perceives both colours and flavours. There is no pattern in the relationships between initial graphemes and the colour or flavour she perceives. Her perceptions of colour are mostly semantically based, but this is not always the case. Her perceptions can be ordered in four subcategories. Firstly the concurrents can be based on the semantics of the test item itself; secondly on the semantics of the flavour she perceives; in the third subcategory it is a combination of both; and the last category houses all perceptions that are in no way related to the semantics of the word, but are linked to the concept only. A test item that falls into the first category is LEAF. S3 only perceives the colour *dark green*, but no flavour. This colour is in accordance with the control group. The word MOUTH falls into the second subcategory. She perceives it as *white*, which is not in accordance with the control group, who picked the colours *red* or *pink*, and the flavour she experiences is *havermoutpap* (oat porridge). Depending on the exact type of porridge and the amount and type of milk added, porridge can be considered to be white or beige. The word POOL has a similar colour-flavour pattern. Pool is perceived by the control group as *light blue*, the water colour of an average swimming pool, so her perception is not based on the semantics of the word. The flavour she experiences is *hachee* (Dutch stew) and the colour she sees is *rust red*. Hachee is usually rust red, so her colour perception matches her flavour perception. For test items in the third subcategory, flavour and colour are interlinked. The item TOOTH is an example of this. The colour S3 perceives is *white*, the colour most people associate with teeth, and the flavour is that of *peppermint flavoured chewing gum*. Another example is the item CHIPS which she perceives as the colour *orange* and the flavour of *paprika crisps*. Paprika crisps are usually orange from the paprika powder, which links colour and flavour to the test item itself. Test items that fall into the fourth subcategory, evoke flavour and colour perceptions that cannot be linked semantically to the test item, nor to each other. Examples of this are BED and CHANGE. S3 perceives BED as *denim blue*, with the flavour of *aardappelkroketjes* (potato croquettes). BED is not a word for which control group agree on similar perceptions, so there is no specific semantic colour linked to the concept. Potato croquettes are often eaten as a part of dinner or as a warm party snack, so they are normally not eaten anywhere near a bed.

5.2 Priming

Earlier, we discussed the consistency tests used to determine whether a person has genuine synaesthesia or not. These tests predict that genuine synaesthetes and non-synaesthetes are respectively 57.2-85.3% and 14-52.3% consistent in the concurrents they perceive. According to these numbers, the percentages of matches the synaesthetes scored in the priming experiment are quite low and those of the participants of the control group are quite high. For the participants of the control group, a semantic prime might confirm their association with the test item, since those associations are largely based on real-life experiences and aspects. For example, in the semantic pair CLEANING-CHORE, the word CLEANING might strengthen the association the participant has with the word CHORE. In addition, since non-synaesthetes do not have associations as strong as synaesthetic concurrents, their choices might have been influenced by the concepts the test items were paired with. As we expected, since the participants of the control group do not have synaesthesia, we did not find any other patterns in the results of the participants of the control group.

Another explanation for the relatively high percentages of matching perceptions of the control group participants is that the set of test items contained words that have a strong relationship with a particular colour in real life. The participants match the test item to that particular colour more easily than they do with test items that do not have such a natural colour. To give an example, the set of test items contained the words LAMP, POOL, and KISS. When we compared the colours the participants picked for these items, we saw that they were largely similar throughout the data set, which we expected, since this was the case in the results of the first experiment. Our investigation involved five participants in the control group and three synaesthetes, all test items occurred twice in each experiment, so the entire data set for this experiment contains sixteen instances of each test item. The test item LAMP elicited the colour *yellow* or *orange* in twelve instances. POOL represented one of the three shades of *blue* present in the colour box in fourteen instances, and the word KISS elicited the colour *red* or a shade of *pink* for all participants. Not all participants picked the exact same colour. However, the perceptions are very similar and, in the case of LAMP, the colours *yellow* and *orange* both apply to people's associations of a lamp in the real world, which again is in accordance with the results of the first experiment.

Participant S1 has the strongest form of grapheme-colour synaesthesia. His results and especially the comments he wrote in the textbox reveal that specific letters trigger specific concurrents. The letter F, for example, only triggered the colour *yellow*. The letter K triggered the colour *red* six times and *orange* once. The word that triggered *orange* was the filler

KITTEN, which was preceded by LAUNDRY. Although we do not analyse the filler items, they can complement the analyses based on the actual test items. S1 states in his comment that his perception is a separated combination of *red* and *yellow*. The L triggered *orange* twice and *yellow* three times, so it is possible that the presence of the L influenced the perception of the K. In S1's results in this experiment, there are eleven letters that trigger only one colour. F=*red*, H=*red*, K=*red*, N=*red*, P=*denim blue*, R=*rust red*, S=*light blue*, T=*white*, V=*orange*, W=*rust red*, Y=*yellow*, Z=*yellow*. However, surprisingly, in a comparison of the concurrents for the test items with these letters with those of the first experiment, we noticed that only two of these letters triggered the exact same colour in the first experiment. Only the concurrents for the F and W are exact matches for the two test items used in both experiments. Six of the remaining letters, H, K, N, R, S and Z match on one of the test items. In three of these cases, K, S and Z, the concurrent that did not match that of the first experiment is still highly similar to the matching concurrent, which we therefore consider broad matches. K seems to trigger *red*, but one test item triggered *orange*; S seems to trigger *light blue*, but one test item triggered *denim blue*; Z seems to trigger *yellow*, but one test item triggered *orange*. It might account for these differences that S1 verified his concurrents with comments in the textbox in the second experiment, but he did not do so in the first experiment. We were able to make additional matches within the priming experiment when we analysed these comments. For example, the T triggered the colour *white* in seven out of eight instances. Only the pair WEST-TEST triggered *light green*. However, S1 commented that the word has a white glow, because he perceives the T as *white*. Therefore, we considered this instance as a match as well. If S1 had commented on his perceptions in the first experiment as well, we might have been able to find more matches across the tests. For example, *light blue* and *denim blue* might have been meeting in the middle if S1 commented that the first was a little darker and the latter a little lighter. As said earlier, S1 sometimes stated in his comments which letter accounted for a particular glow or shade. He also did for some filler items. Although we do not analyse the concurrents for these items, it is interesting to look at some of S1's comments, because these show that S1 is very aware of the origin of some features of his perceptions. S1 picked *red* for the filler item KEY, but commented "maar toch ook met geel accent (die de y geeft)". The four test items of the second experiment beginning with the letter Y all triggered *yellow*. For the filler item KIWI, S1 also picked *red*, and commented "met geel accent en het rood is ietwat donkerder (door de w)". The second half of the concurrent could be traced because of the comment, but the first half is slightly less straightforward. It might be the case that the vowel I accounts for the *yellow* perception. Test items beginning with the Y all triggered *yellow*, and the phonological similarity between the I and the Y leads to the assumption that the I's in KIWI triggered the perception of *yellow*. All instances of test items beginning with a W triggered *rust red*, a darker shade of red than the red in the colourbox, so it is no surprise that the W in KIWI caused a darker shade of red, although the K triggers the brighter shade. S1 perceived all test items beginning with an S as *light blue*, two out of four instances beginning with SH as *light blue* and the other two test items beginning with SH as *denim blue*. In addition, three out of four test items beginning with a T were perceived as *white*, and the remaining test item as *light green* leaning towards *white* and all test items beginning with TH were also perceived as *white*. We might argue that in S1's case the synaesthesia does not take initial sounds into account but the concurrents are triggered by initial graphemes only. Additionally, it might be a possibility that the graphemes of the lexical entries, in particular the initial consonant, influence the structure of S1's mental lexicon. However, it is unlikely that his entire mental lexicon is structured accordingly to graphemes, since people start speaking, and thus building a lexicon, before they learn to spell. If the lexicon were solely based on graphemes, the mental lexicon would have been restructured when spelling is taught, but there is no evidence that this is the case. In addition, our findings are insufficient to make any claims about a possible restructuring of the lexicon at an early age. In order to draw definite conclusions, S1 should be involved in an exhaustive case study which does not solely focusses on synaesthesia, but on the mental lexicon in general.

The fact that S1 has more clear perceptions for letters than for entire words raises a question. If there are strong connections between colours and letters in S1's brain, then why does he not stand out with respect to consistency numbers? His percentage of matches between the first and second experiment was 56.6%, which was in fact the lowest percentage within the group of synaesthetes. It is possible that the vowels play a role in the determination of a concurrent as well, which we think was the case with the two I's in KIWI. In addition, it might be the case that words participants are more familiar with recall stronger perceptions. Perhaps the concepts of the words play a role as well. In order to be able to draw conclusions based on these factors, further research is necessary.

As stated in section 2 synaesthesia is a condition that varies across its different variants, but also within a variant across individuals. Therefore, it is no surprise that the patterns we found in S1's results discussed above are not present in the results of the other two synaesthetes. Participant S2 perceives concurrents on the basis of the concept of the test items in the mental lexicon. After he finished the second experiment, he pointed out that he did not experience concurrents for the English words in the test, but that he did when he translated them into Dutch. This finding is highly relevant, as it indicates that S2's synaesthesia is not purely based on graphemes but rather on concepts. S2's synaesthesia seems to represent the mental lexicon more accurately, since the lexical entries in the mental lexicon are believed to be based on shared properties of the concept they denote. In addition, as we already saw in the first experiment, the concepts of some test items were too abstract for participant S2 to perceive any concurrent. What is interesting is that S2 did perceive concurrents for some of the test items he commented on as too abstract in the first experiment.

However, we could not find a pattern in the test items and the pairs they were part of that did trigger a concurrent in the second experiment in contrast with the first experiment and vice versa. Therefore, no predictions can be made how S2's behaviour will be with respect to when he perceives concurrents in potential further research.

Participant S3, as discussed earlier, differs from the other two synaesthetes in the sense that she had two variants of synaesthesia. The percentages of consistency reveal that the grapheme-colour variant is less strong than the lexical gustatory variant. The percentages were, respectively, 64.6% and 87.8%. Regardless of the variants, these percentages were the highest of all three synaesthetes.

S3's results gathered for the lexical gustatory variant are not bound by initial graphemes. The test item BEACH triggered the flavour of *gekruide toastjes* (seasoned crackers) and the test item BED triggered the flavour of *aardappelkroketjes* (potato croquettes). Whereas participant S1's results concerning test items beginning with a T matched in perception, the results of participant S3 concerning the initial T show great divergence. TEST triggered the flavour of *kersen* (cherries), THIEF triggered the flavour of *druiven* (grapes), THUNDER triggered the scent of *pasgevallen regen* (recently fallen rain), and TOOTH triggered the flavour of *pepermuntkauwgom* (peppermint flavoured chewing gum). The only agreement that may be found is that cherries and grapes are both types of fruit, but the flavours do not relate to each other in any way. According to the subcategories discussed in section 5.1, the perceptions for TEST and THIEF fall in the fourth subcategory, perceptions only linked to the concept,, the perception THUNDER falls in the first subcategory, perceptions based on the semantics of the test item, and the perception for TOOTH falls in the third subcategory, perceptions based on both the semantics of the test item and the perceived flavour. S3 had no perceptions in colour for 21 out of 82 test items, but there were only twelve test items for which she perceived neither a colour nor a flavour.

The colours S3 perceived do not relate to the initial graphemes of the test items. The V, for example, triggered *rust red* once, *orange* once, *light blue* once, and for one test item S3 did not perceive a colour. The G triggered *dark green* twice and *piglet pink* twice. There is no initial letter that triggered one and only one colour for all four test items. The only letter for which the perceptions for four test items match is the H, and S3 had no perception for all of them. Although both her perceptions for both the grapheme-colour variant and the lexical gustatory variant do not depend on the initial graphemes of the test items, S3 had the highest percentage of consistency. The colours and flavours S3 perceived largely did match for two instances of one test item. Both instances of the test item GUEST triggered the flavour of *gekookte aardappelen* (cooked potatoes), HOUSE triggered the flavour of *vleesjus* (meat gravy) twice, LEG tasted like *zoete drop* (sweet liquorice) and SHOT triggered the flavour of *yoghurt met banaan* (yoghurt with banana) twice. This strongly suggests that the elements that trigger S3's concurrents are the mental concepts rather than the initial graphemes.

It is interesting to see that the two forms of synaesthesia function as two separate systems. The perceived colours and flavours per test item do not relate to each other in most cases. The test item BED triggered the colour *denim blue* and the flavour of *aardappelkroketjes* (potato croquettes). Potato croquettes are not *denim blue* in real life, so it is unlikely that these perceptions are based on the same synaesthetic connection in the brain. An interesting question that rises is whether these variants use the same networks of lexical entries in the mental lexicon or whether words are grouped differently per variant of synaesthetic concurrents. Further research involving lists of synonyms has to be conducted to investigate this aspect. Because we focussed on phonological aspects of words, an investigation involving a list of synonyms would contribute to a more accurate analysis of this variant of synaesthesia, because it would provide more information on any similarity in perceptions triggered by words which concepts represent the same meanings. Similar perceptions for synonyms may indicate that the mental lexicon is structured in networks based on the concept rather than initial or dominant graphemes and/or phonemes. Since S3's results did not show any influence of the initial grapheme, we might assume that her results would be significant when experimental material concerning synonyms is used.

5.3 Lexical decision task

Since none of the synaesthetes identified the words presented in the congruent colour any faster than the words presented in the incongruent and neutral colours, we may conclude that synaesthesia is not a facilitating factor in the process of the identification of lexical entries. One of the synaesthetes mentioned that the incongruent colours confused him, but there was no significant difference in his reaction times measured for the incongruent condition. Although our results are not sufficient enough to draw definite conclusions on this subfield, we might speculate about the implications. Since the colours do not affect the reaction times, we might assume that synaesthesia is a one-way condition. This means that colours do not seem to stimulate the retrieval and/or recognition of words, but it is solely the case that words trigger colours. However, further research involving a larger group of participants is necessary to investigate this phenomenon into further detail.

6. Conclusion

The results of both the experiments on primary synaesthetic experiences and priming show that the control group participants largely based the colours they picked on real-life associations. The synaesthetes' perceptions occasionally matched these real-life associations, but were mostly based on other factors, such as with which grapheme the test item started or they were based on the mental concept of the test item. While the synaesthetes' results showed these internal structures, these structures lacked in the control group's results. In the results of the priming experiment, there was no effect of the type of pair, semantic or phonological, a test item was part of. We found very similar patterns for each of the synaesthetes across the primary synaesthetic experiences experiment and the priming experiment, which was in accordance with our expectations.

In the lexical decision task, there was no effect of congruency for any participants, control group or synaesthetes. This is a logical outcome regarding the control group, but it falsifies our hypothesis for the synaesthetes. There was an effect of word type, that is whether the string of letters represented a word or a nonword, for all synaesthetes and 2 out of 5 control group participants. The fact that there was no significant difference for 3 out of 5 control group participants contrasts with the literature. We were not able to explain these outcomes.

Overall, we can conclude that our investigation was too limited to accurately investigate the mental lexicon. However, there are indications that synaesthesia can reveal information about the mental lexicon if a larger group of participants were used, in addition to a more constrained setting and more accurate analysis. S1's and S3's synaesthesia seem to be interconnected with the concepts of words and therefore these perceptions can provide us with information on how these concepts are stored, i.e. the structure of the mental lexicon. It might be the case that it will be, if the uncertainties in the domains of both synaesthesia and the mental lexicon are more unravelled than they currently are. In the next section, some suggestions for further research are discussed.

7. Suggestions for further research

There are many aspects of synaesthesia and the mental lexicon that have not been investigated in this study, and some concepts of this study should be improved in order to draw hard conclusions about the relationship between synaesthesia and the mental lexicon. First of all, the group of participants should have been larger in order to discover, if any, patterns that account for more synaesthetes than just one participant. If a larger set of test subjects were used, the test subjects could be divided into groups according to the variant of synaesthesia they have. The results can then be analysed within one variant and across several variants. In addition, the results and thus their implications may differ from the current results if broad matches were counted together with definite matches.

It should be investigated whether the concurrents synaesthetes perceive differ for spoken stimuli and for written stimuli. When written stimuli are used as test items, the influence graphemes may have on the concurrents can be analysed. However, audio aspects such as stress pattern or phonemes with different graphemic options cannot be investigated properly when the stimuli used are written. In order to be able to draw conclusions on the influence of stress patterns and phonemes, the test subjects need to hear the stimuli. Participant S1 would be suitable for an investigation focusing on stress patterns, as his synaesthesia relies on initial and dominant graphemes. This might be interlinked with sounds and stress patterns. Words that share the same form but have different stress patterns, and thus in which the dominant sounds differ, might trigger different perceptions.

In our investigation, we focussed on whether the possible patterns observed in the data could be attributed to the initial grapheme or the mental concept of the test item. More aspects need to be taken into account than solely the initial graphemes to create a complete picture of the influence of graphemes on synaesthetic perceptions, because the influence of vowels on these perceptions is still unclear. Therefore, these initial graphemes need to be analysed in conjunction with the vowels present. A distinction has to be made between the written and spoken properties of the vowel, as pronunciation and spelling not always coincide. For example, the voice feature of any surrounding consonants influence the length of a vowel, but the spelling does not reflect this difference. In addition, the first vowel may influence the concurrent, but also a similarity in form between vowels or between the vowels and consonants may cause different patterns to occur.

In future experiments, the type of colour picker should be changed. Since it is known that synaesthetes experience a specific shade of a colour, they were highly restricted in their choices because the colour picker box only counted sixteen colours and shades. If a colour picker box with all possible shades were used, the synaesthetes would probably have found it easier to pinpoint their perception. Having these exact colours will make the data in the third test we conducted more reliable and make the statistical analysis easier, as the colours are now a continuum instead of separate categories. Additionally, proximity of colours could be calculated by the computer and would be more reliable. When all colours are represented as points in a continuum spectrum, they have coordinates. This means that distance can be calculated between certain points. Therefore, in a continuum a match and a broad match can be defined as a point that lies within a certain radius from the coordinate of the picked colour. This procedure is a more accurate procedure than interpreting the comments in the text box. In this investigation we had to take the comments participants could write down in the textbox into account and make judgements whether two different shades formed a match after all according to the comments. When *rust red* is picked in the first test and *red* in the second, this was considered a broad match, but not a definite match. However, when participants commented that they perceive *rust red* as a slightly lighter shade and *rood* as a slightly darker shade, then we might have concluded that the perceptions did match, being somewhere in between red and rust red. Additionally, proximity could be defined with a formula and calculated by SPSS. The use of a colour picker box with all possible shades prevent that the researchers have to interpret the results in this way and makes the experiment less exhausting for the participants since they would not have to think about how they could describe their exact perception best.

The stimuli used in our investigation were nouns that start with a consonant. Many synaesthetes, like participant S2, do not perceive concurrents for abstract nouns, but do for concrete nouns. Other categories that represent both concrete and abstract concepts would make a good research topic, because to solely rely on the division within the category of nouns would draw premature conclusions on the division of all abstract and concrete concepts within the networks of the mental lexicon. This makes it interesting to also look at other word categories that represent both abstract and concrete concepts, such as verbs. In addition, semantically similar words, such as “bike”, and “cycling”, which belong to different categories should be compared in order to conclude whether patterns of synaesthetic perceptions emerge between these words. Function words would also be interesting to investigate, as they usually have no reference to any concrete object, but may evoke colours similar to nouns or verbs that they are associated with.

In the lexical decision task, the reaction times for test items with various syllable length should be investigated. Perhaps synaesthetes become slower the more syllables or morphemes a word has, because it might be the case that the presence of more morphemes causes a competition in the brain between the concurrents perceived for each morpheme or because the more letters the more colours are involved. In addition, it gives the opportunity to investigate whether affixes and inflections play a role in synaesthetic perceptions.

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Appendix A

Questionnaire to establish consistency over time

Nederlandse woorden

Woord	Waarneming	Opmerkingen
kerst		
douche		
handschoen		
woensdag		
kop		
zondag		
maandag		
zomer		
tuin		
vrijdag		
dinsdag		
douchekop		
schoen		
leven		
huis		
pasen		
hand		
lente		
donderdag		
fiets		

Engelse woorden

Woord	Waarneming	Opmerkingen
easter		
bike		
Monday		
Friday		
head		
Sunday		
have		
she		
am		
christmas		
garden		
Saturday		
she's		
shower		
live		
is		
shoe		
showerhead		
I'm		
spring		
summer		
Thursday		
you		
I		
Tuesday		
house		
hand		
Wednesday		
you've		
glove		

Appendix B

List of categories and the words that they contain for experiment one

b	Bed
	Beach
	Bar
d	Dog
	Dance
	Design
f	Face
	Fire
	Fist
g	Guest
	Gum
	Garden
h	House
	Hand
	Heart
j	Year
	Young
k	Kiss
	Kick
	King
l	Leg
	Lamp
	Leaf
m	Mother
	Mouth
	Milk
n	Nickle
	Name
	Nail
p	Pleasure
	Pool
	Place
r	Rose
	Rice
	Rooster
s	Sleep
	Snake
	Snow
ʃ	Shot
	Shock
	Shoe

t	Test
	Tooth
	Tea
tʃ	Change
	Chore
	Charger
Ɵ	Thunder
	Thief
	Thing
v	Veal
	Vase
	Verse
w	Wind
	War
	Waste
z	Zoo
	Zipper
	Zone
ʤ	Jacket
	Jeans
	Jail