The Role of Linguistic Biases in Word Learning

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Abstract

Children tend to look at name-unknown objects when they hear novel words, a behaviour that researchers have described through the Mutual Exclusivity (ME) constraint; that children start to learn meanings of words with the assumption that each object has only one name. The application of the ME constraint has been suggested to facilitate word-learning processes. Yet, other researchers argue that children associate novel labels with multiple objects, resulting in the formation of a hierarchy of word-object associations, resolving referential ambiguity across situation using a Cross-situational Statistical Learning strategy. To reconcile these two theories, the current thesis used a typical ME paradigm to test whether children are able to associate a novel label with multiple objects. Results from monolinguals suggested that children were able to map a novel label to a name-known object, contrary to the one-to-one assumption between word-object associations of the ME constraint. Results from bilinguals suggested that they, too, performed in a similar manner as monolinguals. As Woodward and Markman (1991) argued that the ME constraint can be overcome by other linguistic cues, the current thesis tested whether syntactic cues are also taken into account alongside with the ME constraint when children are forming new word-object associations. It was demonstrated that children do take syntax into account when selecting a referent for a novel label. Furthermore, the current thesis revealed that children were more likely to map a novel label to a name-known object if the syntax was congruence with the name-known object but not the name-unknown object. In sum, the current studies suggest that novelty preference during word-object associations should not be taken as evidence that associations between novel labels and name-known objects have not taken place. In contrast, word-object associations are likely to be non-selective; that is, children do not strictly map a novel label to one name-unknown object. Other linguistic cues also play a role during the formation of word-object associations.

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Chapter 1 Introduction

1.1 General Background

Children learn words at an alarming rate (Carey, 1978). Yet, word learning is not a simple task, for one needs to understand meanings of words and have a good understanding of the grammar structure before being able to string words in a meaningful manner. An important part of language learning, apart from phonology and syntactic development, is lexical development, because words are the building blocks of a language. To convey one's intention accurately to another person, one has to name objects correctly[1]. To do so, words have to be mapped to the corresponding objects to be learned as the name of the objects. The present thesis looks at strategies children use to disambiguate novel labels in ambiguous situations. This chapter first provides a brief discussion of the background of the study, followed by an overview of the five studies that are presented in the current thesis.

Many word-learning strategies have been proposed to account for the reliable word-learning patterns observed in early childhood: social pragmatics accounts posit that children learn meanings of words through the context or the intention of the speaker (Tomasello, 1992); syntactic bootstrapping argues that syntax is used to learn meanings of words (Katz, Baker, & Macnamara, 1974); and lexical constraints state that restrictions placed on word-object associations allow children to map words to objects correctly (Markman & Wachtel, 1988). The use of lexical constraints is particularly useful under ambiguous situations, when the context does not provide enough informative cues to the child, such as when children overhear a conversation (Akhtar, 2005; Akhtar, Jipson, & Callanan, 2001; Floor & Akhtar, 2006; although see Weisleder & Fernald, 2013). In such situations, children need to select a

[1] Other than naming objects, children also need to learn other kinds of words such as verbs, adjectives and adverbs. However, learning of these words is not discussed in the current thesis, because firstly, most studies on the ME constraint focus on label learning, and secondly, the learning of different categories of words are studied in depth as a separate topic of its own (e.g., Forbes & Farrar, 1993; Naigles, 1990).

referent for the novel label heard and then form an association between the novel label and the referent to learn the meaning of the novel label.

Researchers have identified three lexical constraints that aid disambiguation: the Whole Object constraint, the Taxonomic constraint, and the Mutual Exclusivity (hereafter known as ME) constraint. The Whole Object constraint proposes that children tend to map a label to an object (e.g., a teapot) rather than to a property (e.g., colourful) or a part of an object (e.g., a spout) (Mervis, 1987). The Taxonomic constraint suggests that children will extend new labels learnt to objects of the same kind (taxonomic relation, e.g., a dog and a cat) instead of to objects that are closely related in space and time (thematic relation, e.g., a dog and a bone; Markman & Hutchinson, 1984). Finally, the ME constraint argues that, to be able to map novel labels to name-unknown objects, and hence learn meanings of new words, children assume that each object has only one name (Markman & Wachtel, 1988). Thus, according to Markman (1990), when a child hears a novel label, the child prefers to map the novel label to a name-unknown object in sight. This theory helps explain “fast-mapping” behaviour, a term used to describe how young children are able to learn meanings of words with just very few encounters with the words (Carey, 1978).

However, when several name-unknown objects are present, children have to use a different strategy to learn the meaning of a novel label. Disambiguation through the ME constraint is not sufficient, because any of the name-unknown objects may be a possible referent for the novel label. The Cross-situational Statistical Learning (hereafter retermed as CSL; Smith & Yu, 2008) account suggests that, in such situations, children associate the novel label to all name-unknown objects present. These associations are stored and their strengths evolve across successive ambiguous trials. The most frequent pairings lead to the strongest associations between name-unknown objects and novel labels.

According to Woodward and Markman (1991), the ME constraint can be overruled by other constraints as it is a probabilistic bias. Based on this claim, the current thesis argued that the frequency of word-object associations may be able to overcome the ME constraint. In other words, if a *name-known* object is present frequently when a novel label is heard, children may be able to pair the novel label with the name-known object, because children's ability in forming many-to-one word-object associations can overcome the novelty bias proposed by the ME constraint. Although studies have tested the effect of other cues (e.g., social pragmatic cues: Diesendruck & Markson, 2001; Jaswal, 2010), syntactic cues (e.g., Booth & Waxman, 2003; Katz et al., 1974) and salience (e.g., Pomper and Saffran, 2018; Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006) on the ME constraint, the effect of frequency on the ME constraint has not yet been tested.

1.2 Outline of Thesis

The current thesis looked in-depth into the ME constraint, the CSL account and the syntactic cues in helping children to map novel labels to name-unknown objects and learn these novel labels. The ME account argues that children learn only one word for each object, whereas the CSL account argues that children are able to form many-to-one word-object associations. The ability to store more than one word-object association should be more prevalent in bilinguals than in monolinguals, because bilinguals need to learn two labels for each object and hence violate the ME constraint on a daily basis.

To gain a better understanding of the word-learning biases, Chapter 2 discusses previous studies of these biases. This chapter forms the foundation of the experiments reported in this thesis. Chapter 3 presents a background of word learning in a bilingual context because a few studies (e.g., Bialystok & Luk, 2012; Byers-Heinlein & Werker, 2009) found that bilinguals perform differently from monolinguals in linguistic tasks. Studies conducted on modelling also showed that models using only monolinguals as data does not predict the performance of bilinguals very well (Zinszer, Rolotti, Li, & Li, 2018). Chapter 3 provides an understanding to word learning in bilinguals, which forms a foundation to Study 3 in Chapter 6. Chapters 4 to 8 present five studies, one study in each chapter. For each study, the aim, methodology, results and discussion of results were presented. The final chapter discusses the results obtained from all five studies and the implication for our understanding of word learning in ambiguous situations.

1.3 Summary of Studies

1.3.1 Overview of Study 1

The question of whether children can learn second labels for name-known objects through accumulation of word-object associations was examined in Study 1 (Chapter 4). In Study 1, 4- to 12-year-old children were tested on the selectivity of word-object association; that is, whether the children are able to associate novel labels with name-known objects. A selective word-object association is defined as the selection of one and only one name-unknown object as a referent for a novel label. This question is particularly important, because the theories outlined previously have a significant impact on our understanding of how children learn other words for the same object, such as synonyms (e.g., dog and hound) and subordinate labels (e.g., dog and poodle). The ME constraint predicts that children need evidence from other linguistic bias to overrule the one-to-one word-object association assumption and subsequently learn other names for the object, whereas following the CSL account, children should be able to learn these other labels without other linguistic biases because they will naturally store multiple associations between labels and objects (although Chen, Zhang, & Yu (2018) demonstrated that temporal separation has an effect on children’s ability in learning labels of different hierarchical levels simultaneously). Thus, if children form word-object associations in a non-selective manner (i.e., able to map a novel label to a name-known object), then Study 1 would provide evidence that frequency of word-object pairings can overcome the ME constraint.

Yet, even though the results obtained in Study 1 suggested that children were able to pair a novel label to a name-known object, it is not yet conclusive that children have formed an association between the novel labels and the name-known objects. Instead, the children's behaviour may be explained by other learning mechanisms. Another plausible explanation is that children identified the target (the corresponding name-known object) via cascaded activation while respecting the ME constraint's claim that each object has only one name.

Evidence of cascaded activation is tested in Arias-Trejo and Plunkett (2009), who found that children are sensitive to relations between objects that are physically closed to each other (i.e., objects that are thematically related to each other, such as a rabbit and a carrot). The researchers showed that children were faster at attending to a target that was preceded by a thematically-related object than to a target that was preceded by a non-related object, suggesting that the activation from the prime image cascaded towards the target image. In the design of Study 1, the name-unknown object and the name-known object always appeared side-by-side, hence, an association between both objects could be formed. Then, when children heard a novel label, they associated it with the matching name-unknown object, which in turn was associated with the name-known object. Consequently, this account suggests that associations are formed at "encyclopaedic" levels, that is, through cascaded activation rather than at a lexical level. To tease apart these two competing explanations, an additional test was introduced in Study 2, testing children aged between 3 to 12 years old.

1.3.2 Overview of Study 2

The aim of Study 2 (Chapter 5) was to differentiate the two competing explanations outlined in section 1.3.1. If it can be shown that children are able to map a novel label directly to the name-known object, then this result suggests that they have formed a lexical association between the novel label and the name-known object. This result would not only provide strong support for the CSL account that children are able to form many-to-one word-object associations, it would also extend the CSL account that children are also able to form associations between novel labels and name-known objects. On the other hand, if children are shown to map the novel label to the name-known object only through cascaded activation, this finding would suggest that frequency of word-object associations is unable to overrule the one-to-one assumption of the ME constraint.

Through correlation tests, it was found in Study 2 that children do form lexical associations between a novel label and name-known objects. In other words, children are able to learn another name for name-known objects. This finding was tested again in Study 3 with 4- to 11-year-old bilinguals, to examine whether bilinguals also show similar patterns of results. Bilinguals speak two languages and have names for most objects in two different languages. Thus, bilingualism affects the ME constraint because the constraint's default assumption is that each object has only one name, whereas bilinguals are able to provide two names for the same object, violating the ME constraint on a daily basis. The findings of many studies support the view that monolinguals are more likely than bilinguals to match a novel label to a name-unknown object in ME-related tasks, showing a stronger ME constraint than bilinguals (Davidson & Tell, 2005; Houston-Price, Caloghiris, & Raviglione, 2010).

1.3.3 Overview of Study 3

Byers-Heinlein and Werker (2009) argued that if the ME constraint is due to maturational factors, then there should be no difference between monolinguals and bilinguals. However, if the constraint outlined above emerges due to language experience, then it is likely that monolinguals will have a stronger ME constraint than bilinguals. Byers-Heinlein and Werker (2009) found that vocabulary size did not predict the children's performance, instead, bilingualism did. This evidence suggests that bilinguals may be more willing to accept another name for a name-known object, because the ME constraint is weaker in bilinguals. Similarly, Poepsel and Weiss (2016) found that there is a difference between monolinguals and bilinguals in CSL-related tasks. They found that bilinguals outperformed monolinguals in two-to-one word-object associations whereas there was no difference between the two groups in one-to-one word-object associations. In light of the differences between monolinguals and bilinguals, Study 3 (Chapter 6) was conducted with the same design as Study 2, with the difference that the participants were bilinguals in Study 3.

The aim of Study 3 was three-fold. First, Study 3 aimed to replicate the findings of previous studies that bilinguals are less novelty seeking in ME-related tasks using an alternative design. Although a few studies have tested whether bilingual children readily accept a second label for a name-known object (Davidson & Tell, 2005; Healey & Skarabela, 2008), the designs of these studies were different from the one adopted throughout this thesis. Testing a hypothesis using different designs provides a stronger test for the hypothesis, because an effect that is obtained in different paradigms is likely to be robust and not due to methodological difference. Therefore, it is interesting to investigate if there is any difference between monolinguals (tested in Study 2) and bilinguals (tested in Study 3) in terms of the strength in the use of the ME constraint. If bilingual children show a weaker ME constraint compared to monolingual children, then Study 3 would support previous studies, which argued that bilinguals constantly overcome the ME constraint due to a need to learn two words for the same object.

Second, Study 3 aimed to investigate the selectivity of word-object associations in bilinguals. Following the argument that bilinguals should show a weaker ME constraint, the second aim of Study 3 is to test whether bilinguals are more likely than monolinguals in forming many-to-one word-object associations. The explanation behind this hypothesis is that bilinguals have more experience with two labels for most objects, leading to less novelty bias in their performance, which is likely to cause them to be more willing to accept the mapping between a novel label and a name-known object.

Third, Study 3 aimed to look into the retention ability of bilinguals, because very few studies have been conducted to test the retention of bilinguals' newly-formed word-object association (Kalashnikova, Escudero, & Kidd, 2018; Rohde & Tiefenthal, 2000). A few studies have tested retention in monolinguals (Akhtar et al., 2001; Bion, Borovsky, & Fernald, 2013; Horst & Samuelson, 2008; Mather & Plunkett, 2011). It was found that the ability to disambiguate the meanings of novel labels during ME trials is not equivalent to word-learning. In other words, having selected an object to be paired with a novel label does not mean that the children have learnt the association between the novel label and that object.

Although Mather and Plunkett (2011) found that children aged 16 months old were able to retain the associations formed earlier in the experiment, Horst and Samuelson (2008) found 24-month-old children to be unable to retain recently-formed word-association even though they were able to select the name-unknown object above chance upon hearing the novel label. Similarly, Bion et al. (2013) demonstrated that 24-month-old children were unable to retain novel word - name-unknown object mappings, whereas 30-month-old children showed evidence of such retention. These studies showed that it is important to test for the retention of word-object associations beyond merely assessing the children's disambiguation ability. Thus, Study 3 not only investigated to what extent bilinguals use the ME constraint, but also to what extent bilinguals are able to retain these newly-formed word-object associations.

1.3.4 Overview of Study 4

As children grow older (at around four to five years old; Gelman & Markman, 1985), many additional cues can be used when selecting referents for novel labels. Syntactic cues are helpful when children are familiar enough with the grammar of the language. If children only follow Whole Object and ME constraints, they would always map a novel label to a name-unknown object. Yet, studies have shown that grammatical cues may help children learn words as well (Bloom & Kelemen, 1995; Hall, Lee, & Bélanger, 2001). For instance, Booth and Waxman (2003) found that 14-month-old infants select a name-unknown object for a novel label that is a noun (e.g., this is a *dax*) but not when the novel label is an adjective (e.g., this is *daxy*). Hence, syntactic cues guide word-object associations as well.

Syntax can also help children to learn labels for different types of nouns. In English, count nouns are usually preceded by an article (e.g., a cat), whereas mass nouns are often preceded by a classifier (e.g., a drop of water). Bloom and Kelemen (1995) found that older children were sensitive to these syntactic cues and were able to select either a count noun or a mass noun depending on the syntax of the instructions. However, an age trend was observed in their study, where younger children were more likely to uphold the Whole Object constraint compared to older children, whose use of syntactic cues was more adult-like. Similarly, Hall et al. (2001) found that children were able to rely on syntax to help them differentiate proper nouns and count nouns, as proper nouns in English are not preceded by any articles (e.g., Tom). According to the ME constraint, children will only learn labels such as parts of an object, after they have learned the basic-level name of that object (Hansen &

Markman, 2009; Markman & Wachtel, 1988). If the ME constraint is systematically enforced, then children would not differentiate count nouns (e.g., find a *dax*) from proper nouns (e.g., find *Dax*). However, Hall et al. (2001) found that the recruited children displayed different responses with distinct syntactic cues, suggesting that the children were able to use syntax to overcome the ME constraint, supporting Woodward and Markman (1991).

Most studies focused on the English language, where syntactic cues differentiate count nouns, mass nouns, proper nouns and plurals. However, many other languages do not have such differentiations in their grammar. For example, in Japanese, classifiers precede nouns, regardless of the type of noun (Imai, 1999). Imai and Gentner (1997) found that even though Japanese children do not have syntactic cues to help them differentiate count nouns from mass nouns, the Japanese children's performance when matching novel labels to name-unknown objects was not significantly different from that of English-speaking children. Based on this result, Imai and Gentner (1997) suggested that the Taxonomic constraint is a stronger cue than syntax when forming word-object association.

Other studies have also found syntactic cues to have a weak predictive power of children's performance in linguistic-related tasks. Imai, Saalbach and Stern (2010) and Mazuka and Friedman (2000) argued that different syntactic cues of different languages are unlikely to affect participants' performance when categorising objects. They argued that if categorisation is based on syntactic cues, then participants who use classifier-based languages (e.g., Japanese and Mandarin) are likely to categorise objects differently from those who use non-classifier-based languages (e.g., English and German). As the researchers found that speakers of both classifier-based and non-classifier-based languages performed in a similar manner when categorising objects, they concluded that it is the Whole Object constraint and the Taxonomic constraint instead of the syntactic cues that affect the participants' performance.

In the Malay language, classifiers are used very similarly to those used in Japanese and Mandarin, where classifiers precede any kind of object, regardless of the object being a mass noun or a count noun (Salehuddin & Winskel, 2012). Study 4 (Chapter 7) was conducted to assess the effect of syntactic cues on the ME constraint, when forming word-object associations. Studies (Imai et al., 2010; Mazuka & Friedman, 2000) using other languages have been conducted to test for the effect of classifiers on taxonomic relations. These studies tested classifier-based languages but did not use any classifier in their instructions for the participants, which may reduce the effect of classifiers on the participants' performance in the tasks. In Study 4, children were tested in their dominant language on whether they would follow syntactic cues (Malay classifiers) or the ME constraint when these two are in conflict with each other. As found in studies on social gestures such as gaze and pointing, the ME constraint will take precedence over other cues for young children but other cues will be stronger in older children, and when in conflict, children will follow the ME constraint (Graham, Nilsen, Collins, & Olineck, 2010; Jaswal, 2010). Study 4 tested the strength of syntactic cues against the ME constraint. If syntactic cues are able to withstand the ME constraint, then it is likely that syntax provides important cues, supporting Hall et al. (2001).

1.3.5 Overview of Study 5

It was found in Study 4 that children made use of classifiers during disambiguation. Critically, it was also found that children are able to use classifiers to overcome the ME constraint to some extent. It is important to examine whether this effect of classifier can help children to retain word-object associations. In Study 4, children were tested only on ME training trials; that is, whether they would map a novel label to a name-unknown object or a name-known object. Thus, it is also necessary to test children's retention of newly-formed word-object associations when both ME constraint and syntactic cues are present during ME training trials.

Study 5 (Chapter 8) examined the effect of these syntactic cues in learning a novel label. Two tests were conducted in Study 5 to achieve this aim. The first test looked at the retention of novel label - name-unknown object associations. If both ME constraint and syntactic cues direct a child's attention towards the name-unknown object, then children should be better at retaining the association between the novel label and the name-unknown object. The second test was on the formation of novel label - name-known object associations. Whether a child is able to learn another label for a name-known object may be affected by additional evidence such as syntactic cues. Although Study 5 did not obtain evidence of effect of syntactic bootstrapping on the retention of word-object associations, the second test in Study 5 showed that children were able to map a novel label to a name-known object if there was supporting evidence from syntactic bootstrapping.

Chapter 2 Word-Learning Biases

To learn the meaning of words, one needs to be able to associate a word to a concept. Although it seems difficult for young children (who have little exposure to the language) to be able to know the correct referent for the label they have just heard (Quine, 1960), children nonetheless learn words without much difficulty. The difficulty in selecting a referent is perhaps best illustrated when facing an ambiguous situation, such as seeing a barking dog, where the word “dog” could refer either to the animal itself, the animal performing an action (e.g., the barking of the dog) or a feature of the animal (e.g., brown, furry, big, teeth baring). When a person is naïve to a new language, it seems impossible to identify the correct referent for the novel label.

Yet, children learn words successfully at a very young age. For instance, at just 14 months of age, infants showed evidence of having learned word-object pairings (Werker, Cohen, Lloyd, Casasola, & Stager, 1998). Using a switch-task paradigm, the infants were first habituated with two sets of word-object pairings. Werker et al. (1998) found that after the habituation period, the infants looked longer at the switched word-object pairings than the original pairings, suggesting that they have learned the word-object pairings during the habituation period and that they were surprised with the change of word-object pairing. Indeed, Bergelson and Swingley (2012) and Tincoff and Jusczyk (2000) found that at just six months of age, infants looked longer at the correct image when they heard the name of the image than when no label was uttered, even when the infants were unable to produce the words themselves or when the images were isolated objects (e.g., a nose without other features of a face). These studies show that at a very young age, children are capable of associating words to objects, suggesting that it is not difficult for children to learn words.

The current thesis looked at word-learning biases that children use when the learning situation is ambiguous. In the following sections, three different word-learning biases are discussed in detail: the Mutual Exclusivity (ME) constraint (Markman & Wachtel, 1988), the Cross-situational Statistical Learning (CSL) account (Smith & Yu, 2008) and syntactic bootstrapping (Lidz, Gleitman, & Gleitman, 2003). These accounts provide potential explanations on how children form word-object associations in ambiguous situations, which form the background of the studies conducted in the current thesis. In the first section, the ME constraint is discussed in terms of how it can explain children's rapid rate of word learning, followed by a discussion on the retention of word-object associations formed through the ME constraint, and whether word-object associations are selective. In the second section, the CSL account is first explained. This explanation is followed by a discussion of whether multiple word-object associations are maintained during word learning and factors that affect children's performance in CSL-related tasks. In the final section, the usage of syntactic bootstrapping in word learning and its interaction with other constraints are discussed.

2.1 Mutual Exclusivity (ME)

2.1.1 Assumptions of ME

Although children learn many words through explicit teaching (e.g., "this is a cat" while pointing to a cat), indirect learning is also very common among children (Bergelson & Swingley, 2012; Mervis & Bertrand, 1994). Carey (1978) found that when children were told to "get the chromium tray, not the blue one", they were able to select the correct tray despite not knowing what "chromium" means. This finding led Carey to conclude that children are able to associate novel labels with either an object or a property of an object that is name-unknown to them, allowing them to learn meanings of words. This behaviour was coined as "fast-mapping", where children are able to associate a word to a referent after only very few encounters with the word. The ability to fast-map allows children to learn meanings of words without being taught explicitly, thus speeding up word-learning processes. Many lexical constraints, including the ME constraint, have been proposed to explain how children are able to fast-map.

Lexical constraints allow children to narrow down the vast number of possible referents and subsequently map a novel label to the correct referent. Three such constraints are the Whole Object constraint, the Taxonomic constraint and the ME constraint. The Whole Object constraint posits that children will map labels to an object instead of to the object's property or a part of the object (Mervis, 1987). This constraint allows children to learn names of objects by assuming that the novel label they heard refers to an object. The Taxonomic constraint suggests that children will extend the referent of a novel label to other similar objects (Markman & Hutchinson, 1984). This principle is important because word learning needs to go beyond the association between a label and a particular object and be able to generalise the association to other exemplars of the object (Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992). Although the Whole Object constraint and the Taxonomic constraint explain how children are able to learn names of objects by assuming that novel labels refer to names of objects, they do not provide an explanation for why children tend to map a novel label to a name-unknown object.

According to the ME constraint, children are able to map novel labels to name-unknown objects because they tend to show a novelty bias (i.e., selecting a name-unknown object) upon hearing a novel label, an action which is explained through the assumption that each object only has one basic-level name (Markman, 1990; Markman & Wachtel, 1988). In other words, children will pair a novel label to a name-unknown object, because name-known objects are already associated with a label, therefore, the name-unknown object is more likely to be a referent for the novel label. Hansen and Markman (2009) and Markman and Wachtel (1988) found that on occasions where no name-unknown objects are available, children preferred to match a novel label to a name-unknown part of an object. These results lead the researchers to conclude that through the ME constraint, children are not only able to fast-map to learn names of objects, they can also learn names of substances, parts and properties of objects, thus widening their vocabulary.

2.1.2 General experimental design of ME

A general experimental design to test for the ME constraint is to show children, in each trial, a name-unknown object and at least one name-known object, while uttering a novel label (most of the time non-words), such as, "Can you get me the *dax*?". This design has been termed as referent selection (i.e., selecting a referent for a novel label), disambiguation (i.e., deciding which object the novel label refers to) or ME training (i.e., learning through ME what the novel label refers to) by previous studies, depending on the objective of the tasks. In the current thesis, this task is referred to as ME training, as children were first asked to select a referent for a novel label, and then tested on their selection on subsequent trials (which are referred to as test trials). If children select the name-unknown object significantly above chance, then the ME constraint is said to prevail.

Many different types of tasks have been conducted, most of which can be divided into object selection tasks and preferential looking tasks. Whereas object selection tasks (e.g., Golinkoff et al., 1992; Horst & Samuelson, 2008; Markman & Wachtel, 1988; Markman, Wasow, & Hansen, 2003; Mervis, Golinkoff & Bertrand, 1994; Samuelson & Smith, 1998) allow researchers to test if children are willing to map a novel label to a name-unknown object, preferential looking tasks (e.g., Bion et al., 2013; Mather & Plunkett, 2009; Schafer & Plunkett, 1998, Tan & Schafer, 2005) may offer a more sensitive test as they reduce task demands because children do not need to physically move objects, nor are they asked explicit questions. Results from these two paradigms yield similar results, where children were found to be able to match a novel label to a name-unknown object, suggesting that the ME constraint is a robust effect.

The robustness of the ME constraint is observed in many aspects of testing. For example, Golinkoff et al. (1992), Horst and Samuelson (2008), Merriman, Bowman and MacWhinney (1989) and Mervis and Bertrand (1994) all found that a single exposure to a name-unknown object is enough for children to associate a novel label to the name-unknown object. This behaviour is an impressive feat when considering that children typically need multiple trials before retaining newly-formed word-object associations (Horst, McMurray, & Samuelson, 2006). The time taken to make a response to the name-unknown object is similarly impressive. Halberda (2006) and Spiegel and Halberda (2011) found that within three seconds of exposure to a name-unknown object, children were able to associate a novel label to the name-unknown object. As young as 17 months old, children tend to gaze longer at the name-unknown object upon hearing a novel label (Halberda, 2003), showing evidence of the ME constraint. These studies show that young children display robust novelty biases, lending support to the ME constraint.

2.1.3 Mechanisms accounting for ME

Several explanations were provided to explain how children are able to make use of the ME constraint. A potential explanation is that young children engage in pragmatic reasoning; that is, they rely on the intention of the speaker when selecting a referent for a novel label (Diesendruck & Markson, 2001). According to this reasoning, if the speaker intended to refer to a name-known object, the name of that object would have been used. As the speaker is using a novel label, children assume that he must be referring to a name-unknown object. In line with this explanation, Pruden et al. (2006) and Paulus and Fikkert (2014) found that young infants (12 and 14 months old) were able to make use of pragmatic reasoning such as eye-gaze to disambiguate two name-unknown objects. As the speaker was looking at one of the objects, that object should be the target that the speaker was referring to. Other supporting evidence found that children will only follow the speaker's eye-gaze if the speaker knows where the object is (e.g., there's *dax*!), compared to when the speaker does not know where the object is (e.g., where's *dax*?) (Nurmsoo & Bloom, 2008). This finding suggests that children use the speakers' intention to decide whether or not the novel label refers to the name-unknown object.

However, Jaswal (2010), Jaswal and Hansen (2006) and Moore, Angelopoulos and Bennett (1999) suggested that pragmatic explanation may not be sufficient in explaining for the ME constraint because they found that a speaker's pointing or gazing towards a name-known object does not deter children's novelty bias. If, according to the pragmatics account, children take the speaker's intention into account, then when the speaker shows an intention to label a name-known object with a novel label, children should map the novel label to the name-known object. As children still show a novelty bias in the presence of these social cues, Jaswal (2010) refuted the pragmatic account as being the explanation behind the ME constraint and children's novelty bias. Thus, although children do make use of social cues during word learning instances, the pragmatic account may not be sufficient in explaining the novelty bias observed in children.

Another explanation for the ME constraint is through disjunctive syllogism, which is an eliminative process (Halberda, 2003, 2006). According to Halberda (2003), in a typical ME training trial, children are faced with two choices: either the name-known or the name-unknown object is the referent for the novel label. As the name-known object already has a name, it is unlikely to be the referent, thus, children would eliminate it from their choice. What is left is the name-unknown object, which is then mapped to the novel label. This theory is supported by Mather and Plunkett (2009), who showed that the novelty bias in response to novel labels increases with age, as older children (who have more exposure and experience with the name-known objects) are able to eliminate the name-known object more easily than younger children. Grassmann, Schulze and Tomasello (2015) also found support for this explanation. Although the children they recruited generally selected the name-unknown object above chance upon hearing the novel label, the children were more likely to show novelty bias when the name-known object was highly familiar (i.e., objects that the children spontaneously labelled), compared to when the name-known object was less familiar (i.e., objects that the children comprehend only). These results suggest that identifying the name-known object as a distractor is a crucial step in the ME constraint's one-to-one word-object mapping explanation for fast-mapping.

Although the ME constraint provides an explanation for word learning, recently, it has been suggested that the ME constraint is more likely to be stemming from a general cognitive process rather than a language-specific ability (Alishahi, Fazly, & Stevenson, 2008; Fazly, Alishahi, & Stevenson, 2010; Mather & Plunkett, 2010). Mather and Plunkett (2010) found that although 10-month-old infants were unable to comprehend the names of the familiar objects, they still showed novelty bias to name-unknown objects. In other words, general cognitive abilities, such as attention (e.g., Grassmann, Stracke, & Tomasello, 2009) and memory (e.g., Samuelson & Smith, 1998), may be accountable for the novelty bias observed in children. For example, Horst, Samuelson, Kucker and McMurray (2011) and Mather and Plunkett (2012) found that children preferred to map a novel label to a super-novel object (i.e., a name-unknown object that was never seen before) compared to a pre-exposed novel object (i.e., a novel object that has been presented to children before but was still name-unknown). Had the ME constraint been a specific linguistic ability, children should not be biased to either of the name-unknown objects because both objects are equally likely to be the correct referent of the novel label.

Moreover, if the ME constraint is a specific linguistic ability, children should show more novelty bias with labels (e.g., a *dax* or a book) than with facts (e.g., the one my father bought or the one I got for Christmas), because the ME constraint would be developed purely for word learning. Mixed results were obtained on this aspect. Although Diesendruck and Markson (2001) found that children were equally likely to show novelty bias with facts or labels, Scofield and Behrend (2007) found that children showed more novelty bias with labels than with facts. Deák and Toney (2013) explained that children may find facts to be more difficult to retain than labels because facts are cognitively more demanding due to the complicated structure of the sentence. Novelty bias may only be more prevalent in labels after children are very experienced with fast-mapping, thus, the ME constraint appears to stem from a general cognitive ability.

In short, a novelty bias in ME training trials is a very robust finding with children, as it allows children to fast-map a novel label to a name-unknown object via the ME constraint. In the current thesis, the ME constraint was tested using a tablet, using the approach introduced by Frank, Sugarman, Horowitz, Lewis and Yurovsky (2016). A simple design was used, where children were presented with one name-known and one name-unknown object while a novel label was played. As the ME constraint is a very robust effect, it was hypothesised that children will show a novelty bias in the battery of studies conducted in the current thesis.

2.1.4 Word learning through ME

Although children show a robust ME effect, selecting a name-unknown object when a novel label was presented does not mean that children have formed an association between the object and the label. Children may be biased to the novel object because of its salience and yet not retain any association formed between the novel label and the name-unknown object. Children's bias towards more interesting objects is supported by Pruden et al. (2006), who found that 10-month-old infants preferred to look at salient objects rather than boring objects when they heard a novel label, even though both objects were name-unknown to them. Moreover, Horst et al. (2011) and Mather and Plunkett (2012) found that object novelty (i.e., whether an object has been presented before) but not nameability (i.e., whether an object is name-unknown) affects children's choice in selecting an object to be mapped with a novel label. If children have not retained the association between the novel label and the name-unknown object, then word learning cannot be said to have occurred. Therefore, it is necessary to test whether children have learned and retained the newly-formed word-object associations.

To test whether children have retained the newly-formed word-object associations, children are generally presented with at least two name-unknown objects. One of these name-unknown objects is the target, which has been labelled before in the ME training trials, whereas the others are distractors, which may or may not have been presented or labelled before. Children are then asked for the novel label. This design is termed as retention test in the current thesis because children are tested whether they have retained the newly-formed word-object associations. If children could select the target name-unknown object, then it can be argued that they have formed and retained the association between the novel label and the name-unknown object. On the other hand, if the selection of name-unknown object was made purely on the basis of novelty preference with no retention of word-object associations, children would select randomly any of the present name-unknown object.

Golinkoff et al. (1992) and Mervis et al. (1994) found evidence that children who were able to fast map were also able to retain the newly-learned association. Not only did they find that children were able to retain the new word-object associations, they also found that children were able to extend the novel labels to other similar looking objects. More recent studies using eye-tracking data (Mather & Plunkett, 2011; Pruden et al., 2006; Wilkinson, Ross, & Diamond, 2003) also found that children are able to retain the newly-formed word-object associations. Thus, children do retain word-object associations successfully, suggesting that fast-mapping through the ME constraint may lead to word learning.

Yet, not all studies obtained supporting evidence of word learning through fast-mapping. For instance, Horst et al. (2006), Horst and Samuelson (2008) and Goldin-Meadow, Seligman and Gelman (1976) found that children were unable to retain newly-formed word-object associations even though they showed novelty bias in ME training trials. The researchers argued that fast-mapping does not provide sufficient experience for children to learn the association, as more trials are needed before children encode this information.

This finding was replicated using event-related potentials (ERP), through measuring brain electro-physiological activities. Specifically, researchers look for N400, which is named so because it is a negative peak (hence "N") that occurs at around 400 milliseconds (hence "400") after the presentation of the target. As the N400 component is usually elicited after the processing of meaningful stimuli, it can be used to reflect word learning and semantic processing (Mangardich & Sabbagh, 2017). Friedrich and Friederici (2011) found that an N400 effect was observed in successful mappings during ME training trials, showing that children have processed the novel label and associated it with the target object. Even though children showed evidence of fast-mapping, the memory of the word-object associations was not consolidated because after a day's gap, the N400 effect was not observed. Taken together, although word learning through the ME constraint is possible, more trials are needed before the word-object associations are fully consolidated. Therefore, it is crucial to test whether children have retained the word-object associations formed during ME training trials.

2.1.5 Factors affecting word learning

Difficulty of the tasks may affect children's performance in the retention test. For example, the number of labels taught and the number of distractors presented may affect children's performance, as a higher number of labels is more taxing on the memory. However, Horst and Samuelson (2008) found that even when children were learning only one novel label, they were unable to retain the newly-formed association. Retention failure in Horst and Samuelson (2008) may be due to a lack of trial repetition. Horst et al. (2006) and Mather and Plunkett (2009) found that a high number of ME training trials is required before successful performance in retention test is possible. Similarly, Deák and Toney (2013) argued that fast-mapping through the ME constraint does not support word production. Instead, many repetitions are required to strengthen word learning, as repetition allows associations to be encoded more strongly.

These factors (e.g., number of novel labels, repetition) that affect task difficulty are dependent on the age of the child, as what seems easy to an adult may be difficult for young children (Woodward & Markman, 1991). Torkildsen et al. (2008) argued that vocabulary size is another factor that affects retention rate. They found that N400 amplitude correlated positively with productive vocabulary, where high producers but not low producers showed the N400 effect during retention test. This finding suggests that the ability in retaining newly-formed word-object associations may depend on the experience of children in word learning. Therefore, the above-mentioned factors need to be taken into account when testing children for their retention ability.

Other variables are also found to influence learning of newly-formed word-object associations in children. Twomey, Ma and Westerman (2018) found that variability in the background of the target object helps learning, as it decontextualises the object. Target objects that are salient also help children, as children are naturally drawn to salient objects

(Houston-Price, Plunkett, & Harris, 2005). In a similar manner, Pomper and Saffran (2018) found that distractors that are boring-looking help learning because boring objects do not compete much with the target for attention from the children. Salience in terms of the novel label can also affect infants' performance in mapping labels to objects (Curtin, 2009). Curtin (2009) found that when the labels were salient, infants were able to learn even minimal pairs that differ in stress patterns. Thus, these variables should be considered before concluding whether children are able to retain newly-formed word-object associations.

In short, whether the ME constraint leads to word learning depends on the difficulty of the tasks and the age of children. If the task is relatively easy for the age group that was tested, then it is likely that children will show some form of retention of the newly-formed word-object associations. The current thesis conducted retention tests using a simple design, where only two name-unknown objects were presented, one of them being the target and the other the distractor. This simple design was used because the aim of the current studies was not to test to what extent children are able to retain associations, but to ensure that children have learned the word-object associations during ME training trials. Therefore, it was expected that children would be able to select the target above chance in this relatively easy retention test.

2.1.6 Limitations of ME

A limitation with a strict interpretation of the ME constraint is that it assumes that children would reject a second label for a name-known object, when in fact, many objects have more than one name, such as synonyms (e.g., a dog and a hound), superordinate-level labels (e.g., a dog and a mammal) and subordinate-level labels (e.g., a dog and a German Shepard). The ME assumption suggests that children are selective when forming word-object associations, because they are biased only to one name-unknown object when selecting a referent for a novel label. To be able to learn multiple labels, children need to be non-selective, where they are willing to map a novel label to more than one object. Although Woodward and Markman (1991) argued that the ME constraint can be overridden by other cues, Jaswal (2010) found that pragmatic cues, such as a speaker gazing or pointing towards a name-known object, are unable to deter children from relying on the ME constraint.

According to Markman and Wachtel (1988), when no name-unknown object is present, children will map the novel label to a part of a name-known object which is name-unknown (e.g., the spout of a teapot), as they would reject a second name for the name-known object. However, studies have found that children are equally likely to give an object a second name (Mervis et al., 1994), conflicting with the strict assumption proposed by the ME constraint. Mervis et al. (1994) claimed that children selected a part of a name-known object in Markman and Wachtel (1988) because they might already know the novel label used (Markman and Wachtel used real English words in their studies). When the same task was conducted with non-words as novel labels, children paired the novel label to a name-known object more frequently than to a part of an object. Moll, Koring, Carpenter and Tomasello (2006) also found that children did not try to map a novel label to a salient part of a name-known object when no other name-unknown object was present, even when the children's gaze was directed towards the salient part of the object. Instead, the children engaged more in searching behaviour. Furthermore, Haryu and Imai (2002) revealed that when taught a novel label for name-known objects, three-year-old Japanese children seldom learned these labels as names for parts of the objects, instead, they preferred to assume that these novel labels are subordinate-level labels. Thus, although children tend to select a name-unknown object in response to a novel label, in contrast to the ME constraint, they do not seem to reject a second name for a name-known object.

Although the ME constraint assumes that children learn one-to-one mapping between words and objects, according to Woodward and Markman (1991), the ME constraint is a probabilistic bias that can be overcome by other constraints, as constraints are ordered in a hierarchical manner. Hence, rejection of the ME constraint is not necessarily evidence against the ME constraint, as it is not an absolute bias. Supporting this argument, Haryu and Imai (1999) found that pointing is a powerful cue in overriding the ME constraint in young Japanese children. Furthermore, they revealed that when given a social context where a food item is the most likely object to be paired with the novel label, older children (5 years old) were able to take social context into account and select the name-known object whereas younger children (3 years old) still selected the non-edible name-unknown object as compared to an edible name-known object.

However, there is contradictory evidence on whether other biases allow children to overcome the ME constraint. For instance, Jaswal and Hansen (2006) and Jaswal and Markman (2007) found that pragmatic cues, such as direct teaching, gazing or pointing, do not lead children to overcome ME constraint and learn a second label for a name-known object (although Jaswal (2010) showed that a combination of pragmatic cues can overrule the ME constraint). The failure to overrule the ME constraint may be, because children only rely on other biases, such as social cues, when the ME constraint is uninformative (Graham et al., 2010). Thus, even though it is possible for children to overcome the ME constraint through social pragmatic cues, these social cues may not be strong enough to allow children to reject the ME constraint and form non-selective word-object associations.

Other thereotical accounts are similar to the ME approach but offer a slightly different explanation of how children fast-map. Whereas the ME constraint focuses on novelty, the Novel Name-Nameless Category principle (N3C, Mervis & Bertrand, 1994) focuses on nameability. Both ME and N3C propose that children map a novel label to a name-unknown object, but the difference between these accounts lies in the reason underlying such selection. According to N3C, children map a novel label to a name-unknown object because they want to avoid having a nameless object. If no name-unknown object is around, children would then learn a second label for a name-known object. To take a teapot as an example again, according to both ME constraint and N3C, a child will map the word “spout” (erronously, in this case) to the object teapot if she has yet to learn the word “teapot”. However, for a child who already understands the label “teapot”, the ME constraint hypothesise that this child will map the novel label “spout” either with a part of the teapot or a property of the teapot. On the other hand, N3C proposed that the child will learn the word “spout” as a second label for the teapot. Thus, N3C provides an alternative explanation to how children learn multiple labels, because it suggests that children are not selective in forming word-object associations. In other words, children are not biased just to name-unknown objects when selecting a referent for a novel label. Instead, children are also willing to match novel labels to name-known objects and learn a second name for these objects. This theory is similar to the lexical gap hypothesis proposed by Merriman et al. (1989), where children select a name-unknown object as a referent for a novel label to avoid having an object that has no label. These alternative accounts provide an explanation for the formation of non-selective word-object associations and learning of second labels for name-known objects without the need to overrule any biases.

Strong interpretations of the ME constraint also face problems when multiple name-unknown objects are present during a naming session. In a natural setting, many objects are present and there is a possibility that there is more than one name-unknown object in the visual range of a child. In such cases, it is not clear how the ME constraint explains the way children narrow down the hypothesis space. That having multiple name-unknown objects in sight complicates word learning instances is supported by Yurovsky, Smith and Yu (2013). In their study, participants were presented with a scene that a baby sees in a natural setting and the participants found it difficult to select the correct referent for beep sounds (presented in place of actual words that the baby heard). Instead, Yurovsky et al. (2013) argued that babies actively seek objects that are possible referents for the novel label they hear and associate the label to these objects, accumulating these associations to form a hierarchy of word-object associations. Storing more than one word-object association is a hypothesis put forward by the CSL account, which is discussed in the next section.

In short, it is necessary to test whether word-object associations are selective, that is, whether children would only form one-to-one mappings between novel labels and name-unknown objects. The current thesis examined this question by testing whether children are willing to associate a novel label with a name-known object if these two were presented together for a few trials, a test known as the selectivity test. If children not only select a target above chance in the ME training trials and the retention test (as mentioned in previous sections), but also in the selectivity test, then it can be argued that the novelty bias observed in ME training trials does not mean that children have formed just one word-object association. Instead, word-object associations are likely to be non-selective.

2.2 Cross-situational Statistical Learning (CSL)

2.2.1 General paradigm of CSL

Often, in the real world, multiple name-unknown objects are present when a novel label is uttered. This situation may pose a problem to language learners, such as children, as they would not be able to know which name-unknown object is the correct referent for the novel label they have heard, even if they make use of the ME constraint. Yurovsky et al. (2013) illustrated this problem, where they found that adult participants performed at chance level when asked to search for a referent for a beep sound (representing names of objects) embedded in parents' speeches to their toddlers. This finding supports the argument that one-trial learning may not be sufficient for a child in learning names of objects (Samuelson, Kucker, & Spencer, 2017). In such cases, the CSL account argues that learners form an association between the novel label and a few objects that co-occur with the label. These associations are accumulated and the strongest word-object association provides a basis for word learning. In order for this hypothesis to work, CSL makes two assumptions: that the labels uttered are relevant to the immediate environment (i.e., talking about a dog that is present at that moment, not about a cat that was seen earlier) and that learners remember the co-occurrence between labels and objects (Kachergis, Yu, & Shiffrin, 2013).

To test whether language learners are able to learn word-object associations across ambiguous situations, a typical CSL paradigm presents participants with at least two name-unknown objects and two novel labels. This design is in contrast with the ME constraint's paradigm, where only one name-unknown object is presented in the ME training trials. As there is more than one name-unknown object in each trial, each individual trial is ambiguous as to which name-unknown object is the correct referent of the novel label. However, the novel labels and the correct referent always co-occur, thus, across multiple trials, participants would be able to learn the correct referent through an accumulation of associations. To illustrate, if the novel label *a* appears with name-unknown objects *A* and *B* in one trial, it is equally likely for pairing *a-A* and *a-B* to be true. In the next trial, when the label *a* appears with objects *A* and *C*, because object *A* appeared with label *a* twice, these two are more likely to be the correct pairing than *a-B* or *a-C*. In other words, an accumulation of associations allows one to compare the frequency of the word-object associations and in turn learn referents for novel labels. To test whether participants have learnt the associations, a four alternative forced choice (4AFC) test is usually carried out. Participants who have learnt the pairings would be able to select the correct referent for the novel labels accurately above chance.

Yu and Smith (2007) and Vouloumanos (2008) found evidence that adults can rely on this aspect of statistical learning. They found that the participants were not only able to select the target above chance in the test trials, they were also able to select the distractor object with the higher frequency of co-occurrence with the novel label when the target was not present in the test. This performance suggests that participants were able to keep track of frequencies of various word-object pairings and use this stored knowledge to determine the referent for novel labels. Supporting these results, Yurovsky, Fricker, Yu and Smith (2014) argued that word learning is achieved through gradual accumulation of associations rather than the absolute mapping between one label and one object. Smith and Yu (2008) found that infants at 12 and 14 months of age, too, can form word-object associations in this manner. Although both adults and children are able to learn through CSL, differences in performance between adults and children are still observed (Newport, 2016). One prominent difference between adults and children is that when both children and adults were presented with novel linguistic patterns that appear to be highly inconsistent, children were more likely than adults to change this patterns and produce more systematic linguistic patterns. Yurovsky and Frank (2015) also cautioned that children's cognitive abilities are different from adults and even having to store two word-object associations is challenging for children. Nonetheless, these studies show that across ages, language learners are able to make use of CSL to learn names of objects.

2.2.2 Theoretical explanations behind CSL

The statistical learning explanation put forward by CSL is in line with the argument that word learning is a continuous process instead of an all-or-none experience. According to

Yurovsky et al. (2014), a successful performance in CSL is achieved through the formation of a hierarchy of word-object associations. Labels and objects that co-occur frequently would have a stronger association than those that co-occur less frequently. Therefore, even when there are multiple possible word-object pairings, children are able to form a hierarchy of word-object associations to verify and rule out spurious word-object pairings (Yu & Smith, 2007). This argument provides an explanation on how children are able to match labels to objects in the real world, even when multiple associations are possible. Furthermore, Yurovsky et al. (2014) found that previous knowledge affects learning performance. Even though their participants had not successfully learned all of the word-object associations, some knowledge, termed as partial knowledge, had been stored about the association that they had not learned. This partial knowledge sped up learning of these old associations, as well as new associations that the participants have not encountered before. Thus, CSL provides an explanation of word learning over time, from the mere tracking of frequency co-occurrence to using partial knowledge in word learning.

If word learning is achieved through CSL, language learners should be able to perform well in CSL-related tasks without explicit instructions, as statistical learning can be achieved implicitly (Kachergis, Yu, & Shiffrin, 2010). Although Poepsel and Weiss (2014) and Vlach and Sandhofer (2014) found confidence ratings (a measure of knowledge awareness) of participants to correlate with participants' performance, Benitez, Yurovsky and Smith (2016) and Yurovsky et al. (2013) found no such correlation, suggesting that learning through CSL is likely to be implicit. Kachergis et al. (2010) also found evidence to support this claim. When their participants were not given explicit instructions to keep track of different associations (i.e., participants were told that they would be tested on recognition memory), participants were still able to map the novel labels to the correct name-unknown object above chance. However, when participants were given explicit instructions (i.e., they were asked to learn meanings of words), the performance was significantly better than the former group of participants, suggesting that language learners use statistical learning automatically, but performance is enhanced when attention is given to remember the associations. Yet, Smith, Smith and Blythe (2009) argued that Smith and Yu (2008) had over-estimated the ability of learners in using CSL. According to Smith et al. (2009), although learners are able to learn through CSL, referential uncertainty and forgetting will cause participants not to be able to perform at an optimal level. Thus, although children and adults are capable of learning words through an accumulation of evidence, a heavy cognitive load may affect this performance and the high level of accuracy obtained in laboratory settings may not transfer to real-life situations.

In short, even though children are faced with ambiguous situations in which there is more than one name-unknown object, and one-trial learning is not possible, they are nonetheless able to match the novel labels to the correct name-unknown objects by accumulating and forming a hierarchy of associations. The current thesis aimed to provide an extension to traditional CSL accounts by presenting both a name-unknown and a name-known object to children in ME training trial (i.e., the selectivity test), whereas in typical CSL-tasks, participants are presented only with name-unknown objects. If children are able to perform above chance in the selectivity test, that is, being able to select the target name-known object for the novel label, then it provides an even stronger argument that word-object associations are non-selective.

2.2.3 Hypothesis testing or associative learning

Being able to form a hierarchy of associations suggests that word learning is not selective, because children would not selectively map a novel label with only one name-unknown object. This argument is in line with the associative learning account of CSL, which proposes that language learners accumulate associations between different labels and objects and learn names of objects through a hierarchy of associations of different strength and frequency. This account is different from the hypothesis testing account of the CSL, which argues that children only form one-to-one mappings between words and objects. Supporting the hypothesis testing account, Ichinco, Frank and Saxe (2009) argued that being able to pair novel labels to targets successfully in CSL tasks does not mean that the participants have formed multiple word-object associations. Instead, language learners could perform well above chance and yet still only form one-to-one mappings between words and objects. According to the hypothesis testing account, participants learn by guessing a referent randomly for the novel label (Trueswell, Medina, Hafri, & Gleitman, 2013). If they are correct, they will be able to strengthen the word-object association in subsequent trials and finally learn the association successfully. On the other hand, if the first guess is wrong, language learners will need to make a new random guess and select another referent for the novel label.

Associative learning accounts propose that multiple word-object associations are maintained during CSL tasks. In their strong forms, participants trace these associations using associative learning and store all associations as evidence (Smith, Smith, & Blythe, 2011). According to this account, language learners will store multiple objects that co-occur with a label and these objects are equally likely to be selected as a referent for the label. This strong account of associative learning is supported by Vouloumanos (2008, Study 2), who presented adult participants with word-object associations of different frequencies: a target object appearing six times (frequency of 6 out of 6), a high frequency distractor twice (frequency of 2 out of 6) and a low frequency distractor only once (frequency of 1 out of 6). Participants were able to select the target above chance and when the target was not available, the high frequency distractor was selected instead, suggesting that participants stored multiple associations. If participants had selectively stored only one-to-one mappings, they would not be able to select the high frequency distractor as it was not the target. This evidence suggests that participants are able to track all co-occurrence of word-object associations and use this knowledge to learn names of objects.

The associative learning account is different from the hypothesis testing account, where the latter argues that language learners store only their first guess of word-object association as evidence. An account of hypothesis testing is the Propose-but-Verify (PbV) theory (Trueswell et al., 2013). According to this theory, children first randomly guess which object is to be paired with the novel label. This choice is tested in subsequent trials. If the object is again present, this guess is strengthened. Otherwise, the associated name-unknown object will be replaced by another name-unknown object without any consideration for objects that appeared previously. PbV is supported by Aravind et al. (2018) and Medina, Snedeker, Trueswell, and Gleitman (2011) and Berens, Horst and Bird (2018), who suggested that adult participants were unable to store multiple hypotheses for word-object associations, as they observed that participants' performance was poor if their first guess was incorrect. If the participants had stored multiple associations, then whether their first guess was accurate or not would be irrelevant, as they have additional information beyond their first guess to help them in subsequent trials. Yet, Fitneva and Christiansen (2011, 2017) found that participants' initial accuracy correlated negatively with successful performance during test, which was in contrast with the theory proposed by PbV. Fitneva and Christiansen (2017) explained that initial erroneous mappings may cause participants to think more critically, leading to better performance later. If participants guessed randomly in each trial, without taking into account other associations that have been presented before, then initially wrong responses should not correlate with participants' performance.

Another account based on hypothesis testing is the Pursuit hypothesis, which is a refined version of PbV (Stevens, Gleitman, Trueswell, & Yang, 2017). According to Pursuit, children behave in a similar manner as proposed by PbV, except that all previous selections are remembered and taken into account when making subsequent selections. This line of explanation includes both the ability to remember multiple associations while taking into consideration the limited cognitive resources causing children not to be able to store all possible associations. Pursuit is in line with the results of Yu, Zhong and Fricker (2012), who found that, contrary to Trueswell et al. (2013), there was no difference between strong and weak learners at the start of the task. After a few trials, strong learners were found to be biased towards a previously seen object if a previous label was presented again, whereas weak learners did not show such bias, suggesting that being able to store multiple associations helps in word learning. In sum, although there is evidence supporting hypothesis testing, there is also considerable contradicting evidence suggesting that participants are able to store more than just one word-object association.

A possible reconciliation for hypothesis testing and associative learning is that language learners actually actively seek information to be stored rather than blindly storing all information available (Yu & Smith, 2011). In other words, in a natural setting where there are countless possible referents, learners do not store all co-occurrences as suggested by a strong interpretation of associative learning, neither do they store just one mapping and then guess again if the initial guess is wrong as suggested by hypothesis testing. Active learning is important because learners can learn by developing strategies (Kachergis et al., 2013). For instance, when learners were allowed to choose which objects to learn, Kachergis et al. (2013) found that learners tend to select the same few word-object pairings before learning a new set of word-object pairings. They also do not learn more than three to four pairings at a time to reduce cognitive load. In a similar manner, infants learn actively by looking longer at certain objects. Yurovsky et al. (2013) found that when adult participants were watching a video that was recorded from a baby's first-person point of view, the participants were actually able to guess accurately the object that was referred to in the beep sound, whereas those watching the video from a third-person's point of view performed at chance level. This finding suggests that children do not store all objects present, instead they actively select and store information that they find relevant. Roembke and McMurray (2016) also supported the argument that multiple associations are stored when learning the meanings of novel labels, as they found that high frequency distractors (60% of co-occurrence) impeded learning compared to low frequency distractors (40% of co-occurrence). With higher task demands and cognitive load, participants store a reduced number of associations (Yurovsky & Frank, 2015).

In short, children are likely to be able to store multiple word-object associations and use this knowledge to help them decide which is the correct referent for novel labels, something that they can achieve implicitly, as found by Kachergis et al. (2010). However, learners are, to some extent, selective in terms of which associations to store. Rather than storing all possible associations or only one guess, depending on the difficulty of the task at hand, children are likely to selectively store a few word-object associations. The studies of the current thesis were designed to be simple and sensitive tests for evaluating the selectivity of word-object associations. Thus, it is hypothesised that children are able to store multiple word-object associations in the current studies.

2.2.4 Factors affecting performance in CSL paradigms

The discrepancy in participants' performance in CSL-related tasks may also be due to certain variables manipulated in the experiment. Other than task difficulty, the number of trial repetitions, frequencies and numbers of distractors and whether the appearance of the target is interleaved also affect participants' cognition and memory, leading to participants keeping track of fewer word-object associations (Yurovsky & Frank, 2015). The following factors will be examined in this section: memory, chunking, temporal interleaving, frequency of distractors and age of participants. An understanding of the role played by these factors allows us to understand in what circumstances participants perform at their optimal level. Although these factors are discussed separately in different paragraphs, they nevertheless intertwine with each other in terms of their influence on word learning.

Memory affects performance in CSL-related tasks, as Shanks, Rowland and Ranger (2005) found participants' reaction time to increase when they were multi-tasking. This finding suggests that performance through CSL requires memory and attention from learners as well, even though Kachergis et al. (2010) found that it can be achieved implicitly. According to Romberg and Saffran (2010), CSL is achieved by operating on a few elements, such as labels, objects, context and social cues together. Therefore, even though participants rely on CSL automatically, storing multiple word-object associations still increases cognitive load from the participants. Beyond visual attention, memory is also needed to remember the visual and auditory information and to bind them so as to form an association between them. This argument explains why repetition of trials helps learning, as associations that are repeated are better consolidated in memory (Perruchet & Pacton, 2006). Words are also associated with other stimuli, such as background, therefore, varying the background enhances learning (Roembke & McMurray, 2016; Twomey et al., 2018). This background variation allows participants to dismiss spurious associations between labels and irrelevant factors that may take up memory space and in turn interfere with word learning.

Memory can also be enhanced by chunking; that is, grouping a list of to-be-learned labels into a few blocks of labels. According to Perruchet and Pacton (2006), the strength of memory is affected by both trial repetitions and interference with the target. Chunking labels into groups becomes effective as it provides an efficient way to encode associations. In line with this argument, Yurovsky et al. (2014) found that presenting participants with blocks of labels leads to better learning, as this method is akin to participants learning only a few pairings in one sitting and adding more pairings once they have acquired some knowledge from this first sitting. Supporting this explanation, Kachergis et al. (2013) demonstrated that when participants get to select which labels to learn, participants tend to learn a few novel labels for a few trials before moving on to another few labels. Benitez et al. (2016) explained that when items are put in blocks, temporal separation between the two blocks is created, leading to a reduction in competition between the labels of these two blocks. When competition is reduced, learning increases. However, chunking may be detrimental to learning second labels. Yurovsky and Yu (2008) found that chunking leads to primacy effect as the first block is encoded better than the second block. This effect was eliminated when the trials were shuffled. Yurovsky, Yu and Smith (2013) also argued that although chunking provides effective coding, the first block interferes with the learning of the second block as prior knowledge about a label inhibits the acquisition of new knowledge about the same label. This explanation is supported by studies (e.g., Poepsel & Weiss, 2014; Yurovsky & Yu, 2008) which found that learners showed primacy bias when learning many-to-one word-object pairs. However, Poepsel and Weiss (2014) found that the primacy bias may be removed with certain manipulations, such as giving explicit instructions about learning two names for an object or explaining to the participants beforehand that the second label is from a different language.

One advantage of chunking is that it creates a temporal separation between two blocks, which suggests that interference in time affects learning in CSL-related tasks. Benitez et al. (2016) and Yurovsky et al. (2013) found that temporal separation eliminates competition between labels, leading to better performance. According to Medina et al.

(2011), a large time gap reduces the impact of incorrect trials on the learning of current blocks, thus improving participants' learning instances. These findings are in contrast with Smith et al. (2011), who argued that interleaving between novel labels leads to more interference, in turn increasing the participants' cognitive load, leading them to store fewer associations. Supporting this explanation, Vlach and Johnson (2013) showed that 16-month-olds were only able to learn pairings that were presented together (i.e., massed trials), whereas 20-month-olds were able to learn from both massed and interleaved trials. The discrepancy in results could be explained through global and local competition. Global competition means the interference between items throughout the experiment, whereas local competition refers to the interference between items that were presented in the same trial (Onnis, Edelman, & Waterfall, 2011). Global competition reduces the interference of noise on word-object associations, as labels are also associated with other irrelevant background variables (Roembke & McMurray, 2016). Thus, global competition interferes with the learning of two-to-one word-object associations when these associations are interleaved. However, for one-to-one word-object associations that are chunked, global competition speeds up learning through increased consistency in word-object associations.

Distractors also interfere with the learning of word-object associations. Roembke and McMurray (2016) found that when foils appear for 60% of the time, participants' performance was worse than if the foils appear only 40% of the time, suggesting that a high frequency competitor impedes learning. A way to overcome the distraction of foils is through repetition of trials, as repeated targets are likely to be learnt by participants. However, excessive repetition does not lead to effective learning as non-repeated trials become novel and require increased attention from the participants, consequently causing the often repeated trials to fade from memory (Kachergis, Yu, & Shiffrin, 2009a). Attention is thus important to consolidate the memory of the word-object associations. This argument explains why minimal pairs are harder to learn and word learning is affected by the novel label's neighbourhood size (Swingley & Aslin, 2007), as similar-sounding words lead to high competition. In a similar manner, distinctive labels prevent co-activation of distractors and thus limits competition, leading to better CSL performance. However, this explanation does not mean that language learners are unable to learn minimal pairs through CSL, as Escudero, Mulak and Vlach (2016) found that their participants were able to learn minimal consonant pairs. This success could be attributed to the need to identify minimal consonant and vowel changes in words to differentiate words.

As with studies on pragmatic cues, the age of participants plays a role in whether they succeed in learning labels. Although Smith and Yu (2008), found that both infants and adults successfully map novel labels to the target name-unknown objects, Fitneva and Christiansen (2017) obtained differences in performance between 4-year-olds, 10-year-olds and adults. Differences between adults and children are also revealed when comparing different studies. For instance, although Escudero et al. (2016) found that adults were able to learn consonant minimal pairs, Werker et al. (1998) found that 14-month-olds were unable to learn such minimal pairs unless the objects were moving, suggesting that there are differences between children and adults in word learning tasks.

In short, many variables play a role in affecting participants' performance in word learning through CSL, as CSL requires attention from the learner. As the current thesis aimed to use a sensitive test for word-object selectivity, the test conducted was simple. If participants are unable to select the target above chance even in such simple tests, then there is a possibility that relying simply on low-level associations is not enough for children to learn a second label for a name-known object. A wide age range, with participants between 4 and 11 years of age, was used in the current study, as Fitneva and Christiansen (2017) found that younger children perform differently from older children, arguably because they rely on different learning mechanisms when forming word-object associations.

2.3 Syntactic Bootstrapping

A linguistic bias that can be used alongside the ME constraint is syntactic bootstrapping. Syntactic bootstrapping allows language users to narrow down possible referents using the syntax (rules of word order) of a particular language. Each language has syntax that allows its speakers to understand each other from the structure of the sentence. Syntactic cues are useful as linguistic biases, because words seldom appear in isolation. Instead, they are usually joined together to form a coherent sentence. As each meaningful sentence is governed by grammatical rules of a particular language, these rules can be exploited to help select a referent for a novel label. This section first looks at studies conducted on verb learning, followed by the usage of syntactic bootstrapping for learning nouns and adjectives. As syntactic bootstrapping is used in relation to other lexical biases (Naigles & Swensen, 2007), the interaction between syntactic bootstrapping and other biases and the age at which children start showing evidence of using syntactic bootstrapping are explored.

Many studies examined the effect of syntax on word learning through verb learning, as syntax typically provides a cue on the type of verb; for instance, when a direct object comes after a verb, it suggests that it is transitive; when a preposition is used together with a verb, it suggests one is dealing with a motion verb (Golinkoff, Jacquet, Hirsh-Pasek, & Nandakumar, 1996; Lidz et al., 2003; Naigles, 1990; although these rules may differ depending on the language). Even though the syntax of languages differ, studies have shown that children universally use syntactic bootstrapping to learn new verbs: whether it is in French (Naigles & Lehrer, 2002), Kannada (Lidz et al., 2003), Mandarin (Lee & Naigles,

2008) or Turkish (Göksun, Küntay, & Naigles, 2008). These studies provide strong evidence that even though the actual grammar itself differs across languages, these grammatical rules exist in most if not all languages, and children are aware and sensitive to these rules, being able to exploit them for their benefits in word learning (Hall, 2009).

Although children can learn the meanings of objects through other lexical constraints, such as the ME constraint and the Taxonomic constraint, syntactic bootstrapping is also useful in learning nouns. Children are just as sensitive to syntactic elements governing nouns as they are to verbs. For example, in many languages, nouns are preceded by a determiner and in some of these languages, the determiners provide information about the grammatical gender of an object. An example of such a language is German, where the determiner for the word *Hund* (dog) is *der*, showing that it is a masculine noun, whereas the determiner for the word *Katze* (cat) is *die*, meaning that it is a feminine noun. Studies have shown that children process this information automatically. Boutonnet, Athanasopoulos and Thierry (2012) found that when Spanish bilinguals were asked to perform a task in English in which they had to decide whether an image was of the same or different semantic category as another object, the participants' ERP patterns showed they had retrieved information about grammatical gender even though this information was irrelevant to the task at hand. Similarly, Bobb and Mani (2013) found that two-year-old German children implicitly relied on grammatical gender about objects even though they were performing another task at a semantic level. This evidence strongly suggests that children retrieve syntactic cues implicitly and that this information can be useful to children when learning names of objects.

Studies conducted in English (e.g., Bloom & Kelemen, 1995; Hall, Quantz, & Persoage, 2000; Hall et al., 2001; Katz et al., 1974) showed that syntactic cues do help children in word learning. In English, count nouns are preceded by a determiner (e.g., an apple) whereas proper nouns are not (e.g., Peter). Sorrentino (2001) found that if the syntax suggests that the novel label is likely to be a proper noun, children did not generalise the novel label to other similar-looking name-unknown objects, as they did when the novel label is likely to be a count noun. Children make such differentiation, because labels for count nouns are basic-level labels whereas labels for proper nouns are for identifying only one particular individual. This finding is supported by Bélanger and Hall (2006), who found that children learned a novel label as a count noun when the novel label was preceded by a determiner (e.g., which is a *dax*?), compared to when the novel label was not preceded by anything (e.g., which is *Dax*?). Moreover, Booth and Waxman (2003) and Hall and Graham (1999) found that children did not blindly match a novel label to a name-unknown object. They found that children only selected a name-unknown object if the syntax indicated that the novel label was a count noun. If syntactic cues suggest that the novel label was likely to be an adjective, the child would not show object novelty bias. Instead, children would select a novel property to be matched with the novel label. Therefore, syntactic bootstrapping allows the ME constraint to be overruled, allowing words such as adjectives and properties of object to be learned.

According to the ME constraint, children learn basic-level labels for objects before learning other types of labels such as labels for properties of objects and proper nouns. For instance, Hall and Bélanger (2009, as cited in Hall, 2009) found that 23-month-olds interpreted novel labels as proper nouns only for name-known objects but not for name-unknown objects, even when animated stuffed toys were used in both conditions. This finding provides supporting evidence for the ME constraint, where young children first learn the basic-level label for objects before learning proper nouns. Yet, Hall (2009) argued that an understanding of proper nouns appear to emerge at about the same time as count nouns in children. Syntactic bootstrapping explains how children are able to learn proper nouns at around the same time as count nouns, in a similar way as to how an adjective for a name-unknown object can be learnt. This explanation suggests that syntactic bootstrapping may enable children to override the assumptions of the ME constraint. However, learning proper nouns using syntactic cues is still influenced by many factors, such as whether an object is animate (Hall, 1991) and nameability (Hall & Bélanger (2009), as cited in Hall, 2009). Hall (1991) found that even though syntax suggests that a novel label is a proper noun (i.e., no determiner in front of the novel label), children will only interpret the novel label as a proper noun if the object is animated, and they will not do so if the object is an artefact.

Age is an important factor in terms of whether syntax is used in word learning. Tomasello (2000) questioned whether children understand syntax the same way as adults, as children's understanding of verbs and nouns is limited compared to adults. Looking at the age at which children start to use syntax, Hirsh-Pasek, Golinkoff and Naigles (1996) found that two-year-olds were able to differentiate different types of verbs. Similarly, Mintz and Gleitman (2002) found that two-year-olds were able to exploit syntax and learn novel labels as adjectives (e.g., this one is *blickish*) but one-year-old infants were unable to do so and learned the novel labels as names of objects. Shi and Werker (2001, 2003) also found that six-month-old infants, English monolinguals and English-Mandarin bilinguals alike, preferred English lexical words (e.g., mommy, chair, taste, play) to grammatical words (e.g., you, the, in, a). These findings support the argument that children at a young age are less sensitive to syntax. Nevertheless, Echols and Marti (2004) found that 18-month-old infants were able to distinguish between nouns and verbs. Hall, Waxman, Brédart, Nicolay (2003) also found age differences in terms of syntax usage. Hall et al. (2003) manipulated the name given to a red name-unknown animate object, where the object was either called Mr Red (descriptive proper name), simply described as a red object (adjective) or Mr Smith (control proper name). The children were watching as this object turned green, and another red name-unknown object was presented to them. Hall et al. (2003) found that although three-year-olds selected the new red object in the descriptive proper name condition, four-year-olds selected the original red object that had turned green. Therefore, Waxman (2004) suggests that, following Haryu and Imai (2002), children younger than three years of age hold strongly to the ME constraint and map novel labels to name-unknown objects regardless of other contradicting evidence. This argument is intuitive, as one needs to have a certain level of knowledge about the grammar of a language before being able to use it to learn the meanings of words. This argument also supports Graham et al. (2010) and Haryu's (1999) claim that the ME constraint is a bias that young children use when other constraints do not help disambiguate items.

Syntax is not just language-dependent (e.g., English uses a count-mass system, German uses a gender grammar system, whereas Mandarin uses a numeral classifier system), but also arbitrary, in each system. Two languages that use gender grammar system may not use the same gender for the same object, for instance, the sun is masculine in French (*le soleil*) but feminine in German (*die Sonne*). Stark differences are also observed in different languages that use numeral classifier systems. Whereas Malay has a classifier specifically for animals (*ekor*), Mandarin has several classifiers, depending on the type and size of animals (e.g., *yì zhī gǒu* – one [classifier] dog; *yì tóu niú* – one [classifier] cow; *yì pī mǎ* – one [classifier] horse). Despite these differences in syntax, Athanasopoulos (2006), Imai (1999) and Imai and Haryu (2001) found that children from different language groups (Japanese and English, specifically) were able to differentiate count nouns and mass nouns without the help of syntax. Imai (1999) then argued that syntax may be a weak cue and that Taxonomic constraint precedes syntactic bootstrapping as younger children rely more on the former constraint than syntactic bootstrapping. This result has been replicated by many other studies that investigated the effect of syntax of a language on object categorisation in children (Imai et al., 2010; Mazuka & Friedman, 2000). They argued that syntactic bootstrapping is likely to be a relatively weak cue compared to other lexical constraints for children, as children speaking different types of language systems did not show differences in their performance.

Thus far, studies that pitted syntactic bootstrapping against the ME constraint have been tested only in English (e.g., Hall et al., 2000; Katz et al., 1974) whereas studies conducted on numeral classifier languages only tested syntactic cues against Taxonomic constraint (Imai & Gentner, 1997). As syntactic bootstrapping was found to be an informative constraint in helping English-speaking children to decide on the correct referent for a novel label, the current thesis aimed to test whether the syntax of a numeral classifier language also provides useful information to children when learning the meanings of words. Children aged between four and nine years of age were recruited, as younger children may not have acquired sufficient experience with the syntax to display a productive use of classifiers (Salehuddin & Winskel, 2011, 2012). Having a wide age range also allowed age trends to be observed, as older children who are more experienced with the language should be more confident when using syntactic cues.

2.4 Research Questions

2.4.1 Contribution

The current thesis aimed to test word-object selectivity using an ME paradigm. Most studies (e.g., Ichinco et al., 2009; Vouloumanos, 2008; Yu et al., 2012) testing for multiple word-object associations used a CSL paradigm, where participants are presented with name-unknown objects only. The current thesis used an ME paradigm, in which participants saw both a name-known and a name-unknown object. Although other studies used ME paradigms, the approach of the current thesis was different: instead of asking children whether the novel label could be a name for a part of a name-known object, in the present thesis, they were merely asked to select one of two name-known objects that they believe corresponds to the novel label. This selectivity test was conducted in both Studies 1 and 2.

The current thesis also looked at the effect of syntax on the ME constraint in Malay, a numeral classifier language. So far, most studies looked at the role of syntax on the acquisition of English. Only a few studies have investigated numeral classifier languages and in those studies, researchers have pitted syntax against Taxonomic constraint, not the ME constraint, as in the present Studies 4 and 5. Studies on verb acquisition have shown that, even though the syntax of different languages differs, language learners nonetheless make use of syntactic bootstrapping to learn verbs. It was thus hypothesised that a similar pattern of result to the one observed in studies conducted in English will be observed in Malay in Studies 4 and 5.

2.4.2 Summary

Although children's fast-mapping behaviour can be explained by the application of the ME constraint and its assumption that each object is given only one name, associative learning accounts have proposed that children learn the labels of objects by storing multiple associations and forming a hierarchy of word-object associations. It is thus an open question whether word-object associations are selective; that is, whether children would reject a novel label as a second name of an already name-known object when children are provided with sufficient exposure to the label-object co-occurrence. This question was evaluated in Studies 1 and 2.

As children grow older, many additional cues become available to them, one of these cues being syntactic bootstrapping. Syntactic cues help in word learning, because in each language, the position of words in a sentence often provides valuable information about the identity of the word. Most studies (e.g., Hall et al., 2000, 2001; Jaswal & Markman, 2001;

Katz et al., 1974) looked at the role of syntax on the acquisition of English: the current thesis evaluated the contribution of syntax to the acquisition of Malay, a numeral classifier language, in word learning. This was the aim of Studies 4 and 5.

Chapter 3 Bilingualism

Linguistic experience shapes one's usage of word-learning mechanisms. For instance, the ME constraint proposed that children's novelty bias can be understood through a one-to-one hypothesis; that is, each object is mapped with only one basic-level label. Yet, Byers-Heinlein and Werker (2009) found bilinguals to conform less to the MEconstraint than monolinguals, as bilinguals know two labels for most objects, thus violating the assumption of the ME constraint. As the ME constraint provides an explanation for children's ability to fast-map (i.e., the ability to map a word to an object after very few encounters with the word) during word-learning experiences, bilinguals' violation of the ME constraint raises a question of whether the ME constraint is a linguistic bias available to all children. Two possibilities are likely if bilinguals do not conform to the ME constraint: either bilingual children match a novel label randomly to an object that they can see, making word learning a very tedious process; or they make use of other mechanisms when selecting a referent for a novel label. Although bilingual adults generally perform worse than monolinguals in lexical decision tasks (Gollan & Acenas, 2004) and picture naming tasks (Gollan, Montoya, Fennema-Notestine, & Morris, 2005), bilingual children are not slower than monolinguals in terms of learning words (Werker, Byers-Heinlein, & Fennell, 2009). These findings suggest that even though bilinguals violate the ME constraint, their word-learning ability is not likely to be worse than monolinguals. Thus, it is important to recruit bilinguals in linguistic tasks to understand how bilinguals learn meanings of words and what mechanisms they use in word learning.

To understand the effect of linguistic background on the formation of word-object associations, bilingual children were tested using an ME paradigm in Study 3. Specifically, they were tested on whether newly-formed word-object associations are selective; that is, whether bilinguals are solely biased towards one particular object as a referent for a novel label, or they are able to map a novel label to a few different objects. To understand the background to Study 3, the general differences between bilinguals and monolinguals are explored in the next section. After that, evidence on bilinguals' usage of the ME constraint and their willingness in accepting a second label for a name-known object are discussed.

Early studies (e.g., Clark, 1987) found that bilinguals learn only one label for each object at an early stage and then learn a second label for the same object much later. However, Pearson, Fernandez and Oller (1995) found that young bilinguals are able to understand two names for the same object. Similarly, Mervis, Golinkoff and Bertrand (1991) illustrated that two-year-olds were willing to use synonyms, which is a clear violation of the ME constraint. Although there is evidence that both monolinguals and bilinguals are able to learn words without much difficulty (Werker et al., 2009), it cannot be denied that differences between monolinguals and bilinguals exist.

3.1 General Differences between Bilinguals and Monolinguals

Bilinguals are people who speak two languages (Harley, 2008), who are categorised into many groups, depending on the criteria used to define bilinguals. For instance, bilinguals can be classified based on the age of acquisition, where early bilinguals are those who acquired the second language from birth or during childhood, whereas late bilinguals are those who learned the second language during or after adolescence (Harley, 2008). Another way of categorising bilinguals is through bilinguals' fluency in both languages. Those who are equally or nearly equally strong in either language are considered as high-proficient bilinguals, whereas those whose first language is more dominant than the second language are known as low-proficient bilinguals (Harley, 2008). Cook, Bassetti, Kasai, Sasaki and Takahashi (2006) argued that pure monolinguals (i.e., those who understand and speak only one language) are very rare to find, so are balanced bilinguals who have native-like competency in both languages. According to Cook et al. (2006), the most common type of bilinguals are those who are conversant in both languages, but still show preference for the dominant language.

Both high and low proficient bilinguals have been shown to differ from monolinguals in many linguistic tasks. Studies that compared bilinguals to monolinguals found that bilinguals tend to utter words slower than monolinguals (Ivanova & Costa, 2008) and make more errors when producing words, saying a semantically-related word instead of the target word (Sadat, Martin, Alario, & Costa, 2012). Bilinguals also experience more tip-of-the-tongue instances, where they find it difficult to retrieve the words that they want to use (Gollan & Acenas, 2004). Having only a limited amount of time in the day, bilinguals, who use two languages, are likely to spend less time using each language compared to monolinguals, who use only one language. Consequently, the frequency of words bilinguals are exposed to is different from that of monolinguals, which may be the cause of bilinguals' poorer performance in linguistic tasks. Differences in performance are still observed even though bilinguals show native-like proficiency in a language (Yan & Nicoladis, 2009), suggesting that proficiency in a language alone may not be sufficient to explain for the difference between monolinguals and bilinguals. Moreover, Kroll, Dussias, Bogulski and Valdes-Kroff (2012) and Thierry and Wu (2007) found that even when bilinguals were asked to complete a task in a particular language, the other language that was not in use was still activated unconsciously. In other words, when bilinguals are trying to retrieve a word that they intend to use, the intended word may face more competition during retrieval than monolinguals who wish to utter the same word. These studies help explain the difference between monolinguals and bilinguals in linguistic tasks.

Yet, bilinguals do not seem to face more difficulties in word learning than monolinguals (Werker & Byers-Heinlein, 2008). Furthermore, Byers-Heinlein, Fennell and

Werker (2013) found no difference between monolinguals and bilinguals in forming word-object associations at 14 months of age. Similarly, Mattock, Polka, Rvachew, Krehm (2010) found both monolingual and bilingual infants to be able to learn word-object pairings of minimal phoneme change. Studies on phonological learning found that at about just four months old, monolingual infants showed preference towards native phonologies (Bosch & Sebastian-Gallés, 1997), suggesting that they are able to distinguish between native and non-native languages. Preference for the native language may be due to the vast experience with and exposure to the language, leading to better discrimination of the sounds and phonemes of the language. Even though bilingual infants' time is split between listening to two languages, Bosch and Sebastian-Gallés (2001), Ramon-Casas, Fennel and Bosch (2017) and Sebastian-Gallés (2010) found bilinguals to be able to distinguish between minimal pairs of their native languages as well. Singh, Fu, Tay and Golinkoff (2017) also found that 18-month-old bilinguals were able to learn novel labels of minimal vowel change. Hence, bilinguals too, like monolinguals, show preference for both their native languages. In addition to that, Byers-Heinlein, Burns and Werker (2010) found that bilingual children were able to differentiate the phonologies of their two native languages. Thus, even though bilinguals have to learn two languages, they do not show difficulties in differentiating and learning words of their native languages.

In terms of executive function, many studies found that bilinguals perform better than monolinguals in overcoming strong habitual responses. For instance, using a Stroop task, where participants need to respond to the font colour of a colour word instead of to the colour word itself (e.g., press a red button if the word "blue" was written in red), Blumenfeld and Marian (2013) found that high-proficient bilinguals showed less Stroop effect than low-proficient bilinguals. In other words, high-proficient bilinguals are more able to inhibit the response towards the colour word and focus on the font colour instead. According to the bilingual inhibitory control advantage hypothesis (Hilchey & Klein, 2011), bilinguals are able to resolve conflicts from distracting cues because they need to constantly supress the non-target language to prevent it from interfering with their speech. This practice leads to greater inhibitory processing skills in bilinguals (although see Antón et al., 2014, for a non-significant difference between bilingual and monolingual children, and Lehtonen et al., 2018 for a meta-analysis that revealed a non-significant difference between monolingual and bilingual adults in terms of executive function).

Although strong executive function is generally related to advantages in later life and greater ability in cognitive control, recent studies found that executive function may also affect one's ability in word learning. Yoshida, Tran, Benitez and Kuwabara (2011) tested the effect of cognitive differences in learning adjectives. According to Yoshida et al. (2011), children need to shift their attention away from nouns in order to learn words other than nouns. This ability to shift is related to executive function, as one needs to suppress the activation of nouns. Yoshida et al. (2011) found that both monolinguals and bilinguals performed equally well in mapping a familiar adjective to a familiar feature but bilinguals were more accurate than monolinguals in matching a novel adjective to a novel feature. Bartolotti and Marian (2012) also found that after being taught a novel language, bilinguals were more able than monolinguals to overcome interference from native-language distractors when performing a word recognition task in the novel language. Although executive function may not be necessary for word learning, these studies provide evidence that bilinguals' stronger inhibitory control may be an alternative cue to them when some cues are not very informative to them.

In short, bilinguals behave differently from monolinguals in many different aspects. Study 3 of the current thesis recruited school-aged Malaysian children. Tan, Stephen, Whitehead and Sheppard (2012) explained that Malaysians in general are exposed to English and western culture through media. Fan, Liberman, Keysar and Kinzler (2015) also demonstrated that mere exposure to a multilingual environment leads to a change in linguistic functioning. Therefore, the current thesis classified Malaysian children as low-proficient bilinguals because they learn English in school and watch many cartoon programmes on television that are in English. Although they may not be proficient in English, they understand English to some extent. The performance of the Malaysian bilingual children is compared against monolinguals who are exposed to one language and have never had exposures to other languages.

3.2 Bilinguals' Usage of the ME Constraint

The ME constraint provides an explanation on how children are able to fast-map by suggesting that children assume each object to be mapped with one label. However, bilinguals violate this one-to-one assumption between words and objects because they know labels for most objects in two languages. Yet, it was revealed that bilingual children can learn meanings of words just as easily as monolinguals (Byers-Heinlein et al., 2013; Werker & Byers-Heinlein, 2008). If the ME constraint is available in children from birth and is not affected by children's linguistic experience, then bilinguals may still make use of the constraint. On the other hand, if the ME constraint is shaped by linguistic experience, then bilinguals are likely to show little evidence of the ME constraint. The current section evaluates previous studies conducted on the effect of bilingualism on the ME constraint. The typical designs used for testing bilinguals are first described, followed by different results obtained from such tests. Then, the developmental changes observed in bilinguals' performance are discussed.

To test for an ME effect in bilinguals, generally, bilingual children participate in the same ME training trials as monolinguals, where they are presented with a name-known object, a name-unknown object and a novel label (e.g., Brojde, Ahmed, & Colunga, 2012; Davidson et al., 1997). If children make use of the ME constraint, they will map the novel label to the name-unknown object. This task is generally compared against either a control task or a baseline task. Control tasks usually test children using familiar labels (e.g., Houston-Price et al., 2010; Kandhadai, Hall, & Werker, 2017; Yoshida et al., 2011). The control task allows researchers to rule out the possibility of bilinguals not understanding the requirements of the task if their performance pattern in the ME training trials is different from monolinguals. In baseline tasks, children are asked to select an object without any label provided to them, such as asking children for an object that they like best (e.g., Byers-Heinlein & Werker, 2009).

Some studies (e.g., Davidson & Tell, 2005; Kandhadai et al., 2017) evaluated the ME constraint by asking bilinguals whether a novel label they heard refers to a name-known object or a part of that name-known object, following Markman and Wachtel's (1988) classic study. According to Markman and Wachtel (1988), on occasions where there is no name-unknown object, children who make use of the ME constraint would learn the novel label as a name for a part or a property of a name-known object. Thus, if bilinguals selected a part of a name-known object as a referent for a novel label, this behaviour would strongly suggest that bilinguals do make use of the ME constraint. Similar designs are also employed in studies using eye-tracking devices (e.g., Byers-Heinlein & Werker, 2009; Houston-Price et al., 2010). As eye-tracking experiments only require participants to look at images, it reduces task demands, especially for younger children.

Even though the ME constraint is a robust effect among monolingual children, bilinguals tend to show non-significant ME effect (e.g., Houston-Price et al., 2010). In other words, although monolinguals tend to show a novelty bias, bilinguals are equally likely in selecting the name-known object as a referent for the novel label, suggesting that they do not conform to the ME constraint. A likely reason for this difference in performance is that, in bilinguals' daily life, they learn two names for most objects, thereby violating the ME constraint. Supporting this notion, Byers-Heinlein and Werker (2009) compared novelty preference in monolinguals, bilinguals and trilinguals in relation to novel labels. It was found that bilinguals and trilinguals, unlike monolingual children, showed less novelty bias, where bilinguals showed a marginal effect whereas trilinguals showed a non-significant effect. This non-significant ME effect is unlikely to be due to the children not focusing or not understanding the task as bilinguals performed similarly to monolinguals when familiar labels are asked for. Furthermore, although Davidson and Tell (2005) revealed that the monolinguals preferred to map the novel label to a part of a name-known object, bilinguals preferred to map the novel label to a name-known object, accepting the novel label as a second name for the name-known object. This evidence suggests that the ME constraint is likely to develop from linguistic experience, as bilinguals who know two labels for most objects do not conform to the one-to-one assumption.

Yet, some studies (e.g., Davidson & Tell, 2005; Davidson et al., 1997; Frank & Poulin-Dubois; 2002) found a significant ME effect in bilinguals. The ME constraint may still be prevalent in bilinguals because, this word-learning bias is informative within a language, where most objects have only one basic-level label in each language. Therefore, it would not be surprising that several studies obtained findings showing a significant ME effect in bilinguals. However, when compared against monolinguals, the novelty preference observed in bilinguals is expected to be weaker than that of monolinguals, which was what Davidson et al. (1997, 2005) found. Davidson et al. (1997, 2005) found significant differences between these two groups of children, where bilinguals showed less evidence of the ME constraint than monolinguals. This comparison is in line with the argument that the ME constraint is shaped through experience. It is also in line with the argument put forward by Byers-Heinlein and Werker (2009), that the ME constraint may develop later in bilinguals than in monolinguals. It is noteworthy that not all studies obtain this pattern of results. For instance, Merriman and Kutlesic (1993) found Serbian-English bilinguals to conform to the ME constraint and Frank and Poulin-Dubois (2002) did not find any significant difference between bilinguals and monolinguals in terms of evidence for novelty bias. Two explanations may account for the discrepancy in results. First, Davidson et al. (1997) explained that even if bilinguals show a novelty bias, they may not do so based on ME constraint's one-to-one assumption between words and objects, but rather to avoid having nameless objects, as proposed by the N3C principle (Mervis & Bertrand, 1994) and the lexical gap hypothesis (Merriman et al., 1989). Second, Kalashnikova, Mattock and Monaghan (2015) argued in their study that differences between monolinguals and bilinguals are most likely to appear when age and linguistic experience are analysed as one complex interaction instead of being analysed separately, as did Frank and Poulin-Dubois (2002). Thus, even though bilinguals do show evidence of the ME constraint, this evidence is usually weaker than monolinguals, supporting the notion that the ME constraint is shaped by linguistic experience.

In line with the argument that experience affects the development of the ME constraint, age is also a variable that affects the ME constraint. Such developmental changes are seen in both monolinguals and bilinguals. For monolinguals, older children have more experience with the one-to-one assumption between words and objects and also a wider vocabulary that allows them to reject name-known objects as distractors, hence, they show stronger evidence of the ME constraint compared to younger children. For bilinguals, older children have more experience in learning multiple labels for single objects as their larger vocabulary contains more translation equivalents (i.e., the same word in two languages), therefore, they are more likely to violate the ME constraint than younger bilinguals. Davidson et al. (1997) found such developmental trend in three- to six year-old children, as did

Kalashnikova et al. (2015) with three- to five-year-old children. Contrary to the age effect observed in Davidson et al. (1997), Houston-Price et al. (2010) and Byers-Heinlein and Werker (2013) found that as young as 17 months of age, bilingual infants did not show evidence of the ME constraint. A likely reason for the difference in results is the vocabulary of children, as Byers-Heinlein and Werker (2013) found significant differences between 17- and 18-month-old infants in terms of the number of translation equivalents they know. Bilinguals who knew more translation equivalent did not show much novelty bias whereas those who knew little translation equivalent showed more evidence of the ME constraint. Therefore, the effect of age on the ME constraint is likely to be modulated by experience.

In short, bilinguals are found to use the ME constraint less as they have more experience in forming many-to-one word-object associations. This finding is more prominent in older bilinguals, who know more translation equivalents than younger bilinguals. In cases where bilinguals show evidence of the ME constraint, they are likely to show less novelty bias than their monolingual counterpart. Further evidence supporting linguistic background as an important factor in building the ME constraint comes from young bilinguals who are able to overcome the ME constraint, as long as they have a wide vocabulary of translation equivalents. Study 3 of the current thesis tested whether bilinguals in Malaysia are able to use the ME constraint when forming word-object associations. Although the recruited children are classified as low-proficient bilinguals, they are frequently exposed to a second language nonetheless. To compare the usage of the ME constraint between monolinguals and bilinguals, the ME training trials were conducted, where children were shown an image of a name-known object and a name-unknown object and were asked for a novel label. These trials were run in the bilinguals’ dominant language to ensure that the children understood the tasks and were comfortable with the instructions.

3.3 Bilinguals' Learning of Second Labels for Name-known Objects

If bilinguals are less likely to map a novel label to a name-unknown object, then they are either more likely to learn a second label for a name-known object, or randomly map a novel label to an object, making word learning a slow process. Not showing novelty preference during ME training trials does not mean that children willingly accept second labels for name-known objects, as it is also likely that children form word-object associations in a random manner. Kandhadai et al. (2017) suggested that bilinguals do not map labels to objects randomly, instead, they have their own systematic interpretation of novel labels. This argument is supported by studies that found bilinguals to rely heavily on pragmatic biases when forming word-object associations (e.g., Brojde et al., 2012; Kalashnikova et al., 2015). If bilinguals are more likely to accept a second label, then it suggests that they are able to learn words, only that they use a strategy different from monolinguals. On the other hand, if bilinguals do not show any systematic manner in selecting a referent for novel labels, then they are likely to be slower than monolinguals in word learning.

Other than asking whether bilinguals will map a novel label to a name-unknown object, studies using an ME design also ask whether bilinguals are more willing in accepting second labels for name-known objects. An example is Healey and Skarabela (2008), who taught children novel labels for name-known objects. They found that both monolinguals and bilinguals were equally likely in learning the novel labels, although the bilinguals were more likely than the monolinguals to use the novel labels in a subsequent task to refer to the name-known objects, suggesting that bilinguals are more willing to accept a second label for name-known objects. Similarly, Davidson and Tell (2005), Kalashnikova et al. (2015) and Kandhadai et al. (2017) found bilinguals to interpret the novel label as a second label for name-known objects significantly above chance. In other words, previous studies have shown that bilinguals are more willing in accepting lexical overlap. Using an eye-tracking design, Houston-Price et al. (2010) also found that bilingual infants systematically fixated on the name-known image when the infants heard a novel label. Another way of testing infants is through surprise trials. Byers-Heinlein (2017) found that monolingual infants looked longest (indicating that they were surprised) in the trials where two novel labels were associated with a name-unknown object or where a novel label was associated with two name-unknown objects. Bilingual infants did not show such surprise at the multiple word-object associations. Bilinguals' lack of surprise may be explained by their acceptance that a single object can have two labels.

CSL designs can also test if children accept more than one label for each object, where children are presented with at least two name-unknown objects and at least two novel labels. Participants' task is to determine the correct referent for the novel label. Studies are designed such that within each individual trial, it is ambiguous as to which is the correct word-object association. However, across trials, participants may accumulate statistics and determine the correct referent through the most frequently occurring object. Monolinguals were found to be able to learn word-object associations through such associative learning (Vouloumanos, 2008; Yu & Smith, 2007; Yurovsky et al., 2014). If bilinguals are able to learn words without the ME constraint, they should be able to perform as well as monolinguals in CSL task. Poepsel and Weiss (2016) tested this by comparing the formation of word-object pairings between English monolinguals, Spanish bilinguals and Chinese bilinguals. They revealed that although bilinguals did not differ from monolinguals in learning one-to-one word-object mappings, they outperformed monolinguals in learning two-to-one mappings. This finding suggests that although bilinguals are less likely to map a novel label to a name-unknown object in ME tasks, they are more able to learn multiple word-object associations in CSL tasks. Escudero, Fu, Mulak and Singh (2016) also demonstrated that although both monolinguals and bilinguals were able to learn word-object associations through CSL, bilinguals were overall better than monolinguals in performing the tasks. These studies provide evidence that bilinguals are more likely than monolinguals at learning two labels for each object, supporting the argument that word learning is shaped by linguistic experience.

Although many studies have tested the usage of the ME constraint in bilinguals, few have tested whether bilinguals are able to retain word-object associations. This lack of retention tests could be because the aim of most previous studies was to establish, using different paradigms, whether bilinguals really do make less use of the ME constraint, as well as evaluating the age trend of such behaviour. When bilinguals were found not to show evidence of a novelty bias, it is no longer necessary to test for retention, as bilinguals are not expected to have formed any novel label - name-unknown object associations. Yet, retention tests are important because many studies have found that bilinguals are able to associate the novel label with the *name-known* object. As selecting or looking longer at an object as a referent for a label does not necessary mean that the child has learnt the associations, it is important to examine whether bilinguals are able to retain the second label that they associated with a name-known object. Both Healey and Skarabela (2008) and Kaushanskaya and Marian (2009) first explicitly taught children novel labels for name-known objects and subsequently tested the children by asking them to retrieve the objects using these novel labels. Both studies demonstrated that bilinguals were able to retain the newly-learned mappings, as the bilinguals were able to select the correct target object in response to the novel labels. The first study that tested bilinguals' retention of implicitly-learned word-object associations was Kalashnikova et al. (2018). After presenting children with ME training trials, children were presented with two name-unknown images while being asked for a novel label. The researchers found that 18-month-old bilinguals were able to retain the newly-formed word-object associations. Thus far, studies have shown that bilinguals are likely to be able to retain newly-learned second labels that are either explicitly or implicitly taught.

Some theories have been proposed to explain how bilinguals are able to accept two labels for a single object. One possible way is that they interpret the label differently from monolinguals. In the absence of any other cues, monolinguals were found to interpret the novel label as a property of a name-known object, whereas bilinguals interpreted the novel label as a second label for the object category (Kandhadai et al., 2017). Another possible way of explaining bilinguals' learning pattern is through the reliance of other cues, such as pragmatic cues (Brojde et al., 2012; Verhagen, Grassmann, & Küntay, 2017; Yow et al., 2017). As the ME constraint is not very informative to bilinguals, being able to make use of other cues helps bilinguals to learn words. Kalashnikova et al. (2015) supported this argument and found bilinguals to show less acceptance of the ME constraint but have a heavier need for social pragmatic cues. Social cues are important in word learning because the speakers are very likely to be looking at or will direct the listener's attention to the object he is referring to. With social pragmatic cues, children are able to limit the number of possible referents for the novel label heard. Groba, de Houwer, Mehnert, Rossi, and Obrig (2018) provided evidence to this argument by analysing brain activation during word learning by using functional near-infrared spectroscopy (fNIRS). They found more activation in right superior temporal sulcus in bilingual children than monolinguals during word learning, an area which is thought to process pragmatic gestures. Therefore, being able to rely on social pragmatic cues may allow bilinguals to be able to learn words without the ME constraint.

In short, bilinguals are likely to be able to learn a second label for name-known objects. The current thesis aims to ascertain if bilingual children are more likely than monolinguals in being non-selective when forming word-object associations. If bilinguals form word-object associations in a non-selective manner, then it would support the argument that they accept second labels for name-known objects and that they can learn through tracking co-occurrences of word-object associations instead of through the ME constraint. Study 3 of the current thesis also tests for the retention rate of bilinguals following implicit learning of word-object mappings.

3.4 Research Questions

3.4.1 Contribution

Although many studies have tested the performance of bilinguals in ME-related tasks, other than Kalashnikova et al. (2018), these studies have not tested retention in bilinguals when they form associations through implicit learning. In other words, although the retention ability in bilinguals has been tested in previous studies, most of these studies used explicit teaching in ME training trials. Study 3 of the current thesis looks at whether bilinguals are still able to retain the word-object associations if they have learned these associations implicitly.

Moreover, CSL tasks found bilinguals to be better than monolinguals in learning two-to-one word-object mappings. This finding raises the question of whether bilinguals can actually store multiple word-object associations. To this end, previous studies focused on what children have selected during ME training trials. However, based on results obtained from CSL tasks, children may be able to store associations between a novel label and an object that they have not selected as the target for that novel label, if the task is not too cognitively demanding. Thus, Study 3 of the current thesis also examines if bilinguals are able to store associations between words and objects that they have not selected as a referent in the ME training trials.

3.4.2 Summary

Bilinguals are different from monolinguals in terms of their linguistic experience, as bilinguals know two languages. This difference shapes the way bilinguals learn meanings of words. Monolinguals have been found to show strong evidence of the ME constraint as this bias helps narrow down possible referents for novel labels. Instead of assuming that each object is given only one name, bilinguals make more use of CSL and social pragmatic cues. In other words, although bilinguals are less likely to match a novel label to a name-unknown object, they are more willing to accept a second label for name-known objects. However, thus far, previous studies have not tested whether bilinguals are able to retain newly-formed word-object associations through implicit learning. This will be tested in Study 3 of the current thesis.

Chapter 4 Testing for Word-Object Non-Selectivity

4.1 Introduction to Study 1

Whereas the Mutual Exclusivity (ME) constraint argues that children assume each object to only have one name (Markman & Wachtel, 1988), the CSL account argues that children learn meanings of words through multiple word-object associations to form a hierarchy of associations (Yu & Smith, 2007). In other words, the ME constraint suggests that word-object associations are selective, but the CSL account argues that word-object associations are non-selective. In the current thesis, selectivity means whether a novel label is mapped with only one name-unknown object. To test whether word-object associations are selective, three different tasks were conducted in the current study: an ME training block, a retention test block and a selectivity test block. The first two blocks were aimed at replicating results of previous studies that children will map a novel label to a name-unknown object (Bion et al., 2013; Golinkoff et al., 1992; Markman & Wachtel, 1988; Mather & Plunkett, 2011; Merriman et al., 1989; Mervis & Bertrand, 1994) using a tablet, whereas the third block tested for the selectivity of word-object associations. The research questions raised in the current study were: (1) will children map the novel label selectively to only one name-unknown object, and (2) will similar result patterns be obtained if ME training trials and retention test were conducted using a tablet, where there is minimal interaction between the researcher and the children during the tasks?

The current study followed the ME design from Mather and Plunkett (2011) used tablet (an iPad) instead of an eye-tracking device. In the ME training block, a name-known image and a name-unknown image were presented side-by-side. This block tested for disambiguation of referent for the novel label through the ME constraint. According to the ME constraint, children would select the name-unknown object upon hearing a novel label, as each object is given only one name (Markman & Wachtel, 1988). This robust effect has been obtained in various ages (from as young as 10 months to 6 years of age) and by using various methods (e.g., habituation paradigm, eye-tracking, using picture cards and real objects selection). As Frank et al. (2016) claimed that a tablet-based paradigm can also be used to test for the ME constraint, the current study tested whether previous ME findings can be obtained in the current study. If previous findings are replicated, then the current study would support Frank et al.'s (2016) proposition that using tablets to test children provides a valid method to assess the ME constraint. Other than replicating Frank et al., the current study also added two tests to the tablet-based paradigm: retention test and selectivity test.

The retention test was conducted to ascertain if children have retained the mappings between the novel label and the corresponding name-unknown image. In this test block, the two name-unknown images used in the ME training block were presented side-by-side. Studies have raised concerns on whether novelty bias shown in ME training trials is equivalent to word learning (Mervis & Bertrand, 1994). This concern is valid and important, as some studies found that children actually do not retain the word-object associations (Horst & Samuelson, 2008), arguing that disambiguation of novel labels through the ME constraint is likely to be incomplete and does not fully support word learning, whereas other studies found that children are able to retain the newly-formed word-object association (Mather & Plunkett, 2011). Thus, it is important to test not just children's response during ME training trials but also their retention ability in this tablet-based study. If children are unable to retain the new word-object association, then word learning cannot be said to have taken place.

The ability of children in retaining the novel word - name-unknown object associations depends on many factors. Older children (30 months old) were found to be better at retention (Bion et al., 2013), although the cut-off point at which children are able to retain the association formed is controversial. Mather and Plunkett (2011) argued that 16-month-old children in their study could retain the newly-formed word-object associations but Bion et al.

(2013) found that 24-month-old children were still not able to retain word-object associations. Repetition of word-object pairs also helps children retain the mappings, as repetition strengthens the association (Horst et al., 2006; Mather & Plunkett, 2009). Children are better at remembering the mappings when there are fewer number of pairings that they have to learn (Vlach & Sandhofer, 2014; although Golinkoff et al., 1992) found that children are able to learn up to six pairings of word-object associations). In the current study, the children recruited were aged between four and 12 years old, ages where children are old enough to retain a small number of word-object mappings over a short period of time. There were only two novel labels and each label was repeated three times in the ME training block. Therefore, it was hypothesised that children in the current study are able to retain the mappings formed in the ME training block.

The wide age range was chosen in the current study, because Fitneva and Christiansen (2017) found differences between young children (4-year-olds), older children (10-year-olds) and adults in CSL tasks. Young children were more likely to learn word-object associations successfully if their initial guess was correct, whereas adults were more likely to learn associations successfully if their initial guess was wrong. Older children’s performance fell in between these two groups, where they were not affected by their initial guesses. Fitneva and Christiansen (2017) argued that such a difference could be due to the developmental changes to the attention-memory system. Adults performed better after wrong guesses because they were able to accumulate evidence from word-object associations across trials, which then improved their performance in the task. Young children, on the other hand, were overwhelmed by the task of learning word-object associations, therefore, would not be able to correct their initial wrong guesses through accumulation of evidence. Thus, it was hypothesised that, although the recruited children in the current study are likely to be able to retain newly-formed word-object associations, their ability in learning a second label for name-known objects (tested in the selectivity test block) may differ depending on their age groups.

The selectivity test block, which investigated whether children have formed an association between the novel label and the name-known object in the ME training block, was the critical test in the current study. According to a strong interpretation of the ME constraint, children should not be able to form any association between novel labels and name-known images (i.e., the distractors) because of the one-to-one assumption between labels and objects. In other words, because word-object associations are highly selective, ME constraint would predict that children do not form any association between the novel label and the name-known image and their performance in the selectivity task should be at chance level.

On the other hand, other studies, such as Mervis et al. (1994) and Yu and Smith (2007), found children to be comfortable in giving more than one name to an object. These findings are in line with the CSL account, which posits that children form many-to-one word-object associations to learn meanings of words when the situation is ambiguous. If the current study obtain results that are in accordance to the latter prediction, then the current study will extend Woodward and Markman's (1991) explanation that other linguistic cues can overrule the ME constraint, where accumulation of word-object mappings, not just linguistic biases, can also overrule the ME constraint. The current study will also be able to show that children can also store more than one word-object association even when the learning situation is not ambiguous.

4.2 Method

4.2.1 Design

A 3 x 2 mixed design was used in the current study. The within-participant variable was block type (ME training, retention test and selectivity test; see Figure 1), whereas the between-participant variable was test order (whether retention test or selectivity test was run first). The two test orders were to counterbalance the sequence in which the children received the test blocks. The current study was pseudo-randomised, where the ME training block always came before the two test blocks. This order allows the children to make use of the ME constraint in deciding the referent for the two novel labels before being tested on the retention of these word-object associations. The dependent variable was the image selected by the children, whether it was the target or the distractor.

Based on previous studies (e.g., Bion et al., 2013; Markman & Wachtel, 1989), a prediction made about the performance in the ME training block was that children would tend to map the novel label to the name-unknown image. Children in the current study were presented with two images in each trial of the retention test and the selectivity test, if the children did not retain any word-object associations in the ME training block, then they would randomly select an image in each test trial. In other words, the probability of children selecting either image is .5 (i.e., chance) had they not formed any word-object association. On the other hand, if the recruited children were able to retain the association between the novel label and the name-unknown image, then they would be able to select the target name-unknown image above chance in the retention test. Similarly, if children had formed an association between the novel label and the name-known image in the ME constraint, then they would be able to select the target name-known image in the selectivity test.

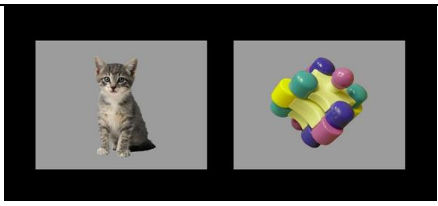
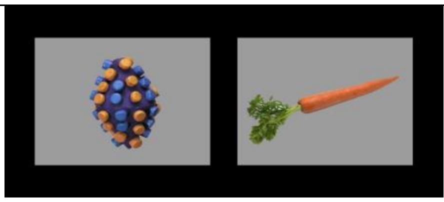
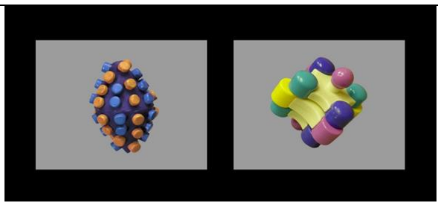
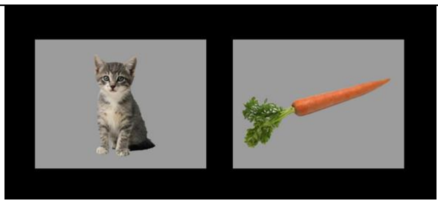
Block type	Image pairs	Auditory stimuli
ME training		Find the modi!
ME training		Find the dax!
Retention test		Find the modi!
Selectivity test		Find the modi!

Figure 1. Examples of different blocks used in Study 1

4.2.2 Participants

One hundred and seventy-four children were recruited in The University of Nottingham, UK, through an event called the Summer Scientist Week 2015 (SSW 2015). Twenty-six children who spoke more than one language at home were excluded from the analyses. This exclusion was to ensure that the results are not confounded by the number of languages spoken at home, as monolinguals and bilinguals were found to perform differently in ME-related tasks (Byers-Heinlein & Werker, 2009; Davidson & Tell, 2005). Of the remaining 148 monolingual children, 83 were girls and 65 were boys. The children's age ranged from 4 years to 12 years (M = 7.36 years, SD = 2.06). This huge age range was then grouped into three smaller age bins; that is, preschool children (n = 66, age range = 4 – 6 years, *M* = 5.03 years, *SD* = 0.72), young children (*n* = 85, age range = 7 – 9 years, *M* = 8.05 years, *SD* = 0.83) and older children (*n* = 23, age range = 10 – 12 years, *M* = 10.70 years, *SD* = 0.70).

As the first (and main) research question of the current study was to test whether children are able to map a novel label to the corresponding name-known object, a post-hoc power analysis for the current study was calculated for the selectivity test using the `pwr` package (Champely, 2018) on R. The function `pwr.p.test` was used because the selectivity test was examined using a one-sample proportions test. Effect size, *Cohen's h*, was set as 0.19, sample size, *N*, as 148, significance level, α, as .05 and alternative hypothesis as two-sided. The power obtained was .65, hence, the sample size of the current study has medium power.

4.2.3 Stimuli

Each trial consisted of a pair of images, one on the left of the screen and another on the right of the screen. Each image had a resolution of 640 x 480 pixels and was a picture of an object on a grey background, obtained from Frank et al. (2016). As an iPad was used to present the image pairs to the children, the size of the images was set to fit comfortably on an iPad screen, with the width of the image set to 400 pixels and the height was set to maintain the ratio of the image, following Frank et al. (2016).

In the current thesis, each name-unknown image was always presented with the same name-known image and novel label in the ME training block. This presentation makes up one critical image pair. Two critical image pairs were used in the current study: a "dax" with a carrot and a "modi" with a cat (see first two rows of Figure 1). Six other familiar images were used as targets for filler trials to prevent children from being overwhelmed by the novel labels and four attractive scenes were used as attention getters to capture children's attention.

The auditory stimuli were labels of the targets of each trial. For the critical image pairs, the label for the name-unknown images were made-up words “dax” and “modi”. The auditory stimuli were embedded in the carrier sentence “Find the __!”. These were recorded by a female native British-speaker in a child-directed manner.

4.2.4 Procedure

The procedure was similar to that used in Frank et al. (2016). At the start of the experiment, there was a warm-up task, where children had to tap on five dots and five smiley faces appearing in random locations on the screen of the iPad. This task allowed the children to familiarise themselves with the iPad. After the warm-up task, the children were given instructions verbally about the experiment. The children were told that they would be presented with two images and a voice would ask them to find an object, for which they had to respond by choosing one of the images shown. Once the children indicated that they had understood the procedure, the experiment started.

There were three experimental blocks: an ME training block, a retention test block and a selectivity test block (see Figure 1). The first block was the ME training block (see first two rows of Figure 1). In this block, the two critical image pairs were presented to the children while the corresponding novel label was played. These image pairs remained on screen until the participant selected one image. To ensure that both images appeared on both sides of the screen an equal number of times, there were eight trials in total, four trials for each novel label. The target in this block was the name-unknown image.

In the retention test (see the third row of Figure 1), the two name-unknown images from the ME training block were presented side-by-side while the novel label was played. The target was the corresponding name-unknown image of the novel label. There were four trials in this block, allowing the location of the targets (on the left or the right of the screen) to be counterbalanced across all children.

In the selectivity test (see the fourth row of Figure 1), children were shown both name-known images from the ME training block (i.e., the “distractors”). In each trial, children heard one of the novel labels used during the ME training block. The target was the name-known image that corresponded with the matching novel label in the ME training block. There were four trials in this block, so that both images appeared as a target on each side of the screen once. The order of the retention test and the selectivity test were counterbalanced across all children. In all trials, no feedback was given to children after they have responded.

Filler trials appeared after every two experimental trials and attention getters appeared after every four experimental trials. In the filler trials, two familiar images were presented and one of these images was named.

4.3 Results

4.3.1 Analysis method

In every trial, the children selected either the target image or the distractor image. Selection of the target image was coded as 1, whereas selection of the distractor image was coded as 0. To test which variable predicts the children’s response successfully, a mixed-effect logistic regression was conducted using with participants and stimuli set as the random effect term. The analyses were run in R 3.3.3 using the `lme4` package (Bates, Mächler, Bolker & Walker, 2015). The models started with a full model to which fixed effect terms were removed one by one so as to obtain an optimal model; variables which significantly changed the model were considered as successful predictors. A full coding of the analyses can be found in Appendix A.

Variables of interest were block type (ME training, retention test and selectivity test), age groups (preschool children, young children and older children), test order (retention test or selectivity test was run first) and the interaction between block type and age groups. Initial analyses demonstrated that test order did not predict children's performance (χ^2 (1) = 0.01, p = .915), therefore, in subsequent analyses, the two test orders were collapse. Removing the interaction between block type and age groups also did not significantly change the model (χ^2 (4) = 4.15, p = .386).

Block type (χ^2 (2) = 375.86, p < .001) and age groups (χ^2 (2) = 8.91, p = .012) were successful predictors of children's performance. Children were more likely to select the target image in ME training block than in either the retention test (β = 1.07, SE = 0.19, p < .001) or the selectivity test (β = 2.85, SE = 0.17, p < .001). Across all three tasks, young children had a higher proportion of correct responses than preschool children (β = 0.66, SE = 0.22, p = .003), but the difference between older children and preschool children was not significant (β = 0.42, SE = 0.31, p = .185).

4.3.2 Main analyses

A one-sample proportions test was conducted to test whether children selected the target above chance for each block type. Chance was set at .50 because children need to select the target image out of two images. Table 1 shows the mean proportion of these three blocks. The proportion is obtained by dividing the number of target selection by the total number of trials, thus, a higher proportion shows participant being target-oriented. As can be seen from Table 1, children selected the target image above chance in the ME training block (χ^2 (1) = 957.96, p < .001, h = 1.12), the retention test (χ^2 (1) = 331.50, p < .001, h = 0.85), and the selectivity test (χ^2 (1) = 21.57, p < .001, h = 0.19).

Table 1. Mean proportion, standard deviation and 95% confidence interval of accurate responses in Study 1

Block type	Mean proportion	SD	95% CI of mean	
			Lower	Upper
ME training	.950 ***	.218	.936	.962
Retention test	.875 ***	.331	.845	.900
Selectivity test	.596 ***	.491	.555	.636

Note. Chance is at .50 for all blocks. *** $p < .001$.

The results obtained from the one-sample proportions tests suggest that the children showed evidence for the occurrence of ME constraint, as they were significantly target-oriented in the ME training block. Children's performance in the retention test block suggests that they were able to retain the associations formed between the name-unknown images and the novel labels. In the selectivity test block, children were also significantly target-oriented, which suggests that an association had been formed between the name-known images (distractors) and the novel labels.

As a few studies (Bion et al., 2013; Horst & Samuelson, 2008) found that children may not retain the association formed during disambiguation (i.e., the ME training block in the current study), the current study tested whether there is a difference between the performance in the three blocks. This is done by comparing the proportion of correct responses of the two tests in question to see if these two proportions are significantly different from each other. The finding from mixed-effect models that children performed worse in both tests than in the ME training block was confirmed in the two-sample test for equality of proportions, where the performance in the retention test was significantly worse than that in the ME training block (χ^2 (1) = 31.11, $p < .001$, $h = 0.27$), whereas the performance in the selectivity test was significantly worse than that in the ME training block (χ^2 (1) = 351.43, p < .001, h = 0.93) and the retention test (χ^2 (1) = 116.81, p < .001, h = 0.65). These differences suggest that although children have fast-mapped successfully in the ME training block, the retention of these newly-formed associations was relatively weak. Similarly, even though children were able to select the correct name-known image for the novel label in the selectivity test, this word-object association is weak compared to the association between the novel label and the name-unknown image.

4.3.3 Analyses on age trend

The mixed-effect model revealed that young children (aged between seven to nine years) performed generally better than preschool children (aged between four to six years), whereas there was no significant difference between older children and preschool children. Although the interaction between age and block type was not significant, two-sample proportions tests were conducted to examine the difference between preschool children and young children in all block types. As the test was run three times (i.e., examining the difference between young and preschool children for each block), the alpha was subject to Bonferroni correction, hence, p-values were compared against .017. The proportions tests showed that young children (M_{training} = .97 (.09), $M_{\text{retention}}$ = .90 (.20)) were significantly better than preschool children (M_{training} = .93 (.14), $M_{\text{retention}}$ = .83 (.26)) in ME training block (χ^2 (1) = 8.11, p = .004, h = 0.19), and marginally better in retention test (χ^2 (1) = 5.59, p = .018, h = 0.22) but not in selectivity test (χ^2 (1) = 3.83, p = .050, h = 0.19).

4.4 Discussion

The two research questions raised in the current study were (1) whether a tablet-based paradigm can replicate results of ME-related tasks and (2) whether novelty bias in ME training trials is equivalent to selective word-object associations. It was found that the children selected the target above chance in all three blocks. In the ME training block, where children were presented with a pair of name-unknown and name-known images to test for ME constraint, children paired the novel label with the name-unknown image. These findings indicate that testing for the ME constraint using a tablet is feasible, supporting Frank et al. (2016). In the retention test block, where children were presented with a pair of name-unknown images to test for the retention of the newly-formed word-object associations, they were able to match the novel label to the corresponding name-unknown image. Hence, the current study has shown that other than testing for the ME constraint, a tablet can also be used to test for retention of word-object associations. More importantly, the current study demonstrated, for the first time, through the selectivity test, that children are able to map a novel label to a name-known image. This result suggests that even though children show novelty bias in the ME training block, they are still able to learn second labels for name-known objects. These three main findings are discussed in detail below.

4.4.1 ME constraint as a default bias

Children of all ages were found to show evidence of the ME constraint, where they selected the name-unknown image when presented with a novel label in the ME training block. In other words, the results obtained in Study 1 replicated the traditional results found by other studies using behavioural paradigm (Golinkoff et al., 1992) and eye-tracking (Bion et al., 2013; Mather & Plunkett, 2011). The results suggest that, using a tablet to conduct empirical studies on the ME constraint is valid. Such devices are very popular among children these days, and children appear to perform as if they were playing with real objects, cards or just watching images on a screen (Frank et al., 2016).

Davidson and Tell (2005) demonstrated that older monolingual children were more likely to show evidence of the ME constraint when naming whole objects, because they have more experience with naming objects than younger children and therefore were able to make better use of the ME constraint. Halberda (2003) found ME constraint to start as young as 17 months of age, and findings such as those by Akhtar et al. (2001), Haryu and Imai (1999) and Jaswal (2010) revealed that children can already fast-map at the age of two to four years of age. As the youngest child in the current study was four years old, it is not surprising that the ME constraint was already very strong among the youngest children of the current study. Despite the ceiling effect obtained in the ME training, the current study still found an age difference in the ME training block, where young children (7 – 9 years old) were significantly more biased to the name-unknown image than preschool children (4 – 6 years old). This finding provides further supporting evidence to Davidson and Tell (2005) that as monolingual children grow older, they have more experience in forming one-to-one word-object associations; therefore, they are more likely than younger children to map a novel label to a name-unknown image.

However, as children in the current study were not tested for their vocabulary size, the difference obtained in the ME training block could also be due to children in the young age group having larger vocabulary size than children in the preschool age group. According to Halberda (2003, 2006), children first reject the name-known object as the target for the novel label before mapping the novel label to the name-unknown object. To be able to reject the name-known object, children need to have knowledge of the label of that object. This explanation suggests that children with a larger vocabulary size may be able to reject name-known objects more easily. As children generally know more words as they grow older, it is not known if the results obtained in the current study were due to age difference alone or vocabulary size.

4.4.2 Word learning through ME constraint

Children also performed well in the retention test, where they could match the novel labels to their corresponding name-unknown images, showing that they have learnt new word-object associations. This result is in accordance to many previous studies (e.g., Golinkoff et al., 1992; Jaswal & Markman, 2003; Mather & Plunkett, 2011; Mervis et al., 1994; & Mervis & Bertrand, 1994), which suggested that fast-mapping leads to word learning. The current study also showed that young children were marginally better than preschool children in the retention test, likely to be because children's encoding becomes stronger as they grow older. Performance in the retention test requires children to remember the associations formed during ME constraint trials, therefore, children with a stronger memory capacity will be more likely to select the target in the retention test. However, it has to be noted that the difference between young children and preschool children were only marginally significant after Bonferroni correction. Thus, strong conclusions cannot be made.

Although children in the current study were significantly more target-oriented in the retention test, the proportion of target selection in the retention test was still weaker than that in the ME training block. Weak performance in retention test has also been found in other studies. Horst and Samuelson (2008) found that children were unable to retain the mappings, suggesting that the retention rate after fast-mapping is not strong. According to Carey (1978) and Horst et al. (2006), because little input is needed to fast-map, word-object associations formed after fast-mapping are incomplete and further refinement of the associations is needed. This argument could explain the weaker performance in the retention test compared to the ME training block, in the current study.

Horst et al. (2006) argued that only after multiple repetitions of trials will children be able to retain the newly-formed associations. This argument was supported by Mather and Plunkett (2009), who found that repetition of trials helped children in retaining word-object associations. In the current study, each word-object pair was repeated three times during the ME training block. Therefore, it was expected that the children in the current study would have enough opportunities to form strong associations between the novel labels and the name-unknown images, leading to successful performance in the retention test, even though more ME training trials would likely improve the retention performance further.

Golinkoff et al. (1992) and Wilkinson and Mazzitelli (2003) found that after a short delay of a few trials, children were still able to retain the word-object associations, whereas Horst and Samuelson (2008) found that after a delay of five minutes, two-year-olds were unable to retain the word-object associations. In the current study, children were not given short breaks in between the retention test and the ME training block[2], which may reduce greatly demands on memory. Therefore, whether children in the current study will still be able to retain the newly-learned word-object associations after a few minutes' delay is unknown.

The difference in results between the current study and Horst and Samuelson's (2008) study may stem not only from the time difference between the ME training block and the retention test but also from slight differences in terms of the age of children and the number of distractors. These subtle differences should not be overlooked as they determine the retention rate of word-object associations among young children. The youngest child in the current study was four years old, whereas Horst and Samuelson (2008) recruited two-year-olds, therefore, it is not surprising that retention rate is relatively high in the current study but

[2] Half of the children were presented with the selectivity test before the retention test. However, as there was no significant difference between the two test orders, having the selectivity test before the retention test is not regarded as a break between the ME training block and the retention test.

not in Horst and Samuelson’s. Moreover, only two name-unknown objects were used in the current study and both objects were given a novel label, whereas in Horst and Samuelson’s Experiment 1C, only one name-unknown object was given a novel label but during the retention test, the children were shown two other name-unknown objects as distractors. Woodward and Markman (1991) argued that tasks that may seem simple to adults may require a huge amount of attention from young children and a lack of positive results may be due to attentional problems. Thus, although the two-year-olds only need to learn one novel label, having to fast-map only once and to select the correct referent from three name-unknown objects in the retention test may make the whole task difficult, leading to non-successful retention in Horst and Samuelson’s (2008) retention test.

4.4.3 Non-selectivity of word-object associations

The current study also found that word-object associations are unlikely to be selective, because children were able to pair the novel label with the corresponding name-known image above chance. According to ME constraint, a named object is not associated with another label unless enough evidence shows otherwise. Woodward and Markman (1991) argued that other cues can overrule the ME constraint, allowing children to learn second labels. The current study showed that even though children show novelty bias during the ME training trials, they were also able to map the novel label to the name-known object. However, no additional cue was provided to the children. Therefore, we argue that the information that allows children to select the target in the selectivity test is the frequency of co-occurrence between the novel labels and the name-known objects. This argument means that the frequency of word-object co-occurrences can also overrule the ME constraint. The finding obtained also supports the associative learning account of CSL, where frequent co-occurrences provide sufficient exposure for an object to be paired with a label. This result showed that novelty preference during the ME training block should not be taken as evidence for one-to-one mapping between words and objects. Although children are biased to the name-unknown object, it does not mean that they have not mapped the novel label to the name-known object too.

According to the Propose-but-Verify (PbV) hypothesis and other hypothesis-testing accounts (Trueswell et al., 2013), children do not store all possible associations between novel labels and name-unknown objects. Instead, children will first randomly map a novel label to an object and then verify this association in a subsequent trial. If the associated object appeared again with the novel label, then this word-object association will be strengthen, otherwise, another object will be randomly selected to be mapped to the novel label.

The current study first presented children with ME training trials, where a name-unknown image and a name-known image were presented side-by-side. Children will have mapped the novel label to the name-unknown image. As subsequent trials showed the same image pairs for the same novel label, children would have strengthened the association between the novel label and the name-unknown image while not encoding the name-known images at all. Following this explanation, PbV will predict that children would select an image randomly in the selectivity test because they have not mapped the novel label to the corresponding name-known image. The results obtained in the current study are not compatible with this account, as the children were target-oriented in the selectivity test. Instead, the current study supports associative learning accounts, where children are willing to match a label with multiple objects present.

The current study also extends the CSL account, where the label is matched not just with name-unknown objects, but also with name-known objects. Previously, studies testing for CSL account used either all name-unknown objects (Ichinco et al., 2009; Poepsel & Weiss, 2014; Yu & Smith, 2007; Yurovsky et al., 2013) or all name-known objects (Stevens et al., 2017; Trueswell et al., 2013). Thus, it is not known if children will also map a novel label to a name-known object if name-unknown objects are present as well. A learner who make use of strong CSL will map the novel label with all objects in sight (Smith et al., 2011), suggesting that the children in the current study should also map the novel label to the name-known objects, as the name-known objects were present when the novel label was heard. However, Yu et al. (2012) found that strong learners actively select referents rather than mapping the novel label to all objects present. As the current task is very simple, with only two name-unknown objects and two novel labels presented to the children, it allows the children to make use of strong associative learning, where children would select a referent from all objects that have co-occurred with the novel label before.

Nevertheless, it is important to acknowledge that the performance in the selectivity test was not as impressive as the other two blocks. A likely explanation is that strong word-object associations will weaken the formation of a new association between the same object and another label. Stronger associations have accumulated more instances of supporting evidence compared to weaker associations, therefore, these stronger associations are located at a higher position in the hierarchy of word-object associations. For instance, Yurovsky and Yu (2008) and Yurovsky et al. (2013) found that first sets of labels are learned better than second sets of labels associated with the same images. According to Yurovsky et al. (2008, 2013), the primacy effect is due to the first labels being encoded with the images first, which then inhibit the learning of the second labels.

In the current study, the name-known images used were a carrot and a cat, objects that are very likely to be very familiar with young children. As these objects have already formed very strong associations with their respective labels, it is not surprising that the association between the novel labels and these objects are weak. Hence, the original labels provide a strong competition for the association between these name-known images and the novel labels, leading to a weak performance in the selectivity test. Even though these name-known images were paired with the novel labels for a total of four trials, these word-object associations are very weak, which may be the reason for the low accuracy scores in the selectivity test. However, because children are still significantly target-oriented in the selectivity test, it also suggests that children are capable of associating a name-known object to a novel word.

The results obtained from the selectivity test is also in line with Yurovsky et al.'s (2014), who argued that word learning is shaped by previous knowledge and that word learning is about building a hierarchy of mappings. When participants need to learn new word-object associations together with associations that they have encountered in a previous learning session but failed to learn successfully, Yurovsky et al. (2014) found that participants were able to learn the old associations faster, as they have already stored some form of information for these associations, termed as partial knowledge. In the current study, children only encountered each novel label four times, therefore, the association between the novel label and the name-known object was still weak. Adding more repetition trials may improve children's performance. Furthermore, Jaswal (2010) demonstrated that two-year-old children did not dismiss the ME constraint when the speaker gazed at the name-known object, but they selected the name-known object significantly more if the speaker gazed and pointed at the name-known object. In the current study, there was no speaker and children most likely relied on the co-occurrence of words and objects to select the target in the selectivity test. If children were provided with other cues, such as the syntactic cues, then they may be more able in selecting the target. This hypothesis was tested in Study 5.

Although the study's results suggest that children have formed an association between a novel label and a name-known image (albeit a weak one), there is another possible explanation for the significant results in the selectivity test. During the disambiguation task, children could have made either one of two mappings, at a lexical or at an encyclopaedic level (refer to Figure 2).

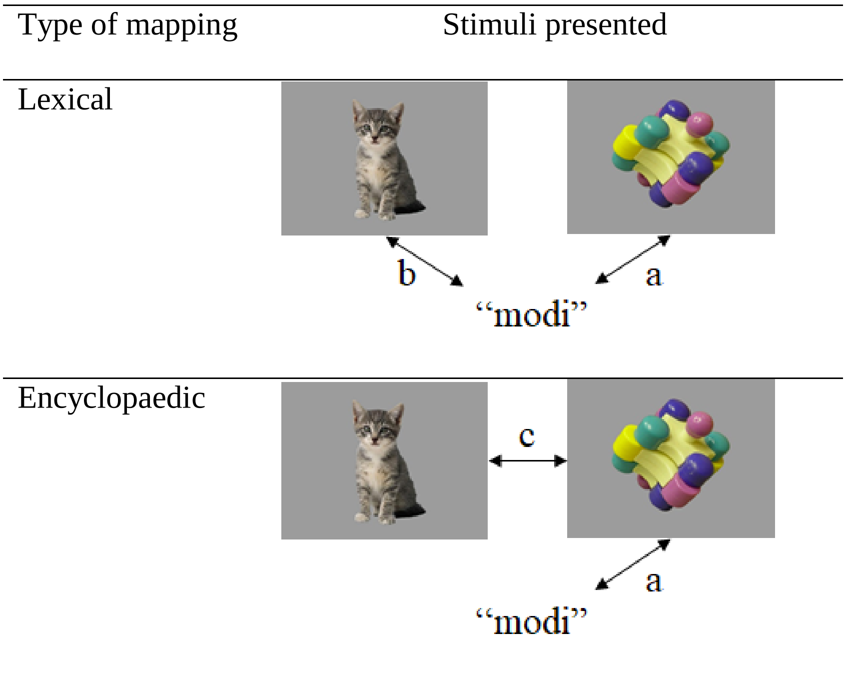


Figure 2. Possible explanations for successful target selection in the selectivity test

Note. Arrows refer to the mappings made by the children.

When the children mapped the novel label "modi" to either the name-unknown image or the name-known image, they had formed an association between the label and the image, hence, a lexical mapping (see arrow *a* and *b* of Figure 2). The lexical mapping allows correct responses to be made in the retention test and the selectivity test. Another type of mapping, the encyclopaedic mapping, may also lead to correct responses in the two tests. According to the ME constraints, participants would have associated the name-unknown image to the novel label, leading to correct responses in the retention test. As the name-unknown image in the current study is always paired with the name-known image in the ME training block, the participants could have also mapped these two images together (see arrow *c* of Figure 2). An example of such pairings in a natural setting is a dog and a bone. Thus, during the selectivity test, the children could have responded correctly by selecting the name-known image that co-occurred with the name-unknown image that was mapped to the novel word during the disambiguation task. Arias-Trejo and Plunkett (2009) demonstrated that children are able to cascade the activation from one object (e.g., a dog) to another related object (e.g., a bone). If correct responses were due to encyclopaedic mapping, the argument that children are able to learn more than one name for an object would not be valid, because the children have not formed lexical mappings between the novel labels and the name-known images (see second row of Figure 2). To differentiate these two types of associations, Study 2 was conducted.

4.4.4 Limitations

In the current study, usage of an inanimate object and an animate object is a possible confound in the design. Hall (1991), Hartin and Merriman (2016), Imai (1999) and Katz et al. (1974) found that children show differences in performance when labelling animate and inanimate objects. With inanimate objects, children tend to interpret a novel label as another label for the object, whereas for animate objects, children tend to interpret the novel label as a proper noun of the object. The bias towards the image “cat” could be because cats can be called by another name (the cat’s name) but carrots are never given another name. However, there was no overall difference in score between the two novel labels, therefore, a bias towards animate object is not likely to have affected the results of the current study. Nonetheless, in the subsequent studies, only non-animate objects were used to prevent this confound.

Another limitation of the current study is the huge age range used. Children’s mind and cognitive ability develop as children grow older, thus, children of different ages are likely to perform linguistic tasks differently. Even though different ages were binned into three groups in the current study, differences between children’s performance due to their age gap may still affect the results of the study. For instance, it was hypothesised that older children would be more target-oriented than younger children as the former group of children were more cognitively advanced. Such a difference was observed only between young children of about 8 years old and preschool children of about 5 years old but not between older children of about 10 years old and young children nor between older children and preschool children. If the current study had recruited only children from a certain age group, with a reasonable sample size, stronger conclusion might have been drawn from the results of the selectivity test.

4.4.5 Summary and conclusion

Study 1 aimed at testing for the selectivity of word-object associations. Although the ME constraint argues that children learn only one word for each object, the CSL account proposes that children are able to form many-to-one word-object associations. To reconcile these two opposing theories, children were presented with a series of tests. The current study found that although children do make use of the ME constraint, they were also able to form an association between the novel label and the name-known object. This result suggests that children form a hierarchy of word-object associations as suggested by the CSL account.

Study 1 is not without its limitations. Although it could be argued that children have learned the association between the novel label and the name-known objects, another explanation is also plausible, where children had only formed an encyclopaedic relation between the novel label, the name-unknown object and the name-known object. The next study aimed to distinguish between both explanations.

Chapter 5 Teasing Apart Explanations for Word-Object Non-Selectivity

5.1 Introduction to Study 2

According to the ME constraint, children will map a novel label to a name-unknown object by assuming that each object only has one name (Markman & Wachtel, 1988). Although children in Study 1 showed novelty bias, they were also able to select the correct name-known image that was previously presented together with a novel label. This finding suggests that word-object associations are not selective; that is, in line with CSL, a label can be associated with more than one object and vice versa (Yu & Smith, 2007). Study 1 found that children are able to store multiple word-object associations, thus, Study 1 extended Woodward and Markman's argument (1991), where we revealed that the accumulation of word-object mappings can also overrule the ME constraint. However, the results are not definitive because two competing explanations may account for the seemingly non-selective word-object associations; that is, the children could have formed either a lexical association or an encyclopaedic association (see Figure 2). The question raised in the current study was: what type of association was formed between the novel label and the name-known object?

The first hypothesis was that children have formed a lexical association between the name-known image and the novel label (see first row of Figure 2). Children would have learned that the name-known image was always present when the novel label was played and there could be a possibility that the novel label is a second label for the name-known image. This hypothesis stems from studies using CSL paradigms (e.g., Poepsel & Weiss, 2014; Yurovsky et al., 2013), which found that children were able to associate two (or more) labels with a name-unknown image. If the performance in Study 1 is due to lexical associations, then it can be argued that Study 1 has extended CSL accounts, as a typical CSL design uses only name-unknown images, and Study 1 used both name-known and name-unknown images. In other words, children not only form multiple word-object associations between novel labels and name-unknown objects but also between novel labels and name-known objects.

The second hypothesis is that children have formed an "encyclopaedic" association between the name-known image, the name-unknown image and the novel label that were presented together during the ME training block (see second row of Figure 2). In this second prediction, children have not associated the novel label with the name-known image, yet they were able to select the corresponding name-known image through cascaded activation. As the name-unknown image and the name-known image co-occurred in the ME training block, these two images were associated together. Through the ME constraint, children are able to form an association between the novel label and the name-unknown object. Thus, when children hear the novel label in the selectivity test, they are able to activate the associated name-unknown image and the activation is subsequently cascaded to the corresponding name-known image. If this hypothesis is true, then it would suggest that children can only form new word-object associations between novel labels and name-unknown objects, with correct responses in the selectivity test achieved through cascaded activation patterns.

In short, following the CSL account, the first hypothesis predicted that children have formed a lexical association between the novel label and the name-known image. On the other hand, based on a strict ME constraint, the second hypothesis predicted that in the selectivity test of Study 1, children have formed an encyclopaedic association, as children can only map the novel label to the name-unknown image. To answer the research question and tease apart these two competing hypotheses, the current study added a new test (the "encyclopaedic" test) to the battery of tasks in Study 1. If children are able to perform above chance in the encyclopaedic test, it would support the second hypothesis, meaning that children make use of cascaded activation when forming word-object associations. However, if children's performance in the encyclopaedic test is at chance level, then children have formed a lexical association between the novel label and the name-known image in the selectivity test, supporting the first hypothesis.

5.2 Method

5.2.1 Design

The design of the current study was similar to that of Study 1, with two exceptions. The first difference was that an additional test block was added to the three blocks in Study 1, making a total of four blocks used in the current study: ME training, selectivity test, encyclopaedic test, and retention test (see Figure 3).

The second difference was the order with which blocks were arranged. In Study 1, the order between the retention test and the selectivity test was counterbalanced. In the current study, the order between the encyclopaedic test and the selectivity test was counterbalanced. The retention test block was administered as the final test block in the current study because the aim of the current study was to tease apart the explanations for non-selectivity in word-object associations and not whether children are able to learn words through the ME constraint. Thus, the retention test was administered at the end of the study just to ensure that children have retained the word-object associations formed in the ME training block.

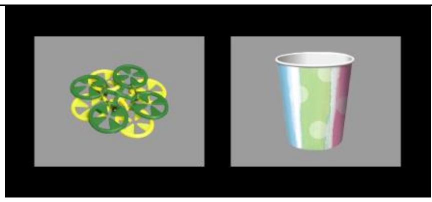
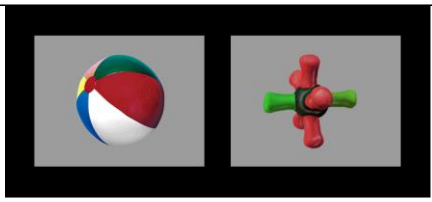
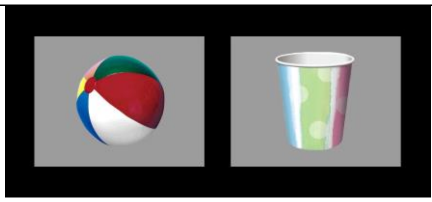
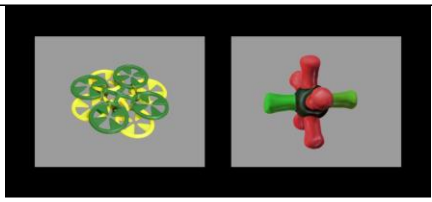
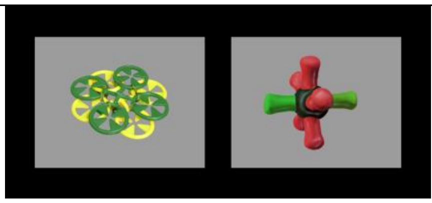
Block type	Image pairs	Auditory stimuli
ME training		Find the dofa!
ME training		Find the pifo!
Selectivity test		Find the dofa!
Encyclopaedic test		Find the ball!
Retention test		Find the pifo!

Figure 3. Examples of different blocks used in Study 2

5.2.2 Participants

Through an event called Summer Scientist Week (SSW) 2016 organised by The University of Nottingham, UK, 150 children were recruited, out of which 124 were monolinguals. Of these English monolinguals, 55 were male and 69 were female. The age range was 3 years to 12 years (M = 7.31 years, SD = 2.28). This age range was grouped into three age bins just like in Study 1: preschool children (n = 66, age range = 3 – 6 years, M =

5.15 years, *SD* = 0.88), young children (*n* = 55, age range = 7 – 9 years, *M* = 7.89 years, *SD* = 0.81) and older children (*n* = 29, range = 10 – 12 years, *M* = 10.59 years, *SD* = 0.57).

Similar to Study 1, a post-hoc power analysis for the current study was calculated for the selectivity test using the `pwr` package (Champely, 2018) on R. The effect size, *h*, was 0.06, sample size, *N*, was 124, significance level, α, was .05 and alternative was two-sided. The power obtained was .10, which means the current study is under-powered.

5.2.3 Stimuli

The stimuli used were the same as Study 1 except for two changes. First, the novel labels used in the current study were "dofa" and "pifo". The novel labels were changed to ensure that both novel labels are bi-syllabic. Second, the critical image pairs for both novel labels were changed so that both name-known images are inanimate yet colourful enough to be interesting to children, where the name-unknown image "dofa" was presented beside an image of a cup (see first row of Figure 3) whereas the name-unknown image "pifo" was presented beside an image of a ball (see second row of Figure 3).

5.2.4 Procedure

The procedure was the same as Study 1 except for three differences. First, there were four experimental blocks instead of three (see Figure 3). Other than the ME training block, the retention test block and the selectivity test block, there was an additional block: the encyclopaedic test block. In the encyclopaedic test block (see the fourth row of Figure 3), children were presented with the two name-unknown images, while they heard the names of the name-known images presented in the ME training block (the distractors). The target of this block is the corresponding name-unknown image; that is, "dofa" for the label "cup" and "pifo" for the label "ball". There were four trials in this block and the target of both novel labels appeared on both sides of the screen once.

Second, there were only two trials in the retention test block (see the fifth row of Figure 3). The reduction in the number of retention trials was to ensure that there was not too many number of trials after the adding of encyclopaedic test block, which may become too over-whelming to the younger-aged children. Each novel label was played once and the target appeared on only one side of the screen.

Third, the sequence of the blocks was different. In this second study, the experiment started with the ME training block, followed by either the selectivity test or the encyclopaedic test. The final block that was administered in the experiment was the retention test block.

5.3 Results

5.3.1 Analysis method

Similar to Study 1, selection of the target image was coded as 1 whereas selection of the distractor image was coded as 0. A backward mixed-effect logistic regression was conducted with participants and stimuli set as the random effect term. The full model included the following variables: block type (ME training, retention test, selectivity test, and encyclopaedic test), age groups (preschool children, young children and older children), test order (selectivity test or encyclopaedic test was run first) and interaction between block type and age groups. Removing test order (χ^2 (1) = 0.77, p = .382) did not change the model significantly, therefore, the two test orders were collapsed in further analyses. Unlike Study 1, the interaction term between age group and block type was marginally significant (χ^2 (6) = 11.91, p = .064), block type remained as a significant predictor of children's responses (χ^2 (3) = 254.66, p < .001), whereas age group was no longer a significant predictor (χ^2 (2) = 0.05, p = .976).

Logistic regression showed that children had a higher proportion of correct responses in the ME training block than in any of the three tests: selectivity test (β = 1.89, SE = 0.14, $p < .001$), encyclopaedic test (β = 1.58, SE = 0.14, $p < .001$), and retention test (β = 1.05, SE = 0.17, $p < .001$). The marginal interaction between block type and age group revealed that older children were significantly more likely to select the target than preschool children in retention test (β = 1.38, SE = 0.48, $p = .004$) but only marginally more likely to do so in the encyclopaedic test (β = 0.65, SE = 0.35, $p = .063$). Logistic regression did not show any other significant difference between age group and block type (ps > .10). There was also a marginal difference between older children and preschool children, where older children were *less* likely to select the target than preschool children (β = 0.48, SE = 0.29, $p = .095$).

5.3.2 Main analyses

To ascertain whether the children have selected the target image significantly above chance for each block, a one-sample proportions test was conducted. The mean proportion of accurate responses were compared against .50 chance.

Table 2. Mean proportion, standard deviation and 95% confidence interval of accurate responses in Study 2

Block type	Mean proportion	SD	95% CI of mean	
			Lower	Upper
ME training	.867 ***	.340	.844	.887
Retention test	.708 ***	.456	.647	.763
Selectivity test	.530	.500	.485	.574
Encyclopaedic test	.598 ***	.491	.553	.641

Note. Chance is at .50 for all blocks. *** $p < .001$.

From Table 2, it can be seen that children were target-oriented in the ME training block (χ^2 (1) = 535.43, $p < .001$, h = 0.82), the retention test block (χ^2 (1) = 42.44, $p < .001$, h = 0.43) and the encyclopaedic test block (χ^2 (1) = 1.68, $p < .001$, h = 0.20), but not in the selectivity test block (χ^2 (1) = 18.82, $p = .195$, h = 0.06). The results in the ME training block support the occurrence of ME constraint, as children were significantly more oriented towards the name-unknown image. The significant result in the retention test block suggests that children were able to retain newly-formed word-object associations. Both findings replicate results obtained from Study 1. However, unlike Study 1, children in the current experiment were unable to perform above chance in the selectivity test. Critically, the children were able to select the target image above chance in the encyclopaedic test, supporting the second hypothesis that children make use of cascaded activation when forming word-object associations.

5.3.3 Analyses on age trend

As the mixed-effect model showed a marginal interaction between age and block type, two-sample proportions tests were conducted to test the performance between preschool children and older children in all blocks. It was found that older children scored better than preschool children in retention test (χ^2 (1) = 3.45, $p = .063$, h = 0.16) but worse than preschool children in the ME training block (χ^2 (1) = 3.72, $p = .054$, h = 0.37). However, after applying the Bonferroni correction, these differences were no longer statistically significant (see Figure 4).

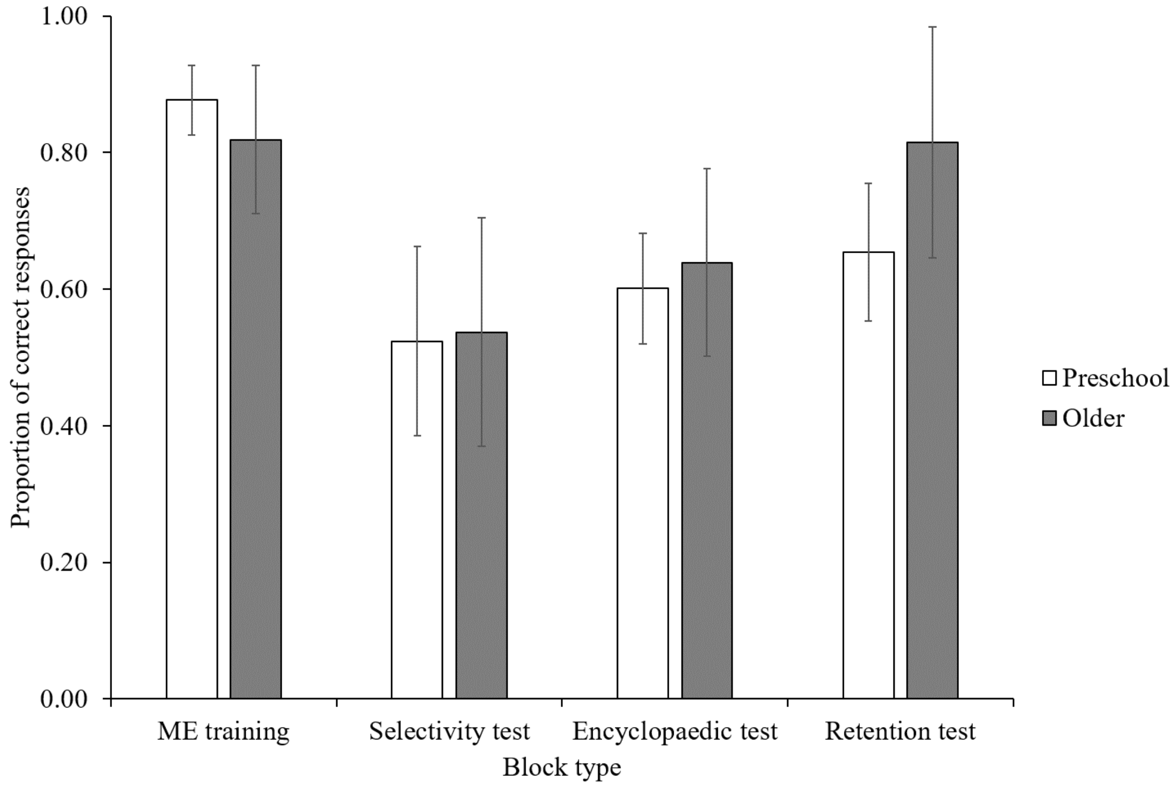


Figure 4. Preschool and older children's proportion of correct responses in all block types for Study 2.

Note. Error bars represent 95% CI, corrected for family-wise error.

5.3.4 Relationship between experimental blocks

Contrary to the first hypothesis but in accordance to the second hypothesis, children performed above chance in the encyclopaedic test but not in the selectivity test. Performing at chance level in the selectivity test means that children have not mapped the novel labels to the name-known images, whereas the significant performance in the encyclopaedic test suggests that children made use of cascaded activation during the formation of word-object associations. In the encyclopaedic test, children had to match the familiar label to the name-unknown image. As the name-unknown images were never presented in the presence of the familiar labels, to be able to select the target, children need to activate the name-known image when they hear the familiar label and subsequently activate the name-unknown image that was presented together with the name-known image during the ME training block. Thus, success in the encyclopaedic test means that children made use of cascaded activation, because based on the hypotheses made, the cascaded activation is the only plausible way to explain for the children's correct responses.

However, these results do not mean that cascaded activation is also the reason for the success observed in the selectivity test in Study 1, as it is just as likely that children have formed a lexical association. First, it cannot explain why children were able to perform above chance in the selectivity test of Study 1 but not in the current study. Second, it cannot explain why children were above chance in the encyclopaedic test but not in the selectivity test of the current study. If children had completed these two tests using the same type of word-object association (i.e., forming encyclopaedic associations through cascaded activation), then the results in these two tests should not be significantly different from each other. Therefore, target preference in the selectivity test block could still be interpreted in two ways: either that the name-known image has been associated with the novel label – which would suggest that word-object associations are non-selective – or that the activation of the novel label leads to the activation of the corresponding name-unknown image, in turn activating its co-occurring name-known image.

To further examine the research question of whether children's performance in the selectivity test is based on lexical or encyclopaedic associations, the correlation between the scores of different blocks was examined. According to the first hypothesis, the CSL account proposes that when a novel label is mapped to multiple images presented in the ME training block, several word-object associations are formed (see first row of Figure 2). A higher score in the ME training block suggests that children were more biased towards the name-unknown image compared to the name-known image, which would lead to a stronger association between the novel label and the name-unknown image but a weaker association between the novel label and name-known image. This difference in association strength is because with a fixed amount of attention, more attention given to an object means less attention to another object due to the competition between these two objects. Hence, when children attend more to the name-unknown object, they form a stronger association between the novel label and the name-unknown object, leading to a weaker association between the novel label and the name-known object, which was given less attention. This reasoning is in line with the arguments put forward by Yurovsky et al. (2013), who suggested that the association between an object and a label will compete with the association between another object and the same label. Thus, if the association between the novel label and the name-known image is lexical, the scores in the ME training block should correlate positively with the scores in the retention test but *negatively* with the scores in the selectivity test.

On the other hand, according to the second hypothesis, based on the ME constraint, the novel label can only be associated with the name-unknown image, and no association can be formed between the novel label and the name-known image (see second row of Figure 2). To succeed in the selectivity test, children need to use cascaded activation: from the novel label to the name-unknown image and subsequently to the corresponding name-known image. This encyclopaedic association would lead to a positive correlation between the ME training block and the selectivity test, as a stronger association between the novel label and the name-unknown image would lead to a stronger cascaded activation. Therefore, an argument following the ME constraint would predict that the scores in the ME training block would correlate positively with the scores from both the retention test and the selectivity test.

It was found that the scores in the ME training block correlated positively with the scores in the retention test ($\rho = .232$, $p = .009$, 95% CI [.026, .365]) but negatively with the scores in the selectivity test ($\rho = -.218$, $p = .015$, 95% CI [-.371, -.034]). The mean proportion of correct responses is shown in Table 2. Hence, the correlation results support the first hypothesis and the line of argument following the CSL account, that children are likely to have formed a lexical association between the novel label and the name-known object.

The same correlation test was conducted for Study 1 to test whether the first hypothesis holds true as well. However, although the direction of the correlations was in line with the predictions outlined above, the correlations were not significant. The non-significant result is likely to be due to the ceiling performance in the ME training block of Study 1, as ceiling effect leads to little room for variability. Comparing the performance in the ME training block for both Study 1 and the current study, it was found that children in the current study performed significantly worse than the children in Study 1 for ME training (χ^2 (1) = 45.94, $p < .001$, h = 0.30), retention test (χ^2 (1) = 32.87, $p < .001$, h = 0.42) and selectivity test (χ^2 (1) = 4.58, $p = .032$, h = 0.13) (see Figure 5).

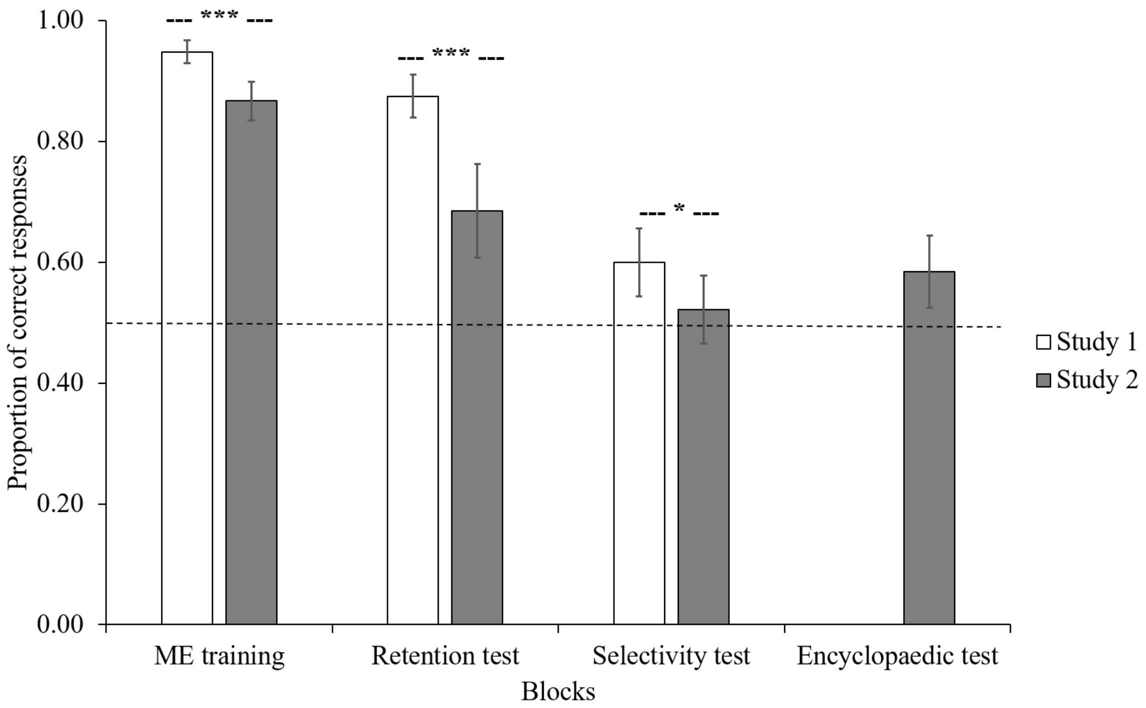


Figure 5. Mean proportion of accurate responses in Study 1 and Study 2

Note. There was no encyclopaedic test in Study 1. Dotted line represents chance (.50). Error bars represent 95% CI. Asterisks show significant difference between Studies 1 and 2.

* $p < .05$. *** $p < .001$.

5.4 Discussion

Results from the current study showed that, in the ME training block, children selected the name-unknown image (the target) when hearing a novel label, hence in line with classical findings of the ME constraint (e.g., Golinkoff et al., 1992; Mather & Plunkett, 2011), as well as those found in Study 1. Children's performance in the retention test was also significantly above chance, suggesting that they were able to retain the association formed between the novel label and the corresponding name-unknown image. Therefore, it replicated findings from Study 1, as well as findings from Bion et al. (2013) and Mather and Plunkett (2011) that the ME constraint is a robust effect and that it can be used to learn new words.

Looking at the difference in performance by different age groups, a counter-intuitive finding was found, where older monolingual children were less likely than preschool monolingual children to show a novelty bias in the ME training block. This result is counter-intuitive because monolingual children were predicted to show stronger evidence of ME constraint as they age, due to their experience with one-to-one mapping between objects and words. This prediction was reported in Davidson et al. (1997) and Kalashnikova et al. (2015). Study 1 of the current thesis found such an age trend as well. One possible reason for this discrepancy is that older monolingual children may start to experience violations to the ME constraints when they expand their vocabulary with synonyms. This possibility needs to be tested by measuring children's vocabulary size in terms of subordinate labels (e.g., poodle - dog), superordinate labels (e.g., animal - dog) and synonyms (e.g., hound - dog) before firm conclusions can be made.

Two further tests were also administered: a selectivity test, to test if word-object associations are selective; and an encyclopaedic test, to ascertain whether children display evidence of cascaded activation patterns. These two tests helped answer the research question about the type of association formed between the novel label and the name-known object. If, as predicted by the first hypothesis, children form word-object associations in a non-selective manner, then the current study would support CSL that children are able to form multiple word-object associations. However, if children had relied on cascaded activation to select the target in the selectivity test (i.e., forming encyclopaedic associations), then it cannot be argued that word-object associations are non-selective. Children were shown to perform significantly above chance in the encyclopaedic test but not in the selectivity test. These results are discussed in detail below, specifically, the role of cascaded activation in word-object associations, the explanation for lexical association in the selectivity test and the possible reasons for the difference observed between the results in the selectivity test of Study 1 and the current study.

5.4.1 Cascaded activation in word learning

In the encyclopaedic test, the two name-unknown images were presented side-by-side while the name of a name-known image was played. As the name-unknown images were never presented in the presence of the familiar labels, target preference could only be due to the cascaded activation from the familiar label to the name-known image and finally to the corresponding name-unknown image, from the ME training block. Contrary to the first hypothesis, the current study found that the children were able to select the target significantly above chance in the encyclopaedic test. This result means that cascaded activation does play a role when children form associations between labels and objects because children are aware of the co-occurrence of different objects. The current study showed that with just four trials, children were able to retain mappings between co-occurring name-known and name-unknown images. Thus, the findings support Markman and

Hutchinson (1984) and Markman's (1990) argument that children are indeed sensitive to temporal and spatial relations between objects. This section discusses thematic and taxonomic relations between objects and how the encyclopaedic test provides an evidence for thematic relations.

Thematic associations are objects that are physically close together. Children tend to associate these objects together, an example that Markman (1990) gave was children categorising a boy and a dog in a group because the boy was walking the dog (hence being in close proximity with each other). Children's sensitivity to these thematic relations between objects can be tested through cascaded activation (Arias-Trejo & Plunkett, 2009, 2013; Huang & Snedeker, 2010). For instance, Mani, Durrant and Floccia (2012) and Moores, Laiti and Chelazzi (2003) reported evidence of cascaded activation between thematically-related objects in priming tasks. McCauley, Weil and Sperber (1976) also demonstrated that six-year-olds were faster at naming pictures when the target pictures were preceded by primes that were thematically related to the target. This evidence suggests that the priming cue activates the target picture through cascaded activation as these two images were associated together. Supporting these results, Markman and Hutchinson (1984) and Markman (1990) found that young children less than six years of age tend to sort objects based on thematic relations. Similarly, in the encyclopaedic test of the current study, children were able to select the target above chance through cascaded activation; that is, from the familiar label to the name-known image and subsequently the corresponding name-unknown image. Thus, the current study provided evidence that children are able to learn associative relation between objects, one that is similar to that of thematic associations.

Related to thematic association is taxonomic association. Taxonomic associations are formed between objects of the same category, hence, these objects are related in meaning, such as a lion and a dog are categorised as animals. As taxonomic relations refers to word meanings, McCauley et al. (1976) found that only eight-year-olds were better at the task when the prime was either taxonomically or thematically related to the target whereas six-year-olds were only affected by thematically-related primes. This finding suggests that younger children who are still building their vocabulary may find it more difficult to understand the taxonomic connections (although see Waxman and Namy (1997), who found no difference between taxonomic and thematic relations).

Evidence for taxonomic associations in children can be seen in priming studies as well. To perform successfully in taxonomically-related priming tasks, cascaded activation between objects is required. For instance, it was demonstrated that the participants' reaction time in detecting a target object (e.g., a shirt) was slower if taxonomic competitors (e.g., a pair of trousers) were present (Meyer, Belke, Telling, & Humphreys, 2007). Interference in the performance was explained to be due to the spreading of an activation from the target to taxonomically associated objects. Mani et al. (2012) also found that toddlers were faster at recognising a target word if a taxonomically-related prime preceded the target. Similarly, Huang and Snedeker (2010) revealed that five-year-old children looked at the distractor picture if it was taxonomically related to the phonological neighbour of the target (looking at a key (distractor) when the target was a log, and the phonological neighbour is a lock).

In the encyclopaedic test of the current study, children were asked for a label where the target was not present. As the children were able to select the corresponding object above chance, the current study demonstrated that the activation of one object can be cascaded to another associated object, allowing children to complete target-selection tasks. Therefore, the current study supports the findings of these previous studies that cascaded activation plays a role in linguistic tasks.

Despite the differences between thematic and taxonomic relations (i.e., thematic is based on physical proximity whereas taxonomic is based on categorical relations), both types of object relations help in word learning. Thematic relations help children in word learning by providing a context to serve as a cue for memory (Suanda, Mugwanya, & Namy, 2014). For instance, children will learn that a name-unknown object is likely to be used in a dining room if it appears frequently with forks and spoons. Taxonomic relations also help learning by allowing learners to categorise words into relevant chunks, easing memory (Chen & Yu, 2017). As an example, when children remember that a cobra is an animal, they will be able to reject non-animals as the target for the word. Therefore, previous studies have demonstrated that children are aware of the relations between objects and are able to use this knowledge to their benefit.

Many of these studies tested for thematic and taxonomic relations by using real-world objects, where the relationship between objects has already been established. Few studies tested made-up relations between name-unknown objects. One such study is by Markman and Hutchinson (1984), who showed young children a few name-unknown images and explained the function of these images to the children to establish thematic relations between these images. The current study presented children with a name-known image and a name-unknown image that co-occurred with each other in the ME training trials. Although the function of the name-unknown image was not specified to the children, the children were able to cascade from the name-known image to the name-unknown image. This finding suggests that children can extract thematic information through physical proximity without knowing the function of the objects. Thus, the current findings support previous studies that objects that are related activate each other.

As co-occurrences of objects form a context, it is not surprising that children are sensitive to the associations between objects. For instance, Kachergis, Yu and Shiffrin (2009b) found that a diverse context helps in learning words, because high diversity in a context allows learners to make use of the newly-learned word-object association to learn the names of other name-unknown objects. Therefore, the relation of one object with another helps in learning a new word, which may explain why young children form thematic associations between objects. As children in the current study were able to select the target above chance in the encyclopaedic test block, it shows that children are able to associate two objects together in just a few trials. Hence, the current study supports previous studies that children are able to form associations between objects that co-occur frequently.

5.4.2 Accounting for lexical associations

In the current study, the encyclopaedic test *per se* was not able to differentiate the two competing hypotheses (lexical association or encyclopaedic association), because children could have used different strategies to complete the encyclopaedic and the selective tests. To tease apart these two hypotheses, correlation analyses were looked into. According to the ME constraint, the ME training block should correlate positively with the selectivity test because children select the target in the test through cascaded activation, from the novel label to the name-unknown object and finally the name-known object. In contrast, the CSL account predicts that the performance in the selectivity test correlates *negatively* with performance in the ME training block. The prediction by the CSL account is formed because it proposes that lexical associations can be formed between novel labels and *both* the name-unknown and the name-known images presented to the child. A strong bias to the name-unknown image would lead to a stronger association formed between the novel label and the name-unknown image but a weaker association between the novel label and the name-known image. This difference happens because when children attend more to the name-unknown image (thus forming a stronger association), they attend less to the name-known image as the total amount of one's attention is fixed. A negative correlation between the ME training block and the selectivity test was indeed observed in the current study, which provides support in favour of the first hypothesis that word-object associations are non-selective and that learning operates similarly to CSL.

The correlation results are in line with Vouloumanos (2008), who found that participants were able to select a novel object which had a higher co-occurring frequency with the novel label, even though the frequency difference between the two novel objects was slight. Using an ME paradigm (i.e., a presentation of mixture of name-unknown and name-known images), the current study lends further support to CSL that children learn words through accumulating word-object associations. The correlations obtained also contradict a strong interpretation of the ME constraint, which argues that children will only learn another name for a name-known object if there is enough evidence to allow the children to overcome ME. In the current study, even though children showed evidence of novelty bias, they were also able to form a lexical association between the name-known image and the novel label. Therefore, novelty preference during ME training should not be taken as evidence that the name-known object has not been mapped to the novel label.

Instead, the current study is more in line with Woodward and Markman's (1991) argument that the ME constraint can be overcome by other cues. In the ME training trials of the current study, even though the name-known image was presented beside the name-unknown image, suggesting that the name-known image could be another possible referent for the novel label, children still selected the name-unknown image above chance. Children showed novelty bias in the ME training trials as there were no other cues that supported the name-known image as the target. This finding suggests that the ME constraint is a strong linguistic bias. However, as children were also able to form lexical associations between the novel label and the name-known object, it suggests that word-object associations are not selective. Even though the accumulation of word-object associations cannot overrule the ME constraint, children have stored information about the word-object associations nonetheless. Thus, novelty bias should not be taken as evidence of one-to-one word-object associations.

5.4.3 Explaining for selective word-object associations

Children in the current study did not perform above chance in the selectivity test. Although it could be argued through the correlation test that the children have formed a lexical association between the novel label and the name-known object, a non-significant result in the selectivity test undermines this argument. Three reasons may be possible in explaining the non-significant result.

First, it could be that the children have not formed any association between the novel label and the name-known images. This reasoning is possible following the arguments of a strict ME constraint, that each object only has one name. However, we refute this possibility for two reasons. One reason is that, children in Study 1 were able to perform above chance in the selectivity test, thus, it has been shown that children are able to form associations between the novel label and the name-known images. Another reason is that, even if children in Study 1 had formed encyclopaedic associations instead of lexical associations in the selectivity test, the performance in the selectivity test in the current study should still be above chance because it has been found that children are able to perform above chance through cascaded activation. Therefore, it is unlikely that the children have not formed any associations between the novel label and the name-known images.

Second, it is noteworthy that there were only four trials for each novel label in the ME training block of the current study. According to Horst et al. (2006) and Horst and Samuelson (2008), although children are able to fast-map and disambiguate the correct referent for novel labels within a few trials, they are unable to retain the newly-formed word-object associations after five minutes of delay, as fast-mapping is not sufficient for stable word learning. If children require many trials before they can successfully retain the newly-learned associations between novel words and name-unknown object, then it is likely that the children in the current study would need more trials in the ME training block before they could successfully retain the association between the novel label and the name-known object during the selectivity test.

Third, the non-significant result in the selectivity test of the current study is related to the task difficulty. Many studies (Smith et al., 2011; Yurovsky & Frank, 2015; Yurovsky et al., 2013) have found that task difficulty has an effect on the number of word-object associations participants (children and adult alike) could keep track. When the task is relatively easy and the number of word-object associations is small, participants tend to keep track of all mappings and form a full hierarchy of word-object associations, in other words, showing a strong form of CSL learning pattern (Smith et al., 2011). However, when the cognitive load increases, either by increasing the number of distractors or the number of labels needed to be learned, participants start to select which information to store and move from a strong associative learning to Pursuit-like learning, where only the selected referent is stored and tested subsequently whereas the other distractors are not remembered (Smith et al., 2011). Both Studies 1 and 2 of the current thesis were designed to be simple, where the children only had to learn two novel labels in total and there was only one name-known object as a distractor for each target. However, in Study 1, one of the distractors was a cat, an animate object, whereas the other distractor was a carrot, an inanimate object. As Hall (1991) and Hartin and Merriman (2016) found differences in children's performance towards artefacts and animals, it is likely that using an animate object as a distractor affected children's performance in Study 1. Although no difference in performance was observed in Study 1, having an animate and an inanimate object may ease the task, leading to higher overall accuracy in Study 1 compared to the current study, as seen on Figure 5.

Moreover, in Study 1, the number of syllables for the two novel labels was not standardised. Although there are studies (Horowitz & Frank, 2015; MacDonald, Yurovsky, & Frank, 2017) that used a mixture of monosyllabic and bi-syllabic words for their novel labels, these studies presented more than two novel labels to the participants, thus, the participants could not disambiguate the referent for the novel labels solely through the number of syllables. In Study 1, there were only two novel labels and the number of syllable may serve as a cue that simplifies the task, together with one of the distractors being an animate object, leading to highly accurate performance. Standardising these two variables in the current study may have led to a heavier cognitive load when trying to learn the association between the novel label and the name-known images, leading to chance level performance in the selective test in the current study. When additional cues support the name-known object as the referent of the novel label, children were able to select the target above chance in the selective test, as shown in Study 5. Nonetheless, the correlational analyses suggest that a low level learning mechanism of the CSL-type is at play.

5.4.4 Limitations

Although it is possible to explain for the findings in the selectivity test and the encyclopaedic test using the reasons outlined in previous sections, it must be acknowledged that the current study is under-powered. Thus, the non-significant result in the selectivity test could be due to not having enough participants. This limitation could also explain for the non-significant age difference between older children and preschool children in all experimental blocks. When the participants were grouped into different ages, the sample size for each age group was reduced to 66 for preschool children, 55 for young children and 29 for older children. A larger and more equal sample size for each age group may yield more meaningful data.

Different images used in Study 1 and the current study also makes it difficult to explain why children were target-oriented in Study 1 but not in the current study. Although it is likely that using both inanimate and animate objects may ease the task (as explained in section 5.4.3), this is only an ad-hoc explanation. If children consistently perform better with inanimate-animate image pairs than with inanimate-inanimate image pairs, then stronger claims might have been made about their behaviour in the selectivity test of the current study.

5.4.5 Summary and conclusion

Study 2 was aimed at teasing apart two plausible hypotheses, lexical associations or encyclopaedic associations, to account for children's performance in the selectivity test. If children had formed a lexical association between the novel label and the name-known image, then it could be argued that word-object associations are likely to be non-selective. On the other hand, if children's performance in the selectivity test was achieved through cascaded activation, then it is likely that ME constraint prevails, that children assume by default that each object has only one name, unless enough contradicting evidence says otherwise. Although the encyclopaedic test showed that children were able to form word-object associations through cascaded activation, the correlation between the ME training block and the selectivity test showed that the achievement in the selectivity test is likely to be due to lexical associations formed between the novel labels and the name-known images. As the correlation provides a more plausible explanation to children's performance in the selectivity test, we argue that children have formed a lexical association between the novel label and the name-known object.

Extending the findings on lexical associations, it is hypothesised that if children are able to form a lexical association between the novel label and the name-known object, then the same pattern of correlation should also be observed in bilinguals. This prediction is made because bilinguals were demonstrated to be able to accept two labels for most objects (Byers-Heinlein & Werker, 2009), hence, they should be more able in learning the association between novel labels and name-known objects. Therefore, Study 3 was conducted by replicating Study 2, with bilingual children.

Chapter 6 Effect of Bilingualism on Mutual Exclusivity

6.1 Introduction to Study 3

Bilinguals are those who can speak two languages. According to Byers-Heinlein and Werker (2009), bilinguals are likely to show a weaker ME constraint because they violate the one-to-one word-object assumption on a daily basis: bilinguals learn two languages and will know labels of most objects in their two languages. Are bilinguals then more willing than monolinguals to give objects a second label? Study 2 was replicated, this time by recruiting bilingual children in Malaysia with the aim to compare the performance of bilinguals against monolinguals previously recruited from the UK. The current study set out to answer three questions: (1) whether bilinguals show weaker ME constraint compared to monolinguals, (2) whether bilinguals are able to retain the newly-formed word-object associations, and (3) whether bilinguals are better than monolinguals in learning a second label for a name-known object. Based on the findings of previous studies (e.g., Byers-Heinlein & Werker, 2009; Houston-Price et al., 2010), a few predictions can be made about children's performance in relation to these three questions, which are discussed below.

Two hypotheses were made with regard to the first question. The first hypothesis was that in the ME training block, where children were presented with a name-unknown image and a name-known image, bilinguals would be less likely to map the novel label to the name-unknown image compared to monolinguals. In other words, bilinguals would make less use of the ME constraint than monolinguals and would be less likely to map novel labels to name-unknown images. If this result is obtained, then the current study would support previous studies that found none (Houston-Price et al., 2010; Kandhadai et al., 2017) or reduced (Byers-Heinlein & Werker, 2009; Davidson & Tell, 2005) evidence of the ME constraint in bilinguals. The second hypothesis was that there would be a negative age trend in bilinguals' performance in the ME training block, that is, older bilinguals are less likely to use the ME constraint than younger bilinguals. According to Davidson et al. (1997) and Kalashnikova, Mattock and Monaghan (2015), older bilinguals are less likely to use the ME constraint as they have more experience of many-to-one word-object associations. This argument is in line with Byers-Heinlein and Werker (2009), who argued that ME constraint is shaped by language experience. Therefore, the current study predicted a negative correlation between bilinguals' age and their usage of the ME constraint.

The prediction made for the second question was that in the retention test, where two name-unknown images were presented side-by-side, bilinguals would perform less well compared to monolinguals. This hypothesis was made based on the assumption that the performance in the retention test is related to the performance in the ME training block. Several studies (e.g., Bion et al., 2013; Horst & Samuelson, 2008), as well as Study 1 and Study 2, found that children did not perform as well in the retention test as in the ME training block, suggesting that disambiguation of referent for the novel label through the ME constraint does not automatically lead to word learning. Following the arguments of association-based learning accounts (e.g., CSL), if children have formed a strong association between the novel label and the name-unknown object, they would be more able to retain this word-object association. Thus, if bilinguals select the name-unknown object in the ME training block less often than monolinguals, then bilingual children are likely to perform worse than monolinguals in the retention test. This line of argument is also consistent with the explanation put forward in Study 2 to explain non-selectivity in word-object associations. If the retention test correlates positively with the ME training block, then bilinguals would score less well in the retention test due to a weaker performance in the ME training block.

For the third question, it was hypothesised that bilinguals in the current study would perform better than monolinguals in the selectivity test. In the selectivity test, children were presented with two name-known images which are typically known as distractors in the ME training block. As bilinguals are found to be more willing to accept a new label for a name-known object (Healey & Skarabela, 2008), bilinguals in the current study were expected to be better at forming associations between a novel label and a name-known object. This hypothesis is also in line with the hypotheses mentioned earlier. If bilingual children had performed poorly in the ME training block, that is, selecting the *name-known* object when they heard a novel label, then bilingual children are likely to be better at retaining the novel label - name-known object associations during the selectivity test.

These three hypotheses were evaluated by and compared in the performance between bilinguals and monolinguals. The present experiment, with bilinguals, was conducted in the language that each participant was comfortable with, either in English, Malay or Mandarin.

6.2 Method

6.2.1 Design and Procedure

The design and procedure of the current study were the same as those in Study 2.

6.2.2 Participants

There were 131 children (65 male, 66 female) in the current study, all who were able to speak more than one language. The children' age ranged from 3 years to 11 years (M = 8.55 years, SD = 1.84). These children were defined in the current study as bilinguals because they learn at least one language other than their mother tongue in school. Children who attended National Type Chinese Primary Schools were taught Mandarin, Malay and English (Mandarin was used as a medium of instruction), whereas children who attended National Primary Schools were taught Malay and English (Malay was used as a medium of instruction). In international schools, children recruited spoke a language other than English at home and they used English in school (English was used as a medium of instruction). For a complete list of the languages that the children speak, see Appendix B.

Although learning another language at school is not the most accurate way to classify a person as a bilingual, this method has practical advantages (Cook et al., 2006). Moreover, children in Malaysia not only have to learn languages in school, they also have to sit for exams prepared by their school teachers, typically three to four times a year. Therefore, children have consistent exposure to the languages learned in school, even though they may not use the second language every day.

Although cultural differences between English and Malaysians exist, all children from Study 2 and the current study were recruited from an urban environment (Nottingham vs Kuala Lumpur). Tan et al. (2012) explained that Malaysians were exposed to western culture and thus show performance that is similar to Westerners. Due to urbanisation, Malaysian children who live in an urban environment (especially in the capital, where the children were recruited) have lifestyle comparable to the West. Hence, although information on social economic status or the educational background of the children' parents were not obtained, we do not expect these factors to impact qualitatively the children's performance.

The experiment was conducted in a language that the children were comfortable with, which was determined by asking the children for their preferred language before the start of the experiment. Sixty-four children (33 boys, 31 girls) took part in Malay, 48 children (21 boys, 27 girls) in Mandarin and 21 children (13 boys, 8 girls) in English. The children who took part in Malay were aged 6 years to 11 years (M = 8.48 years, SD = 1.76), whereas those who took part in Mandarin were aged 7 years to 11 years (M = 9.21 years, SD = 1.40), and those who took part in English were aged 3 years to 11 years (M = 7.24 years, SD = 2.23). The different ages were categorised into three age groups: preschool children (n = 16, age range = 3 – 6 years, M = 5.44 years, SD = 0.96), young children (n = 68, age range = 7 – 9 years, *M* = 7.99 years, *SD* = 0.86) and older children (*n* = 47, age range = 10 – 11 years, *M* = 10.51 years, *SD* = 0.51).

A post-hoc power analysis for the current study was calculated in the same manner as in Study 2. The effect size, *h*, was set as 0.19 whereas the sample size, *N*, was 131. The power obtained was .60, which means that the current study has medium power.

6.2.3 Stimuli

The stimuli used are the same as Study 2 except for three changes. First, the novel labels used were different in the Malay and Mandarin versions of the study, where the made-up words followed the phonotactic rules of the target language. Instead of "dofa" and "pifo", "rufin" and "gotus" were used for the Malay version, whereas "tí léi" and "bō tǎ" were used for the Mandarin version. These novel labels were tested for neighbours, as Swingley and Aslin (2007) found that children learned novel labels that have familiar phonological neighbours less readily. Ten native Malay speakers and ten native Mandarin speakers were asked to rate whether the aforementioned made-up words sounded like any words in their native language. All the novel labels had an average rating of 0, that is, there was no known phonological neighbour for each of these novel labels. Thus, these novel labels were used as the auditory stimuli of the current study.

Second, the name-known images of the critical image pairs were a cup and a shoe in the current study instead of a cup and a ball. The image ball was changed to a shoe because the word "ball" and the Malay equivalent "bola" are cognates, which are words of two languages which share similar form, such as "piano" in Spanish and English (Kroll, Bobb, & Hoshino, 2014). According to Blumenfeld and Marian (2007) and Dijkstra, Miwa, Brummelhuis, Sappelli and Baayen (2010), cognates affect bilinguals' performance in linguistic tasks. Hence, to prevent any possible effect of cognates on the current study, a shoe was used instead. The name of the critical image pairs in English and their equivalent in Malay and Mandarin are shown in Table 3.

Table 3. Names of images used in different languages of Study 3

Language	Image pair 1	Image pair 2
English	"dofa" and cup	"pifo" and shoe
Malay	"rufin" and *cawan*	"gotus" and *kasut*
Mandarin	"tí léi" and *bēi zi*	"bō tă" and *xié zi*

Third, instead of the carrier sentence "Find the __!" that was used in Study 2, "Can you find the __?" was used instead in the English version of the current experiment. For the Malay version, the carrier sentence was "Carikan __! (Find __!)", and for the Mandarin version, it was "nǎ yí gè shì __? (Which one is __?)". These sentences were recorded by female native speakers in a child-directive manner.

6.3 Results

6.3.1 Analysis method

Results were coded and analysed as in Study 1. To ascertain which variable (block type, age group, language of experiment, test order, interaction between age group and block type) predicts the children's response successfully, a mixed-effect logistic regression was run with participants and stimuli set as the random effect term. Test order (χ^2 (1) = 1.71, p = .191) and language of experiment (χ^2 (2) = 3.56, p = .169) were not successful predictors of children's response in the tasks. Therefore, subsequent analyses lumped different test orders and test language together. The interaction between block type and age group did not reach significance (χ^2 (6) = 9.83, p = .132), neither did age groups (χ^2 (2) = 0.09, p = .958). Block type was the only significant predictor (χ^2 (3) = 192.77, $p < .001$). Similar to Studies 1 and 2, children had a higher proportion of correct responses in the ME training block than in the other tests: selectivity test (β = 1.29, SE = 0.13, $p < .001$), encyclopaedic test (β = 1.42, SE = 0.13, $p < .001$), and retention test (β = 1.42, SE = 0.6 $p < .001$).

6.3.2 Main analyses

A one-sample proportion test was conducted to test whether children selected the target image significantly above chance for each block, by comparing the mean proportion of accurate responses to .50 chance. Even though the mixed-effect model showed that children perform better in the ME training block than in any of the test blocks, it was revealed that children selected the target above chance in all block type: ME training block (χ^2 (1) = 452.16, $p < .001$, $h = 0.71$), retention test (χ^2 (1) = 4.64, $p =.031$, $h = 0.14$), selectivity test (χ^2 (1) = 19.32, $p < .001$, $h = 0.19$), and encyclopaedic test (χ^2 (1) = 9.55, $p = .002$, $h = 0.14$). Table 4 shows the proportion of participants for each score category.

Table 4. Mean proportion, standard deviation and 95% confidence interval of accurate responses in Study 3

Block type	Mean proportion	SD	95% CI of mean	
			Lower	Upper
ME training	.828 ***	.378	.803	.850
Selectivity test	.597 ***	.491	.553	.639
Encyclopaedic test	.568 **	.496	.525	.611
Retention test	.568 *	.496	.506	.628

Note. Chance is at .50 for all blocks. * $p < .05$. ** $p < .01$. *** $p < .001$.

The significant result in the ME training block suggests that bilinguals, like monolinguals, make use of the ME constraint when forming word-object associations. A two-sample test for equality of proportions test supports the findings from the mixed-effect models, that bilingual children performed significantly better in the ME training block than in the retention test (χ^2 (1) = 80.25, $p < .001$, $h = 0.58$); and the selectivity test (χ^2 (1) = 99.17, $p < .001$, $h = 0.52$; see Table 4 for the proportion of accurate responses). Thus, bilingual children's pattern of performance was similar to monolinguals in Study 2, where bilinguals were able to fast-map, with retention rates below those of fast-mapping rates.

6.3.3 Relationship between experimental blocks

The correlation between scores of different blocks was analysed to ascertain whether performance in the selectivity test is likely explained by relying on lexical association or via encyclopaedic mappings. If the association between the novel label and the name-known object takes place at a lexical level, the scores in the ME training block would correlate positively with the scores in retention test but negatively with the scores in selectivity test, due to the competition between the name-unknown image and the name-known image for the association with the novel label. Otherwise, if children have formed encyclopaedic associations between the novel label, the name-unknown object and the name-known object, performance in the ME training block would correlate positively with the performance in both the retention test and the selectivity test.

The current study did not obtain any significant correlation between the ME training block and the retention test ($\rho = -.147$, $p = .094$, 95% CI [-.33, .01]) and between the ME training block and the selectivity test ($\rho = -.102$, $p = .245$, 95% CI [-.25, .09]). Hence, the correlation test could not differentiate the two learning accounts (lexical or encyclopaedic).

6.3.4 Comparison between monolinguals and bilinguals

The next question to ask is whether bilinguals also show the same pattern of results as monolinguals in the different blocks. To compare the performance between monolinguals and bilinguals, a mixed-effect model was run with participants and stimuli set as the random effects. The fixed effects were language (monolinguals or bilinguals), age groups (preschool, young or older children), block type (ME training, selectivity test, encyclopaedic test and retention test) and interaction between language and block type.

Results obtained revealed that only block type appear as a significant main effect (χ^2 (3) = 427.66, p < .001), whereas removing the other two predictors did not affect the model (ps > .10). There was, however, a significant interaction between language and block type (χ^2 (3) = 20.61, p < .001). This interaction was further analysed using proportions test.

Two-sample tests for equality of proportions were conducted to look into the interaction between block type and language. Monolinguals' performance was set as the baseline frequency and bilinguals' performance was tested against it. It was found that monolinguals were significantly more target-oriented than bilinguals in the ME training block (χ^2 (1) = 5.74, p = .017, h = 0.11), in the retention test (χ^2 (1) = 10.25, p = .001, h = 0.29) and in the selectivity test (χ^2 (1) = 3.36, p = .037, h = 0.13). There was no significant difference between monolingual children and bilingual children for the encyclopaedic test (χ^2 (1) = 0.82, p = .365, h = 0.06). The proportion of correct responses for both monolingual and bilingual children is shown in Figure 6.

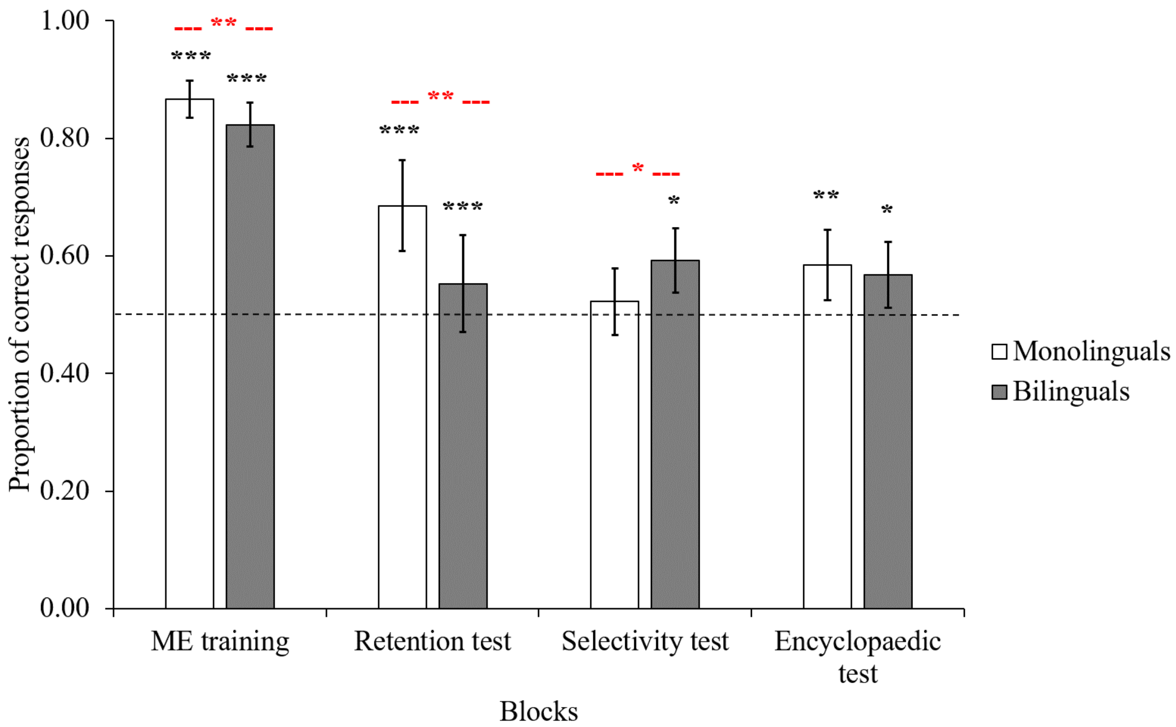


Figure 6. Mean proportion of accurate responses in monolinguals and bilinguals

Note. Dotted line represents chance (.50). Error bars represent 95% CI. Black asterisks refer to the significant difference from chance; red asterisks refer to the significant difference between monolinguals and bilinguals. * $p < .05$. ** $p < .01$. *** $p < .001$.

6.4 Discussion

The present study was designed to answer three questions: (1) whether bilinguals would rely on the ME constraint, (2) whether they would retain the newly-formed word-object associations, and (3) whether they would readily learn a second label for name-known objects. Byers-Heinlein and Werker (2009) demonstrated that bilinguals showed less bias to name-unknown objects, suggesting that bilinguals (and trilinguals) apply a weaker version of the ME constraint. This weaker ME constraint is likely to be due to bilinguals required to violate the ME constraint's assumption that each object only has one name, as they learn two labels for most objects. If bilinguals conform less to the ME constraint, then it is likely that they would learn another word-object association more willingly. The current study compared the performance of monolinguals and bilinguals in ME-related tasks and found mixed results. Although the current findings showed that bilinguals use less ME constraint than monolinguals, they were not better than monolinguals in forming additional associations between novel labels and name-known objects. The consequences of these results on word-learning mechanisms in bilinguals are discussed below.

6.4.1 Usage of ME constraint during referent selection

The current study set out to answer the question of whether bilinguals would show less ME effect compared to monolinguals. Two hypotheses were made: first, that bilingual children would score less well in the ME training block due to a weaker form of ME constraint compared to monolinguals; second, that there would be a negative correlation between age and bilinguals' performance in the ME training block as older bilinguals should use the ME constraint less than younger bilinguals. The current study revealed that bilinguals were able to select the target above chance in the ME training block. This result means that the bilinguals showed evidence of using the ME constraint, where they select the name-unknown image when they hear a novel label. A comparison between monolinguals and bilinguals revealed that bilinguals showed less bias to the name-unknown image in the ME training block compared to monolinguals. This result provides a more nuanced version than some studies on bilinguals (Houston-Price et al., 2010; Kandhadai et al., 2017), which found that bilinguals failed to show any evidence of the ME constraint. Instead, the current study aligns well with Davidson et al. (1997, 2005) and Kalashnikova et al. (2015), who demonstrated that bilinguals too make use of the ME constraint, but not as strongly as monolinguals. Thus, the first hypothesis that the ME constraint is weaker in bilinguals, is supported.

The difference in performance between monolinguals and bilinguals is unlikely to be due to the different images used between Study 2 and the current study (i.e., monolinguals saw a ball whereas bilinguals saw a shoe), because both a ball and a shoe are colourful inanimate objects that children are familiar with. Byers-Heinlein and Werker (2009) used both a ball and a shoe as name-known objects in their experiment and no significant difference between these stimuli was reported. Instead, it is likely that the difference in performance between monolinguals and bilinguals is caused by bilinguals' infrequent use of the ME constraint, as argued by previous studies (Davidson & Tell, 2005; Kalashnikova et al., 2015; Kandhadai et al., 2017).

The current study adds to the battery of studies testing for the ME constraint in bilinguals. The current study employed a traditional design to test for the ME constraint, similar to that of Byers-Heinlein and Werker (2009) and Houston-Price et al. (2010), where children were presented with a name-known object, a name-unknown object and a novel label. The difference between these studies and the current study was that the two previous studies recruited infants and used a looking paradigm whereas the current study required responses (i.e., tapping on the correct image) from older children. Davidson and Tell (2005) conducted a study that was similar to Markman and Wachtel's (1988), testing whether young children (aged between three and six years old) would select a name-known object (hence, violating the ME constraint) or a part of that object (hence, conforming to the ME constraint) as a referent for a novel label. Kalashnikova et al. (2015) taught children (aged between three and five years old) either one or two novel labels for each name-unknown object, testing whether children were able to learn both novel labels above chance in the two-novel-labels condition (hence, violating the ME constraint). Despite the differences in the design, previous studies and the current study found bilinguals to show similar pattern of performance; that is, having a weaker ME constraint compared to monolinguals, suggesting that the weaker usage of ME constraint in bilinguals is a robust effect.

That some studies (Byers-Heinlein and Werker, 2009; Kandhadai et al., 2017; Houston-Price et al., 2010) obtained non-significant results of the ME constraint, whereas others (Davidson et al., 1997, 2005; Kalashnikova et al., 2015) and the current study found bilinguals to use ME constraint could be due to the differences in children's age. Byers-Heinlein and Werker (2009) and Houston-Price et al. (2010) recruited infants of around 17 to 22 months old, whereas Davidson et al. (1997, 2005) recruited young children of three and six years old and the current study recruited school-going children, aged between three to 11 years old. Byers-Heinlein and Werker (2009) argued that the ME constraint may start to develop later in bilinguals, as by then they have come across more instances in which the ME constraint is violated. Thus, the difference in the findings could result from bilinguals not showing evidence of the ME constraint until about three years of age. At around three years of age, children start to hold the ME constraint very strongly regardless of the linguistic experience (Frank & Poulin-Dubois, 2002; Haryu, 1991, as described in Haryu & Imai, 1999). Furthermore, Kalashnikova et al. (2015) argued that when no other information is available, bilinguals would make use of the ME constraint when forming word-object associations. Thus, it is not surprising that the bilingual children in the current study showed evidence of the ME constraint, as did Davidson and Tell (2005).

Another possible reason for the difference in results between studies is the group of bilinguals taking part in the study. As Poepsel and Weiss (2016) argued, the ME constraint is used even by adults. However, after experiences with many-to-one word-object associations, the ME constraint in adults is weaker. Therefore, high-proficient bilinguals who have extensive vocabularies in both languages, and hence know two words for most objects would be less likely to use the ME constraint and more readily open to forming multiple word-object associations compared to low-proficient bilinguals who have less exposure to the second language and less overlap in the vocabulary.

Differences between high- and low-proficient bilinguals are observed in Cook et al. (2006). Although Cook et al. (2006) revealed no difference between the English proficiency levels of high-exposure bilinguals (i.e., Japanese who stayed in the US for more than three years) and low-exposure bilinguals (i.e., Japanese who stayed in the US for less than three years), high-exposure bilinguals showed the same level of shape-bias (i.e., matching objects based on shape rather than materials) as monolinguals whereas low-exposure bilinguals were significantly less shape-biased than monolinguals and the high-exposure bilinguals. Similarly, Byers-Heinlein and Werker (2013) found that bilinguals (17 to 18 months of age) who knew many translation equivalents (i.e., the same word in two languages) did not show novelty bias in ME training trials, whereas bilinguals who did not know many translation equivalents showed evidence of the ME constraint like monolinguals. These findings suggest that different levels of exposure to the second language affect one's usage of linguistic cues, such as the ME constraint.

Bilinguals in the current study only learned a second language in school, whereas the children in Houston-Price et al. (2010) used the second language in day-care centres. Hence, the current study may also have recruited low-proficient bilinguals, who violate the ME constraint less often in daily life, and hence display a higher tendency to use the ME constraint.

The effect of language proficiency on children's performance in linguistic tasks suggests that it is the role of language use rather than the status of being either a bilingual or a monolingual that is a successful predictor of children's performance. In other words, linguistic experience is a continuous process rather than a binary variable. Byers-Heinlein and Werker (2009) provided support for this argument, where trilinguals (presumably having more translation equivalents than bilinguals) were less likely than bilinguals to match a name-unknown object to a novel label. Moreover, Byers-Heinlein and Werker (2013) demonstrated that different levels of translation equivalent affect the level of novelty bias in children, providing support for the argument that linguistic experience is a continuous process. In Byers-Heinlein and Werker's (2013) study, even though all the recruited children were categorised as bilinguals, the children showed different patterns of performance in the ME training trials, where children with more translation equivalents showed less novelty bias. This evidence suggests that the number of translation equivalents may be more reliable as an independent variable than the status of being a bilingual.

Contrary to the second hypothesis, age was not a good predictor of children's performance in the current study. Younger bilinguals were expected to be more conforming to the ME constraint due to their reduced exposure to violations of the constraint. However, no such difference was obtained, which is in contrast with Davidson et al. (1997), who revealed that older bilingual children (five and six years old) showed less ME constraint than younger bilinguals (three and four years old). In an experiment pitting the ME constraint against pragmatics, Haryu (1991) also found age differences in Japanese children, where three-year-olds tend to hold more strongly to ME constraint compared to five-year-olds. However, age is not always found to be a good predictor of children's performance. Using CSL paradigms (i.e., showing children at least two name-unknown objects and novel labels in every trial), Suanda et al. (2014) obtained no age trend in five- to seven-year-olds' performance. Similarly, Vlach and DeBrock (2017) found that age did not predict the performance of three- and four-year-old children. In other words, older children were not more able than younger children to learn word-object associations in these two studies. Perhaps, presenting just two novel labels in the current study, made the task relatively easier than other studies, and hence led to reduced difference between older and younger bilinguals.

In short, the current study showed that bilinguals do make use of the ME constraint to some extent, but not as strongly as monolinguals, a difference likely attributed to differences in language experience. Although an age difference in task performance was expected, it was not observed, potentially hindered by the small sample size of each age group.

6.4.2 Retention of word-object associations

The second question was whether bilinguals are able to retain newly-formed novel word to name-unknown object associations. It was hypothesised that bilinguals would perform worse than monolinguals in the retention task due to their weaker ME constraint. The current study showed that bilingual children were able to learn and retain the associations formed in the ME training block, as they selected the target above chance in the retention test block. This finding supports Byers-Heinlein et al. (2013) and Werker et al. (1998), who used switch paradigms to ascertain whether monolingual and bilingual infants could learn associations between labels and images. They obtained no significant difference between the performance of monolingual and bilingual infants, suggesting that the ability to form word-object associations is present in both monolinguals and bilinguals. In line with this finding, the current study demonstrated that bilingual children were able to retain word-object associations formed in the ME training blocks, showing pattern of performance that is similar to monolinguals who were recruited in Study 1 and Study 2.

Even though bilinguals were able to perform in the retention test above chance, the current study also found a significant difference between monolinguals and bilinguals, where monolinguals were better than bilinguals at retaining the association formed in the ME training block. One reason for this difference could be that bilinguals have a weaker retention rate or weaker memory compared to monolinguals. However, we argue that this reasoning is unlikely, because Byers-Heinlein et al. (2013) demonstrated that 14-month-old monolinguals and bilinguals were equally good at learning word-object associations. Moreover, in a task where three-year-old children were taught novel names for name-known objects, Healey and Skarabela (2008) found bilinguals to be more willing than monolinguals in using these novel names for the name-known objects in a subsequent test. If bilinguals have a weak retention rate, then they would not be able to select the correct referent during the test phase. This evidence suggests that bilinguals are unlikely to have a weaker retention rate than monolinguals.

Instead, we argue that the difference in performance is due to bilinguals applying the ME constraint in a weaker form, leading to weaker associations between the novel labels and the name-unknown images, which caused bilinguals to perform worse than monolinguals in the retention test. Thus, the weaker performance is not due to weaker retention rate but weaker associations formed. This argument is consistent with a CSL-like learning mechanism, where the strength of word-object associations depends on the attention provided to the association. If children focused on a particular object when forming a word-object association, then this association will be stronger, leading to better retention rate of the object as a referent. Otherwise, if children split their attention towards two objects when they hear a novel label, then the strength of these two word-object associations will be relatively weaker than if children focused on only one object.

This line of reasoning that bilinguals form a weaker mapping between the novel labels and the name-unknown images is also similar to that proposed by Horst and Samuelson (2008) and Mather and Plunkett (2009), where children require many trials of pairings before they are able to learn the associations. As bilinguals do not always map the novel label to the name-unknown object, it is likely that they need more trials than monolinguals to learn the word-object associations. In Kalashnikova et al. (2018), 18-month-old bilinguals did not show significant difference from monolinguals in the retention test because they were comparable to the monolinguals in showing novelty bias in the ME training trials. Thus, the hypothesis for the second question is supported, as bilinguals performed worse than monolinguals in the retention test.

6.4.3 Learning second labels for name-known objects

The third question asked in the current study was whether bilingual children are better than monolinguals at mapping a novel label to a name-known object. This question is not new as many studies have tested using different designs, whether bilinguals are able to learn a second label for a name-known object. Frank and Poulin-Dubois (2002) and Kalashnikova et al. (2015) taught children two labels for each name-unknown object, whereas Healey and Skarabela (2008) taught children one novel label for each name-known object. Although Frank and Poulin-Dubois (2002) did not find any difference between monolinguals and bilinguals, Healey and Skarabela (2008) and Kalashnikova et al. (2015) found bilinguals to be better than monolinguals at learning second labels. Using a typical CSL paradigm, Poepsel and Weiss (2016) also revealed that bilingual adults formed more readily multiple mappings than monolingual adults.

The current study revealed that bilingual children were able to select the name-known image that was paired with the novel label previously, adding to the evidence (e.g., Davidson & Tell, 2005; Healey & Skarabela, 2008; Kalashnikova et al., 2015) that bilingual children are willing to give a second name to a name-known object. The approach that the current study used was different from previous studies. Instead of direct teaching, the current study used a method similar to the CSL paradigm, where children were presented with two images and a novel label and were not told which image the novel label refers to. As a name-unknown image and a name-known image were shown, the ME constraint suggests that children prefer to map the novel label to the name-unknown image over the name-known image. However, if children are open to learning multiple labels, then there is a possibility that children are also able to learn that the novel label is a second name for the name-known image. As the current study found bilinguals to perform above chance in the selectivity test, we argue that even without direct teaching, children are able to associate a second label to a name-known object. However, it should be noted that there are differences between the current study and previous studies when it comes to testing whether infants are able to learn a second label for a name-known object (what we refer to as the selectivity test in the current study). Previous studies typically had more difficult tests, where they included multiple name-known and name-unknown distractors during the test, whereas the current study presented children with only two choices: the name-known target and the name-known distractor. This simpler test may allow children to perform above chance in the selectivity test even though they were not explicitly taught second label for the name-known object.

As was observed in monolingual children, bilingual children were able to select the target image above chance in the encyclopaedic test as well. Because successful target selection in the encyclopaedic test can only be achieved through cascaded activation, we can infer that bilinguals, too, use cascaded activation where necessary. To test whether bilingual children’s performance in the selectivity test is explained by lexical associations, correlations between the ME training block and the two test blocks were tested. These correlation analyses are important in teasing apart the competing ME and CSL accounts. According to a strict ME account, children form an association only between the novel label and the name-unknown image in the ME training block. To be able to select the target in the selectivity test, children need to rely on cascaded activation from the novel label to the name-known image via the name-unknown image. The reliance on cascaded activation would result in a positive correlation between the ME training block and the selectivity test block.

On the other hand, a CSL account predicts that children would have formed an association between the novel label and both the name-unknown image and the name-known image. A stronger association between the novel label and the name-unknown image would lead to a weaker association between the novel label and the name-known image, due to the competition between the two associations. This competition is caused by a fixed amount of attention that needs to be divided between two associations, hence, when one association is stronger, the other becomes weaker. Therefore, according to the predictions of a CSL account, performance in the selectivity test should correlate negatively with the performance of the ME training block.

Contrary to the results obtained from Study 2, no significant correlation was obtained between the ME training block and the two test blocks. As the performance in the ME training block is not related to the performance in the two test blocks, the two competing hypotheses cannot be teased apart. It is important to understand why the correlations between different experimental blocks were not significant in the current study, because we expected the correlations to be significant based on the results obtained from Study 2. Two possible reasons were provided. First, it could be that the task was relatively easy for school-aged children, leading to the correlation to be non-significant. However, as children did not perform at ceiling in the selectivity test, we argue that this explanation is unlikely to be the reason. A second reason for the non-significant correlation is that bilinguals use a different strategy when forming word-object associations. Perhaps, having a weaker ME constraint leads bilinguals to map the novel label equally to both objects, leading to a non-significant correlation between ME training block and selectivity test. Nonetheless, as the correlation between the two blocks was not significant, it cannot be argued conclusively that bilingual children in the current study have formed a lexical association between the novel label and the name-known object.

Although the monolinguals in Study 2 did not perform above chance in the selectivity test, whereas bilinguals in the current study did, the performance between monolinguals and bilinguals in the selectivity test block was not significantly different. This result is similar to that in Pomper and Saffran's (2018) study, where the performance of two groups of children were not significantly different from each other even though one group was able to select the target above chance whereas the other group was not able to. One possible reason for this result is that due to the few number of repetitions in the ME training block, monolingual children were unable to select the target above chance because they have not encoded fully the mappings between the novel labels and the name-known images. However, as compared to bilinguals, monolinguals' performance was not significantly different, suggesting that both monolinguals and bilinguals should be able to form a hierarchy of associations between objects and labels if enough repetitions of trials were provided.

6.4.4 Limitations

A weakness of the current study is that the current study did not use exactly the same stimuli as those in Study 2. The stimuli were changed in the current study to avoid cognate effect (see section 6.2.3). In doing so, we risk presenting different sets of stimuli to different groups of participants (i.e., monolinguals saw a cup and a ball, bilinguals saw a cup and a shoe), leading to a likely confound that might affect the results. Although the difference in task performance between monolinguals and bilinguals was according to the predictions made about monolinguals and bilinguals, it cannot be completely ruled out that the difference in behaviour is not due to the presentation of different stimuli.

Another limitation of the current study is that bilingual children's level of proficiency was not measured objectively. Therefore, it was only assumed in the current study, through knowledge about the society in Malaysia, that the recruited children were low-proficient bilinguals. Moreover, social economic status (SES) and educational background of the parents were also not obtained in Study 3, hence it is not known whether difference in terms of SES and parents' educational background could have caused the difference in task performance between monolinguals and bilinguals. This demographic information was omitted because parents are usually too busy to complete forms unrelated to school activities and there is also a high possibility that parents will disallow their children from participating in the current study if personal information was required.

A possible issue raised is that the monolinguals in Study 2 were recruited from an event for children (i.e., the Summer Scientist Week), therefore, children might be highly motivated as they were eager to be a "scientist", whereas the bilinguals in the current study were only recruited from schools and they may not be as motivated as monolingual participants in Study 2. However, children's motivation to participate in experiments was unlikely to cause differences in results. This is because the bilinguals recruited in schools were very eager and highly motivated as well, as they were fascinated by the iPad used in conducting the experiment, and they were given stickers as a token of appreciation. There could also be a possibility that the monolingual children who attended the Summer Scientist Week might be academically stronger than the bilingual children, simply because they came from families that participate in activities organised by universities. Because proficiency tests were not administered, conclusions drawn from the current study cannot rule out possibilities of the confounding variables raised here.

6.4.5 Summary and conclusion

Study 3 aimed at testing differences between monolinguals and bilinguals when forming word-object associations. In particular, Study 3 looked at three questions: (1) whether bilinguals are less likely than monolinguals to map a novel label to a name-unknown object, (2) whether they are more able to retain newly-formed word-object associations and (3) whether they are more likely to be able to form an association between a novel label and a name-known object. As bilinguals needed to learn more than one name for most objects, it was hypothesised that they would be less likely to use the ME constraint but more likely to associate a novel label with a name-known object.

It was demonstrated that although bilinguals are able to map novel labels to name-unknown objects, they do so less robustly than monolinguals, hence, the hypothesis that bilinguals show weaker ME constraint is supported. However, and contrary to our hypothesis, there was no difference between monolinguals and bilinguals in terms of the ability in forming associations between novel labels and name-known objects. Based on these findings, it can be concluded that bilinguals apply the ME constraint but not to the same extent as monolinguals. As bilinguals use ME constraint to a lesser extent, the next question to ask is what additional information do bilinguals rely on when disambiguating potential referents in ambiguous learning situations. Although it is possible to learn word-object associations purely through accumulation of associations (as explained using CSL; Yu & Smith, 2007), it is more efficient to use several cues when trying to select a referent for a novel label. As the Malay language uses classifiers for all kinds of objects, the next study looked at the effect of syntactic cues, in particular, classifiers, on the use of the ME constraint and how classifiers help children learn new word-object associations.

Chapter 7 Effect of Syntactic Bootstrapping on Mutual Exclusivity

7.1 Introduction to Study 4

A strict ME account argues that children will map a novel label to a name-unknown object due to the assumption that each object is only given one name (Markman & Wachtel, 1988). Only when enough contradictory evidence is accumulated to show that an object should be given another name, children learn a second label for the same object (i.e., now a name-known object). As children are capable of learning new labels for an object that they already know, this suggests that children are flexible learners. Studies 1 to 3 showed that children are able to form a few associations between words and objects based on their co-occurrence with each other.

Another way a child can learn multiple associations, according to the ME constraint, is if a stronger bias can overcome the ME constraint (Woodward & Markman, 1991). According to Woodward and Markman (1991), different lexical biases are ranked in a hierarchical manner, with biases that are ranked high overriding biases that are ranked low in the hierarchy. Whether other biases can override ME constraint have been tested in many previous studies. For instance, Jaswal and Markman (2007) revealed that social pragmatic cues are unable to overcome novelty bias, arguing that social pragmatics may be ranked lower than the ME constraint. Imai (1999) also obtained similar findings, supporting that the ME constraint is ranked higher than social pragmatic cues among infants because social pragmatic cues are not accessible to young infants yet.

Although children also use many cues other than the ME constraint, when the two cues are in conflict with each other, the ME constraint usually prevails. For instance, social pragmatic cues, such as pointing and gazing at a particular object, were found to be useful in disambiguation tasks (Graham et al., 2010). However, when these cues are pitted against the

ME constraint, children tend to disregard social cues, suggesting that social cues may not be strong enough to act as a contradicting evidence to ME biases.

Syntactic bootstrapping is also informative to children. Many studies conducted on the English language found that children do make use of syntactic bootstrapping to learn meanings of words (Bloom & Kelemen, 1995; Hall et al., 2000; 2001; Jaswal & Markman, 2001; Katz et al., 1974). For instance, if syntactic cues indicate that the novel label is unlikely to be an object (e.g., Look at the *dax* one!), children typically do not show evidence of the application of the ME constraint on the object. Instead, they would map the novel label to a novel property of the object.

In English, syntax also allows children to differentiate proper nouns, count nouns and mass nouns. For instance, classifiers are used mainly for mass nouns (e.g., a cup of tea). However, in some Asian languages, such as Japanese, Mandarin and Malay, all types of nouns (regardless of whether they are count nouns or mass nouns) may be preceded by a classifier, hence, these different types of nouns are not necessarily differentiated through syntax. In these languages, classifiers are used even for count nouns. For instance, in Mandarin, “a cat” is “*yì* (one) *zhī* (classifier for small animals) *māo* (cat)”, whereas in Malay, it is “*seekor* (one - classifier for animals) *kucing* (cat)”.

Imai and Haryu (2001) tested the effect of different syntax systems (English and Japanese) on learning proper and count nouns. In their design, they omitted classifiers, as classifiers are not obligatory in Japanese (Imai & Haryu, 2001). In other words, unlike English where it is ungrammatical for nouns to stand alone without either an article or a classifier before them, in Japanese it is grammatical to omit the classifier preceding the noun (Imai & Haryu, 2001). Imai and Haryu (2001) found that although the Japanese language does not differentiate between count and proper nouns, Japanese children were still able to differentiate these two types of nouns during disambiguation, just like the English-speaking children. The researchers concluded that the ME constraint and Taxonomic constraint provide a more useful information than syntactic bootstrapping.

The current study asked if Malay-speaking children will also make use of syntactic bootstrapping like their English-speaking counterparts, even though the syntax of English and Malay are different. As testing syntactic bootstrapping against the ME constraint has thus far been done only on the English language, it is important to also conduct similar studies on languages that use syntax systems different from that of the English language. In Malay, the language tested in the current study, although classifiers may also be omitted in certain circumstances, children are taught classifiers in school (Salehuddin & Winskel, 2011). As classifiers are formally taught in the national education syllabus, it is expected that children will take classifiers into account when learning meanings of words. Hall and Graham (1999) demonstrated that English-speaking children are able to learn that labels that are not preceded by a determiner are not nouns, therefore, not labels of objects. In a similar manner, Malay-speaking children are expected to learn that labels following certain classifiers should conform to particular shape, or type, of name-unknown objects.

To test for the effect of classifiers on the ME constraint, the current study had four conditions: match-both, match-novel, match-familiar, and mismatch-both. In the match-both condition, the classifier matched both the name-unknown image and the name-known image. It was hypothesised that children would show an ME bias in the match-both condition as syntactic bootstrapping does not provide additional nor useful information. In the match-novel condition, the classifier matched only the name-unknown image, therefore, both syntactic bootstrapping and ME constraint direct the child towards the name-unknown image. With two congruent cues, children’s response towards the name-unknown image should be strengthened. In the match-familiar condition, the classifier only matched the name-known image. In this condition, syntactic bootstrapping is pitted against the ME constraint. If children take syntactic bootstrapping into account, they would select the name-known image; on the other hand, if the ME constraint is stronger, they would select the name-unknown image. Finally, in mismatch-both condition, the classifier matched neither image. Children's performance was expected to be the same as in the match-both condition, where they make use of the ME constraint as syntactic bootstrapping does not provide useful information.

7.2 Pilot Study

7.2.1 Method

A pilot study was conducted to assess the validity of the selection of name-unknown images and novel labels. The name-unknown images were obtained from various internet sources, as well as from Frank et al. (2016). Ten young adults who were native Malay speakers were recruited in this pilot study. There were three parts to this pilot study. The first part aimed at assessing the novelty of 32 name-unknown images: participants were asked to rate the novelty of the images from 1 (not at all familiar) to 5 (very familiar). The second part evaluated the suitability of the classifiers for 32 name-unknown images on a five-point rating scale, from 1 (not at all suitable) to 5 (very suitable). This second part ensures that the manipulation of the classifiers in each condition matches adult use of the classifier. In the third part of the pilot study, 39 made-up two-syllabic words were tested for similar-sounding words. This test was conducted because Swingley and Aslin (2007) found that children learn novel labels with familiar phonological neighbours less well, as phonological neighbours compete with these novel labels for activation and attention. Participants were asked to rate whether the labels sounded like any words they knew, where 0 referred to an absence of similar-sounding words whereas 1 referred to the presence of similar-sounding words. For novel labels rated as 1, the participants were asked to specify the identity of these known words.

7.2.2. Results

7.2.2.1 Novelty of images

The mean ratings for all name-unknown images were compared against an average rating of 2.50 (i.e., neither a novel nor a familiar image) using a one-sample t-test. It was found that these ratings (M = 2.71, SD = 0.70) were not significantly lower than 2.50, $t(9)$ = 1.37, p = .204, d = 0.60. As these images did not receive ratings below average, the ratings of these name-unknown images were then compared against those of the name-known images (M = 4.44, SD = 0.45). It was revealed that there was a significant difference between these two types of images, $t(7)$ = 8.14, p < .001, d = 3.01, suggesting that the name-unknown images are less familiar to the participants than the name-known images, thus, these name-unknown images were used in the current study.

7.2.2.2 Suitability of classifiers

The average rating of suitability of the classifiers in non-matching conditions (match-familiar and mismatch-both) was 1.20 (SD = 0.23), which was significantly lower than an average rating of 2.50 (i.e., neither a suitable nor an unsuitable classifier), $t(9)$ = -11.98, p < .001, d = 11.3. Therefore, the classifiers used in match-familiar and mismatch-both conditions were not suitable for the name-unknown images. The average ratings of suitability of the classifiers in matching conditions (match-both and match-novel) was 4.21 (SD = 0.64). This rating was significantly higher than 2.50, $t(9)$ = 13.39, p < .001, d = 5.34. Thus, the classifiers used were suitable for the name-unknown images in the matching conditions.

The average rating of the name-unknown images in non-matching conditions was then compared to the average ratings in the matching conditions. It was found that the former conditions had an average rating that was significantly higher than the latter conditions,

$t(9) = 20.66$, $p < .001$, $d = 6.92$. This result suggests that the manipulation of the classifiers was successful: the classifiers used in match-both and match-novel conditions matched the name-unknown images whereas the classifiers used in match-familiar and mismatch-both conditions did not match the name-unknown images.

7.2.2.3 Novelty of labels

Out of the 39 novel labels, none had ratings above the average rating of .50. As only 32 labels were needed, the novel labels were eliminated if they shared a phoneme with a real Malay word. First, labels that shared a phoneme with simple words that young children are likely to know (*kuning* (yellow) for "kunil", *adik* (younger sibling) for "adim", *kemas* (tidy) for "kemap", *matang* (mature) for "mafang" and *lapik* (protective layer) for "lamik") were eliminated, leading to five novel labels being removed. "witan" was also eliminated because it shared a syllable with *hutan* (forest), a word that is likely to be understood by young children. Finally, a novel label that had a rating of .30 (highest rating among all labels) was eliminated, leaving 32 novel labels, one for each trial (see third column of Appendix C for a complete list of the novel labels).

The highest rating of the remaining 32 novel labels was .20, which was marginally less than an average rating of .50, *p*s = .051; whereas the other novel labels had ratings that were significantly less than .50, *p*s < .05. One label, "jupang", shared a phoneme with a real Malay word, *kupang* (10 cents), yet it was ruled out as a problem as this word only had a rating of .10.

7.3 Main Study

7.3.1 Method

7.3.1.1 Design

A within-participant design was used in the current study. The independent variable was condition, which had four levels (see Figure 7). The first level was match-both, where the classifiers matched both the name-unknown image and the name-known image. The second level was match-novel, where the classifiers matched the name-unknown image but not the name-known image. The third level was match-familiar, where the classifiers matched the name-known image but not the name-unknown image. The fourth level was mismatch-both, where the classifiers did not match either image. Eight classifiers were used in each condition (see Table 5). Therefore, the current study has 32 trials (see Appendix C for a complete list of the trials). The meanings and usage of these classifiers are listed in Table 5. The dependent variable was the image selected by the children, whether it was the name-unknown image or the name-known image.

Table 5. Meanings and examples of classifiers used in Study 4[3]

Classifiers	Meanings	Examples
Batang	For objects that are long	*Sebatang jalan* (a road)
Biji	For small objects[4]	*Sebiji telur* (an egg)
Ekor	For animals	*Empat ekor lembu* (four cows)
Helai	For objects that are thin	*Sehelai daun* (a leaf)
Keping	For something that is flat and thin	*Dua keping kertas* (two sheets of paper)
Ketul	For chunky objects	*Seketul tulang* (a bone)
Orang	For human	*Lima orang guru* (five teachers)
Utas	For objects with individual units	*Seutas rantai* (a necklace)

[3] Translated from Kamus Dewan (the dictionary published by Malaysia's board for Language and Literature)
[4] Grammar books also explain that *biji* can be used for round objects.

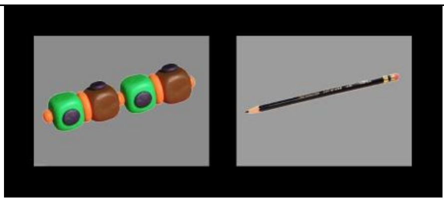
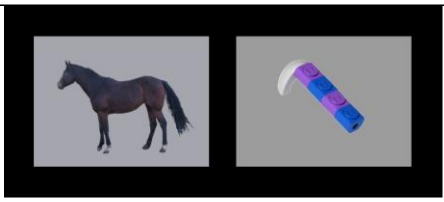
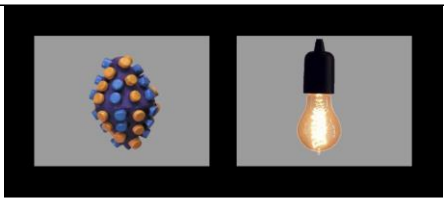
Condition	Image pairs	Auditory stimuli
Match-both		*Carikan sebatang himdek*! (Find a [classifier] himdek!)
Match-novel		*Carikan sebatang buhi*! (Find a [classifier] buhi!)
Match-familiar		*Carikan sebatang wukca*! (Find a [classifier] wukca!)
Mismatch-both		*Carikan sebatang sungkil*! (Find a [classifier] sungkil!)

Figure 7. Examples of different conditions for classifier *batang* used in Study 4

7.3.1.2 Participants

Sixty-seven children were recruited from a National Primary School which uses Malay as a medium of instruction but also teaches English. The children (30 male, 37 female) were all dominant Malay speakers. The participant's age ranged from 5 years to 9 years (M = 7.21 years, SD = 1.29). This age range was grouped into two: preschool children (n = 23, age range = 5 – 6 years, M = 5.74 years, SD = 0.45), young children (n = 44, age range = 7 – 9 years, M = 7.98 years, SD = 0.82).

A post-hoc power analysis for the current study was calculated for the match-familiar condition using the `pwr` package (Champely, 2018) on R. Match-familiar condition is used because the current study aims to test whether children will select the name-known image if the classifiers match the name-known image. The effect size, *h*, was set as 0.22, sample size, *N*, as 67, significance level, α, as .05 and alternative hypothesis as two-sided. The power calculated was .44, which is of average power.

7.3.1.3 Stimuli

Each trial consisted of a pair of images, one on the left of the screen and another on the right of the screen. To ensure that children see each image only once, there were 32 pairs of images, each pair consisting of a name-unknown and a name-known image. Similar to Study 1, each image had a resolution of 640 x 480 pixels and was a picture of an object on a grey background. The name-known images were objects that young children are familiar with. The name-unknown images were images of made-up objects obtained from various internet sources and Frank et al. (2016).

The novel labels followed the phonotactic rules of the Malay language but did not have any familiar phonological neighbour (see third column of Appendix C). These novel labels were embedded in the carrier sentence "Carikan se[classifier] __! (Find a __!)". These sentences were recorded by a female native speaker in a child-directed manner.

7.3.1.4 Procedure

The procedure was similar to Study 1, with four differences. The first difference was that, the children in the current study were told the following: "In this game, you will see two pictures, one here (the researcher points to the left side of the iPad) and another here (the researcher points to the right side of the iPad). You will then hear new words, words that you have not heard before. You will have to tap on one of these pictures (the researcher points to both sides of the iPad) that you think matches the words you hear." The second difference was that there was only one block (i.e., ME training) in the current study. Therefore, all 32 trials were randomised across participants. The third difference was that trials were not repeated. Therefore, all children saw each image pair just once. The fourth difference was that there were no attention getters nor filler trials in the current study.

7.3.2 Results

7.3.2.1 Analysis method

To test which variables affected children's performance, a mixed-effect logistic regression was conducted with participants and stimuli set as random effects. The full model consisted of the following variables of interest: condition, age group and interaction between condition and age. It was revealed that other than age groups (χ^2 (1) = 3.15, $p = .076$), all variables improved the model significantly: condition (χ^2 (3) = 17.67, $p = .001$) and the interaction term between condition and age (χ^2 (6) = 51.52, $p < .001$).

The mixed-effect model showed that children were more novel-oriented in the match-novel condition than in the match-both condition (β = 1.42, SE = 0.49, $p = .004$), marginally less novel-oriented in the match-familiar condition than in the match-both condition (β = -0.92, SE = 0.49, $p = .057$) and not significantly different in match-both and mismatch-both condition (β = 0.10, SE = 0.49, $p = .836$). A breakdown of the interaction term revealed that young children were less novel-oriented than preschool children in match-familiar condition (β = -0.83, SE = 0.29, $p = .004$), but were more novel-oriented than preschool children in match-novel condition (β = 1.22, SE = 0.32, $p < .001$). Subsequent analyses were conducted to further analyse the effect of these predictors on children's performances.

7.3.2.2 Main analyses

To test whether children were biased to a particular image in different conditions, one-sample proportion tests were conducted by comparing the raw count in each condition to the .50 chance. For each trial, children had to select between a name-unknown image and a name-known image. Selecting the name-unknown image leads to a score of 1.

As shown in Table 6, children selected the name-unknown image significantly above chance in the match-both condition (χ^2 (1) = 11.64, p < .001, h = 0.15); the match-novel condition (χ^2 (1) = 187.48, p < .001, h = 0.64); and the mismatch-both condition (χ^2 (1) = 25.54, p < .001, h = 0.22). In the match-familiar condition, children selected the *name-known* image significantly above chance (χ^2 (1) = 17.55, p < .001, h = 0.18).

Table 6. Mean proportion, standard deviation and 95% confidence interval of novel responses in Study 4

Condition	Mean proportion	SD	95% CI of mean	
			Lower	Upper
Match-both	.575 ***	.495	.531	.617
Match-novel	.797 ***	.403	.760	.829
Match-familiar	.390 ***	.488	.349	.433
Mismatch-both	.591 ***	.492	.548	.633

Note. Chance is at .50 for all conditions. *** p < .001.

The significant novel-oriented result in match-both and mismatch-both conditions suggests that children rely on the ME constraint when syntactic bootstrapping does not provide exploitable information. In the match-novel condition, both syntactic bootstrapping and the ME constraint direct the child's attention towards the name-unknown image. Therefore, it is not known if the children's performance in the match-novel condition is due to the ME constraint or syntactic bootstrapping. If the children took syntax into account, they would be more novel-oriented in the match-novel condition than in the match-both and mismatch-both conditions. The significant familiar-oriented response in the match-familiar condition suggests that children were affected by the syntactic cues, otherwise, they would have selected the name-unknown image. If this argument stands, then children should be more familiar-oriented in the match-familiar condition than all other conditions.

Two-sample tests for equality of proportion was conducted to examine the differences between conditions. This was done by comparing the proportion of correct responses of the two tests in question to see if these two proportions are significantly different from each other. First, the match-both condition and the mismatch-both condition were compared against each other. We did not expect to witness any significant difference between these two conditions because syntactic bootstrapping did not provide disambiguating information in either condition, and children could only rely on the ME constraint. As expected, the proportion test showed that there was no significant difference between these two conditions (χ^2 (1) = 0.25, p = .620, h = 0.03). Thus, in subsequent analyses, the other two conditions were compared against the match-both condition as a baseline condition.

If syntax plays a role in word-object association, then children should be more novel-oriented in the match-novel condition than in the syntax-neutral condition because in match-novel condition, both ME constraint and syntactic bootstrapping direct the children's attention towards the name-unknown image. The two-sample test for equality of proportion showed that children were significantly more novel-oriented in the match-novel condition than in the match-both condition (χ^2 (1) = 60.26, p < .001, h = 0.49), thus supporting the argument that children make use of syntactic bootstrapping when mapping a novel label to an object. Following the same line of argument, if children make use of syntactic bootstrapping, they should be less novel-oriented in the match-familiar condition than in the match-both condition because syntax directs children's attention towards the familiar image. The proportion test showed that children were significantly less novel-oriented in match-familiar than in match-both condition (χ^2 (1) = 35.88, $p < .001$, $h = 0.37$), again supporting the argument that children make use of syntax when associating a label to an object. Children also selected the name-unknown image more often in the match-novel condition than in the match-familiar condition (χ^2 (1) = 182.04, $p < .001$, $h = 0.86$).

7.3.2.3 Analyses on age trend

The significant interaction between age groups and condition was supported by two-sample proportions tests. The mean proportion of novel responses is provided in Figure 8. Young children were more novel-oriented than preschool children in the match-novel condition (χ^2 (1) = 7.457, $p = .006$, $h = 0.25$) but less novel-oriented than preschool children in the match-familiar condition (χ^2 (1) = 28.76, $p < .001$, $h = 0.49$). There was no significant difference between young children and preschool children in the responses for the match-both condition (χ^2 (1) = 2.60, $p = .107$, $h = 0.16$).

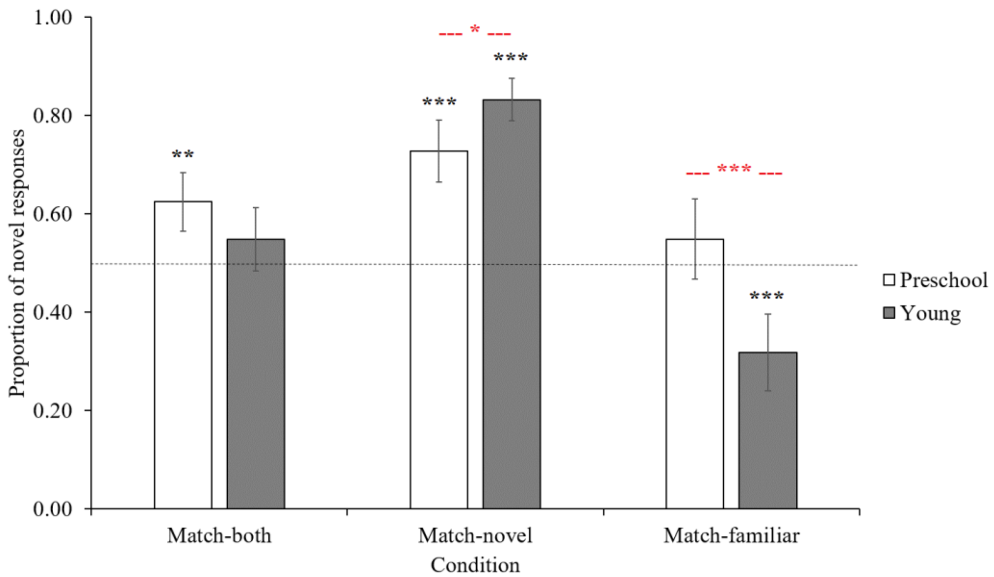


Figure 8. Proportion of novel responses for each condition and each age group in Study 4.

Note. Dotted line represents chance (.50). Error bars represent 95% CI. Black asterisks show difference against chance, red asterisks show difference between age groups.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Thus, as children grow older, they are more likely to select the name-unknown image in the match-novel condition but select the *name-known* image in the match-familiar condition. This finding suggests that children make more use of syntactic bootstrapping as they grow older as older children are more likely to be influenced by syntactic bootstrapping and take it into account when selecting a referent for novel labels. Therefore, it could be argued that children make use of syntax as they grow older.

7.4 Discussion

Study 4 tested the effect of classifiers on the ME constraint through four conditions. It was demonstrated that children were novel-oriented in match-both, mismatch-both and match-novel conditions but were familiar-oriented in match-familiar condition. This finding suggests that children make use of syntactic bootstrapping. This result is further supported by comparing the performance between conditions. As children were more novel-oriented in the match-novel condition than in the match-both and mismatch-both conditions, it could be argued that children take syntactic bootstrapping into account when selecting a referent for a novel label. These findings are discussed below: first, using the results in match-novel condition, the role of syntactic bootstrapping in referent selection is discussed; then, through the findings in match-familiar condition, whether syntactic bootstrapping can overrule the ME constraint is discussed.

7.4.1 The role of syntactic bootstrapping in referent selection

Hall et al. (2000, 2001) demonstrated that children make use of syntactic bootstrapping when selecting a referent, arguing that the ME constraint is not a strict bias that children follow blindly and that ME constraint can be overcome. To demonstrate the usage of syntactic cues in ME training trials, the current study extended previous studies (Katz et al., 1974) and tested children using the Malay language. The Malay language is similar to the Japanese language, where all nouns can be preceded by classifiers.

The recruited children were novel-oriented in match-both and mismatch-both conditions, where classifiers did not play a role. This finding suggests that children rely on the ME constraint when other cues do not provide helpful information. The children were also novel-oriented in the match-novel condition, when both syntactic bootstrapping and the ME constraint aligned to direct the child's attention towards the name-unknown object. Because the children were more novel-oriented in the match-novel condition than in either of the match-both and mismatch-both conditions, the current study provided supporting evidence to previous studies that children are able to make use of syntactic cues. If syntactic bootstrapping is not taken into account, then children's performance in the match-both, mismatch-both conditions and match-novel condition should not be different from each other. As it was found that children were more novel-oriented in match-novel condition, it can be concluded that children do take syntactic bootstrapping into account. Therefore, the current study extended the claims of previous studies that was conducted on the English language (Hall et al, 2000, 2001; Katz et al., 1974), that syntactic bootstrapping is likely to be used by children when selecting a referent for a novel label.

The current study also supports Lee and Naigles (2008) that even though the exact grammar of each language differs, children are still able to use the grammatical rules of their language to learn words. Although the usage of syntactic bootstrapping in verb learning has been tested in many languages (e.g., Lidz et al., 2003), the usage of syntactic cues in noun learning focused mainly on English (Hall et al., 2000, 2001). However, English syntactic cues, such as form class cues, are absent in many other languages. Haryu and Imai (1999) found that Japanese children, whose language does not have form class cues to differentiate proper nouns and count nouns, were also able to perform similarly to English-speaking children in learning proper and count nouns. This evidence leads to the argument that children may not need syntactic bootstrapping when forming word-object associations. Despite this finding, children have shown a great ability to learn grammar (Naigles & Swensen, 2007). The current study found that Malay-speaking children were able to make use of classifiers of the Malay syntax when forming word-object associations, suggesting that syntactic bootstrapping is a reliable cue for forming word-object association. This finding is similar to previous studies on verb learning, where learners of different languages are able to make use of syntactic bootstrapping in word learning tasks. Even though the syntax of Malay is different from English, the current study found that Malay-speaking children also make use of syntactic bootstrapping during referent selection. Although it is possible for children to form word-object associations accurately without syntactic cues (Haryu & Imai, 2001), when syntactic cues are available, children will exploit this information to their benefit. Thus, we argue that syntactic bootstrapping is informative to children who have grasped enough grammar of the language that they are speaking.

Children are likely to be more familiar with the grammar of a language at an older age, as they have more experience with the language. Therefore, it is expected that older children are more able to use syntactic bootstrapping compared to younger children. This hypothesis is again supported in the current study. A significant difference between preschool children and young children was found in match-novel condition. This means that as children grow older, they are more likely to select the name-unknown image. Although this result could also be due to the ME constraint, the difference between young children and preschool children in the match-both condition was not significant. The current study also show that young children were more likely than preschool children to select the name-known image in the match-familiar condition. This result suggests that older children were more likely than younger children to select an image that is congruent with the information obtained from syntactic bootstrapping. As the ME constraint directs children's attention towards the name-unknown image whereas syntactic bootstrapping directs children's attention towards the name-known image, this significant difference in the match-familiar condition suggests strongly that older children are more likely to take syntactic bootstrapping into account. Thus, syntactic bootstrapping is useful in helping children select a referent for novel labels.

7.4.2 Overcoming the ME constraint through syntactic bootstrapping

With evidence showing that children do make use of syntactic bootstrapping, an important question that arises is whether syntactic bootstrapping can overcome ME constraint. According to Woodward and Markman (1991) and Markman and Wachtel (1988), children can overcome the ME constraint if there is enough contradicting evidence, arguing that children's acceptance of a second label is not an evidence against the ME constraint. For instance, other biases, such as pragmatic cues, can help children overcome the ME constraint Supporting this claim, Moll et al. (2006) found children to be able to follow eye-gaze to locate the referent of a novel label. Children can also make use of the intention of the speaker to help disambiguation of referents (Nurmsoo & Bloom, 2008). However, it has been found in several studies that children do not always follow these biases and sometimes, when these biases are in conflict with the ME constraint, the ME constraint takes precedence (Jaswal, 2010). Thus, it is important to know whether syntactic bootstrapping, another type of bias in word learning, can overcome the ME constraint. The answer from the current study suggests that this is the case, although this is age-dependent.

In the match-familiar condition of the current study, syntactic bootstrapping and ME constraint were pitted against each other. This conflict between two cues allows us to test to what extent children follow the ME constraint. If children are biased solely towards the ME constraint, then they should be novel-oriented in this condition as well. As we found that children were familiar-oriented, we could conclude that children take syntax into account when pairing a novel label to an object and that syntax may take precedence over the ME constraint. This finding supports Woodward and Markman (1991) that the ME constraint can be overridden by other cues. It is also in line with Naigles and Lehrer (2002) and Lee and Naigles (2008), who found that syntactic cues are helpful in verb learning in many languages. The current study found that syntactic cues are also informative in noun learning, not just in English, but also in Malay.

Many cues tested in previous studies appeared to be weaker compared to the ME constraint. For example, in Pruden et al. (2006) and Jaswal and Hansen (2006), children still selected the name-unknown object even though pragmatic cues directed the children's attention to the name-known object. As children in the current study were able to select the name-known image above chance in the match-familiar condition, it is likely that syntactic bootstrapping is able to overrule the ME constraint bias and allow children to learn more than one label for each object. This argument is in line with Woodward and Markman (1991) and Kalashnikova, Mattock and Monaghan (2016), who argued that the ME constraint is a probabilistic bias that can be overcome to allow children to learn multiple labels for an object. Whether a bias can overcome another bias depends on its rank in the hierarchy of lexical biases (Imai & Haryu, 2001). If a bias is regarded as being in a lower rank than the ME constraint, then it will not be able to overcome the ME constraint (Jaswal & Hansen, 2006).

However, children's use of syntactic bootstrapping depends on age. Older children are more likely to use classifier as the key to disambiguate information, as shown in their tendency to select the name-known image in match-familiar condition and to select the name-unknown image in match-novel condition. A likely explanation is that older children have more experience with grammar, hence, are more confident in using syntactic bootstrapping when deciding on the referent of a novel label. In the current study, young children selected the name-known image significantly more often than preschool children in the match-familiar condition, supporting the hypothesis that older children are more likely to overcome the ME constraint with syntactic cues. Stronger claims can be made about the effect of syntactic knowledge on children's ability to overrule the ME constraint in future studies when children's knowledge about classifiers is measured.

7.4.3 Limitations

A factor that the current study did not take into account is the difference between age and cognition. Although it is generally accepted that older children are more cognitively mature, the current study looked at children's understanding of classifiers. Salehuddin and Winskel (2009) showed that Malay children generally only start to learn about classifiers formally through schools. Thus, the significant difference between young children and preschool children in making use of classifiers may be due to the fact that the latter group of children had no knowledge of classifiers at all. A test to gauge the level of these children's ability in comprehending classifiers, would have helped strengthen the conclusions made.

The correct use of some classifiers (*biji* and *keping* and *helai*) requires additional information such as material and size, which cannot be perceived through just observing the name-unknown image on an iPad screen. Although the pilot study conducted showed that the manipulation of the classifiers was successful, there could still be a possibility that children could not gauge whether the classifiers used were suitable for the name-unknown images, which could have affected the results obtained in the current study.

Furthermore, the children recruited in the current study were bilinguals. As shown in Study 3, bilinguals, such as Malaysian children who learn at least two languages in school, tend to show a weaker evidence of ME constraint. Thus, these children may be more willing to use syntactic cues to overcome the ME constraint because they are less likely to rely on the ME constraint in the first place.

7.4.4 Summary and conclusion

Study 4 aimed to test the effect of classifiers on ME constraint. According to Woodward and Markman (1991), lexical biases are ranked hierarchically and biases of a higher rank can overcome biases of a lower rank. Although Hall et al. (2001) found that syntactic bootstrapping can overcome the ME constraint for English-speaking children, such a study has not been conducted on other languages. The current study thus looks at the strength of syntactic bootstrapping in the Malay language.

It was demonstrated that children do make use of syntactic bootstrapping, as the children were strongly novel-oriented when both syntax and ME constraint suggested the name-unknown image to be the correct referent for the novel label. They were able to select the name-known image as the referent, although this effect is only apparent for seven-year-olds and older. In sum, Malay-speaking children take syntax into account when associating novel labels to name-unknown objects, just as English-speaking children do (Hall et al., 2000). This finding suggests that grammar is an important cue in helping children learn words, with its importance growing with age.

Chapter 8 Effect of Syntactic Bootstrapping on Word-Object Selectivity

8.1 Introduction to Study 5

According to Hansen and Markman (2009) and Markman and Wachtel (1988), the ME constraint promotes word learning, because children are able to map a novel label to a name-unknown object through the one-to-one assumption for word-object associations. This theory is further expounded by Woodward and Markman (1991), who argued that the ME constraint is probabilistic and the one-to-one word-object assumption can be overridden by other biases. Bloom and Kelemen (1995) and Hall et al. (2000, 2001) provided concrete evidence to this modification by demonstrating that English-speaking children are able to make use of syntactic bootstrapping to overrule the ME constraint. Similarly, in Study 4 of the current thesis, it was revealed that Malay-speaking children were able to make use of syntactic bootstrapping when selecting referents for novel labels. In other words, Study 4 of the current thesis also supported Woodward and Markman's (1991) claim that other constraints (in our case, syntactic bootstrapping) are able to overcome the ME constraint. This evidence is obtained where children did not show novelty bias when the classifier matched only the name-known object but not the name-unknown object.

The finding that children make use of syntactic bootstrapping during ME training trials raises two questions: (1) whether syntactic bootstrapping can affect children's retention of newly-learned words and (2) whether syntactic bootstrapping can affect children's ability to store more than one word-object association. If syntactic bootstrapping is taken into account when forming word-object associations, then having two supporting cues (syntax and ME constraint) should help children in retaining these newly-formed word-object associations. In other words, when children take syntactic bootstrapping into account while selecting a target for novel labels, having the syntactic cue as an additional cue to the ME constraint should improve the retention of word-object mapping as there are now two cues that support the name-unknown object as the target. This claim is made because when there is more than one evidence supporting an object as the referent of a novel label, the additional evidence should facilitate children's learning of word-object association. Similarly, when there is evidence supporting a *name-known* object as the referent of a novel label, children should be more able to remember the mapping between the novel label and the name-known object. Thus, when syntactic cues is congruent with the name-known objects, children should show more non-selective word-object associations; that is, being able to map a novel label to more than one object.

To investigate the effect of syntactic bootstrapping on the retention and the selectivity of word-object associations, Study 5 was conducted. The design of the current study was based on Studies 1 and 4. As in Study 1, there were three blocks in the current study: an ME training block, a retention test and a selectivity test. Similar to Study 4, in the ME training block, classifiers preceded novel labels (e.g., find a [classifier] *dax*) and there were two conditions related to these classifiers: match-novel and match-familiar. In the match-novel condition, the classifier matched the name-unknown image. It was hypothesised that when syntactic bootstrapping and ME constraint are congruent with each other, children will show heightened novelty bias in the ME training block. In the match-familiar condition, the classifier matched the *name-known* image but not the name-unknown image. It was found in Study 4 that, in this match-familiar condition, children showed significantly less novelty bias than if syntactic bootstrapping was congruent with the ME constraint. This combination of design allows us to replicate and to extend the results in Study 4 to the current study, Study 5. Study 4 tested only ME training trials, whereas the current study also included a retention test and a selectivity test. By adding these two test blocks, the current study can provide answers to the two research questions raised and shed light on whether information provided through syntactic bootstrapping can boost retention rate in children.

To the best of our knowledge, previous studies have not tested whether syntactic bootstrapping can affect children's retention of newly-formed word-object associations. With regards to the first question of whether syntactic cues can affect children's retention of newly-formed word-object associations, it was hypothesised that if children are able to use different cues when mapping a novel label to a target, then these cues should also affect children's retention rate of word-object associations. Specifically, in Study 4, it was revealed that when syntactic bootstrapping is congruent with ME constraint, novelty response in ME training trials was heightened. Therefore, the response in the retention test is also likely to be strengthened, as there is more supporting evidence for the association between the novel label and the name-unknown object. In a similar vein, for the second question of whether syntactic cues affect children's ability to form multiple word-object associations, when syntactic bootstrapping is incongruent with the ME constraint, children have a cue that supports the name-known object as the target for the novel label. Study 4 showed that novelty response in ME training trials was significantly less than chance, meaning that children selected the name-known object as the referent for the novel label. This finding suggests that children should show better retention of the association between the novel label and the name-known object. The hypotheses to the two research questions were tested in the current study.

8.2 Method

8.2.1 Design

The design of the current study was the same as Study 1 except for an additional variable, making the current study of 3 x 2 x 2 design. The within-participant variables were block type (ME training, retention test and selectivity test) and condition (match-novel and match-familiar), as shown in Figure 9. The between-participant variable was the order of the test blocks, similar to Study 1, either the retention test or the selectivity test was run first.

Although there are many classifiers in Malay, Study 4 used only eight common ones. In the current study, only one classifier was used, to limit the number of trials and to ensure that the duration of the whole experiment was not too long. The current study used the classifier *biji* because it is a familiar classifier to children. This claim was made based on the results obtained from Study 4, where children were able to select the target above chance in both match-novel and mismatch-novel conditions for the classifier *biji*. Although children were most familiar with the classifiers *orang* and *ekor* (i.e., the proportion of target-oriented children was the highest for these two classifiers), these two classifiers were not used in the current study because these classifiers are specifically for human and animals, respectively. Using these classifiers may lead to the confound of using animated images as targets. Thus, the classifier with the next best response (i.e., the classifier *biji*) was used.

8.2.2 Participants

Sixty-two children were recruited from a National Primary School which uses Malay as a medium of instruction but also teaches English. There were 31 boys and 31 girls. The children were Malay dominant speakers who were aged between 6 and 9 years old (M = 7.50 years, SD = 1.11).

The age range was divided into preschool children (n = 31, age range = 6 – 7 years, M = 6.52 years, SD = 0.51) and young children (n = 31, age range = 8 – 9 years, M = 8.48 years, SD = 0.51). This binning of ages is slightly different from Studies 1 to 4 in that the seven-year-old children were now categorised as preschool children instead of young children. This change was due to Study 5 being conducted early in January, when the school term in Malaysia has just commenced (the other studies were conducted around mid- to end- school term). As children in Study 5 were tested on their knowledge of classifiers, and Salehuddin and Winskel (2009) demonstrated that Malay children learn classifiers from school more than from their conversations with their caretakers. Therefore, it is more logical to classifier the seven-year-olds together with preschool children as they have not gone through many months of schooling.

To test whether the sample size is enough, a post-hoc power analysis for the current study was calculated for the selectivity test in the same way as Study 1. The effect size, *h*, was set as 0.10, whereas the sample size, *N*, as 62. The power obtained was .12, which is of low power.

8.2.3 Stimuli

The images used were taken from those used in Study 4. The auditory stimuli were the novel labels "mipo" and "camling", embedded in the carrier sentences "*Carikan sebiji __!* (Find a [classifier] __!)" and "*Yang mana satu __?* (Which one is a __?)". The former sentence was for the ME training block whereas the latter sentence was for the two test blocks (see third column of Figure 9). To prevent the classifier from being a cue to the children when selecting the correct referent in the test blocks, the classifiers were not mentioned in the carrier sentence. Thus, two different carrier sentences were used.

Instead of filler trials and attention getters, two foil trials were used between every two ME training trials (see third and fourth row of Figure 9). Each foil trial consisted of one name-unknown image and one name-known image, emulating the ME training trials. As the classifier *biji* (a classifier for either small or round objects) was used in the current study, the name-unknown image in one of the foil trials was round (see third row of Figure 9), whereas the name-known image in the other foil trial was round (see fourth row of Figure 9). The auditory label for the foil trials was "*Tengok!* (Look!)". Each foil trial appeared for four times, thus, children see the foil images for the same number of times as they see the images presented in the ME training trials. This presentation allowed the familiarity of the foil images and the ME training images to be controlled. The familiarity control was important because the foil images were presented alongside the ME training images in the two test blocks.

During the retention test block, the name-unknown image of the two foil trials were presented alongside the name-unknown images from the ME training block. Similarly, in the selectivity test block, the name-known image of the two foil trials were presented alongside the name-known images from the ME training block. This change in presentation was to ensure that children could not use the ME constraint to guess the correct referent in the test blocks after being exposed to the match-novel and the match-familiar conditions in the ME training block.

As it was hypothesised that children will be able to learn the association between the novel label and the name-unknown object in the match-novel condition better than in the match-familiar condition, children who are less confident in the word-object association of the match-familiar condition will be less likely to select the target image when asked for the novel label in the test blocks. However, if only two images (i.e., the target and the distractor from the ME training block) were shown, children can disambiguate the target by rejecting the distractor that they have learned successfully. Therefore, more than two images in the test blocks (i.e., the images from the foil trials were presented in the test blocks as well) were used to prevent the children from making use of the ME constraint to select the target.

In between every two test trials, there were filler trials, where familiar images were presented and one of the images was named. As these filler trials were spaced in between test trials that showed four images in each trial, the filler trials also had four images in each trial.

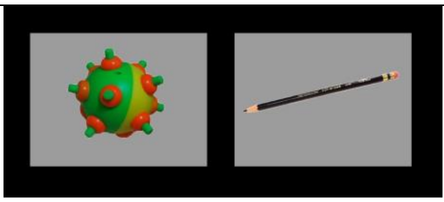
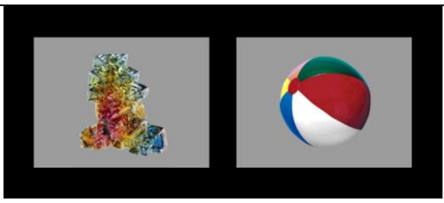
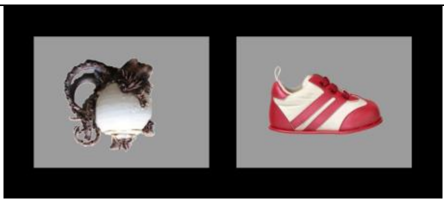
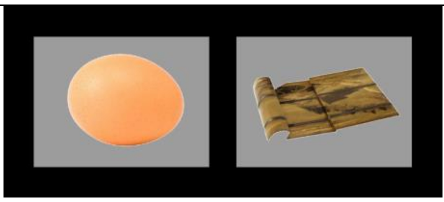
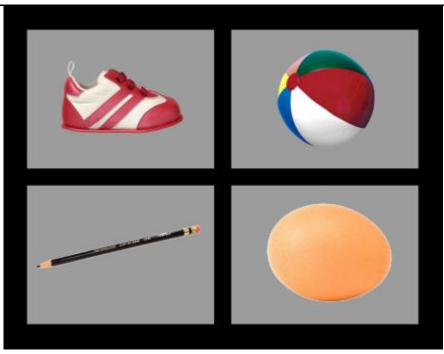
Block type	Images	Auditory label
ME training (match-novel condition)		*Carikan sebiji mipo!* (Find a [classifier] *mipo*!)
ME training (match-familiar condition)		*Carikan sebiji camling!* (Find a [classifier] *camling*!)
Foil (round novel object)		*Tengok!* (Look!)
Foil (round familiar object)		*Tengok!* (Look!)
Retention test		*Yang mana satu mipo?* (Which one is a *mipo*?)
Selectivity test		*Yang mana satu camling?* (Which one is a *camling*?)

Figure 9. Examples of different blocks used in Study 5

8.2.4 Procedure

The procedure was the same as Study 1, except for two differences. First, instead of attention catchers in between experimental trials in the ME training block, two foil trials were used (see third and fourth row of Figure 9). The two foil trials always appeared one after another. Second, other than the instruction given in Study 1, children in the current study were also told that the voice would sometimes ask them to “look”, to which they should select an image that they like. This additional instruction was provided so that children know what to do in the foil trials.

8.3 Results

8.3.1 Analysis method

A mixed-effect logistic regression was used to test which variables affect children’s performance. The variables of interest were block type, condition, age group, test order, interaction between age and condition and interaction between block type and condition. These were removed one-by-one from the full model with participants and stimuli set as the random factor.

Test order was not significant (χ^2 (1) = 0.04, p = .841). It was shown that block type (χ^2 (2) = 210.86, p < .001) affects the model when removed, whereas condition (χ^2 (1) = 1.25, p = .264) and age group (χ^2 (1) = 1.48, p = .224) did not change the model significantly. The interaction between age and condition (χ^2 (2) = 0.001, p = .971) and between block and condition (χ^2 (2) = 3.65, p = .162) were also not significant.

8.3.2 Main analyses

Block type was a significant variable that affects children's performance, therefore, performance in each block type was tested against chance using a two-sample test for equality of proportions test.

Table 7. Mean proportion, standard deviation and 95% confidence interval of accurate responses in Study 5

Block type	Mean proportion	SD	95% CI of mean	
			Lower	Upper
ME training	.738 ***	.204	.696	.776
Retention test	.552 ***	.360	.488	.615
Selectivity test	.210	.203	.162	.267

Note. Chance is at .50 for ME training block, .25 for test blocks. *** $p < .001$.

As can be seen from Table 7, children were significantly more target-oriented in the ME training block (χ^2 (1) = 111.34, $p < .001$, $h = 0.97$) and in the retention test (χ^2 (1) = 119.36, $p < .001$, $h = 0.63$) but not in the selectivity test (χ^2 (1) = 1.94, $p = .164$, $h = -0.10$). This finding suggests that like in Study 2, children were able to show novelty bias in the ME training block and evidence of word learning in the retention test but not in the selectivity test.

8.3.3 Analyses on different conditions

Condition, that is, either match-novel or match-familiar, did not predict children's performance, nor did it interact with block type or age group to affect children's target selection in different test blocks. However, as children's performance was expected to differ depending on the type of classifiers provided, children's performance in the two conditions was nonetheless analysed separately.

Two-sample proportions tests were conducted to test children's performance in different conditions. Children's target selection was not significantly different between the two conditions in the ME training block (χ^2 (1) = 0.094, p = .759, h = 0.04), and in retention test (χ^2 (1) = 0.58, p = .444, h = 0.11). Children were, however, marginally more target-oriented in the match-familiar condition than in the match-novel condition for the selectivity test (χ^2 (1) = 2.94, p = .086, h = 0.24). When compared against chance, children were found to be able to select the target above chance in both conditions for ME training block and retention test (ps < .001). For the selectivity test, children were not significantly above chance in the match-familiar condition (χ^2 (1) = 0.01, p = .917, h = 0.02) but significantly *below chance* in the match-novel condition (χ^2 (1) = 4.74, p = .029, h = 0.22) (see Figure 10).

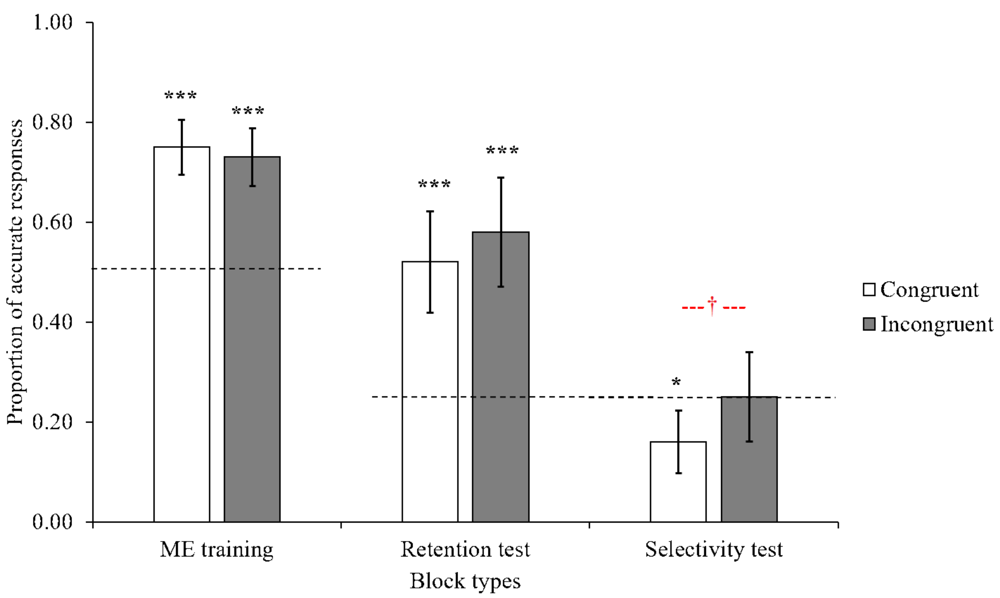


Figure 10. Mean proportion of accurate responses for different block types and conditions in Study 5

Note. The dotted line represents chance (.50 in ME training block; .25 in test blocks). Error bars represent 95% CI. Black asterisks refer to difference from chance; red asterisks refer to difference between conditions. † p < .10. * p < .05. *** p < .001.

8.3.4 Relationship between experimental blocks

As correlations between different experimental blocks provide evidence on whether the performance in the selectivity test can be explained through lexical associations, correlations between different blocks were tested. It was shown that the ME training block correlated positively with the retention test, ρ = .568, p < .001, 95% CI [.359, .709], but not with the selectivity test, ρ = -.163, p = .207, 95% CI [-.386, .103]. Although the direction of the correlations is in line with the explanation provided in Study 2, that children's target selection in the selectivity test can be explained through lexical associations, the correlation was nonetheless non-significant.

It was shown in the previous section that the proportion of target-oriented children for the selectivity test was different in the two conditions. This difference may lead to correlations between experimental blocks of the two conditions to be different from each other as well. Therefore, correlations between experimental blocks were investigated for each condition. It was demonstrated that for the match-novel condition, there was a significant positive correlation between the ME training block and the retention test, ρ = .412, p = .001, 95% CI [.171, .593], and a significant negative correlation between the ME training block and the selectivity test, ρ = -.333, p = .008, 95% CI [-.523, -.070]. This pattern of result is in line with that of Study 2. For the match-familiar condition, children showed a significant positive correlation between ME training block and the retention test, ρ = .454, p < .001, 95% CI [.208, .618], but the correlation between the ME training block and the selectivity test was not significant, ρ = .031, p = .808, 95% CI [-.197, .301].

8.4 Discussion

The current study aimed to test whether syntactic bootstrapping can have an effect on the retention of newly-learned word-object associations and word-object selectivity.

Although Study 4 of the current thesis found that syntactic bootstrapping can overrule the ME constraint, such a finding was not replicated in the current study. Instead, the current study found children to show evidence of a novelty bias regardless of the congruence between classifiers and novelty. Similarly, syntactic bootstrapping did not affect children's retention of newly-learned word-object associations. In other words, even though there were two congruent cues in the match-novel condition, children did not show better retention rate than in the match-familiar condition, where the cues were incongruent with each other. These findings are discussed in terms of the interaction between salience of objects and syntactic bootstrapping in the following section.

Even though syntactic bootstrapping did not affect the performance in the ME training block and the retention test, in the selectivity test, children were marginally more target-oriented in the match-familiar condition than in the match-novel condition. This result is in accordance to the hypothesis made earlier, that children would be more target-oriented in the selectivity test if syntactic bootstrapping provides evidence in favour of the name-known object. To understand why syntactic bootstrapping affected children's performance in the selectivity test block but not in the other two experimental blocks, the effect of linguistic cues on word-object non-selectivity are discussed below.

8.4.1 Interaction between salience and syntactic bootstrapping

Although it was predicted that children should be more target-oriented in the match-novel condition than in the match-familiar condition of the ME training block and the retention test, two-sample proportions tests revealed that there was no significant difference between these two conditions. In other words, children were not affected by syntactic bootstrapping in the ME training block and the retention test block. We propose that this contradicting result is due to the salience of the name-unknown image in the match-familiar condition. According to Nothdurft (2000), salience is characterised as high luminance, brightly coloured and stong contrast from the background. The argument that salience of objects has an effect on children's target selection is made based on previous studies (e.g., Pomper & Saffran, 2018; Pruden et al., 2006) showing that salience of images affect children's target selection during ME training trials. To understand how salience of images may lead to a non-significant effect of syntactic bootstrapping, the performance in the ME training block is first discussed, followed by the performance in the retention test block.

In section 2.1.2, it has been explained that children are naturally drawn to salient objects when selecting a referent for novel labels (Pruden et al., 2006). This argument is supported by more recent studies (e.g., Horst et al., 2011; Mather & Plunkett, 2012), which found that children were biased to name-unknown objects that they had never seen before than to name-unknown objects that had been presented to them before. These studies suggest that novelty and salience of objects are important factors in affecting children's referent selection.

In the current study, both name-known images had an average novelty rating of 5 (a higher rate refers to less novelty; the highest possible rating is 5), whereas the name-unknown image for the match-familiar condition had an average rating of 1.6 and the name-unknown image for the match-novel condition had a rating of 2.4. Although the average rating of the name-known images is higher than that of the name-unknown images in both conditions, the name-unknown image in the match-familiar condition had a lower rating than the name-unknown image in the match-novel condition. This difference in novelty rating may have an effect on children's performance as children pay more attention to salient objects. In other words, the difference in image salience may interact with syntactic bootstrapping in affecting children's performance. Table 8 shows the interaction between different cues in terms of the images supported by these cues.

Table 8. Images supported by different cues in different conditions of Study 5

Cues	Match-novel condition	Match-familiar condition
Salience	Name-unknown image	Name-unknown image
ME constraint	Name-unknown image	Name-unknown image
Classifiers	Name-unknown image	Name-known image

It is likely that children are aware of the syntactic cue provided in the ME training block, that is, knowing that the classifier is suitable only to one of the images presented to them. This assumption is made because in Study 4, children were more novel-oriented in the match-novel condition than in the syntax-neutral condition. However, in the current study, the name-unknown image in the match-familiar condition was very salient, allowing the salience of the image to overrule syntactic bootstrapping (see Table 8). When syntactic bootstrapping is overcome, children become biased to the name-unknown image as a target for the novel label even in the match-familiar condition, where the classifier matched the name-known image.

This line of argument supports Ellis (2006), who proposed that when two cues are present, the stronger cue will overcome the other cue if the two cues are incongruent with each other. It is also in line with Woodward and Markman (1991), who argued that linguistic cues are structured in a hierarchical manner and cues in a higher position are able to displace cues in a lower position. Following this argument provides an explanation to why children showed evidence of syntactic bootstrapping in Study 4 but not Study 5. In Study 4, eight different name-unknown images were used for each condition, therefore, any difference between novelty ratings was averaged out and did not affect syntactic cues provided to the children. Hence, the non-significant difference between the two conditions in the ME training block of the current study may be due to the salience of objects overshadowing syntactic bootstrapping (see Table 8).

That salience of objects has an effect on children's referent selection during ME training trials has been suggested in many studies. For instance, Markman et al. (2003) controlled for the salience of familiar and novel objects when testing for ME constraint. Woodward and Markman (1991) also argued that when the familiar objects were over-exposed to children prior to the ME training trials, the novel objects may become less salient than the familiar objects, affecting children's target selection in the ME training trials. These concerns are supported by Pomper and Saffran (2018), who found that salient name-known objects (distractors) is detrimental to target selection. Furthermore, Hall et al. (2001) suggested that presenting children with objects having a salient part on it may lead children to associate a novel label with the salient part instead of with the object itself. Indeed, many studies (Hansen & Markman, 2009; Markman & Wachtel, 1988; Mervis et al., 1994; Moll et al., 2006) testing whether children will map a novel label to a name-known object or a name-unknown part of that object often highlight to children the salient parts of these objects (e.g., stickers, protruding part of an object). Similarly, when testing whether children will learn a novel label as an adjective, Hall et al. (2000) and Waxman and Booth (2001) chose a salient property (e.g., fluorescent, multi-coloured) for objects. Findings of the current study have the propensity to support the argument made by these studies that salience is an important factor, because when the name-unknown image of the match-familiar condition was highly salient, children did not take the syntactic cues into account anymore when selecting target for the novel label (see Table 8).

The retention test block tested whether children have retained the newly-formed word-object associations. It is noteworthy that children were still above chance in the retention test even when there were now three distractors in the retention test. When the number of distractors increases, the difficulty of the retention test increases as well, as children need to reject more distractors before deciding on the correct image. In the current study, one of the distractors was given a label whereas the other two distractors were not. All four images appeared exactly four times in the ME training block. As children cannot use image familiarity to identify the correct image, being able to select the target above chance strongly suggests that children were able to make use of the ME constraint to learn word-object associations. Many studies (e.g., Golinkoff et al., 1992; Mather & Plunkett, 2009, 2011; Mervis et al.,1994) found that if children have encoded the word-object associations strongly enough, then they will show some form of learning during the test block. As the target in the match-novel condition was supported by the ME constraint and syntactic bootstrapping, whereas the target in the match-familiar condition was highly salient (see Table 8), it is not surprising that children were target-oriented in the retention test for both conditions.

A significant positive correlation was obtained between the ME training block and the retention test block, replicating Study 2 of the current thesis. This finding suggests that the success in retention test is related to the performance in the ME training block, which explains why syntactic bootstrapping has no effect on the retention test. When syntactic bootstrapping is overshadowed by salience of the name-unknown image in the ME training block, it is unlikely for it to have any effect in the retention block. Hence, even though the classifier matched the name-known image in the match-familiar condition, there was no significant difference between the match-familiar and the match-novel condition. Although this finding is in contrast with the hypothesis, it is actually in line with the argument put forward earlier, that salience affects children's formation of word-object associations. As the name-unknown image in the match-familiar condition is highly salient, it is natural that children are able to retain the word-object association in the match-familiar condition.

8.4.2 Effect of linguistic cues on word-object non-selectivity

Overall, children did not select the target above chance in the selectivity test. This is not surprising, seeing that children's performance in previous studies of the current thesis is relatively weak in the selectivity test when compared to the retention test. In Studies 1 to 3, children had a choice of two images, whereas in the current study, children had a choice of four images, increasing the difficulty of the test. This change may explain why children fail to select the target in the selectivity test. Moreover, as children were influenced by the salience of the name-unknown image, syntactic bootstrapping was likely to be overshadowed in the selectivity test. Yet, children's performance in the selectivity test was in line with the hypothesis that children were more able to select the target in the match-familiar condition than in the match-novel condition. The hypothesis was made based on the reasoning that children who encoded the name-unknown image strongly in the match-novel condition should in turn encode the name-known image weakly, leading to weak performance in the selectivity test for this condition. In the match-familiar condition, children should have encoded the name-unknown image weakly, because the classifier supported the name-known image as the target. To understand the findings obtained in the selectivity test, this section explores reasons children are able to make use of syntactic bootstrapping even though they were influenced by the salience of images in the ME training block.

The difference in performance between conditions in the selectivity test block is unlikely to be due to novelty differences between images. In the match-familiar condition, the name-unknown image was highly salient, leading to children showing a bias towards it in the ME training block, even though syntactic bootstrapping indicates that the classifier *biji* matched the name-known image only. In this case, children would have formed a weak association between the novel label and the name-known image, as their attention was focused on the name-unknown image. This behaviour would be similar to that in the match-novel condition, where both the ME constraint and syntactic bootstrapping supported the name-unknown image as the referent for the novel label, thus, making the association between the novel label and the name-known image weak. Hence, if children's performance in the selectivity test block had been affected by the novelty of the images, then children should *not* be able to select the target above chance in the match-familiar condition, as the name-unknown image was very salient and demanded attention from children. As children were more likely to select the target in the match-familiar condition than in the match-novel condition of the selectivity test, it is likely that those children had taken syntactic bootstrapping into account. However, as children only performed at chance level in the match-familiar condition and significantly below chance in the match-novel condition, firm conclusions cannot be made that syntactic bootstrapping helped in encoding word-object associations.

That syntactic bootstrapping is observed in the selectivity test but not in the other two experimental blocks can be explained through overshadowing of cues (Ellis, 2006; Smith, Colunga & Yoshida, 2010). According to Ellis (2006), overshadowing happens when a strong cue overcomes a weaker cue, leading to the weaker cue being used little or not at all. Blocking, on the other hand, refers to a second cue made redundant by the first cue as the two cues provide the same outcome. In the match-familiar condition, syntactic bootstrapping is more likely to be overshadowed by salience and the ME constraint than blocked by these cues. This assumption is made because, in the current study, syntactic bootstrapping was an informative cue that provided an outcome that was different from that provided by salience and ME constraint cues.

In the ME training block and the retention test block, syntactic bootstrapping was overshadowed and thus its outcome was not elicited in children's behaviour (i.e., children selected the name-unknown image as the target of the novel label, see Table 8). In the selectivity test, children needed the information provided by syntactic bootstrapping in order to select the target, therefore, in the match-familiar condition where the classifier matched the name-known image, children were able to select the target above chance. If syntactic bootstrapping had been blocked by salience, then children would not be target-oriented in the match-familiar condition. Thus, just as novelty bias should not be taken as evidence of non-selective word-object associations, not taking a cue into account when making a response does not mean that children have not encoded the cue at all.

One question raised earlier (in Study 2) is whether the successful target selection in the mismatch condition of the selectivity test is explained through lexical associations or encyclopaedic associations. In Study 2, it was established that lexical associations between novel labels and name-known objects lead to a negative correlation between the ME training block and the selectivity test block because children have only a limited amount of attention. When children are biased towards the name-unknown image in the ME training block (i.e., high target selection), they will have little attention for the name-known image, leading to a low proportion of target selection in the selectivity test. This argument has been replicated in Studies 1 and 3. Although these studies did not obtain a significant correlation between ME training block and the selectivity test, the direction of the correlations was in line with the explanation above. However, in the match-familiar condition of the current study, selectivity test showed a *positive* non-significant correlation with the ME training block, suggesting that children may have formed an encyclopaedic association in the match-familiar condition.

Yet, it is surprising that children form an encyclopaedic association only in the match-familiar condition, but not in the match-novel condition. In the match-novel condition, children showed correlational results similar to those of Study 2, where there was a significant positive correlation between ME training block and retention test block and a significant negative correlation between ME training block and selectivity test block. One possible reason to reconcile the differences in results may be that, in the match-familiar condition, each image had one supporting cue as the referent for the novel label: the name-unknown image was supported by ME constraint whereas the name-known image was supported by syntactic bootstrapping. Having two incongruent cues may lead children to pay roughly equal attention to both images. Due to the highly salient name-unknown image, children had selected the name-unknown image instead of the name-known image in the ME training block. However, this selection does not deter children from being target-oriented in the selectivity test, as the information obtained through syntactic bootstrapping was still encoded in the memory. To verify this explanation, future studies need to be conducted to see if this pattern of results can be replicated.

8.4.3 Limitations

The current study changed the way the ages were binned into groups in Study 4, preschool children were defined as those aged less than 6 years, whereas young children were defined as those aged between 7 to 9 years. However, in the current study, preschool children were defined as children between 6 to 7 years old, whereas young children were aged between 8 and 9 years old (see Table 9). Although the reason for such a change has been explained and justified, nonetheless making comparisons across studies can still be difficult. When the age groups in the current study were grouped in the way it was done in Study 4, problem related to sample size will arise, where there were only 15 children aged six years old but 44 children aged between seven to nine years old.

Besides, the number of images in the retention test and the selectivity test were different as well. Previously in Studies 1 to 3 (there was no test blocks in Study 4), only two images were presented in both the test blocks, where two name-unknown images were presented in the retention test whereas two name-known images were presented in the selectivity test. In the current study, four images were presented in each test trial to prevent children from selecting the target based on ME constraint (explained in detail in section 8.2.3). However, such a change led to the problem of the results of the current study not being directly comparable with the results of Studies 1 to 3 of the current thesis.

8.4.4 Summary and conclusion

As Study 4 found a significant effect of syntactic bootstrapping, the current study looked at the effect of syntactic bootstrapping on the performance in the retention test and the selectivity test. It was hypothesised that children are better at retaining the word-object association in the match-novel condition because both ME constraint and syntactic bootstrapping direct children's attention towards the name-unknown object. It was also hypothesised that children will be better at forming non-selective word-object associations when the classifier supports the name-known image.

Yet, contrary to what was found in Study 4, children in the current study did not show evidence of using syntactic bootstrapping during ME training trials. This led to syntactic bootstrapping not having a significant effect on the retention test. It was suggested that syntactic bootstrapping did not have an effect on the ME training block and the retention test block, because the name-unknown image in one condition was more salient than the name-unknown image in another condition. However, children showed an effect of syntactic bootstrapping during the selectivity test, where they were more likely to learn a second label if syntactic bootstrapping provides evidence for it. This finding suggests that although children showed a novelty bias in spite of syntactic bootstrapping showing contradictory evidence, it does not mean that children have not encoded the information provided through syntactic bootstrapping.

Chapter 9 General Discussion and Conclusion

9.1 Results Summary

Carey (1978) found that children tend to map a name-unknown object to a novel label. The ME constraint explains that children show such novelty bias because they assume a one-to-one mapping between words and objects (Markman & Wachtel, 1988); that is, children associate name-unknown objects with novel labels because name-known objects are already paired with their respective labels. On the other hand, CSL suggests that children store more than one word-object association when selecting referents for novel labels in an ambiguous situation (Yu & Smith, 2007). As these two theories differ in terms of the number of word-object associations that children can form at one instance, the current thesis tested whether children's word-object mappings are selective, where a selective word-object association means the selection of only one name-unknown object as a referent for a novel label.

To examine the selectivity of word-object associations, we first tested for novelty bias in children during ME training trials, as the current thesis take novelty bias as an evidence for the ME constraint. Then, the current thesis tested whether children who showed a novelty bias during ME training trials were also able to associate a novel label with a name-known object. If children are able to map a novel label with a name-known object, then the current thesis argues that evidence for the ME constraint is not evidence against CSL, as the presence of a novelty bias does not necessarily mean that word-object associations are selective. In other words, children who selected a name-unknown object as a target for a novel label are also able to map the novel label to a name-known object. See Table 9 for a summary of manipulation.

Table 9. Summary of manipulations in Studies 1 to 5

Study	Block	Language	Condition	Age group (*M*, *SD* (years))
1	training, retention, selectivity	Monolinguals	-	preschool (5.03, 0.72) young (8.05, 0.83) older (10.70, 0.70)
2	training, selectivity, encyclopaedic, retention	Monolinguals	-	preschool (5.15, 0.88) young (7.89, 0.81) older (10.59, 0.57)
3	training, selectivity, encyclopaedic, retention	Bilinguals	-	preschool (5.44, 0.96) young (7.99, 0.86) older (10.51, 0.51)
4	-	Bilinguals	match-both, match-novel, match-familiar, mismatch-both	preschool (5.74, 0.45) young (7.98, 0.82)
5	training, retention, selectivity	Bilinguals	match-novel, match-familiar	preschool (6.52, 0.51) young (8.48, 0.51)

Five studies were conducted to answer the question of whether word-object associations are selective. Study 1 tested whether children are able to map a novel label to a name-known image, as explained above. As hypothesised, children showed evidence of a novelty bias in the ME training block, supporting the ME constraint as an informative cue, as

ME constraint can be used to learn meaning of words. Children were also able to associate novel labels with name-known objects, leading to the argument that novelty bias during ME training trials may not mean selective word-object associations. As children could have selected the name-known target through cascaded activation (i.e., from the novel label to the name-unknown object and then the name-known object, see Figure 2), Study 2 explored the different explanations for children's ability to select the name-known target that was associated with the novel label. Through correlation analyses, it was concluded that children have formed lexical associations between novel labels and name-known objects.

In Study 3, the performance between monolinguals and bilinguals in using the ME constraint was compared. This comparison was made because Houston-Price et al. (2010) found that bilingual infants do not show evidence of novelty bias as they are likely to know more than one label for most object. It was revealed that the ME constraint is a robust effect, as even the bilinguals showed a novelty bias in the ME training block. However, the bilinguals used the ME constraint less strongly than monolinguals, supporting Davidson and Tell (2005) and Byers-Heinlein and Werker (2009) that linguistic experience affects the development of the ME constraint.

As the ME constraint was demonstrated in Studies 1 to 3 to be very robust in young children, Studies 4 and 5 next examined the effect of syntactic bootstrapping on the use of the ME constraint. These two experiments were conducted, because Woodward and Markman (1991) argued that the extent to which children rely on the ME constraint depends on whether other cues are available. Study 4 showed that children took syntactic bootstrapping into account when forming word-object associations in the ME training block. This conclusion was made because when syntactic cues were in conflict with the ME constraint, children relied on syntactic cues more often than chance, suggesting than syntactic bootstrapping can be used to overcome the ME constraint. Study 5 investigated the effect of these syntactic cues on the selectivity of word-object associations; that is, the effect of additional cues on the mappings between novel labels and name-known images. Study 5 revealed that children were successful in mapping novel labels to name-known images when the syntactic cues supported this association. Nevertheless, children's performance in this test depends on the difficulty of the task as well, where children are less able to form more than one word-object mapping if the task is difficult.

Together, these five studies address three main issues: (1) the usage of ME constraint when forming word-object associations, (2) word learning through the ME constraint, and (3) non-selectivity of word-object associations. These three issues are discussed in the sections that follow. A table with summary findings from Studies 1 to 5 is seen in Table 10.

Table 10. A summary of results (chi-squared value from mixed-effect models) of Studies 1 to 5

Fixed effects	Studies				
	1	2	3	4	5
Block	375.86 ***	254.66 ***	192.77 ***	-	210.86 ***
Condition	-	-	-	17.66 ***	1.25
Age	8.91 *	0.05	0.09	3.15 †	1.48
Block-Age	4.15	11.91 †	9.83	-	-
Condition-Age	-	-	-	40.06 ***	0.001
Block-Condition	-	-	-	-	3.65

Note. "Block" refers to block type, "age" refers to age groups. A dash sign (-) means such a fixed effect is not available in that study. † $p < .10$. * $p < .05$. *** $p < .001$.

9.2 The ME Constraint as a Disambiguation Tool

The current thesis supports Markman and Wachtel (1988) that children make use of the ME constraint when forming word-object associations, because in the ME training block of all five studies in the current thesis, children selected the name-unknown image upon hearing the novel label. According to Markman and Wachtel (1988), children see many objects in natural settings that are possible referents for a novel label. To form word-object associations, children tend to map a novel label to a name-unknown object, rejecting name-known objects as targets because name-known objects already have a label. Many previous studies, including the current thesis, have provided support for the ME constraint through different means of testing. For instance, Horst and Samuelson (2008) tested two-year-olds using object selection task and found a robust novelty bias, which is an evidence for the ME constraint. Bion et al. (2013) and Halberda (2003) also found similar pattern of results in 17- and 18-month-olds through eye-tracking. Testing the expectation of toddlers, Jin and Song (2017) found that if the speaker did not select a name-unknown object that was originally mapped to a novel label, 12- and 14-month-old toddlers expected speakers to change their mind and reach out for the original name-unknown object. Although testing for the ME constraint was not the aim of Jin and Song (2017), the fact that children expected speakers to reach for the same name-unknown object when the same novel label was uttered suggests that children readily form word-object associations through the ME constraint.

The current thesis employed a new method that was proposed by Frank et al. (2016), which was to test children using a tablet. Unlike most object selection tasks testing for the ME constraint (e.g., Horst & Samuelson, 2008), testing children using a tablet paradigm reduces the interaction between the researcher and the children to minimum. Even with such little interaction, children nonetheless selected the target image above chance. As children showed a robust novelty bias in ME training trials regardless of the method of testing and the age at which they were tested, the current thesis supports the argument that the ME constraint is a robust effect.

This robustness of the ME constraint is further observed in Study 1, where an image of a cat was used as a name-known distractor in one of the ME training trials. According to Katz et al. (1974), children are naturally drawn to animated objects because these objects are salient, in turn allowing children to map both basic labels and proper labels to these objects. Pomper and Saffran (2018) also showed that when animals were used as name-known objects, children show less novelty bias due to the salient features of the animals. As children in Study 1 still showed a novelty bias and was not overwhelmed by the salience of the cat image, it is an evidence that the ME costraint is a robust effect.

Moreover, in Study 2 of the current thesis, one of the novel labels, “pifo”, had a phonological neighbour that children are familiar with: pillow. Swingley and Aslin (2007) and Mather and Plunkett (2011) argued that young children have difficulty in learning associations between name-unknown objects and novel labels that have familiar phonological neighbours because the phonological neighbours compete with the novel label. As children in Study 2 still selected the name-unknown image above chance, the current thesis argues that the use of the ME constraint is very robust in children between 3 and 12 years of age. Even though the current thesis found concrete evidence for the usage of the ME constraint, the novelty bias is still affected by other factors: syntactic cues, salience and bilingualism, as shown in Studies 4, 5 and 3, respectively. These factors are discussed in detail below.

Although the ME constraint is robust among children, Kalashnikova et al. (2016) and Woodward and Markman (1991) suggested that it is a probabilistic bias that can be overcome by other cues. This claim is supported by Hall et al. (2000), Hall, Corrigall, Rhemtulla, Donegan and Xu (2008) and Katz et al. (1974), who found that English-speaking children were able to overrule the ME constraint through syntactic cues, specifically form class cues, as children differentiated between count nouns, proper nouns and adjectives. The current thesis supports these studies as it was found in Study 4 that syntactic bootstrapping is taken into account during the formation of word-object associations and that syntactic bootstrapping may help children overcome the ME constraint. This evidence is obtained when children were less likely to select the name-unknown image in response to a novel label when the classifier matched the name-known image instead of the name-unknown image.

Study 4 also extends the findings of previous studies (e.g., Hall et al., 2000; 2001; Jaswal & Markman, 2001), as previous studies were conducted only on English-speaking children, whereas Study 4 tested Malay-speaking children using Malay. Although the use of syntactic bootstrapping in verb learning has been tested in many languages (e.g., Kannada, French, Mandarin), in noun learning, researchers have focused on English. Thus, it is important to test if children of other language groups will also employ syntactic bootstrapping when forming word-object associations. Study 4 found that Malay-speaking children were able to make use of the Malay syntax (i.e., classifiers) during ME training trials, therefore, they are also able to use syntactic bootstrapping to overcome the ME constraint like their English-speaking counterparts.

Even though Study 4 showed that children made use of syntactic bootstrapping during ME training trials, whether syntactic bootstrapping can overrule the ME constraint is still dependent on the age of children. Specifically, Study 4 showed that older children were more likely than younger children to take syntactic bootstrapping into account when selecting a referent for a novel label. This behaviour is likely to be due to older children's more extensive experience in using language, hence, being more familiar with classifiers and be able to use them confidently. This argument is in line with that of Salehuddin and Winskel (2011) and Salehuddin (2014), who found that dominant Malay-speaking children usually first learn about classifiers in school, thus, older children, who are more advanced in schooling years, would be more exposed to the classifiers than younger children. Age differences in the usage of syntactic cues is observed in other studies as well (Bloom & Kelemen, 1995). For instance, Hall et al. (2003) and Mintz and Gleitman (2002) found that two-year-olds were able to make use of syntactic cues when selecting a referent whereas one-year-olds could not.

That children are more able in using linguistic cues if they are fluent in the language is also in line with the argument that knowledge affects children's target selection in ME training trials. For instance, Grassmann et al. (2015) and Halberda (2003, 2006) found that children with a wider vocabulary were more able to disambiguate the referent for novel labels using the ME constraint. Similarly, Verhagen et al. (2017) found that bilinguals were likely to make more use of social pragmatic cues and less of the ME constraint if they were tested in their non-dominant language. However, as the current study looked at the age of children instead of their proficiency in classifiers, further studies need to be conducted to verify whether knowledge of classifier affects children's usage of this information.

The current thesis also suggests that salience of objects should be treated as a cue of its own, as it affects children's target selection in ME training trials. Many studies found that novelty of objects affects children's target choice when selecting a referent for a novel label (Horst et al., 2011; Mather & Plunkett, 2012 for ME training trials; Smith & Yu, 2013 for CSL tasks), leading to the argument that the ME constraint is based on the novelty of objects rather than the nameability of the objects. Whereas novelty is whether a person has seen the object before, salience is defined by Nothdurft (2000) in terms of bright luminance and strong contrast against the background. Novelty and salience are related because a novel object usually captures the attention of a child, as infants and young children are found to show profound interest in novel objects. However, these two properties are in fact different cues because Pomper and Saffran (2018) found that children were biased to the salient *name-*

known object instead of to the novel name-unknown object, hence, disregarding the ME constraint. Similarly, Pruden et al. (2006) found that children selected the salient object despite social pragmatic cues suggesting that the boring-looking object should be the target, even though both objects were novel and name-unknown.

Study 5 of the current thesis provided further evidence that salience and novelty provide different cues. We found that salience can overrule syntactic bootstrapping because children fail to take syntactic cues into account in Study 5 due to a highly salient image. In Study 4, where images were comparable in terms of salience, syntactic cues were able to overrule the ME constraint. Taken together, although children are aware of different linguistic cues that lead them to the possible referent for a novel label, children are likely to be biased to the object that captured their attention, in other words, biased to objects that are salient. This line of argument supports Dysart, Mather and Riggs (2016) and Samuelson and Smith (1998) that attention is required during the formation of word-object associations, as the object that a child focused on is likely to be selected as the referent for a novel label. However, the current thesis argues that it is salience rather than novelty that captures the attention of children, as some familiar objects may be more salient than novel objects (Houston-Price et al., 2005; Pomper & Saffran, 2018).

Yet, children do not erroneously learn novel labels as alternative labels for salient name-known objects. As explained earlier, novel name-unknown objects are usually salient because children are interested in new objects, thus, in these cases, the ME constraint is a reliable bias to depend on. However, Pomper and Saffran (2018) argued that in some scenarios, children have salient name-known objects (e.g., a favourite toy or a pet) around them at the time of hearing a novel label, leading to the possibility that the ME constraint will be overridden. To explain how children are able to learn mappings between words and objects accurately despite being drawn to salient objects, a slight modification to Woodward and Markman's (1991) explanation on hierarchy of cues is proposed.

Rather than having a higher ranking cue overcoming a lower ranking cue (e.g., syntactic cues overcoming the ME cosntraint as in Study 4 of the current thesis and Katz et al., 1974), we propose that children accumulate evidence from different cues, such as the statistics of co-occurrences, the ME constraint, syntactic bootstrapping and social pragmatic cues. The object that accumulated the most number of supporting cues would suffice as the referent of the novel label. This proposal is akin to the arguments of some studies that other cues, such as the intention of the speaker, should be taken into account in CSL accounts (Frank, Goodman & Tenenbaum, 2009; Wang & Mintz, 2018). Evidence are likely to be weighted differently depending on the child's ability. For instance, if children have strong linguistic knowledge, either having a wide vocabulary (Grassmann et al., 2015) or an understanding of grammar (Hall et al., 2003; Mintz & Gleitman, 2002), then they will rely more on linguistic cues such as the ME constraint or the syntactic bootstrapping. If children are not familiar with the language used, they will rely more on non-linguistic cues such as salience of objects and social pragmatic cues (Verhagen et al., 2017). Thus, if most cues direct children's attention towards a less salient object, children might still be able to map a novel label to that object.

Another factor that affects the ME constraint is bilingualism, as linguistic background shapes learning experiences (Byers-Heinlein and Werker, 2009). As bilinguals know two basic-level labels for most objects, they violate the ME constraint and are less likely to make use of the ME constraint. On the other hand, monolinguals are more biased towards using the ME constraint than bilinguals, due to their experience with one-to-one associations between words and objects. The current thesis supports the notion that bilingualism affects the ME constraint. In Study 3, although it was found that bilinguals showed evidence of the ME constraint, when compared against monolinguals from Study 2, bilinguals were significantly less likely to do so than monolinguals.

This finding supports Davidson and Tell (2005) and Davidson et al. (1997) that bilinguals make less use of the ME constraint due to their unique experience compared to monolinguals. This finding also supports the argument made earlier on the accumulation of cues. As bilinguals have a different linguistic experience compared to monolinguals, they are likely to weigh linguistic cues in a manner that is different from monolinguals. Specifically, whereas monolinguals rely strongly on the ME constraint, bilinguals give a smaller weight to the ME constraint. Thus, bilinguals in the current thesis show evidence of novelty bias that is weaker than that in monolinguals, replicating the pattern of results of Kalashnikova et al. (2015).

However, evidence on the effect of bilingualism on the ME constraint in the literature is mixed and not straightforward. Some studies such as Houston-Price et al. (2010) and Kandhadai et al. (2017) found that bilinguals did not show evidence of the ME constraint whereas other studies found bilinguals to be able to select the name-unknown object above chance, not significantly different from monolinguals (Frank & Poulin-Dubois, 2002; Merriman & Kutlesic, 1993). Kalashnikova et al. (2015) provided a possible explanation for the difference in results between studies, which is that the difference between monolinguals and bilinguals may not be observable in simple comparisons between variables, as the difference between monolinguals and bilinguals may be a product of complex interactions between different variables.

We propose yet another reason for the difference observed between studies, that is, children who know translation equivalents (i.e., the same word in two languages, e.g., “a child” in English and “ein Kind” in German) are more likely to violate the ME constraint. Byers-Heinlein and Werker (2013) found that bilingual children who knew many translation equivalents were more likely to violate the ME constraint than bilinguals who do not have many translation equivalents (although see Frank & Poulin-Dubois, 2002). Menjivar and Akhtar (2017) also found that in terms of learning novel labels for name-known objects, four-year-old bilinguals outperformed children who were regularly exposed to a second language, who in turn outperformed monolinguals. This evidence suggests that it is the direct experience of violating the ME constraint (i.e., having translation equivalents) that affects novelty response rather than mere exposure to a bilingual environment. The current thesis supports these previous studies as Study 3 recruited low-proficient bilinguals who were more dominant in their first language. Thus, these recruited bilinguals still show evidence of a novelty bias, albeit significantly less than monolinguals.

In short, the ME constraint is a bias that is robust in children, as reported by many previous studies. Even though it is affected by many factors, such as linguistic background and salience of objects, it is nonetheless useful to children in forming word-object associations.

9.3 Learning Meanings of Words through Fast-Mapping

As salience and novelty of objects affect children's target selection in the ME training block (Mather & Plunkett, 2012; Pomper & Saffran, 2018), children's ability to select the name-unknown object as the referent for the novel label may stem from pure novelty bias, whereas the word-object association may not be retained. This reasoning leads to the need for a retention test. The current thesis conducted retention tests by presenting children with two name-unknown images that were presented previously in the ME training block, while asking for a novel label. It was revealed that children were able to retain the newly-formed word-object associations significantly above chance, as children were able to select the target above chance in the retention test block in all studies[5] of the current thesis. Therefore, the current thesis supports Golinkoff et al. (1992), Mather and Plunkett (2011) and Wilkinson et al. (2003) that word-object associations formed through the ME constraint can lead to some form of word learning.

However, it should be noted that there was no break between the retention test and the ME training in the current study, therefore, it cannot be compared to studies that gave children a break before testing for their knowledge. Friedrich and Friederici (2011) have shown through ERPs that short-term (tested immediately after the training sessions) and long-term (tested one day after the training sessions) retention rate are different. Learning may be weaker if there is a temporal break between training and testing as children are likely to forget what they have just learned (Smith, Suanda, & Yu, 2014), especially when the current study only had four ME training trials for each label.

Although it is more ecologically valid for word learning researches to focus on long-term retention rate, short-term retention test can still yield meaningful results, because if children even fail to retain the word-object mapping for a short period of time, then it is likely that they are unable to retain the association in the long run as well. This section first discusses the evidence obtained from the current thesis on the relationship between attention and the retention of word-object associations. Then, this section discusses two factors that affect retention rate in relation to attention: task difficulty and repetition of trials.

The current thesis supports Samuelson and Smith (1998) that attention plays a role in word learning. Supporting evidence comes from the correlation between ME training and retention test (Studies 2 and 5), results from bilinguals (Study 3) and the correlation between age and performance in the retention test (Study 1). In Studies 2 and 5, there was a significant positive correlation between the ME training trials and the retention test trials. This pattern of

[5] Retention tests were conducted only in Studies 1, 2, 3 and 5. There were no test trials in Study 4.

results suggests that when children pay more attention to the target in the ME practice trials, they are more able to retain word-object associations. Thus, the current thesis suggests that attention plays a role in encoding word-object associations.

The current thesis also compared bilinguals (Study 3) to monolinguals (Study 2) in ME training trials and retention test trials. Although bilinguals and monolinguals completed these tasks under similar conditions, they showed different patterns of performance. Specifically, bilinguals were less likely than monolinguals to select the target image (i.e., the name-unknown image) in the ME training trials and in the retention test. The performance difference is unlikely to be due to bilinguals having a weaker memory because they were able to select the target above chance in the selectivity test whereas the monolinguals could not. Instead, it is more likely that bilinguals paid less attention to the name-unknown object in the ME training trials than monolinguals, thus, bilinguals were less able to select the target in the retention test.

Another supporting evidence that attention plays a role in word learning is through the analysis of age effects. In Study 1, it was found that older children were more able than younger children to retain the newly-formed word-object associations. As older children are more advanced in cognitive ability, it is not surprising that they are better than younger children at attending to and remembering newly-formed word-object associations. For instance, Bion et al. (2013) found that 24-month-old toddlers were unable to show evidence of retention whereas 30-month-old toddlers could. Fitneva and Christiansen (2017) also found age differences in the correlation between training and testing. However, as the current thesis did not measure children’s eye movements, strong conclusions cannot be drawn. Nevertheless, as children’s behaviour conform to the argument that retaining word-object associations requires sufficient attention from children, the current thesis lends support to Samuelson et al. (2017) that attention is needed in word learning.

Whether children pay attention to the target during ME training trials and whether this attention is turned into successful encoding of word-object mappings depends on the difficulty of the task. Task difficulty affects children's retention rate because more difficult tasks are more difficult to encode. Using a CSL-design, Vlach and Sandhofer (2014) found that adult participants retained word-object pairings most successfully if they were given an easy task (i.e., 2x2 presentation of 18 word-object pairs) and were tested immediately whereas participants who were given difficult but manageable tasks (i.e., 3x3 presentation of 18 word-object pairs) retained the word-object mappings most successfully after a delay of one week. Participants who had to learn the word-object associations under a difficult condition (i.e., 4x4 presentation of 18 word-object pairs) performed the worst whether they were tested immediately or a week later.

The retention test of the current thesis was made to be easy (two novel labels with two name-unknown images for each label in Studies 1 to 3) as testing for retention of word-object associations is not the main aim of the current study. The retention test was administered just to ensure that children have learned word-object associations through the ME constraint. As the current study found that children selected the target above chance in the retention test, this result supports other studies that the ME constraint can lead to word learning (Kalashnikova et al., 2018; Spiegel & Halberda, 2011). In Study 5, children were presented with a total of four name-unknown images, two of which were labelled in a non-ostensive manner in the ME training block, and two were presented without any labels in the foil trials. Although children were able to select the target above chance in the retention test, the proportion of children that was target-oriented was significantly less than that in Studies 1 to 3 (ps $< .001$; see Table 11). Having more distractors makes the task more difficult because children need to reject more number of distractors before being able to select the target. Thus, higher number of distractors in a difficult task leads to less attention given to the target, making word learning more difficult.

Table 11. Comparison of mean proportion, standard deviation and 95% CI between Studies 1 to 5 on the performance in the retention test

	Mean	SD	95% CI	
			Lower	Upper
Study 1	.875	.331	.845	.900
Study 2	.708	.456	.647	.763
Study 3	.568	.496	.506	.628
Study 5	.552	.360	.488	.615

The current thesis also supports the argument that repetition is a factor that affects children's retention rate. When the trials are repeated, children are able to encode the word-object associations better. As the current study repeated each word-object pairing three times and tested children immediately after the ME training trials, children were successful in retaining these associations. Many previous studies (e.g., Horst & Samuelson, 2008; Mather & Plunkett, 2009) also supported Horst et al.'s (2006) argument that repetition of trials is important in allowing children to learn the word-object associations that were encountered in ME training trials. Although children can fast-map even with limited encounters with the novel labels, they can only retain this newly-formed word-object associations for a short period of time. For instance, Friedrich and Friederici (2011) found that six-month-olds were able to retain the newly-learned word-object associations immediately after ME training trials, but after a day's delay, the infants did not show evidence of having remembered these pairings. In fact, Horst and Samuelson (2008) found that two-year-old children were unable to show evidence of retention after a five-minute delay between training and testing.

The current thesis argues that the strength of encoding is important in deciding how much repetition is needed for children to retain word-object associations. If children have already encoded the word-object association very strongly in one trial, they would not need many repetitions to learn the mapping. This claim is made based on the comparison between monolinguals in Study 2 and bilinguals in Study 3, which showed that bilinguals retained the word-object associations significantly less than the monolinguals. In the current thesis, children only need to learn two novel labels and each label was repeated three times. Monolingual children found it sufficient to retain these word-object associations for a short period of time (they were tested immediately after the ME training trials). However, bilinguals did not retain the word-object pairings as well as monolinguals even though the number of trials were the same (see Figure 6). As bilinguals showed less novelty bias in the ME training trials, their encoding of these word-object associations is relatively weaker than monolinguals. Because of the weaker encoding, bilinguals are likely to need more repetition than monolinguals before being able to remember the associations between the novel label and the name-unknown object. In Kalashnikova et al. (2018), monolinguals and bilinguals did not show significant differences in the ME training trials, hence, no difference was observed in the retention test. Therefore, although repetition helps word learning, children who have encoded the associations strongly may not need as many repetitions as those who have encoded the word-object mappings weakly.

In short, children are avid word learners as they are able to retain newly-learned word-object associations. Retaining word-object associations requires memory, therefore, strong encoding of the association is necessary before children can remember it. Thus, the current thesis suggests that repetition promotes word learning because repetitive presentation of the word-object associations allows stronger encoding of the associations. However, this prediction needs further tests by manipulating the number of repetitions provided to the participants.

9.4 Non-Selectivity of Word-Object Associations

Although a novelty bias (an evidence for the ME constraint) is very strong in children, this finding merely indicates that children prefer to map novel labels to novel name-unknown objects, but not necessarily that children will accept just one name-unknown object as a referent for a novel label. Previous studies provided indirect support for this argument. For instance, Woodward and Markman (1991) explained that children can overcome the ME constraint with stronger linguistic biases, indicating that it is possible for children to map a novel label to objects that are neither novel nor name-unknown. Moreover, MacDonald et al. (2017) found that when the learning situation is ambiguous, children tend to store more than one word-object association. As Yoshida, Rhemtulla and Vouloumanos (2012) showed that children can use statistical information and linguistic constraints concurrently to facilitate word learning, the current thesis tested whether children can learn a second label for a name-known object even if they show a novelty bias, provided that the name-known object co-occurs frequently with a novel label.

In what was termed as the selectivity test, the current thesis[6] presented children with two name-known objects that appeared in the ME training trials as distractors. By selective, we mean that children will only map a novel label to one object and reject another possible referent despite statistical evidence for this other possible referent. As children were able to select the target name-known object upon hearing the novel label in the selectivity test, word-object associations are unlikely to be selective because children were able to learn a second

[6] Selectivity tests were conducted only in Studies 1, 2, 3 and 5. There were no test trials in Study 4.

label for name-known objects even though they showed novelty bias. To understand how the findings in the current thesis explain for non-selectivity, this section first differentiates two possible explanations for the results obtained from the selectivity test, followed by a discussion of factors that affects children's performance: task difficulty, presence of supporting evidence and linguistic experience.

Even though children selected the target above chance in the selectivity test in Studies 1 and 3, it is not conclusive that children have formed a lexical association between the novel label and the name-known object. In the current thesis, children were always presented with a pair of name-unknown and name-known images in the ME training trials. When children were asked to select a name-known image for a novel label in the selectivity test, children may have selected the target via cascaded activation from the novel label to the name-unknown image and then to the name-known image (see second row of Figure 2). If children have formed this kind of association, then they may not have learned that the novel label is a second label for the name-known image. Instead, children have just associated that the two images always co-occur with each other.

As explained in the previous section, children who pay more attention to an object will be more able to retain the word-object association. Thus, when increased attention is given to the name-unknown object, the name-known object will not be attended to a similar extent. This divide in attention means that children will not be able to select the target in the selectivity test as well as they could in the retention test. As a result, the performance in the selectivity test should correlate *negatively* with the performance in the ME constraint, whereas the performance in the retention test should correlate positively with the performance in the ME constraint. Although Studies 2 and 5 of the current thesis obtained significant correlations that support the explanation provided, the current findings should still be interpreted carefully. Pomper and Saffran (2018) cautioned that attention is necessary but not sufficient in word learning, therefore, depending on the cognitive demand of the task, correlations between training and testing may not be significant. When most children fail to learn the word-object pairings, differences between scores may not be meaningful to interpret. In the current thesis, children did not select the target above chance in Studies 2 and 5, therefore, further studies need to be conducted before strong claims can be made.

As the selectivity test examines whether children are able to retain the associations between the novel labels and the name-known objects, the performance in this test block is affected by the difficulty of the task. Children recruited in the current thesis were able to select the target above chance in the selectivity test of Study 1 but not of Study 2. This performance difference suggests that in a more difficult task, children are not able to store multiple word-object associations. In Study 1, the distractor images were of different categories (i.e., one was an animate object, the other inanimate), hence children could use this information to ease the learning of the word-object pairings but this is not possible in Study 2 as both name-known objects were inanimate. It is unlikely that the image pairs in Study 2 were impossible to learn, as bilinguals in Study 3 were able to perform above chance in the selectivity test. If children in Study 2 had been given more repetition trials, they might be able to retain the association between novel labels and name-known objects. This finding is similar to that of Horst and Samuelson (2008), where children were unable to retain newly-learned word-object pairings even in seemingly simple task (e.g., learning only one novel label with two name-known object distractor, see Experiment 1c).

Similarly, in Study 5, when four images were presented in the selectivity test, children performed at chance level. As there were two more distractors, children were more prone to err in this test, supporting Vlach and Sandhofer (2014) that participants performed best in simple tasks if they were tested immediately after learning. Even in the retention test block where children had been scoring consistently above chance in the two-image design (Studies

1 to 3), in the four-image design (Study 5), children's performance dropped significantly even though they were still able to select the target above chance (see Table 11). In the selectivity test, children did not consistently score above chance, only doing so if the images were easy to remember (e.g., in Study 1). Thus, it comes as no surprise that the children were unable to select the target above chance in the four-image design. Therefore, the current thesis argues that attention is one of the components required in word learning, because in a difficult task where children need to focus their attention on a particular object, they have trouble learning the pairing between the novel label and another object.

Having additional evidence helps children in retaining word-object associations even in difficult tasks. In Study 5 of the current thesis, we manipulated the design so that syntactic bootstrapping provides a useful cue to forming multiple associations. Although children were unable to select the target above chance in the overall selectivity test, there was a difference in performance between the two conditions. When the name-known image was supported by syntactic bootstrapping to be a referent for the novel label (i.e., in the match-familiar condition), children selected the target above chance in the selectivity test. Similarly, when syntactic bootstrapping did not support the name-known image as the referent (i.e., in the match-novel condition), children did not select the target above chance.

This finding suggests that children accumulate evidence when deciding on the referent for a novel label, as explained earlier on how children select a referent in ME training trials. This argument is in line with that of Waxman and Gelman (2009) that different cues (associative learning and knowledge from linguistic systems) are used concurrently by children when learning meanings of words. If children in Study 5 had not taken the information obtained from syntactic bootstrapping into account, they would not show different patterns of performance in the two conditions. Therefore, it is likely that children weigh the evidence for each object before selecting it as a target.

If linguistic experience affects whether children will rely heavily on the ME constraint or not, then linguistic experience should also affect whether children are more or less likely to accept a second label for a name-known object. Previous studies, such as Onnis, Chun and Lou-Magnuson (2017), found that bilingualism predicts performance in associative learning, where bilingual adults were able to learn two novel grammatical rules simultaneously. Bilinguals' advantage in learning multiple word-object pairings is also shown in Escudero et al. (2016), where bilinguals were more able than monolinguals in using CSL to learn word-object associations.

The current thesis provided support to this bilingual advantage as well. In the current thesis, Study 2 found that monolingual children were unable to learn the associations between novel labels and name-known objects in the selectivity test. However, bilinguals in Study 3 were able to select the target above chance. This finding suggests that children readily remember a second label for name-known objects if they have experience in doing so. However, not all studies found such a difference between monolinguals and bilinguals. For instance, Aravind et al. (2018) found that regardless of the linguistic experience of children, children tend to perform badly in subsequent trials if their first guess was wrong, suggesting that children retain only one word-object association, as proposed by PbV (Trueswell et al., 2013). As Menjivar and Akhtar (2017) found that the difference between monolinguals and bilinguals is most prevalent in difficult tasks, administering different types of task may magnify or diminish any differences between monolinguals and bilinguals.

In short, children in the current thesis showed evidence of non-selectivity when forming word-object associations during word learning instances. However, as storing multiple associations (two in our studies) is cognitively taxing, children only do so when the task is relatively easy or when there is evidence showing that such an association is plausible.

9.5 Conclusion and Future Work

In conclusion, the current study showed that children make use of the ME constraint very much like a default bias because the one-to-one assumption between words and objects is very robust. This claim is made because throughout the five studies, children selected the name-unknown image as the target of the novel label significantly above chance. Even though slightly different stimuli were used in each study of the current thesis, children still showed significant novelty bias (except in the match-familiar condition of Study 4, where syntactic cues overruled ME constraint). These findings suggest that the ME constraint plays an important role in word learning, but the usage of this constraint is modulated by linguistic experience, attention and the presence of other cues. The current thesis supports Byers-Heinlein and Werker (2009) that the ME constraint develops from one's linguistic experience. If children experience many one-to-one instances for word-object associations, they will be more likely to make use of the ME constraint. These children will attend more to the name-unknown object when they hear a novel label and learn this word-object mapping, at least for a short period of time. On the other hand, children who violate the ME constraint, such as by knowing many translation equivalents for names of objects, are less likely to make use of the ME constraint. These children tend to attend to both name-unknown and name-known objects when they hear a novel label, as either object may be a referent for the novel label. The current thesis suggests that this split in attention may cause children to need more trials before being able to retain the word-object associations. The current thesis also found that children are aware of other linguistic cues and are able to accumulate evidence from these cues to select a referent for a novel label. Children are biased to select an object as the target if this object has increased supporting evidence.

Future work will need to explore some aspects that have not been examined in the current thesis. There are at least three areas which are still untested. First, although we explained previously that children's language proficiency should affect their usage of syntactic cues, this claim is made based only on the positive correlation between age of children and their willingness to take syntactic bootstrapping in account. More convincing conclusions can only be made if children's language proficiency has been manipulated as a variable.

Second, the current thesis argued that children should select the object with the strongest supporting evidence as the target. In Study 5, the image that accumulated most cues was the name-unknown image, thus, it is not known if children selected this image due to the ME constraint or to the accumulation of evidence. To test this further, future studies will need to examine if children will select the *name-known* object in ME training trials if this object is supported by more cues than the name-unknown object.

Third, the current thesis proposed that the difference in performance between monolinguals and bilinguals in the retention test can be reduced by giving bilinguals more repetitions. This hypothesis is made based on Samuelson et al.'s (2006) findings that repetition is needed for long-term retention of newly-formed word-object associations. To test this proposal, future studies could give more repetitive trials to children who did not focus their attention on one particular image and test if providing more repetitions will boost their performance in the retention test.

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Appendices

Appendix A: Statistical codes of full mixed-effect models in Studies 1 to 5

Study 1

```
m0V1<-
glmer(Response~Age_group*Trial_type+Trial_order+(1|ID)+(1|Item
), data=MonoE1, family="binomial",
control=glmerControl(optimizer="bobyqa", optCtrl = list(maxfun
= 100000)))
```

Study 2

```
m0V2<-
glmer(Response~(1|ID)+(1|Item)+Trial_order+Age_group*Trial_typ
e, data=MonoE2, family="binomial",
control=glmerControl(optimizer="bobyqa", optCtrl = list(maxfun
= 100000)))
```

Study 3

```
m0V3<-
glmer(Response~(1|ID)+(1|Item)+Trial_order+Exp_Lang+Trial_type
*Age_group, data=ME3, family="binomial",
control=glmerControl(optimizer="bobyqa", optCtrl = list(maxfun
= 100000)))
```

Comparing Study 2 and 3

```
m1V2.3<-
glmer(Response~(1|ID)+Age_group*Language+Age_group*Trial_type+
Language*Trial_type, data=ME2v3, family="binomial",
control=glmerControl(optimizer="bobyqa"))
```

Study 4

```
m1V4<-glmer(Response~(1|ID)+(1|Item)+Condition*Age_group,
data=ME4, family="binomial",
control=glmerControl(optimizer="bobyqa"))
```

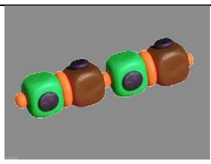
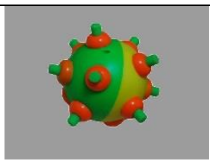
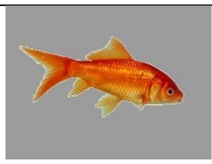
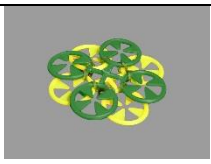
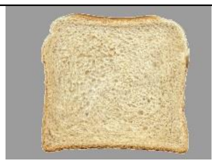
Study 5

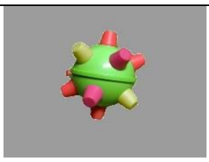
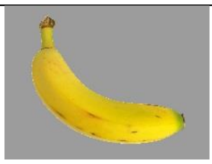
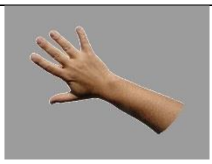
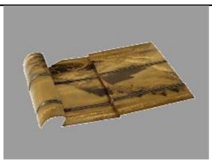
```
m0V5<-
glmer(Response~(1|ID)+Trial_order+Age_group*Condition+Trial_ty
pe*Condition, data=ME5, family="binomial",
control=glmerControl(optimizer="bobyqa", optCtrl = list(maxfun
= 100000)))
```

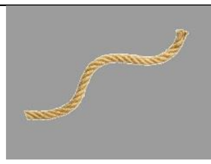
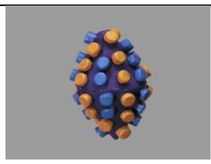
Appendix B: List of languages spoken by children in Study 3

Language(s) spoken at home	Language(s) learned in school	No. of children
Malay	Malay, English	64
Mandarin	Mandarin, Malay, English	41
English	Malay, English	5
Mandarin	English	4
English	Mandarin, Malay, English	3
Spanish	English	3
Tamil, English	Malay, English	3
Cantonese, Mandarin	Mandarin, Malay, English	2
German	English	2
Hokkien, Mandarin	Mandarin, Malay, English	2
Hakka, Mandarin	Mandarin, Malay, English	1
Hindi	English, Spanish	1
Mandarin	Malay, English	1
Tamil, English	Mandarin, Malay, English	1

Appendix C: Complete list of stimuli used in Study 4

Condition	Classifier	Auditory label	Name-unknown image	Name-known image
Both Match	Batang	Himdek		
	Biji	Kibua		
	Ekor	Tomgok		
	Helai	Duhak		
	Keping	Tasung		
	Ketul	Modi		
	Orang	Mipo		
	Utas	Sengho		

Match-novel	Batang	Buhi		
	Biji	Ifi		
	Ekor	Rufin		
	Helai	Gotus		
	Keping	Nimwa		
	Ketul	Camling		
	Orang	Gangjo		
	Utas	Pifom		
Match-familiar	Batang	Wukca		

	Biji	Mijas		
	Ekor	Pafka		
	Helai	Pamu		
	Keping	Rimaut		
	Ketul	Banung		
	Orang	Rewik		
	Utas	Fisek		
Mismatch-both	Batang	Sungkil		
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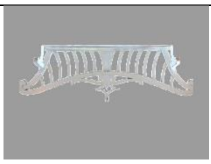
	Ekor	Lijok		
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	Keping	Ekjim		
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	Orang	Gusbil		
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