TEMPERAMENT AND EARLY WORD LEARNING: THE EFFECT OF SHYNESS ON REFERENT SELECTION AND RETENTION

by

Matt Hilton

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF LANCASTER UNIVERSITY FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

LANCASTER UNIVERSITY

June 2016

Declaration

I declare that the thesis is my own work, and has not been submitted in substantially the same form for the award of a higher degree elsewhere.

MHilton

Signature

09/06/2016

Date

Abstract

The current thesis examined individual differences that can impact on the disambiguation and learning of novel word meanings, focusing on the effects of shyness, defined as an aversion to novelty in social situations (Putnam, Gartstein & Rothbart, 2006). A systematic pattern of attention during labeling is crucial in supporting children's novel word disambiguation (Halberda, 2006), and in determining whether these novel word meanings will be learned (Axelsson, Churchley & Horst, 2012). This thesis hypothesized that shyness affects novel word disambiguation and learning by modulating attention during labeling. This thesis showed that shy children did not reliably select a novel object as the referent of a novel label, while less-shy children did. Crucially, only less-shy children showed evidence of learning the novel label-referent mappings (Paper 1). However, these differences were only apparent in an unfamiliar environment (Paper 2), likely because shy children attended much more to features of the unfamiliar environment than less-shy children, which reduced their attention to the objects during labeling. Examination of children's eye-gaze during novel object labeling supported the conclusion that shyness exerts an effect on word learning via attention. Shy children did not demonstrate robust disengagement from the novel object during labeling (Paper 3), which meant that competitor objects could not be ruled out as referents, a critical process in determining whether a novel word-referent mapping will be formed (Mather & Plunkett, 2009). Furthermore, shy children's bias to attend to faces (Brunet et al., 2009) reduced their attention to potential referents during labeling (Paper 4). This thesis thus argues that shyness impacts on word disambiguation and learning by modulating the attentional processes that support these abilities, clearly demonstrating that shyness affects one of the earliest stages of language development: word learning.

Acknowledgements

The work presented in this thesis was funded by the Faculty of Science and Technology at Lancaster University, and I would like to thank the many families who donated their precious time to take part in my research.

I would also like to thank Prof. Gert Westermann, for being a fantastic supervisor, mentor, ally and friend. Thanks too to Dr. Katherine E. Twomey - I am so grateful for the help and advice, working with you in Sussex and then in Lancaster has been magic. Such endless support and encouragement from you both has kept me buoyant in the stormy sea of PhD study. I would also like to express my gratitude to Dr. Jessica Horst, for the inspiration, support and advice that led directly to this PhD.

Finally, thanks to the countless people who have made my time in Lancaster a joy, to CG for always shining bright, to my family who have always been incredibly supportive, to my dad who has always been there for me, and in particular to my mum for being the strongest role model I could hope for.

Dedication

For Molly and Tommy

Statement of Authorship

Authorship contributions

Paper 1: SHY CHILDREN'S FORMATION AND RETENTION OF NOVEL WORD-OBJECT MAPPINGS

Conception and design of study: **Matt Hilton**, Gert Westermann
Acquisition of data: **Matt Hilton**
Analysis and/or interpretation of data: **Matt Hilton**, Gert Westermann
Drafting the manuscript: **Matt Hilton**
Revising the manuscript critically for important intellectual content: **Matt Hilton**, Gert Westermann
Contribution of principal author: 85%

Paper 2: PARENTS AS EXPERIMENTERS: REDUCING UNFAMILIARITY HELPS SHY CHILDREN LEARN WORDS

Conception and design of study: **Matt Hilton**, Katherine E. Twomey, Gert Westermann
Acquisition of data: **Matt Hilton**
Analysis and/or interpretation of data: **Matt Hilton**, Katherine E. Twomey, Gert Westermann
Drafting the manuscript: **Matt Hilton**
Revising the manuscript critically for important intellectual content: **Matt Hilton**, Katherine E. Twomey, Gert Westermann
Contribution of principal author: 85%

Paper 3: EYE MOVEMENTS DURING THE LEARNING OF NOVEL WORD-OBJECT MAPPINGS IN SHY AND LESS-SHY CHILDREN

Conception and design of study: **Matt Hilton**, Gert Westermann
Acquisition of data: **Matt Hilton**
Analysis and/or interpretation of data: **Matt Hilton**, Katherine E. Twomey, Gert Westermann
Drafting the manuscript: **Matt Hilton**
Revising the manuscript critically for important intellectual content: **Matt Hilton**, Katherine E. Twomey, Gert Westermann
Contribution of principal author: 85%

Paper 4: THE EFFECT OF SHYNESS ON CHILDREN'S USE OF EYE-GAZE TO DETERMINE THE REFERENTS OF WORDS

Conception and design of study: **Matt Hilton**, Gert Westermann
Acquisition of data: **Matt Hilton**
Analysis and/or interpretation of data: **Matt Hilton**, Gert Westermann
Drafting the manuscript: **Matt Hilton**
Revising the manuscript critically for important intellectual content: **Matt Hilton**, Katherine E. Twomey, Gert Westermann
Contribution of principal author: 85%

We the undersigned agree with the above stated "proportion of work undertaken" for each of the above manuscripts contributing to this thesis:

Signed: MATT HILTON ____________________________

KATHERINE E. TWOMEY ____________________________

GERT WESTERMANN ____________________________

Table of Contents

Epigraph

Shyness is nice, and
Shyness can stop you
From doing all the things in life
You'd like to

-The Smiths, Ask, 1986

Shyness and Early Word Learning: An Introduction

Matt Hilton

Lancaster University

Shyness and Early Word Learning: An Introduction

It has become a cliché to begin works such as this by marveling at children's ability to learn language. Children's language acquisition is typically fêted here as "impressive" (Horst & Samuelson, 2008, p. 129; Houston-Price, Plunkett, & Harris, 2005, p. 175), "remarkable" (G. A. Miller & Gildea, 1994, p. 140), "staggering" (Markman & Wachtel, 1988, p. 121), and most awe-inspiring of all, as "wizardry" (Carey, 1978, p. 266). It is unfortunate that these descriptions now seem somewhat hackneyed, because the ease with which children acquire language is nonetheless astounding. In the same time taken to complete a PhD (and with far fewer study breaks), children have gone from newborn babes to language experts, being able to produce complex sentences (Fenson et al., 1994), understand word play jokes (Johnson & Mervis, 1997) and they are even at the earliest stages of being able to read (Hilbert & Eis, 2013). This is *even more* impressive given that children have also mastered a multitude of other skills in this time, including walking (Adolph & Eppler, 1998) and counting out loud (Starkey & Cooper, 1995). Wizardry indeed.

Such impressive language abilities have emerged by children's third birthday because they have already acquired a substantial lexicon (Fenson et al., 1994), something that children begin to do in earnest during the second year of life, as evidenced by the rapid acceleration in the receptive and productive vocabulary size of the child: At 12 months of age children can say on average ten different words, but one year later children can say on average over 300 different words (Dale & Fenson, 1996). The widely-used terms *vocabulary spurt* or *naming explosion* reflect this sudden acceleration in children's vocabulary size (Bloom, 1973), and interest in the mechanisms of this acceleration has been extensive and consistent.

For many years it was argued that the vocabulary spurt must be the result of some fundamental developmental changes within the child. One influential account attributed the rapid acceleration of vocabulary growth to the emergence of children's understanding that words refer to things (e.g. Reznick & Goldfield, 1992). Further work suggested other intrinsic changes that could explain this acceleration, such as children's understanding of concepts that allow for object differentiation (Lifter & Bloom, 1989), and development of social cognition (Ninio, 1995). More recently, however, it has been argued that some qualitative change in children's cognition may not be necessary to bring about a rapid expansion in vocabulary size.

McMurray (2007) showed that features of the language input to a child can bring about a rapid acceleration in language learning when modeled computationally, without parameters reflecting qualitative intrinsic changes that had previously been hailed as necessary to bring about spurt-like language learning. Instead, McMurray's (2007) model suggested that extrinsic factors, specifically variability in the learnability of words, can explain children's early language learning with no need for specialized abilities to emerge within the child.

The debate about the role of intrinsic vs. extrinsic factors in explaining the vocabulary spurt continues (e.g. Mayor & Plunkett, 2010). McMurray, Horst and Samuelson's (2012) in-depth examination of the state of the art addressed this debate and argued that children's language acquisition must be understood in terms of the mechanisms that underlie it. Importantly, the process by which a word comes to be known must be broken down and considered in terms of the processes that support children's disambiguation of word meaning in-the-moment, and the processes by which this meaning comes to be learned. McMurray and colleagues (2012) argue that understanding the relation between these distinct processes can help better explain children's rapid language acquisition.

An unfortunate consequence, however, of a focus on the vocabulary spurt debate is that attention is drawn away from an equally fascinating aspect of language development at this age: its variability. Figure 1 shows norms for children's productive vocabulary growth during the second year of life (Dale & Fenson, 1996). At first sight, Figure 1 illustrates the acceleration in language knowledge that characterizes the vocabulary spurt. However, Figure 1 also shows that the rapid increase in vocabulary size is accompanied by an increase in variability. This variability in language acquisition means that age is typically a poor predictor of language ability. As seen in Figure 1, on their second birthday, the average American child can say 307 different words. Yet the bottom 10th percentile of children can say fewer than 66 different words, while the top 10th percentile can say more than 528 different words (Dale & Fenson, 1996).

Such variability means that defining typical language development at this age is difficult. For example, while children in the bottom 10th percentile are at risk of later language difficulties (Dale, Price, Bishop, & Plomin, 2003), the majority of these children will go on to develop language normally (Desmarais, Sylvestre, Meyer, Bairati, & Rouleau, 2010; Kelly, 1998; Whitehurst & Fischel, 1994). Therefore, in better examining factors other than age that explain this language variability, we may begin to distinguish normal from delayed language development in early childhood.

Interestingly, while research into the vocabulary spurt initially focused on intrinsic factors that could explain language acceleration, research into variability at this age has initially focused on extrinsic factors, specifically differences in

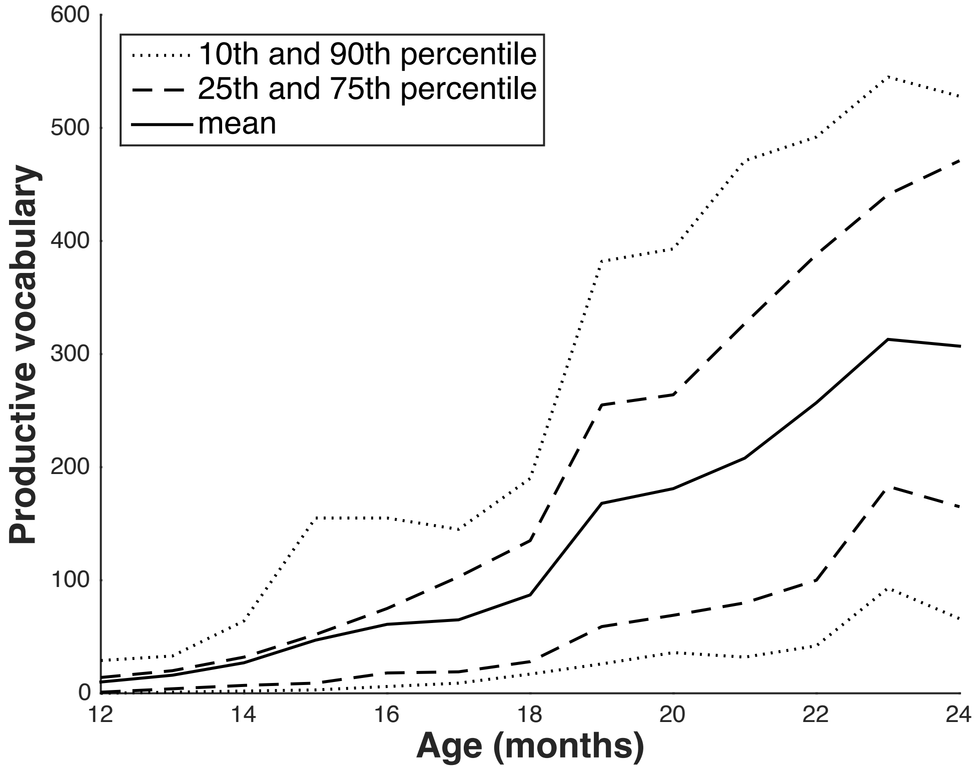


Figure 1. Mean and key percentiles of children's productive vocabulary scores from 12 – 24 months of age. Plot reproduced from Dale & Fenson (1996).

language input. Children must hear language in order to acquire it, and so it was argued that variability in this language input likely explains the variability in language acquisition. Research thus explored candidate extrinsic factors that affect language acquisition by modulating the language environment of the child. One of the most intensively researched extrinsic factors is *socioeconomic status,* usually measured via household income or maternal education. Children from poorer backgrounds consistently show slower language acquisition than their better-off peers (Brooks-Gunn, Rouse, & McLanahan, 2005; Feldman et al., 2000; Fernald, Marchman, & Weisleder, 2013; Hernandez, Denton, & Macartney, 2007; Rescorla, 1989), and it is argued that this effect is exerted by altering the properties of the language input to the child.

Originally, researchers claimed that the effect of socioeconomic status on language development is due to differences in the number of words that each child is exposed to. Hart & Risley (2003) argued that children from the poorest social groups hear 30 million fewer words than children in the wealthiest social groups, and the authors demonstrated that those children who heard fewer words learned fewer words. More recently, however, this argument has been refined, emphasizing that the *quality* of the language input is also key in driving the effect of socioeconomic status on language development (Hirsh-Pasek et al., 2015). For example, children from poorer backgrounds hear less infant-directed speech than children from better-off households (Rowe, 2008). Since children learn language better from infant-directed speech than adult-directed speech (Thiessen, Hill, & Saffran, 2005), the language development of less well-off children is therefore likely restricted due in part to reduced learnability of their language input.

Research into the effects of socioeconomic status on language development illustrates the key role of extrinsic factors in explaining variability in early language acquisition, and, importantly, emphasizes that this effect is more nuanced than simply affecting the sum of words heard. Similarly, a number of other environmental factors have been found to impact on children's language acquisition. For example, language development is positively affected by storybook reading (Scarborough & Dobrich, 1994), parental use of gesture (Rowe, Özçalışkan, & Goldin-Meadow, 2008), and the amount of mother-child conversation (Hoff-Ginsberg, 1991). Nevertheless, these explanations of variability in early language development all converge in their focus on variability in language input.

Clearly, understanding differences in input can explain some of the variability in language development. But this raises an interesting question: if children were exposed to identical language input, would this eliminate variability between children in their rate of language acquisition? The answer is likely no, on both empirical and theoretical grounds. Empirically, it has been shown that identical twins, despite their shared early experience, can acquire language at markedly different rates from each other (Stromswold, 2001). Theoretically, children's language acquisition would remain variable given universal input because development more generally is characterized by variability, and this variability is not governed solely by environmental factors. The rate at which motor skills develop, for example, varies greatly (e.g. Rule & Stewart, 2002), as does the development of cognitive skills other than language, such as face perception (e.g. Cohen & Cashon, 2001). Current theories of cognitive development that emphasize the interrelated, dynamic nature of emerging developmental systems (Mareschal et al., 2007; Spencer et al., 2006) would thus predict that variability in one cognitive domain could mean variability in the development of other cognitive domains (see also Karmiloff-Smith, 1998).

An understanding of developmental systems as emerging and dynamic predicts that language acquisition would likely be subject to variability even in the absence of variation in language input. The current thesis builds on this understanding, takes inspiration from McMurray and colleagues' (2012) argument that acceleration in language acquisition must be understood in terms of the mechanisms by which children decipher and learn the meaning of words, and argues that this approach must also be taken in examining variability in language acquisition. In doing so, this thesis shifts the focus away from extrinsic factors, instead examining the role of intrinsic processes in contributing to this variability.

This introduction therefore reviews our current knowledge of the processes that are key in supporting early language acquisition. Our current knowledge of the factors that may impact on these processes is discussed, alongside a thorough examination of a candidate intrinsic factor that requires further investigation: shyness. Finally, this introduction will outline the course of research to be undertaken.

Learning a Word

McMurray et al. (2012) argue that language acquisition must be understood in terms of the processes by which children decipher the meaning of words, the processes by which children learn these meanings, and the relation between the two sets of processes. Research into the first set of processes, those by which a child disambiguates word meaning, has been a focus of research for many decades, and Quine's (1960) thesis is a good starting point from which to examine subsequent research.

Disambiguating a Word's Meaning

In Quine's (1960) seminal work, he likened the infant to a naïve linguist, attempting to learn a foreign language from native speakers. Quine (1960) explained that the linguist cannot rely on the natives to explicitly teach him the meaning of every spoken word, as this task would take forever. Instead the linguist must draw conclusions about the meaning of the words spoken by the interactional partner based on the stimuli present at the time they are said. For example, a rabbit may run past accompanied by an exclamation of the word *gavagai* from the native. The linguist must then form their own hypothesis about the likeliest meaning of the word.

Carey & Bartlett (1978) offered evidence that children go about learning words in the same way as Quine's (1960) imagined linguist: by forming hypotheses about the meaning of the words that they hear in the absence of explicit instruction. The authors reported on an experiment in a nursery classroom in which an olive-green and a red tray were present. Individually, children were asked by their teacher to fetch "…the chromium one, not the red one, the chromium one." (p. 18). Children determined that the teacher was referring to the olive green tray and fetched it accordingly. Using their knowledge of the meaning of the word *red*, the children seemed to rapidly form the hypothesis that *chromium* means olive green. Children's ability to map the word chromium to the color olive-green was termed *fast mapping.* There then followed much research into the ways in which children come to infer the intended referent of a word with no explicit instruction from interactional partners.

Children are able to rapidly determine the meaning of a heard word as early as the second year of life (17-18 months; Halberda, 2003), by determining that a novel label will refer to a novel object if all other potential referents are familiar, and there has been sustained interest in the mechanisms that support this particular behavior. Understanding these mechanisms is key in exploring the role that this disambiguation ability can play in language acquisition (McMurray et al., 2012).

Early accounts assumed that children's novel word disambiguation was the result of innate constraints. Markman (1994) posited innate constraints that the child places upon words' potential meanings. Markman (1994) argued that children constrain the potential meaning of words according to three assumptions: the *whole object assumption,* the *taxonomic assumption,* and the *mutual exclusivity assumption*. The whole object assumption leads children to map a label onto a whole object, rather than one of its constituent parts. For example, the whole-object assumption means that children map the word *car* to the whole object, rather than to the wheel. The taxonomic assumption was put forward in order to explain why children find thematic relations between objects much more salient than taxonomic relations, yet they generalize labels according to taxonomic rather than thematic relations. For example, a pet Poodle and its bowl are highly thematically related, because they occur so often together. Once the child has learned that the poodle is known as a dog, the child is nevertheless more likely to refer to an unfamiliar Great Dane as a dog than the bowl. The taxonomic assumption thus explains this behavior as the result of an innate assumption that words should be extended to other members of the same taxonomic category.

Children's mapping of a novel label onto a novel object was suggested by Markman (1994) to be the result of the *mutual exclusivity assumption*: that an object will have only one label. Markman’s (1994) account describes the mutual exclusivity assumption as a default assumption, meaning that it can be overridden if other cues (such as syntax) clearly demonstrate that the assumption does not apply in a particular case. Importantly, Markman's (1992, 1994) constraints approach argues that the mutual exclusivity assumption is innate, and that while it can only be demonstrated once the child has learned her first words, it is an essential prerequisite for language learning.

As acknowledged by Markman (1994), however, there are alternative accounts of children’s selection of a novel object as the referent of a novel label. Clark’s (1990) Principle of Contrast, for example, explains children’s behavior on these tasks in terms of a series of mental computations in which all known lexical items and their meanings are contrasted against each other. Importantly then, children’s disambiguation is the result of the assumption that all words are contrastive. If children hear a new word, they assume it must have a meaning different to the words which are already known, a subtly different mechanism from Markman’s (1994) for the same behavior.

Golinkoff, Mervis and Hirsh-Pasek (1994), offered an alternative account of children’s novel word disambiguation, in terms of *lexical principles*. The lexical principles approach differed from previous accounts in that these principles can be acquired, and need not be present from birth (Golinkoff et al., 1994), although this possibility is not ruled out completely. Golinkoff and colleagues' (1994) developmental framework argued that six lexical principles are constructed during development, and their construction allows for fast and efficient language learning. Three principles emerge first, and are tightly related. The first is the principle of *reference*, the understanding that words refer to objects, actions and attributes. The second principle is that of *extendibility*, the understanding that words do not only refer to the referent object, but that these words can be extended to other exemplars and category members. The final principle of tier one is that of *object*, the understanding that words map onto whole objects.

Golinkoff and colleagues (1994) argued that once the tier one principles have emerged, the more sophisticated tier two principles are then acquired. They build upon the tier one foundations, and one offers a further alternative to a mutual exclusivity assumption: The *Novel Name-Nameless Category* (N3C) principle. Such a principle means that children will seek out a novel object on which to map a novel label. This behavior has subsequently been termed as a "map novelty to novelty" (Halberda, 2006, p. 314) strategy.

These accounts all make different assumptions about the mechanisms of children's novel word disambiguation, and each have been individually critiqued. Clark's (1990) contrast theory, for example, was called into question because it was suggested that it failed to explain why children would come to select the novel object as the referent of a novel label (Markman et al., 1994). Specifically, according to the principle of contrast children will assume that a new term has a new meaning, but this does not exclude the possibility that the novel word refers to a familiar object, because difference in meaning does not mean difference in reference. For example, *doll* and *Barbie* have different meanings, but they can refer to the same thing.

Markman's (1994) mutual exclusivity assumption also fails to address the discrepancy between meaning and reference. This approach was also criticized because further research showed that children do not reject a familiar object as the referent of a novel word when no novel object is present (Mervis, Golinkoff, & Bertrand, 1994). Importantly, Golinkoff and colleagues (1994) argued that the mutual exclusivity assumption should predict that children's novel word disambiguation is strongest when children are first learning words, because the assumption is innate and a supposed key driver of word learning. However, evidence shows that children's disambiguation of a novel word becomes stronger as development progresses (Bion, Borovsky, & Fernald, 2013).

These three accounts, though, are similar in that they assume children's word disambiguation is equal to word learning, because the emergence of this ability during the second year of life was hailed as one of the fundamental developmental abilities that brings about the vocabulary spurt, given that both the ability and the spurt emerge at about the same time (Goldfield & Reznick, 1990; Halberda, 2003). Discussion of the processes that support word disambiguation has thus been inseparable from that of the processes involved in word learning. Only later was it argued that it is necessary to examine and attempt to understand the processes that lead to novel word disambiguation, before then aiming to understand whether these processes can also support learning (e.g. Horst & Samuelson, 2008).

New, looking time approaches have since allowed for a more fine-grained analysis of the mechanisms involved in word disambiguation separately from word learning. Halberda (2006) used looking time measures to examine preschool children's novel word disambiguation. Each child saw a novel object and a familiar object, while hearing a familiar or novel label. If children were looking at the novel object as they heard a novel label, they first looked towards the familiar competitor before their attention turned back to the novel object. This finding suggested that rejecting familiar competitors as potential referents is key in disambiguating the novel label, in line with Markman's (1994) mutual exclusivity assumption. This argument therefore indicates that attention to familiar competitors is key in supporting the mapping of the novel word onto the novel object, supported by Horst and colleagues (2010), who found that increasing the number of familiar competitors did not affect formation of the novel word object mapping, but reduced the likelihood that the mapping was be retained, which indicated that less attention is paid to the novel target as the number of familiar competitors increases.

However, subsequent work suggested that familiar objects are not only rejected as competitors because the child already knows a label for them. Horst, Samuelson, Kucker & McMurray (2011) presented children with pre-familiarized novel competitors alongside a previously unseen novel object while asking for a novel label (e.g., *Can you show me the dax?*). Even though children were not taught labels for the pre-familiarized objects, they still selected the most novel object as the referent. This suggests that children's novel word disambiguation cannot be explained simply as rejection of objects for which a word is known, because children reliably rejected nameless but familiar objects as potential referents for a novel label. Instead, Horst and colleagues (2011) argued that lower-level attentional processes can be sufficient to explain children's novel word disambiguation.

McMurray and colleagues (2012) provided yet further evidence that children's selection of a novel object as the referent of a novel label need not be the result of specific constraints or biases. McMurray et al. (2012) found that selection of a novel object as the referent of a novel label can be simulated in a connectionist computational model via dynamic competition. Specifically, upon hearing a novel word, selection of a novel object can be explained in terms of activation and suppression of units within the connectionist model, with no need for any inference-based reasoning about the mutual exclusivity of word meanings. This model frames children's disambiguation in terms of the activation of potential meanings, with the most strongly-activated meaning selected as the most likely referent of a word (Kucker, McMurray, & Samuelson, 2015). Here, familiar competitors are ruled out by suppressing the activation of their possible meaning.

Children's novel word disambiguation is therefore likely the result of low-level attentional processes that modulate the activation and suppression of possible word meanings. Thus, factors that influence children's attention can consequently affect their novel word disambiguation. These factors could be extrinsic, such as the salience of the objects. Importantly however, intrinsic factors may also come to bear on children's attention. Kucker and colleagues (2015), suggested that a child's novelty bias is an intrinsic factor that affects novel word disambiguation by driving attention, which impacts on subsequent referent selection. Currently however, any further intrinsic factors that can impact on attention during novel word disambiguation are not well understood. We should therefore begin to more thoroughly examine these factors. Importantly, these factors may then also help predict whether novel word meanings can be learned or not.

Learning Word Meanings

The emergence of the ability to map a novel label onto a novel object appears sometime in the second year of life (Halberda, 2003), and as previously mentioned, such a neat and quick method for working out the meaning of words led many to assume that this behavior could explain children's rapid language acquisition, suggesting that its emergence could explain the so-called vocabulary spurt (e.g. Markman, 1992). Furthermore, given that the ability was understood to be innate, it seemed unlikely that such a seemingly sophisticated ability would be present if it did not serve to support word learning. Thus formation of novel word-object mappings was assumed to also mean learning of novel word-object mappings. More recent work, however has shown that novel word disambiguation and word learning must be considered as related, but separate processes.

One limitation of the argument that novel word disambiguation means word learning has been discussed above, that these abilities do not appear to be innate (McMurray et al., 2012), meaning that there is no need to assume that they hold a special status as word learning mechanisms. Furthermore, computational models of children's vocabulary growth rate show slow initial learning followed by rapid acceleration with no specialized learning mechanisms (McMurray, 2007). Importantly, no theory has yet managed to explain why word-object pairings formed via novel word disambiguation would be so easily learned.

Interestingly, the two seminal works invariably called upon in introductions to papers on novel word disambiguation (this thesis included) specifically stated that being able to decipher a word's meaning does not mean learning from a single exposure. When Quine (1960) imagined his naïve linguist drawing the conclusion that *gavagai* means rabbit, this conclusion is described as "tentative, subject to testing in further cases" (p. 29). Carey and Bartlett (1978) also clearly stated that novel word disambiguation offers "only a small fraction of the total information that will constitute a full learning of the word" (p.18), and the authors coined the separate term *extended mapping* to describe the subsequent processes involved in learning the word.

Issues with the feasibility of novel word disambiguation as driving word learning have also been borne out empirically. Horst and Samuelson (2008) reviewed the state of the art and concluded that the existing literature did not provide strong enough evidence that children's referent selection leads to word learning. The authors argued that although many researchers had successfully shown that children map a novel label to a novel object when all other potential referents are familiar (Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Mervis & Bertrand, 1994; Wilkinson, Ross, & Diamond, 2003), there was little evidence that these newly-formed word-object mappings are then learned. The few studies that did test children's recall of these mappings were, according to Horst and Samuelson (2008), limited because they tested recall after only a small delay (e.g. Dollaghan, 1985), or included a review of object names before test (e.g. Goodman, McDonough, & Brown, 1998). These limitations meant that it could not be concluded whether children's behavior on recall trials reflected their retrieval of the word-object mapping from long term memory, or whether performance on these trials was due to shorter term effects.

Horst and Samuelson (2008) set out to examine whether children learn mappings formed via novel word disambiguation, and in doing so set the standard for subsequent investigations into the behavior. They presented children with a series of *referent selection trials* and *retention trials*. On each referent selection trial, children were presented with one novel and two familiar objects. On each trial, children were then asked to select either a familiar object (e.g. "where's the cup?") or a novel object using a pseudoword (e.g. "where's the cheem?"). Across all referent selection trials, children were presented with eight novel words and their referents. As expected, it was found that children were on average able to indicate that the novel label referred to the novel object.

Horst and Samuelson's (2008) focus however, was on retention trials. These trials were designed to address the inconsistencies and limitations of previous work. Retention trials were presented after a five-minute break, to ensure that performance was due to recall from long-term memory. Children were presented with each novel object as a target, alongside two other previously-seen novel objects, and were asked to select the target using the novel word with which it was paired during referent selection. Thus on each trial, each potential referent had been seen an equal number of times, and each novel label had been heard the same number of times, eliminating the possibility that children could have used salience as a cue. No evidence was found that children could retain the word-object mappings that they had formed during referent selection. The authors concluded that children's referent selection does not lead to retention, but rather that referent selection and retention are governed by different mechanisms.

Much like Quine (1960) and Carey and Bartlett (1978), a number of researchers have recently argued that children's behavior on referent selection and retention trials operate on two different timescales (e.g. Axelsson, Churchley, & Horst, 2012; Bion et al., 2013; McMurray et al., 2012). Competition, as previously discussed, supports children's in-the-moment referent selection, while retention is governed by longer term associative processes. Importantly, this means that the processes supporting referent selection can operate independently of learning.

Conversely, the processes that support word learning can operate independently from the processes underlying referent selection. Smith and Yu (2008) demonstrated that the association between word and object can also be strengthened across repeated exposures, via *cross-situational statistical learning* (CSL; see also Yu & Smith, 2007). Smith and Yu (2008) presented infants with six novel word-object pairings. On each trial, two randomly selected objects were presented side-by-side as their corresponding labels were heard. This process continued for 30 trials, until each novel word-object pairing had been presented ten times. Importantly, on each trial, children were given no explicit cue as to the referent of each novel label. This meant that initially, children had no way of determining which label referred to which object. When tested by presenting each novel object alongside a competitor and recording which object the child looked at following the onset of the novel label, children nonetheless showed that they had learned the word-object mappings. Thus, when no other cue was available, children tracked the co-occurrence of each label with each object across trials to learn which label referred to which object.

Smith and Yu (2008) argued that outside of the lab, cross-situational word learning must play a key role in early language acquisition. In a cluttered real-world environment children do not learn via novel word disambiguation alone, because the number of potential referents is large, which increases the probability that an in-the-moment word-object mapping may be wrong. Therefore, children's reliance on longer-term associative processes to support word learning means that any false word-object associations can be pruned before the correct associations are learned. The role of associative processes in retention also supports Horst and Samuelson's (2008) lack of retention findings and suggests that children require a stronger association between the word and label beyond the association that is formed by referent selection alone.

In contrast to these low-level associative-learning explanations for children's retention of word meaning, some theories describe language acquisition in terms of children's developing social cognitive skills. The most prominent, the social-pragmatic theory, argues that children form hypotheses about and learn the meaning of words by inferring the intentions and referential focus of adults around them (e.g. Bloom, 1997). Baldwin's work led the way in developing a social-pragmatic explanation of children's word learning, demonstrating that 18-month-old children map a word onto an object only if the interactional partner is attending to the object being labeled, but not if the object is present and being touched by the child without being the focus of the labeler's attention (Baldwin et al., 1996).

Yet the social-pragmatic account need not be in competition with associative accounts of word-learning. More recent theories have argued that both explanations likely play a role in children's early language development. For example, Hirsh-Pasek and colleagues (2000) formed an emergentist coalition model of word learning, and building on their earlier lexical principles framework, argued that children make dynamic use of both social and non-social cues to determine the meaning of words. The emergentist coalition model of word learning emphasizes the dynamic nature of children word learning because it acknowledges that the specific combination of cues children rely on to determine and learn word meanings varies across development and across contexts.

The argument that children's word learning informs language learning dynamically across development is also a critical assumption of dynamic systems accounts of children's language development (e.g. Gogate, Walker-Andrews & Bahrick, 2001). Furthermore, proponents of this account have argued that the mechanisms underlying children's use of both social and non-social cues to referent selection can be explained in terms of the same underlying mechanisms. For example, neurocomputational models can reliably capture children's use of social and nonsocial cues to determine the referents of words (McMurray et al., 2012; Samuelson, Smith, Perry & Spencer, 2011), and critically these models can also explain how use of these cues changes over time to inform learning. It thus seems that associative processes are a crucial component of word retention via both social and nonsocial cues.

Unsurprisingly, the mechanisms underlying referent selection and retention can (and do) work together, as demonstrated by the findings that under certain conditions, learning can take place from a single exposure, but only if attention to the target object is somehow heightened (e.g. Horst & Samuelson, 2008). Increased attention to the novel object as it is labeled thus likely strengthens the association between the two. Attention to the target object is therefore crucial in determining whether an association will be formed between the novel object and the novel label. A key implication of this research then is that word learning results from attention to the target, but as previously discussed, heightened attention to the novel object may not be necessary for referent selection (Halberda, 2006).

Horst, Scott and Pollard (2010) neatly demonstrated that disambiguation of the novel word requires less attention to the target than is necessary for the word to be learned. The authors presented children with referent selection trials, but varied the number of competitors presented alongside the target. The number of competitors did not affect children's selection of the novel object as the referent of the novel word, but increasing the number of competitors decreased the likelihood that the novel word was retained. Horst et al. (2010) concluded that increasing the number of competitors weakened the association between the word and the object, because more competitors meant that less attention could be directed to the novel object.

Word learning from referent selection therefore requires attention to be focused on the novel target. Several studies built on this assumption by demonstrating that features of the referent selection task can be manipulated to encourage children to focus on the novel object, supporting the formation of word-object associations so as to allow learning from a single exposure. Axelsson and Horst (2014) repeatedly exposed children to novel word-object pairings, varying whether the same familiar competitors were consistently presented alongside the novel object, or whether different competitors were presented across exposures. The authors found that children retained the novel word-object mappings best when the novel object had been presented with consistent familiar competitors. The authors explained this result by arguing that children could better focus their attention on the novel target in the 'consistent competitor' condition because they did not always need to rule out the competitors as potential referents. This evidence implies that children learn best from referent selection in environments with consistent familiarity. Similarly, Twomey, Ranson & Horst (2014) found that varying the color of the novel object across exposures improved children's retention, instead of repeatedly presenting the same novel object. The assumption here was that moderate variability in the novel object highlights the commonalities between objects, helping children form a robust representation.

In examining the role of extrinsic factors such as competitor novelty and target salience in modulating the link between referent selection and retention, we have thus begun to understand children's word learning from a mechanistic perspective. More recently, there has been some interest in individual differences that can explain variability in children's word learning. In a cross-situational learning task, Yu and Smith (2011) presented children with trials similar to that of Yu and Smith (2008). Children were presented with the same novel word-object pairings on a screen across a number of trials, and on each trial a different novel competitor was displayed next to the novel object. The authors found marked differences in the scanning patterns of children across these trials. Some children showed sustained interest in the target (and increasingly familiar) object as it was displayed across trials, while some children tended to focus more on the novel competitor throughout the experiment. Crucially, children who were better able to focus attention on the target object throughout labeling were better able to retain the novel word-object mappings. This work is a clear and exciting demonstration that individual differences in attention during the labeling of objects can affect children's learning of these word-object mappings.

Yet the mechanisms behind these individual differences in attention are unclear. There are two potential explanations: attention is driven by transient state-based effects (either intrinsic or extrinsic, e.g. noise, fatigue) or longer term intrinsic trait-based effects (e.g. novelty bias), and these two types of effect likely operate in combination. If attentional differences arise from transient state-based effects, errors on referent selection trials should be due to in-the-moment distractions rather than difficulty with the task. However, no reports of referent selection explain whether errors on novel label referent selection trials (typically around 25% of trials are coded as incorrect; Axelsson et al., 2012; Horst & Samuelson, 2008; Horst et al., 2010; Twomey et al., 2014) are due to a few children failing to map the novel label to the novel object on many trials, or many children failing to map the novel label to the novel object on a few trials. There is indeed some evidence that these errors may be caused by consistent individual differences: Wilkinson and colleagues (2003) reported that 25% of children in their sample were classified as unreliable in selecting the novel object as the referent of the novel label.

Insights into the underlying mechanisms of children's novel word disambiguation have come from studies using eye-tracking as a means to examining the time course of children's looking patterns during labeling. These have yielded important insights that serve to support the argument that familiar competitors are crucial in supporting the formation of a novel word-object mapping. Furthermore, recent studies that use looking time measures of children's word learning have shown differences in scanning pattern between children. Halberda (2006) demonstrated that on approximately 50% of trials children were looking at the familiar competitor as the label was heard, while on other trials children were looking at the novel object. Again, there has been no examination of the causes of this variation in looking. While eye-gaze is a notoriously noisy measure (e.g. Morgante, Zolfaghari, & Johnson, 2012), it is possible that certain intrinsic factors can explain some of the variability in looking during referent selection trials. This would mean that these factors could then act as a predictor of word learning.

If children's attention during referent selection were only affected by in-the-moment sources of variability, then children's word learning should be protected from this variability outside of the lab. Specifically, if retention is governed by associative processes that occur across contexts and timeframes, in-the-moment factors affecting attention should be neutralized over repeated encounters of the word-object mapping in situations in which those factors are no longer present. If, however, children's attention during referent selection is affected by enduring trait-based individual differences, then these individual differences could exert an effect on word learning, because they would affect attention across contexts and timeframes, which means that the study of possible enduring individual differences affecting referent selection may explain variability in early language acquisition. These enduring trait-based individual differences in children's behavior are better known as temperament.

Temperament

Theories and discussions of child temperament have typically been characterized by disagreements between researchers, as described in the seminal roundtable report by Goldsmith and colleagues (1987). There are, however, some broad themes of agreement. First, temperament is defined as differences in the behavioral style of the child, which must be understood as distinct from differences in the behavior of the child. While behavior can be shaped by in-the-moment demands and constraints, temperament concerns itself with the behavioral tendencies of the child that affect behavior across contexts. Temperament therefore refers to a collection of behavioral styles, typically termed *dimensions*. Second, the mechanisms behind children's temperament are understood to be biologically-based. This assumption explains why temperament is protected from the effects of extrinsic factors (Buss & Plomin, 1975) and why a child's temperament emerges early, and can be measured soon after birth (Rothbart, 1981). Finally, the behavioral tendencies that characterize a child's temperament are stable throughout childhood, but the relationship between temperament and behavior weakens over time as children mature and learn *coping mechanisms* which can mask the effect of their temperament (Thomas & Chess, 1977).

The source of most disagreement between temperament theorists has been about the specific dimensions that are included within their operationalization of the term. Thomas and Chess (1977) identified nine dimensions (e.g. Rhythmicity, Distractibility) that should be included in a theory of temperament, based on content analyses of parental interviews (see also Thomas & Chess, 1957), but this description of temperament subsequently fell out of favor due to redundancy between the proposed dimensions (Martin, Wisenbaker, & Huttunen, 1994). Buss and Plomin

(1975) described four dimensions of temperament (emotionality, activity, sociability, and impulsivity) and their only criteria for traits to be considered a dimension of temperament were that the trait must be stable, evolutionarily adaptive and present in phylogenetic relatives. Other theorists referred to temperament only as differences in children's emotionality (Goldsmith & Campos, 1982).

Rothbart's (1981) theory of temperament, in which she suggested that stable and enduring differences in emotionality are underpinned by attention and neurobiology, has arguably been the most influential. Rothbart refers to her approach as "bottom up" (Rothbart, Ahadi, Hershey, & Fisher, 2001, p. 1394), in this case taken to mean that the central dimensions that form the concept are theoretically-driven, rather than based upon scales and dimensions created via factor analyses of measured children's behavior. Rothbart (1981) initially described six temperamental dimensions: Activity level, smiling and laughter, fear, distress to limitations, soothability, and duration of orienting. These six dimensions have then been extended in further reports, depending on the age range of the sample (see also Putnam, Gartstein, & Rothbart, 2006).

Rothbart's (1981) approach allows measurement of temperament from infancy to adulthood, and Rothbart's operationalization of the term has become widespread. Rothbart and colleagues have also created a range of questionnaires that can measure temperament, from the age of three months to adulthood. For example, Putnam, Gartstein and Rothbart's (2006) Early Childhood Behavior Questionnaire (ECBQ) measures children's temperament between the ages of 18 and 36 months by asking parents to report on their children's behavior in a range of situations. The ECBQ measures three central domains of temperament: *surgency/extraversion*, *effortful control* and *negative affect*. Each scale is then broken down into constituent subdimensions. Here, the negative affect dimension is key because it is broken down into eight subdimensions, including discomfort, fear and shyness. Shyness has consistently been shown to explain variability in children's verbal ability (Coplan & Evans, 2009), which could also impact on word learning, and will be the focus of the current thesis.

Shyness

Children show individual differences in their approach to novel social situations. Some children show excitement and cheerfulness upon meeting new people and encountering new environments, while others seem to find these experiences more uncomfortable. Children who consistently show discomfort in novel social situations would be considered shy (Kagan & Snidman, 2004; Putnam et al., 2006), and because these behaviors can be enduring and stable, these behaviors are measured in most models of infant temperament (Sanson, Pedlow, Cann, Prior, & Oberklaid, 1996).

Shyness, however, is a complex concept, which has historically led to differences between scholars in their precise operationalization of it. Leary (1986) made a distinction between *feeling shy* and *acting shy*, a distinction that has remained at the heart of the debate about how best to define and measure shyness (e.g. Asendorpf, 1989; Cheek & Melchior, 1990; Crozier, 1990, 1995). Shyness as the subjective experience of feeling shy has come to be understood as the result of anxiety brought about by potential negative social evaluation (R. S. Miller, 1995), while acting shy is understood to be characterized by inhibited or hesitant responses (Pilkonis, 1977).

Being driven by potential negative self-evaluation would mean that the subjective experience of shyness is not present in infants and children younger than four years of age, because they have not yet developed a *social self* (Buss, Iscoe, & Buss, 1979) which is brought about by a distinction between their own and others' feelings and the understanding that others have a different perspective (Buss, 1986). However, acting shy is demonstrable from a much younger age, suggesting that these behaviors are likely not driven by anxiety of negative self-evaluation.

The reported discrepancy between feeling shy and acting shy has led to various attempts to explain the relation between the two. Buss (1986), for example, suggested that we must consider them as two related, but separate types of shyness. More influentially though, others have opted only to examine the behavioral responses typical of shy individuals, using the more general term *behavioral inhibition* (Coll, Kagan, & Reznick, 1984). Behaviorally inhibited children are characterized by cautious and hesitant reactions to novel stimuli (Kagan, Reznick, & Snidman, 1987). An early marker of behavioral inhibition is distress to novelty at the age of four months (Kagan & Snidman, 1991), suggesting that these inhibited responses to novelty are driven by an aversion to the unfamiliar.

Shyness is inhibition specifically to novel *social* stimuli (Kagan, Reznick, Clarke, Snidman, & Garcia-Coll, 1984), and could therefore be considered a subdimension of behavioral inhibition. It is, however, important to note that behavioral inhibition and shyness are subtly different but tightly related, which appears to have led to some ambiguity within the extant literature. Sometimes, the terms behavioral inhibition and shyness have been used interchangeably (Coplan, Prakash, O'Neil, & Armer, 2004). Theories relating to behavioral inhibition have been applied to shyness (e.g. Kagan, Reznick, & Snidman, 1988) and vice versa (e.g. Smith Watts et al., 2014). Others have even coined the term "shy-inhibited" (Prior, Smart, Sanson, & Oberklaid, 2000, p. 461). The discrepancies between terms and definitions mean that the precise implications of the findings from these reports are difficult to collate.

Measurement of behavioral inhibition has also been problematic. Most measure behavioral inhibition by recording children's responses to novel people and to novel objects, before averaging across responses to both types of stimuli to create a behavioral inhibition score (e.g. Calkins & Fox, 1992; Kagan, Reznick, & Gibbons, 1989; Kagan et al., 1987). However, this method of measuring behavioral inhibition means that it is impossible to ascertain whether children were equally inhibited to both social and non-social stimuli and thus it fails to rule out that inhibition to the social stimulus (i.e. shyness) can alone explain any effect. Consequently, the distinction between shyness and behavioral inhibition in past literature is unclear. Despite this, a key contribution of such previous work is that consistently demonstrating inhibited behaviors, or acting shy (Leary, 1986), can be observed from the second year of life (e.g. Kagan, Reznick, Snidman, Gibbons, & Johnson, 1988).

Rothbart and colleagues' (Putnam et al., 2006; Rothbart, 1981, 2007) approach to temperament allows for a clearer operationalization of shyness. In line with work on behavioral inhibition, Rothbart and colleagues suggest that shyness should be measured in terms of behavior specifically in response to novel social stimuli. Individuals who often show discomfort or latency to respond in novel social situations are considered more shy than those who appear more comfortable and at ease in these situations (e.g. Putnam et al., 2006). Rothbart and colleagues' approach is therefore beneficial because its definition of shyness allows for a standardized means of measuring it, shown in their parent-report questionnaire measures of temperament. Putnam et al.'s (2006) parent-report measure of temperament asks parents about children's nonverbal reactions to novel social situations, for example how often they watch rather than join in playing with unfamiliar children.

It should be noted that other reports opt to measure shy-type behaviors online, by observing children in the first five minutes after being introduced to an unfamiliar experimenter (Asendorpf & Meier, 1993; Evans, 1987; Smith Watts et al., 2014). However, parent-report measures of shyness are popular, and arguably a more valid measure of temperament, because they offer an insight into children's behavior across times and contexts (Crozier, 1995; Putnam et al., 2006; Rothbart et al., 2001).

Shyness can be considered a subdimension of temperament given that it is relatively stable throughout childhood (Sanson et al., 1996). The early emergence and enduring nature of shyness is in line with the concept of temperament as a biologically-based individual difference, supported by evidence of psychobiological differences between shy and less-shy individuals (e.g. Gray, 1987; Kagan, 1981; Kagan et al., 1987; Kagan, Snidman, & Arcus, 1998; Kagan & Snidman, 1991; Sloan Wilson, Clark, Coleman, & Dearstyne, 1994). The argument that shyness is biologically-based has been further supported by research which has found that shyness is a moderately heritable trait (Plomin & Daniels, 1986).

More recently, some have called for a move away from a strictly biological model of shyness, to a more nuanced model in which the environment can modulate the child's susceptibility to shyness given certain biological risk-factors (Schmidt & Miskovic, 2013) . For example, sensitive parenting has been shown to moderate children's shyness as development progresses (Coplan, Arbeau, & Armer, 2007), an account that would explain why shyness is only a moderately stable trait. In any case, the current work takes an agnostic stance to the precise origins of shyness, emphasizing only that shyness is an enduring individual difference that modulates children's approach in novel social situations.

Importantly, shyness is measured as distinct from cognitive ability, meaning that while possibly related, children's behavioral style is not measured in terms of their development of cognitive skills. This means that no measures of children's language ability are taken to inform how their shyness is classified. However, one of the most-often observed effects of shyness is on verbal behavior (Crozier, 2000). This suggests that shyness may explain some variability in early language acquisition.

Shyness and Language Acquisition

Effects of shyness on language development have been shown using a number of paradigms. For example, Asendorpf and Meier (1993) recorded shy and less-shy children's vocalizations during a normal day by asking them to wear a small sound recorder, and found that shy children spoke less than less-shy children outside of school time in both familiar and unfamiliar situations. Other measures of children's unprompted speech production have also shown that spoken language is negatively associated with shyness (e.g. Crozier & Badawood, 2009; Evans, 1987). Finally, shyness is negatively correlated with productive vocabulary when measured via parent report checklists of their children's vocabulary (Paul & Kellogg, 1997; Slomkowski, Nelson, Dunn, & Plomin, 1992).

Various theories have been put forward to explain how shyness impacts on language development during early childhood. Based on their finding that shyness affects children's productive vocabulary, but not receptive vocabulary, Smith Watts and colleagues (2014) argued that shyness does not affect children's language learning, but instead leads to a reticence to respond. Such an explanation is supported by other findings that shy children tend to speak less in unfamiliar, but not familiar, settings during school time (Asendorpf & Maier, 1993), and it explains the often-reported scenarios in which shy individuals know an answer to a question but are reluctant to volunteer it as a response (e.g. Harkins, 1990). Furthermore, a reticence-to-respond explanation for shy children's reduced verbal ability could explain why shyness does not seem to affect children's longer-term academic performance (Hughes & Coplan, 2010).

The reticence to respond account does not, however, explain other reports that shyness does impact on receptive vocabulary (Slomkowski et al., 1992; Spere, Schmidt, Theall-Honey, & Martin-Chang, 2004). Furthermore, it cannot be ruled out that an impact of shyness on children's expressive language skills is the result of underlying differences in receptive vocabulary ability. Indeed, alternative explanations make the clear prediction that shyness also affects the processes that children use to acquire language. The *lack of practice makes lack of perfect* (Coplan & Evans, 2009) explanation suggests that shy children's restricted production of language, alongside their discomfort in novel social situations, means that their language acquisition is slowed. We know that the quality (as well as the quantity) of the language heard by children during development is key in determining their acquisition of the language (e.g. Hart & Risley, 2003), and shy children's reduced participation in verbal interaction may reduce the quality and quantity of language that they are exposed to.

A further explanation for the effect of shyness on language acquisition attempts to turn the effect on its head by claiming that shy children's language development does not lag behind. Instead, less-shy children show better than average ability to acquire language. Support for this perspective comes from suggestions that shy children's language development is within the normal range (e.g. Spere et al., 2004). Defining language acquisition as normal or not during the second and third years of life is, however, problematic, because this age is marked by such variability in vocabulary scores (Fenson et al., 1994).

One final explanation for the effect of shyness on language development draws on findings that shy children are characterized as risk-averse (Levin & Hart, 2003). An aversion to risk means that shy children weight the costs of being wrong as higher than the gain of "hazarding a hunch" (Coplan & Evans, 2009, p. 212) as a response to those around them. This means that shy children may be less likely to form hypotheses about the possible meaning of words. While discussed as an explanation for the impact of shyness on language development, such a description seems to fit better as a possible mechanism that may drive one of the other explained accounts.

These explanations for the effect of shyness on early language development offer a sound theoretical framework: that shy children are reticent to respond; that shy children show difficulty acquiring language and that less-shy children have an advantage in learning language. There is also no need for these explanations to be mutually exclusive: it is possible that each explanation offers an insight into certain aspects of language development. We still cannot, however, conclude that shyness impairs children's language acquisition, as well as their language production. Previous research has focused mainly on productive vocabulary measures (Asendorpf & Meier, 1993; Coplan, 2000; Crozier & Badawood, 2009; Crozier & Perkins, 2002; Spere, Evans, Hendry, & Mansell, 2009) and thus it has been difficult to tease apart any effects of shyness on receptive language skills, especially given the conflicting findings based on parent-report measures (Smith Watts et al., 2014; Spere et al., 2004). It is here argued that when viewed in light of our understanding of children's word learning, it is likely that shyness affects the processes by which children disambiguate and learn the meaning of words. The effect of shyness on children's language development may therefore also be explained in terms of these processes.

Thesis Aims

This review raises important questions that the current thesis aims to address. The current work will investigate whether shyness affects word learning by modulating children's attention during referent selection, which impacts on retention of novel word-object mappings. To do this, this thesis will present both behavioral measures of word learning and fine-grained time course analyses of children's eye-gaze during object labeling.

Paper 1 will examine whether shyness affects retention of novel word object-mappings formed during referent selection on a typical experimenter-led "fast mapping" task. The finding that shyness affects referent selection and retention would highlight the interconnected and dynamic nature of typically disparate areas of research (i.e. word learning and temperament). It would also suggest that variability in children's referent selection can explain variability in language acquisition, because shyness would impact on the associative processes that support word learning across exposures to novel word-object mappings.

Paper 2 will then examine the mechanisms underlying the effect of shyness on referent selection and retention, and will do so by examining whether shy children's aversion to novel social situations can explain any effect of shyness on referent selection and retention. Shy children's aversion to novelty is defined in terms of novel people and situations (Asendorpf, 1990; Kagan & Moss, 1962; Kagan et al., 1987; Putnam et al., 2006), and this may disrupt children's referent selection. The majority of investigations of referent selection employ lab-based tasks run by an experimenter

(Axelsson et al., 2012; Horst & Samuelson, 2008; Twomey et al., 2014). These previous lab-based tasks took place in an environment characterized by unfamiliarity: an unfamiliar experimenter, an unfamiliar room and unfamiliar stimuli. Shy children may therefore be prone to attend more to environmental aspects which would limit the attention that could be directed to disambiguating the novel label. Paper 2 therefore examines the effect of shyness on referent selection and retention in an environment designed to be more familiar to children than in Paper 1.

Any effect of these implicit processes of word disambiguation are difficult to glean from behavioral tasks, so Papers 3 and 4 therefore use eye-tracking technology to examine whether shyness affects children's looking pattern across the array of objects on a referent selection task. In Paper 3, eye-gaze analyses will be used to examine whether the relation between shyness and aversion to novelty (Rothbart, 1988) and to risk (Levin & Hart, 2003) leads to an effect of shyness on children's attention to the objects presented on word learning trials. This paper aims to break new ground by being one of the first to examine children's eye-gaze using an eye-tracker on typical referent selection trials with two familiar competitors. Paper 3 also aims to analyze whether differences in looking during referent selection can predict retention.

Paper 4 aims to draw the findings of Papers 1, 2 and 3 together by tracking children's gaze as they are presented with referent selection trials on which an onscreen actor looks at and labels the target object. This will allow an examination of the effect of novel social stimuli (i.e. an unfamiliar adult) on children's attention during referent selection. Paper 4 also aims to analyze whether differences in looking during referent selection can predict retention.

Overall, while we know that shyness can explain some variability in children's vocabulary size, we do not know the precise mechanism by which shyness exerts this effect. The current work thus aims to take current understanding about the processes by which children learn words (McMurray et al., 2012) and examine whether shyness affects these processes, which could explain the impact of shyness on children's language development. In doing so, the current work thus tries to shed light on recent arguments that children's referent selection does not impact on word learning (Bion et al., 2013), by demonstrating that enduring individual differences in attention driven by shyness may consistently impact on children's referent selection, which could thus affect their retention of the newly formed word-object mappings.

References

Adolph, K. E., & Eppler, M. A. (1998). Development of visually guided locomotion. *Ecological Psychology*, *10*(3-4), 303–321. http://doi.org/10.1080/10407413.1998.9652687

Asendorpf, J. B. (1989). Shyness as a final common pathway for two different kinds of inhibition. *Journal of Personality and Social Psychology*, *57*(3), 481–492. http://doi.org/10.1037/0022-3514.57.3.481

Asendorpf, J. B. (1990). Development of inhibition during childhood: Evidence for situational specificity and a two-factor model. *Developmental Psychology*, *26*(5), 721–730. http://doi.org/10.1037/0012-1649.26.5.721

Asendorpf, J. B., & Meier, G. H. (1993). Personality effects on children's speech in everyday life: Sociability-mediated exposure and shyness-mediated reactivity to social situations. *Journal of Personality and Social Psychology*, *64*(6), 1072–1083. http://doi.org/10.1037/0022-3514.64.6.1072

Axelsson, E. L., Churchley, K., & Horst, J. S. (2012). The right thing at the right time: why ostensive naming facilitates word learning. *Frontiers in Psychology*, *3*, 88. http://doi.org/10.3389/fpsyg.2012.00088

Axelsson, E. L., & Horst, J. S. (2014). Contextual repetition facilitates word learning via fast mapping. *Acta Psychologica*, *152*, 95–99. http://doi.org/10.1016/j.actpsy.2014.08.002

Baldwin, D., Markman, E., Bill, B., Desjardins, R., Irwin, J., & Tidball, G. (1996). Infants' reliance on a social criterion for establishing word-object relations. *Child Development,67*(6), 3135-3153. http://doi.org/10.2307/1131771

Bion, R. A. H., Borovsky, A., & Fernald, A. (2013). Fast mapping, slow learning: Disambiguation of novel word–object mappings in relation to vocabulary learning at 18, 24, and 30 months. *Cognition*, *126*(1), 39–53. http://doi.org/10.1016/j.cognition.2012.08.008

Bloom, L. (1973). *One word at a time*. The Hague: Mouton.

Bloom, P. (1997). Intentionality and word learning. *Trends in Cognitive Sciences, 1*(1), 9-12. http://doi.org/10.1016/S1364-6613(97)01006-1

Brooks-Gunn, J., Rouse, C. E., & McLanahan, S. (2005). Introducing the issue. *Future of Children*, *15*(1), 5–13.

Buss, A. H. (1986). A theory of shyness. In W. H. Jones, J. M. Cheek, & S. R. Briggs (Eds.), *Shyness: Perspectives on research and treatment* (pp. 39–46). Boston, MA: Springer US. Retrieved from http://dx.doi.org/10.1007/978-1-4899-0525-3_4

Buss, A. H., Iscoe, I., & Buss, E. H. (1979). The development of embarrassment. *Journal of Psychology*, *103*(2), 227.

Buss, A. H., & Plomin, R. (1975). *A temperament theory of personality development*. New York, NY: Wiley.

Calkins, S. D., & Fox, N. A. (1992). The relations among infant temperament, security of attachment, and behavioral inhibition at twenty-four months. *Child Development*, *63*(6), 1456–1472. http://doi.org/10.1111/j.1467-8624.1992.tb01707.x

Carey, S. (1978). The child as word learner. In M. Halle, J. Bresnan, & G. Miller (Eds.), *Linguistic theory and psychological reality*. Cambridge, MA: MIT Press.

Carey, S., & Bartlett, E. (1978). Acquiring a Single New Word (Vol. 15, pp. 17–29). Presented at the Proceedings of the Stanford Child Language Conference.

Cheek, J. M., & Melchior, L. A. (1990). Shyness, Self-Esteem, and Self-Consciousness. In H. Leitenberg (Ed.), *Handbook of Social and Evaluation Anxiety* (pp. 47–82). Boston, MA: Springer US. Retrieved from http://dx.doi.org/10.1007/978-1-4899-2504-6_3

Clark, E. V. (1990). On the pragmatics of contrast. *Journal of Child Language*, *17*(02), 417–431. http://doi.org/10.1017/S0305000900013842

Cohen, L. B., & Cashon, C. H. (2001). Do 7-month-old infants process independent features or facial configurations? *Infant and Child Development*, *10*(1-2), 83–92. http://doi.org/10.1002/icd.250

Coll, C. G., Kagan, J., & Reznick, J. S. (1984). Behavioral inhibition in young children. *Child Development*, *55*(3), 1005–1019. http://doi.org/10.2307/1130152

Coplan, R. J. (2000). Assessing nonsocial play in early childhood: Conceptual and methodological approaches. *Play Diagnosis and Assessment (2nd Ed.)*, 563–598.

Coplan, R. J., Arbeau, K. A., & Armer, M. (2007). Don't fret, be supportive! Maternal characteristics linking child shyness to psychosocial and school adjustment in kindergarten. *Journal of Abnormal Child Psychology*, *36*(3), 359–371. http://doi.org/10.1007/s10802-007-9183-7

Coplan, R. J., & Evans, M. A. (2009). At a loss for words? Introduction to the special issue on shyness and language in childhood. *Infant and Child Development*, *18*(3), 211–215. http://doi.org/10.1002/icd.620

Coplan, R. J., Prakash, K., O'Neil, K., & Armer, M. (2004). Do you "want" to play? distinguishing between conflicted shyness and social disinterest in early childhood. *Developmental Psychology*, *40*(2), 244–258. http://doi.org/10.1037/0012-1649.40.2.244

Crozier, W. R. (1990). Social psychological perspectives on shyness, embarrassment and shame. In W. R. Crozier (Ed.), *Shyness and Embarrassment: Perspectives from Social Psychology* (pp. 19–59). Cambridge, England: Cambridge University Press.

Crozier, W. R. (1995). Shyness and self-esteem in middle childhood. *British Journal of Educational Psychology*, *65*(1), 85–95. http://doi.org/10.1111/j.2044-8279.1995.tb01133.x

Crozier, W. R. (2000). Shyness and social relationships: Continuity and change. In W. R. Crozier (Ed.), *Shyness: Development, Consolidation and Change* (pp. 22–29). London, UK: Routledge.

Crozier, W. R., & Badawood, A. (2009). Shyness, vocabulary and children's reticence in Saudi Arabian preschools. *Infant and Child Development*, *18*(3), 255–270. http://doi.org/10.1002/icd.623

Crozier, W. R., & Perkins, P. (2002). Shyness as a factor when assessing children. *Educational Psychology in Practice*, *18*(3), 239–244. http://doi.org/10.1080/0266736022000010267

Dale, P. S., & Fenson, L. (1996). Lexical development norms for young children. *Behavior Research Methods, Instruments, & Computers*, *28*(1), 125–127. http://doi.org/10.3758/BF03203646

Dale, P. S., Price, T. S., Bishop, D. V. M., & Plomin, R. (2003). Outcomes of early language delay. Predicting persistent and transient language difficulties at 3 and 4 years. *Journal of Speech, Language, and Hearing Research*, *46*(3), 544–560. http://doi.org/10.1044/1092-4388(2003/044)

Desmarais, C., Sylvestre, A., Meyer, F., Bairati, I., & Rouleau, N. (2010). Three profiles of language abilities in toddlers with an expressive vocabulary delay: Variations on a theme. *Journal of Speech, Language, and Hearing Research*, *53*(3), 699–709. http://doi.org/10.1044/1092-4388(2009/07-0245)

Dollaghan, C. (1985). Child meets word "fast mapping" in preschool children. *Journal of Speech, Language, and Hearing Research*, *28*(3), 449–454. http://doi.org/10.1044/jshr.2803.454

Evans, M. A. (1987). Discourse characteristics of reticent children. *Applied Psycholinguistics*, *8*(02), 171–184. http://doi.org/10.1017/S0142716400000199

Feldman, H. M., Dollaghan, C. A., Campbell, T. F., Kurs-Lasky, M., Janosky, J. E., & Paradise, J. L. (2000). Measurement properties of the Macarthur Communicative Development Inventories at ages one and two years. *Child Development*, *71*(2), 310–322. http://doi.org/10.1111/1467-8624.00146

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., … Stiles, J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, *59*(5), i–185. http://doi.org/10.2307/1166093

Fernald, A., Marchman, V. A., & Weisleder, A. (2013). SES differences in language processing skill and vocabulary are evident at 18 months. *Developmental Science*, *16*(2), 234–248. http://doi.org/10.1111/desc.12019

Gogate, L. J., Walker-Andrews, A. S. & Bahrick, L. E. (2001), The intersensory origins of word-comprehension: an ecological–dynamic systems view. *Developmental Science, 4*, 1-18. http://doi.org/10.1111/1467-7687.00143

Goldfield, B. A., & Reznick, J. S. (1990). Early lexical acquisition: rate, content, and the vocabulary spurt. *Journal of Child Language*, *17*(01), 171–183. http://doi.org/10.1017/S0305000900013167

Goldsmith, H. H., Buss, A. H., Plomin, R., Rothbart, M. K., Thomas, A., Chess, S., McCall, R. B. (1987). Roundtable: What is temperament? Four approaches. *Child Development*, *58*(2), 505.

Goldsmith, H. H., & Campos, J. J. (1982). Toward a theory of infant temperament. In R. N. Emde & R. J. Harmon (Eds.), *the development of attachment and affiliative systems* (pp. 161–193). Boston, MA: Springer US. Retrieved from http://dx.doi.org/10.1007/978-1-4684-4076-8_13

Golinkoff, R. M., Hirsh-Pasek, K., Bailey, L. M., & Wenger, N. R. (1992). Young children and adults use lexical principles to learn new nouns. *Developmental Psychology*, *28*(1), 99–108. http://doi.org/10.1037/0012-1649.28.1.99

Golinkoff, R. M., Mervis, C. B., & Hirsh-Pasek, K. (1994). Early object labels: the case for a developmental lexical principles framework. *Journal of Child Language*, *21*(01), 125–155. http://doi.org/10.1017/S0305000900008692

Goodman, J. C., McDonough, L., & Brown, N. B. (1998). The role of semantic context and memory in the acquisition of novel nouns. *Child Development*, *69*(5), 1330–1344. http://doi.org/10.2307/1132269

Gray, J. A. (1987). Perspectives on anxiety and impulsivity: A commentary. *Journal of Research in Personality*, *21*(4), 493–509. http://doi.org/10.1016/0092-6566(87)90036-5

Halberda, J. (2003). The development of a word-learning strategy. *Cognition*, *87*(1), B23–B34. http://doi.org/10.1016/S0010-0277(02)00186-5

Halberda, J. (2006). Is this a dax which I see before me? Use of the logical argument disjunctive syllogism supports word-learning in children and adults. *Cognitive Psychology*, *53*(4), 310–344. http://doi.org/10.1016/j.cogpsych.2006.04.003

Harkins, J. (1990). Shame and shyness in the aboriginal classroom: A case for "practical semantics." *Australian Journal of Linguistics*, *10*(2), 293–306. http://doi.org/10.1080/07268609008599445

Hart, B., & Risley, T. R. (2003). The early catastrophe: The 30 million word gap by age 3. *American Educator*, *27*(1), 4–9.

Hernandez, D. J., Denton, N. A., & Macartney, S. E. (2007). Young hispanic children in the 21st century. *Journal of Latinos and Education*, *6*(3), 209–228. http://doi.org/10.1080/15348430701312859

Hilbert, D. D., & Eis, S. D. (2013). Early intervention for emergent literacy development in a collaborative community pre-kindergarten. *Early Childhood Education Journal*, *42*(2), 105–113. http://doi.org/10.1007/s10643-013-0588-3

Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., … Suma, K. (2015). the contribution of early communication quality to low-income children's language success. *Psychological Science*, *26*(7), 1071–1083.

Hirsh-Pasek, K., Golinkoff, R. M., & Hollich, G. (2000). An emergentist coalition model for word learning: mapping words to objects is a product of the interaction of multiple cues. In R. M. Golinkoff & K. Hirsh-Pasek (Eds.), *Becoming a word learner: a debate on lexical acquisition*. New York, NY: Oxford Press.

Hoff-Ginsberg, E. (1991). Mother-child conversation in different social classes and communicative settings. *Child Development*, *62*(4), 782–796. http://doi.org/10.1111/j.1467-8624.1991.tb01569.x

Horst, J. S., Parsons, K. L., & Bryan, N. M. (2011). Get the story straight: Contextual repetition promotes word learning from storybooks. *Frontiers in Psychology*, *2*, 17. http://doi.org/10.3389/fpsyg.2011.00017

Horst, J. S., & Samuelson, L. K. (2008). Fast mapping but poor retention by 24-month-old infants. *Infancy*, *13*(2), 128–157. http://doi.org/10.1080/15250000701795598

Horst, J. S., Scott, E. J., & Pollard, J. A. (2010). The role of competition in word learning via referent selection. *Developmental Science*, *13*(5), 706–713. http://doi.org/10.1111/j.1467-7687.2009.00926.x

Houston-Price, C., Plunkett, K., & Harris, P. (2005). Word learning wizardry at 1;6. *Journal of Child Language*, *32*(01), 175–189. http://doi.org/10.1017/S0305000904006610

Hughes, K., & Coplan, R. J. (2010). Exploring processes linking shyness and academic achievement in childhood. *School Psychology Quarterly*, *25*(4), 213–222. http://doi.org/10.1037/a0022070

Johnson, K. E., & Mervis, C. B. (1997). First steps in the emergence of verbal humor: A case study. *Infant Behavior and Development*, *20*(2), 187–196. http://doi.org/10.1016/S0163-6383(97)90021-7

Kagan, J. (1981). *The second year*. Cambridge, MA: Harvard University Press.

Kagan, J., & Moss, H. A. (1962). *Birth to maturity: A study in psychological development*. Ann Arbor, MI: Yale University Press.

Kagan, J., Reznick, J. S., Clarke, C., Snidman, N., & Garcia-Coll, C. (1984). Behavioral inhibition to the unfamiliar. *Child Development*, *55*(6), 2212–2225. http://doi.org/10.2307/1129793

Kagan, J., Reznick, J. S., & Gibbons, J. (1989). Inhibited and uninhibited types of children. *Child Development*, *60*(4), 838–845. http://doi.org/10.2307/1131025

Kagan, J., Reznick, J., & Snidman, N. (1988). Biological bases of childhood shyness. *Science*, *240*(4849), 167–171.

Kagan, J., Reznick, J. S., & Snidman, N. (1987). The physiology and psychology of behavioral inhibition in children. *Child Development*, *58*(6), 1459–1473. http://doi.org/10.2307/1130685

Kagan, J., Reznick, J. S., Snidman, N., Gibbons, J., & Johnson, M. O. (1988). Childhood Derivatives of inhibition and lack of inhibition to the unfamiliar. *Child Development*, *59*(6), 1580–1589. http://doi.org/10.2307/1130672

Kagan, J., & Snidman, N. (1991). Temperamental factors in human development. *American Psychologist*, *46*(8), 856–862. http://doi.org/10.1037/0003-066X.46.8.856

Kagan, J., & Snidman, N. (2004). *The long shadow of temperament*. Cambridge, MA: Harvard University Press.

Kagan, J., Snidman, N., & Arcus, D. (1998). Childhood derivatives of high and low reactivity in infancy. *Child Development*, *69*(6), 1483–1493. http://doi.org/10.1111/j.1467-8624.1998.tb06171.x

Karmiloff-Smith, A. (1998). Development itself is the key to understanding developmental disorders. *Trends in Cognitive Sciences*, *2*(10), 389–398. http://doi.org/10.1016/S1364-6613(98)01230-3

Kelly, D. J. (1998). A clinical synthesis of the “late talker” literature implications for service delivery. *Language, Speech, and Hearing Services in Schools*, *29*(2), 76–84. http://doi.org/10.1044/0161-1461.2902.76

Kucker, S. C., McMurray, B., & Samuelson, L. K. (2015). Slowing down fast mapping: Redefining the dynamics of word learning. *Child Development Perspectives*, *9*(2), 74–78. http://doi.org/10.1111/cdep.12110

Leary, M. R. (1986). Affective and behavioral components of shyness. In W. H. Jones, J. M. Cheek, & S. R. Briggs (Eds.), *Shyness: Perspectives on research and treatment* (pp. 27–38). Boston, MA: Springer US. Retrieved from http://dx.doi.org/10.1007/978-1-4899-0525-3_3

Levin, I. P., & Hart, S. S. (2003). Risk preferences in young children: early evidence of individual differences in reaction to potential gains and losses. *Journal of Behavioral Decision Making*, *16*(5), 397–413. http://doi.org/10.1002/bdm.453

Lifter, K., & Bloom, L. (1989). Object knowledge and the emergence of language. *Infant Behavior and Development*, *12*(4), 395–423. http://doi.org/10.1016/0163-6383(89)90023-4

Mareschal, D., Johnson, M. H., Sirois, S., Spratling, M., Thomas, M. S. C., & Westermann, G. (2007). *Neuroconstructivism - I: How the Brain Constructs Cognition*. Oxford: OUP Oxford.

Markman, E. M. (1992). Constraints on word learning: Speculation about their nature, origins and word specificity. In M. Gunnar & M. Maratsos (Eds.), *Modularity and constraints in language and cognition*. Hillsdale, NJ: Erlbaum.

Markman, E. M. (1994). Constraints on word meaning in early language acquisition. *Lingua*, *92*, 199–227. http://doi.org/10.1016/0024-3841(94)90342-5

Markman, E. M., & Wachtel, G. F. (1988). Children's use of mutual exclusivity to constrain the meanings of words. *Cognitive Psychology*, *20*(2), 121–157. http://doi.org/10.1016/0010-0285(88)90017-5

Martin, R. P., Wisenbaker, J., & Huttunen, M. (1994). Review of factor analytic studies of temperament measures based on the Thomas-Chess structural model: Implications for the Big Five. In C. F. Halverson, G. A. Kohnstamm, & R. P. Martin (Eds.), *The developing structure of temperament and personality from infancy to adulthood* (pp. 157–172). Hillsdale, NJ.

Mayor, J., & Plunkett, K. (2010). A neurocomputational account of taxonomic responding and fast mapping in early word learning. *Psychological Review*, *117*(1), 1–31. http://doi.org/10.1037/a0018130

McMurray, B. (2007). Defusing the childhood vocabulary explosion. *Science*, *317*(5838), 631–631. http://doi.org/10.1126/science.1144073

McMurray, B., Horst, J. S., & Samuelson, L. K. (2012). Word learning emerges from the interaction of online referent selection and slow associative learning. *Psychological Review*, *119*(4), 831–877. http://doi.org/10.1037/a0029872

Mervis, C. B., & Bertrand, J. (1994). Acquisition of the Novel Name–Nameless Category (N3C) Principle. *Child Development*, *65*(6), 1646–1662. http://doi.org/10.1111/j.1467-8624.1994.tb00840.x

Mervis, C. B., Golinkoff, R. M., & Bertrand, J. (1994). Two-year-olds readily learn multiple labels for the same basic-level category. *Child Development*, *65*(4), 1163–1177. http://doi.org/10.1111/j.1467-8624.1994.tb00810.x

Miller, G. A., & Gildea, P. M. (1994). How children learn words. In V. P. Clark, P. A. Eschholz, & A. F. Rosa (Eds.), *Language: Introductory Readings* (pp. 139–

147). London: Macmillan Education UK. Retrieved from http://dx.doi.org/10.1007/978-1-349-13421-2_8

Miller, R. S. (1995). On the nature of embarrassabllity: Shyness, social evaluation, and social skill. *Journal of Personality*, *63*(2), 315–339. http://doi.org/10.1111/j.1467-6494.1995.tb00812.x

Morgante, J. D., Zolfaghari, R., & Johnson, S. P. (2012). A critical test of temporal and spatial accuracy of the Tobii T60XL Eye Tracker. *Infancy*, *17*(1), 9–32. http://doi.org/10.1111/j.1532-7078.2011.00089.x

Ninio, A. (1995). Expression of communicative intents in the single-word period and the vocabulary spurt. In *Children's Language* (Vol. Volume 8, pp. 103–126). Hove, UK: Lawrence Erlbaum Associates.

Paul, R., & Kellogg, L. (1997). Temperament in late talkers. *Journal of Child Psychology and Psychiatry*, *38*(7), 803–811. http://doi.org/10.1111/j.1469-7610.1997.tb01598.x

Pilkonis, P. A. (1977). The behavioral consequences of shyness. *Journal of Personality*, *45*(4), 596.

Plomin, R., & Daniels, D. (1986). Genetics and shyness. In W. H. Jones, J. M. Cheek, & S. R. Briggs (Eds.), *Shyness: Perspectives on research and treatment* (pp. 63–80). Boston, MA: Springer US. Retrieved from http://dx.doi.org/10.1007/978-1-4899-0525-3_6

Prior, M., Smart, D., Sanson, A., & Oberklaid, F. (2000). Does shy-inhibited temperament in childhood lead to anxiety problems in adolescence? *Journal of the American Academy of Child & Adolescent Psychiatry*, *39*(4), 461–468. http://doi.org/10.1097/00004583-200004000-00015

Putnam, S. P., Gartstein, M. A., & Rothbart, M. K. (2006). Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior Questionnaire. *Infant Behavior and Development*, *29*(3), 386–401. http://doi.org/10.1016/j.infbeh.2006.01.004

Quine, W. V. O. (1960). *Word & Object*. The MIT Press.

Rescorla, L. (1989). The Language Development Survey: A screening tool for delayed language in toddlers. *Journal of Speech and Hearing Disorders*, *54*(4), 587–599. http://doi.org/10.1044/jshd.5404.587

Reznick, J. S., & Goldfield, B. A. (1992). Rapid change in lexical development in comprehension and production. *Developmental Psychology*, *28*(3), 406–413. http://doi.org/10.1037/0012-1649.28.3.406

Rothbart, M. K. (1981). Measurement of temperament in infancy. *Child Development*, *52*(2), 569–578. http://doi.org/10.2307/1129176

Rothbart, M. K. (1988). Temperament and the development of inhibited approach. *Child Development*, *59*(5), 1241–1250. http://doi.org/10.2307/1130487

Rothbart, M. K. (2007). Temperament, Development, and Personality. *Current Directions in Psychological Science*, *16*(4), 207–212. http://doi.org/10.1111/j.1467-8721.2007.00505.x

Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of temperament at three to seven years: The Children's Behavior Questionnaire. *Child Development*, *72*(5), 1394–1408. http://doi.org/10.1111/1467-8624.00355

Rowe, M. L. (2008). Child-directed speech: relation to socioeconomic status, knowledge of child development and child vocabulary skill. *Journal of Child Language*, *35*(01), 185–205. http://doi.org/10.1017/S0305000907008343

Rowe, M. L., Özçalışkan, Ş., & Goldin-Meadow, S. (2008). Learning words by hand: Gesture's role in predicting vocabulary development. *First Language*, *28*(2), 182–199.

Rule, A. C., & Stewart, R. A. (2002). Effects of practical life materials on kindergartners' fine motor skills. *Early Childhood Education Journal*, *30*(1), 9–13. http://doi.org/10.1023/A:1016533729704

Samuelson, L. K, Smith, L. B, Perry, L., K & Spencer, J. P. (2011) Grounding word learning in space. *PLoS ONE 6(12)*, e28095. http://doi.org/1010.1371/journal.pone.0028095

Sanson, A., Pedlow, R., Cann, W., Prior, M., & Oberklaid, F. (1996). Shyness ratings: Stability and correlates in early childhood. *International Journal of Behavioral Development*, *19*(4), 705–724.

Scarborough, H. S., & Dobrich, W. (1994). On the efficacy of reading to preschoolers. *Developmental Review*, *14*(3), 245–302. http://doi.org/10.1006/drev.1994.1010

Schmidt, L. A., & Miskovic, V. (2013). a new perspective on temperamental shyness: differential susceptibility to endoenvironmental influences. *Social and Personality Psychology Compass*, *7*(3), 141–157. http://doi.org/10.1111/spc3.12014

Sloan Wilson, D., Clark, A. B., Coleman, K., & Dearstyne, T. (1994). Shyness and boldness in humans and other animals. *Trends in Ecology & Evolution*, *9*(11), 442–446. http://doi.org/10.1016/0169-5347(94)90134-1

Slomkowski, C. L., Nelson, K., Dunn, J., & Plomin, R. (1992). Temperament and language: Relations from toddlerhood to middle childhood. *Developmental Psychology*, *28*(6), 1090–1095. http://doi.org/10.1037/0012-1649.28.6.1090

Smith, L. B., & Yu, C. (2008). Infants rapidly learn word-referent mappings via cross-situational statistics. *Cognition*, *106*(3), 1558–1568. http://doi.org/10.1016/j.cognition.2007.06.010

Smith Watts, A. K., Patel, D., Corley, R. P., Friedman, N. P., Hewitt, J. K., Robinson, J. L., & Rhee, S. H. (2014). Testing alternative hypotheses regarding the association between behavioral inhibition and language development in toddlerhood. *Child Development*, *85*(4), 1569–1585. http://doi.org/10.1111/cdev.12219

Spencer, J. P., Clearfield, M., Corbetta, D., Ulrich, B., Buchanan, P., & Schöner, G. (2006). Moving toward a Grand Theory of Development: In memory of Esther Thelen. *Child Development*, *77*(6), 1521–1538. http://doi.org/10.1111/j.1467-8624.2006.00955.x

Spere, K. A., Evans, M. A., Hendry, C.-A., & Mansell, J. (2009). Language skills in shy and non-shy preschoolers and the effects of assessment context. *Journal of Child Language*, *36*(01), 53–71. http://doi.org/10.1017/S0305000908008842

Spere, K. A., Schmidt, L. A., Theall-Honey, L. A., & Martin-Chang, S. (2004). Expressive and receptive language skills of temperamentally shy preschoolers. *Infant and Child Development*, *13*(2), 123–133. http://doi.org/10.1002/icd.345

Starkey, P., & Cooper, R. G. (1995). The development of subitizing in young children. *British Journal of Developmental Psychology*, *13*(4), 399–420. http://doi.org/10.1111/j.2044-835X.1995.tb00688.x

Stromswold, K. (2001). The heritability of language: a review and metaanalysis of twin, adoption, and linkage studies. *Language*, *77*(4), 647–723. http://doi.org/10.2307/3086845

Thiessen, E. D., Hill, E. A., & Saffran, J. R. (2005). Infant-directed speech facilitates word segmentation. *Infancy*, *7*(1), 53–71. http://doi.org/10.1207/s15327078in0701_5

Thomas, A., & Chess, S. (1957). An approach to the study of sources of individual differences in child behavior. *Journal of Clinical and Experimental Psychopathology*, *18*(4), 347–357.

Thomas, A., & Chess, S. (1977). *Temperament and development.* Oxford, England: Brunner/Mazel.

Twomey, K. E., Ranson, S. L., & Horst, J. S. (2014). That's more like it: multiple exemplars facilitate word learning. *Infant and Child Development*, *23*(2), 105–122. http://doi.org/10.1002/icd.1824

Whitehurst, G. J., & Fischel, J. E. (1994). Practitioner review: Early developmental language delay: What if anything should the clinician do about it? *Journal of Child Psychology and Psychiatry*, *35*(4), 613–648. http://doi.org/10.1111/j.1469-7610.1994.tb01210.x

Wilkinson, K. M., Ross, E., & Diamond, A. (2003). Fast mapping of multiple words: Insights into when "the information provided" does and does not equal "the information perceived." *Journal of Applied Developmental Psychology*, *24*(6), 739–762. http://doi.org/10.1016/j.appdev.2003.09.006

Yu, C., & Smith, L. B. (2007). Rapid word learning under uncertainty via cross-situational statistics. *Psychological Science*, *18*(5), 414–420. http://doi.org/10.1111/j.1467-9280.2007.01915.x

Yu, C., & Smith, L. B. (2011). What you learn is what you see: using eye movements to study infant cross-situational word learning. *Developmental Science*, *14*(2), 165–180. http://doi.org/10.1111/j.1467-7687.2010.00958.x

Shy Children's Formation and Retention of Novel Word-Object Mappings

Matt Hilton and Gert Westermann

Lancaster University

Author Note

A version of this paper is currently under review:
Hilton & Westermann (under review). Shy children's formation and retention of novel word-object mappings. *Journal of Child Language.*

Abstract

This study examined the effect of shyness on the processes that underlie early word learning. Shy and less-shy 24-month-old children (*N*=32) were presented with sets of one novel and two familiar objects. When asked to select a familiar object by name, shy children did so less often than less-shy children. When asked for a novel pseudoword, only less-shy children reliably selected the novel object, whereas shy children responded at chance level. Only less-shy children then showed evidence of retaining these novel mappings. These findings demonstrate that shyness affects children's language development by affecting the disambiguation and retention of a word's meaning.

Shy Children's Formation and Retention of Novel Word-Object Mappings

In learning language, pre-verbal children face a challenging task. Not only must they work out what the words they hear mean, but they must also remember these words and their referents. Given the complexity of the speech that children hear and the limitless potential meanings of the words this task seems almost impossible (Quine, 1960), and there has been much interest in the general mechanisms by which children are able to learn words. For example, children constrain the potential meaning of words they hear according to the shape (Landau, Smith & Jones, 1988) and taxonomic category (Markman & Hutchinson, 1984) of potential referents. Constraining the potential meaning of heard words in these ways is the first step towards successful word learning (McMurray, Horst & Samuelson, 2012).

While a focus on these general mechanisms has helped to better understand the processes by which children acquire language, the vast variability in early language development must also be more thoroughly examined. At the age of 2, the number of different words that a child can typically produce as reported by parents can range from 7 to 668 (Dale & Fenson, 1996), and a similarly wide range is demonstrated in 2-year-old children's spontaneous speech production (Huttenlocher, Haight, Bryk, Seltzer & Lyons, 1991). Nevertheless, the large majority of children with low productive vocabularies will go on to develop language normally (Desmarais et al., 2008; Kelly, 1998; Whitehurst & Fischel, 1994).

Variability in vocabulary scores has been traditionally explored by examining the extrinsic factors that can serve to affect a child's vocabulary, with a particular focus on the effect that socioeconomic status (SES) can have on vocabulary growth. American English speaking children from poorer backgrounds are consistently shown to have lower vocabularies than their better-off peers (Evans, 2004), an effect also found in other countries, such as the United Kingdom (Feinstein, 2003), and in non-English speaking American groups, such as Spanish speakers (Hurtado, Marchman & Fernald, 2007). The parental investment model (e.g. Brooks-Gunn & Duncan, 1997) claims that higher-SES children benefit from parental investment in education, housing, nutrition and so on, and such investment can lead to a language input of greater quantity and higher quality. While it has long been known that children from poorer backgrounds are exposed to about 30 million fewer words by age three than those from better-off backgrounds (Hart & Risely, 1995), more recent research has shown that the quality of this language exposure is also important (Hoff, Loursen & Tardif, 2002).

While extrinsic factors such as SES can affect the language development of the child by moderating the quality and the quantity of language input, there have also been calls for an examination of the intrinsic factors that affect cognitive development (Mareschal et al., 2007). Children's behavioral styles vary widely, yet the effect of these variations is often neglected in explaining language development. One intrinsic factor that has been shown to affect early language acquisition is temperament, and more specifically, shyness.

There have been many attempts to operationalize the construct of shyness in young children. From general constructs such as behavioral inhibition as studied in young infants (Kagan, Reznick & Snidman, 1987), to more specific conceptualizations focusing on the specific shy-type behaviors exhibited in certain contexts (e.g. peer-to-peer interactions; Gazelle, 2008), the current work draws on a broader definition of shyness, based on Putnam, Gartstein and Rothbart's (2006) operationalization of shyness as an enduring, biologically-based individual difference characterized by discomfort in (predominantly novel) social situations, as measured via the Early Childhood Behavior Questionnaire (ECBQ). Reports on use of the ECBQ have shown that shyness can be reliably measured in children from the age of 18 months (Putnam et al., 2006).

While it has long been known that shyness affects children's verbal communication (Broberg, Hwang, Lamb & Broberg 1990), this research has typically focused on the effect of shyness on language measured much later in development, when children are at least four years old (Asendorpf & Meier, 1993; Broberg et al., 1990; Coplan & Weeks, 2009; Crozier & Badawood, 2009; Crozier & Perkins, 2002; Evans, 1996; Reynolds & Evans, 2009). Only recently, however, has interest turned to the effect of shyness on the critical early stage of language acquisition during the second year of life (Smith Watts et al., 2014).

Drawing on the finding that expressive vocabulary is more affected by shyness than receptive vocabulary during early childhood, Smith Watts and colleagues (2014) concluded that shy children's evidenced lower language ability at this age is due only to reticence to respond, rather than any difficulty in learning the meaning of words. Shy children's reticence to respond has been demonstrated in home settings (Reynolds & Evans, 2009), in experimental settings (Crozier & Perkins, 2002), and is also supported by research on non-western cultures (Crozier & Badawood, 2009). This could mean that measures designed to test children's demonstration of word learning in the lab, which require an explicit response from participants, would systematically underestimate the abilities of shy children. It is, however, imperative to more thoroughly examine the impact of shyness on the processes that precede children's acquisition of a word, something that parental reports of vocabulary size cannot measure. A careful examination of the literature on these processes gives a strong indication that shyness could indeed play a role at this early stage of language learning.

Laboratory examinations of children's "remarkable" ability to acquire words during the second year of life often employ fast mapping tasks that demonstrate the ability to rapidly associate novel labels with novel objects (Axelsson, Churchley & Horst, 2012; Halberda, 2006; Horst & Samuelson, 2008; Horst, Samuelson, Kucker & McMurray, 2011; Spiegel & Halberda, 2011; Vlach & Sandhofer, 2012). In these tasks, children are usually presented with a novel object alongside objects for which a label is already known and are asked to identify the object referred to by a novel pseudoword (e.g. "Where's the blicket?"; Markman & Wachtel, 1988). Children begin to demonstrate the ability to pick the novel object from the age of 15 months (Markman, Wasow, & Hansen, 2003), and more recent work indicates that some children may do this as early as 12 months (Xu, Cote, & Baker, 2005).

An important question of fast mapping tasks is whether children can retain the word-object mappings that they have formed. The first fast mapping study (Carey & Bartlett, 1978) described children learning a color-word by being shown two trays and being asked for "the chromium one, not the blue one." In this study most children reliably chose the non-blue tray and they could generally remember the word for the chromium color one week after the initial, single exposure.

Since Carey and Bartlett's (1978) seminal study a number of further studies have provided a more nuanced picture of children's fast mapping abilities that distinguishes between the initial ability to select the correct referent and the ability to retain the label-object mapping over a period of time (Axelsson, Churchley, & Horst, 2012; Horst & Samuelson, 2008; Kucker, 2013; Munro, Baker, McGregor, Docking & Arculi, 2012). In tests of retention children are presented with (usually three) objects for which they have fast mapped novel labels and are asked for one of these objects using the novel label. A number of studies have revealed that despite success in forming the initial word-object mapping, children often have difficulty retaining these mappings. For example, in one typical study Horst and Samuelson (2008) found that after a five-minute delay, 24-month-old children were unable to select the correct object above levels that would be expected by chance. The authors also found that by reinforcing the mapping by ostensively naming the object (e.g., by pointing) after the child had made the initial word-object mapping, the likelihood of retaining it was increased. A potential mechanism for this improved retention is that ostensive naming directs the child's attention to the referent during naming and restricts attention to competitors (Axelsson et al., 2012), reflecting other work that has investigated the link between attention and retention in these tasks. While it was found that children's looking times to target objects during labeling cannot predict their retention of the newly-formed mapping (Booth, McGregor & Rohlfing, 2008), other work has shown that looking during labeling can predict retention for those children who can learn to direct their gaze away from novel competitors and towards the labeled object across repeated exposures to word-label pairings (Smith & Yu, 2013). Together this suggests that attention during word learning is a dynamic and complex process, with the child having to successfully divide attention between the target and competitors.

A closer look at the literature reveals considerable individual differences in fast mapping ability. For example, in a study investigating the age-related development of fast mapping, Wilkinson, Ross, and Diamond (2003) classed 25% of the under-42-month-old children in their experiment as unreliable fast mappers. In other studies, 24-month-old children selected the correct novel object only on approximately three quarters of trials (Horst & Samuelson, 2008; Twomey, Ranson,

& Horst, 2014). Similarly, in a study by Mervis and Bertrand (1994) with 16-20 month old children, half of the children did not reliably select the novel object when asked with a novel label.

Children are clearly variable in their demonstration of the mechanisms that underpin word learning, but there has been little interest in the intrinsic factors that may contribute to this variability. We know that shyness affects the rate of language acquisition, and this effect could be exerted by moderating the in-the-moment processes used to acquire language in the first instance. If shy children do not demonstrate use of these mechanisms in the same way as their less-shy peers, this means that shyness is affecting the acquisition of language from one of its earliest stages: the initial mapping of a label to its referent. Such a fine-grained analysis of the effects of shyness on the formation of label-referent mapping, rather than focusing solely on vocabulary size, would mean that we can begin to understand the precise ways in which language is shaped by shyness.

In the present study, 2-year-old children took part in both referent selection and retention tests of mapping novel labels to novel objects. Shy and less-shy children completed the same referent selection trials in which they were presented with one novel object alongside two familiar objects and were asked for a novel label. Trials were included in which children were asked for a familiar object. After a 5-minute break, children in both conditions completed the same retention trials. We also investigated whether ostensive naming of targets during referent selection affected children's performance.

Method

Participants

Thirty-two typically developing 24-month-old children participated (*M* = 24 m, 8 days, SD = 11 days; range = 23 m, 19 days to 24 m, 29 days; 16 girls and 16 boys) during 2013/14. All children were monolingual, predominantly from middle-class families of Caucasian ethnicity living in the North West of England, UK. Families were recruited by contacting parents who had previously indicated interest in participating in child development research. Parents' travel expenses were reimbursed and children were offered a storybook for participating. Data from nine additional children were excluded from analyses due to experimenter error (*n*=1), parental involvement (*n*=2) failure to complete the word learning task (*n*=3) and the parent not returning the questionnaire (*n* = 3).

The Early Childhood Behavior Questionnaire (ECBQ) was used to assess children's shyness as an enduring, biologically-based individual difference. The ECBQ asks parents to rate on a scale from one to seven how often their child has demonstrated particular behaviors over the previous two weeks (1 = *never*, 7 = *all the time*), as a means to assessing the child's score on 18 fine-grained subdimensions of temperament. While these subdimensions include areas such as attention focusing, activity level and high- or low-intensity pleasure, the shyness subdimension was of particular interest for the current study. The shyness scale consists of twelve items that assess how children react in situations that elicit shy behavior, for example "When approaching unfamiliar children playing, how often did your child watch rather than join?" and "In situations where s/he is meeting new people, how often did your child become quiet?" Standardized Cronbach's alpha for the shyness measure was 0.76. Each child was scored from 1-7 by averaging their parents' responses to the twelve questions relating to shyness (after correcting for reverse coded questions). A score of 1 is considered the least shy, and a score of 7 is considered the most shy. Once all data was collected, the median score for all children was calculated (3.67). Children scoring above the median formed the shy group and those scoring less than the median formed the less-shy group. Three children's scores equaled the median, and they were randomly assigned to a group, ensuring equal sample size ($n = 16$). There were equal numbers of boys and girls ($n = 8$) in each group. There was no difference between groups in age, $t\ (30) = 1.45$, $p = .16$. Shyness scores were calculated after the testing session had taken place, which meant that the experimenter was blind to the shyness score of the participants during testing.

In order to examine whether ostensive naming interacts with shyness to affect referent selection and retention, eight boys and eight girls were assigned to an ostensive naming and a no ostensive naming condition. Assignment of children to ostensive and no ostensive naming conditions occurred before it was possible to calculate a median shyness score, so children were randomly assigned to each condition prior to each testing session. There was no difference between conditions in age, $t\ (30) = -1.34$, $p = .189$. As expected by a random assignment, there were equal numbers of less-shy children in the ostensive naming ($n = 8$), and no ostensive naming ($n = 8$) conditions. Similarly, there were equal numbers of shy children in the ostensive naming ($n = 8$) and no ostensive naming ($n = 8$) conditions.

Stimuli

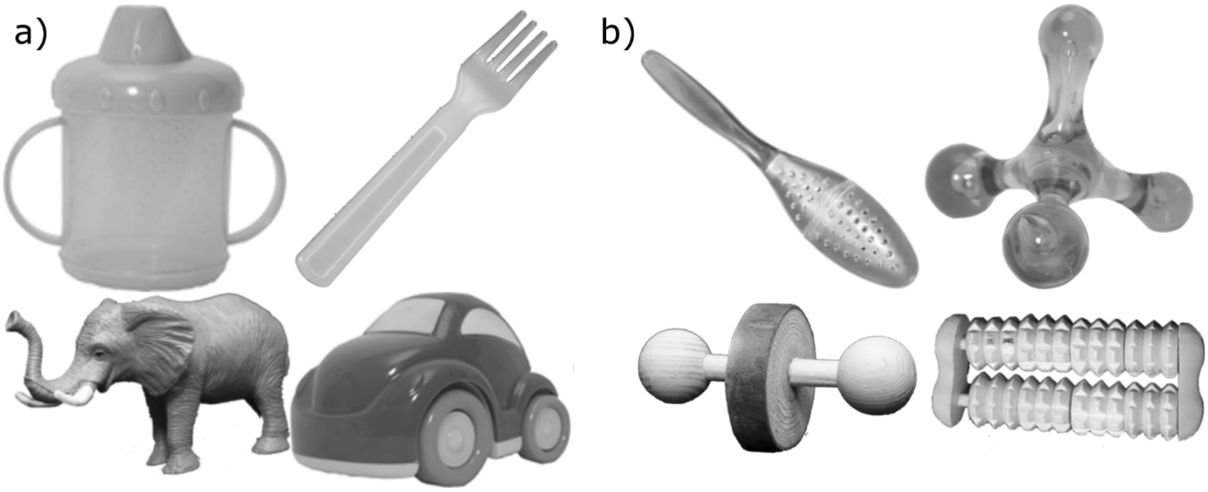


Figure 1. A subset of the stimuli used in the experiment. Panel A shows examples of the familiar objects used in the experiments. Panel B shows the four unfamiliar objects that were used in the experiment.

All stimuli were used in both conditions. Eleven objects, selected because they are easily named by 24-month-olds, acted as familiar objects and consisted of animals (duck, elephant, fish, pig), vehicles (car, motorbike, helicopter) and household objects (spoon, fork, cup and ball). Four novel objects, selected because they are not normally familiar to 24-month-old children, were a plastic roller, a wooden massager, a tea strainer and a miniature dumbbell (see Figure 1). Four distinct non-words (cheem, koba, sprock, tannin) were used to name the novel objects, taken from previous research using similar methodology (Behrend, Scofield, & Kleinknecht, 2001; Markson & Bloom, 1997; Horst & Samuelson, 2008; Samuelson & Horst, 2007). The assignment of each name to each novel object was randomized across participants. To ensure the objects would be familiar and novel to each participant as expected, parents were shown photographs of the objects before the experiment began and confirmed their familiarity or novelty. All objects were similar in size (approximate mean size 5 cm x 6 cm x 9 cm). The objects were presented on a wooden tray, divided into three equal compartments for the objects to be placed.

Procedure and Design

Prior to their visit to the lab, parents completed the ECBQ, and during their visit children took part in the word learning task.

Word learning task.

Warm up trials. During the task children sat on their parent's lap across a white table from the experimenter. Once settled, the warm up trials began. All trials consisted of three objects being presented to the child on the tray. For warm-up trials, the three objects were familiar and their purpose was to introduce the child to the forced-choice task, and to ensure that they understood the instructions of the experimenter. For each trial the experimenter presented the objects and asked for the target six times (i.e. "Wow a duck! Where's the duck? See the duck! Find the duck! Get the duck! Can you get the duck?") The experimenter then slid the tray forward into reaching distance for the child, and gave the child the opportunity to retrieve the requested object. If correct, the child was praised, and if incorrect the child was corrected. The order in which the objects were requested was randomly determined prior to testing. Warm-up trials continued until children had correctly selected each referent once. The majority of children needed no more than three warm-up trials (8 children needed four warm-up trials and one child needed six warm-up trials.)

Referent selection trials. The referent selection trials began immediately after warm up trials. Referent selection trials proceeded in the same manner as the warm up trials, but differed in three ways. First, two of the objects were familiar and one was novel. Second, neither praise nor corrections were given following the child's referent selection. Third, children were offered the chance to explore the three objects for thirty seconds before they were asked to select an object. During this exploration time, the three objects were presented on the tray to the child, and the child and caregiver played with the objects for thirty seconds. During this exploration parents were instructed to avoid labeling or asking for labels for the objects, and if needed the experimenter directed the child's attention to each of the objects at least once, either by pointing at it, or if that was unsuccessful by maneuvering it into the child's line of vision. Once thirty seconds had elapsed, the objects were returned to their positions on the tray, and the child was asked for the target object.

Once children had selected an object, it was returned to its position on the tray. Those in the ostensive naming condition then saw the target object ostensively named (irrespective of whether they had correctly chosen the target object or not). This involved the experimenter pointing at the target object and labeling it (e.g. "It's a car."). Children in the no ostensive naming condition saw the experimenter point to the target object and say "there it is." To ensure that children in each condition heard the label an equal number of times (which was relevant for the subsequent retention test), children in the ostensive naming condition heard the label one time fewer during the initial request, by removing a labeling phrase (e.g. "Where's the koba?"). This meant that children in both conditions heard the object labeled six times.

Each child was presented with four sets of three objects, and each set was shown twice. In one of these presentations the child was asked for a novel object, and in the other was asked for a familiar object. The objects comprising each set and the labels assigned to each novel object were randomized across children. The order of sets and trials was pseudo-randomized, ensuring that any trial type (i.e. familiar or novel) was not presented on more than two consecutive trials.

Retention trials. Following the referent selection trials there was a five-minute break, during which the child was offered crayons and paper for coloring. This break was to ensure that any retention in the following trials was the product of long-term memory (following Horst & Samuelson, 2008). After the five-minute break, the child participated in four retention trials, which did not differ between conditions. Again, children were presented with sets of three objects. These were all novel objects that had been presented during referent selection. Across the four retention trials, each novel object was the target once. The two novel objects presented alongside the target were randomly determined. On presentation of each set, the child was asked to select the target once (e.g. “Where’s the koba?”). The tray was slid forward and the child indicated the chosen object. The order of trials was randomized across participants.

Results

Word Learning Tasks

Each child took part in four familiar and four novel referent selection trials. For each, a “proportion of correct choices” measure was calculated by dividing the number of correct responses by the total possible (i.e., 4 for familiar and 4 for novel referent selection trials). There were no main effects of ostensive naming found on retention trials, and analyses were therefore collapsed across this factor.

Referent selection task. One participant did not respond on two referent selection trials, and another did not respond on one referent selection trial. A response was elicited from children on all other referent selection trials. Overall, selection of the correct familiar object was higher than would be expected by chance (M = .87, SD = .18), t (31) = 16.94, p < .001; d = 2.98. Furthermore, in trials where a novel label was given children selected the novel object significantly above chance, demonstrating the ability to fast map (M = .59, SD = .32), t (31) = 4.60, p < .001; d =

0.80. Overall, children were better at selecting the familiar than the novel object, t (31) = 6.12, $p < .001$; $d = 1.10$.

Retention task. A response was elicited for all retention trials. The following analyses only included retention trials in which the child had correctly selected the target during the corresponding novel referent selection trials. For example, if the child had chosen the car when asked for the *cheem* during referent selection, the retention trial for the mapping of *cheem* was not included. Overall, children were unable to retain the object-label mappings they had made during referent selection, selecting the target object no more often than would be expected by chance ($M = .38$, $SD = .35$), t (31) = .765, $p = .14$, *ns*.

We investigated whether particular objects were more likely to be selected than others during referent selection and retention trials. We found that children did not select certain familiar objects more often than others, χ^2 (7, N=128) = 1.08, $p > .99$, *ns*. Likewise, novel object selection was not greater for any particular object, χ^2 (3, N=125) = 2.56, $p = .46$, *ns*. Again during the retention task children did not choose any novel objects more often than others, χ^2 (3, N=128) = 5.19, $p = .16$, *ns*.

Shyness and Referent Selection

As expected, children in the less-shy group were scored as less shy ($M = 2.73$, $SD = 0.62$) than children in the shy group ($M = 4.14$, $SD = 0.48$), and the two groups differed in shyness score, t (30) = 7.19, $p < .001$.

As shown in Figure 2, children in the less-shy group were better than would be expected by chance at selecting the familiar object, t (15) = 16.84, $p < .001$; $d = 8.69$, and novel object, t (15) = 5.76, $p < .001$; $d = 2.97$. In contrast, children in the shy group were better than would be expected by chance only at selecting the familiar object, t (15) = 9.96, $p < .001$, d = 5.14, but not at selecting the novel object, t (15) = 1.53, p = .15.

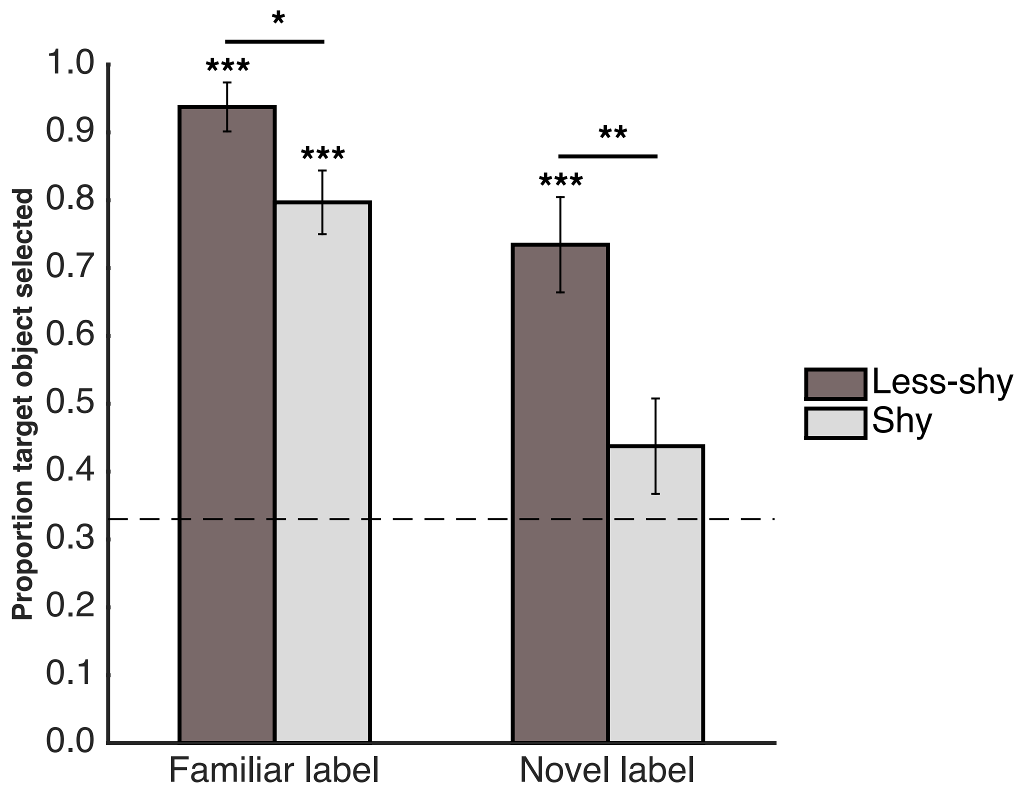


Figure 2. Shy and less-shy children's proportion of correct choices during referent selection trials. The dotted line represents chance (0.33). Error bars represent 1 SE. *p < .05. **p < .01. ***p <.001 (Bonferonni corrections apply to between-groups comparisons).

In order to further examine how shyness affects children's referent selection, a 2 (trial type: familiar or novel) x 2 (shy group) mixed Analysis of Variance (ANOVA) was performed. This revealed a main effect of trial type, F (1, 28) = 40.00, $p < .001$, $\eta_p^2 = .57$, meaning that children chose the target object more often on familiar trials (M = .87, SD = .18) than novel trials (M = .59, SD = .32). There was no interaction between trial type and shyness, F (1, 28) = 3.09, p = .09. As expected, there was a significant main effect of shyness group, F (1, 28) = 10.16, p = .003, $\eta_p^2 = .25$, meaning that children in the less-shy group chose the target object more often (*M* = .84, *SD* = .02) than children in the shy group (*M* = .62, *SD* = .02).

A median-split approach to these analyses was adopted in line with previous research into individual differences in word learning (e.g. Axelsson, Perry, Scott & Horst, 2016; Dixon, Salley & Clements, 2006; Fernald, Marchman & Weisleder, 2012), yet we acknowledge that this approach is not universally accepted (McCelland et al., 2015). As such, analyses were also run with shyness as a continuous variable, in order to support the results of the analyses by median-split. It was found that shyness was not significantly related to children's object selection on familiar label trials, r_s (32) = -.27, p = .14, but shyness was significantly related to children's object selection on novel label trials, r_s (32) = -.38, p = .03, demonstrating that an increase in shyness score meant a decrease in proportion of trials on which the novel object was selected as the referent of a novel label when shyness was coded as a continuous variable.

Shyness and Retention

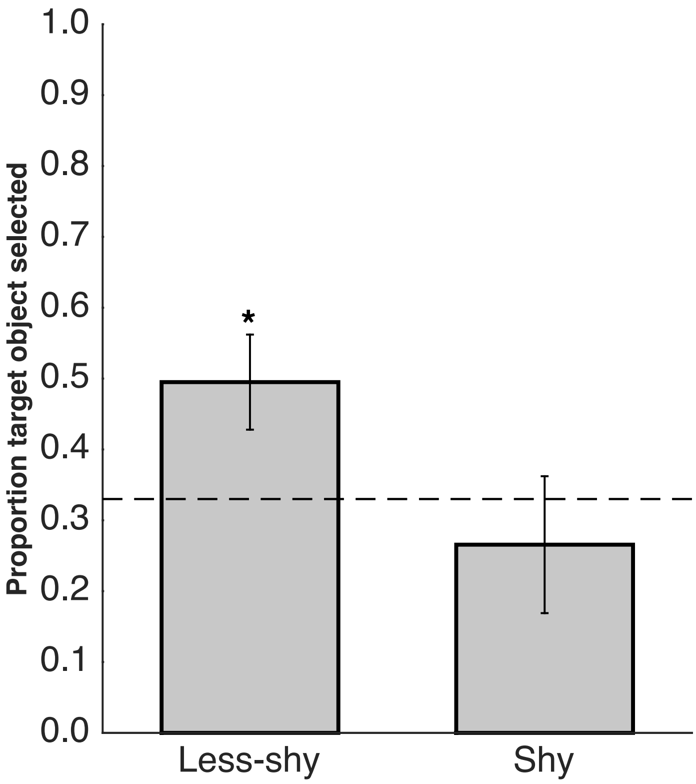


Figure 3. Proportion of word-object mappings retained by less-shy and shy children after a 5-minute break. The dotted like represents chance (.33). Error bars are 1 SE. *p<.05.

As shown in Figure 3, children in the less-shy group were significantly better at retaining the word-object mappings (M = .51, SD = .27) than would be expected by chance, t (14) = 2.61, p = .02, d = 0.65. In contrast, children in the shy group performed at chance during retention (M = .30, SD = .40), t (13) = -.25, p = .81. A 2 (shy group) x 2 (ostensive naming) Analysis of Variance (ANOVA) revealed no main effect of ostensive naming, F (1, 24) = .07, p = .79, no main effect of shyness, F (1, 24) = 3.65, p =.07, and no significant interactions.

Discussion

The present study found that shy children were less likely than less-shy children to correctly identify a requested familiar or a novel object from a set of three.

Specifically, shy children, but not less-shy children, performed at chance in trials in which a novel object was requested using a novel label. Furthermore, after a five-minute break, shy children did not show evidence of retention of the mappings that they had previously made, whereas less-shy children demonstrated retention above levels expected by chance. This study found no evidence that ostensive naming affects children's retention of novel word-object mappings.

The results of our study suggest that the mapping of a novel label to a novel object is not as robust and automatic for all children as has been previously reported (Halberda, 2003; Horst & Samuelson, 2008), and they show that shy children as a group do not demonstrate use of fast mapping to disambiguate the referents of words that they hear in a lab setting. Furthermore, the mappings that were formed by shy children were not then subsequently retained. The present study also indicated that selection of a correct familiar referent is similarly affected by shyness, as expected in light of recent findings that familiar word recognition is supported by the same processes as the mapping of a novel word to a novel object (McMurray, Horst & Samuelson, 2012).

Importantly, our results emphasize that a child's emerging temperament can affect basic processes involved in word learning. When considered alongside the finding that shy children do not reliably retain any mappings that they have made, this study suggests that intrinsic factors, and not just differences in input, are important contributors to variability in early language acquisition.

Several hypotheses have been proposed to explain shy children's lower vocabulary scores, and each hypothesis offers a different explanation for the findings of the present study. The *I know it but won't say it* hypothesis (Coplan & Evans, 2009) suggests that shy children learn words normally, but are reticent to demonstrate this ability. This hypothesis is supported by Smith Watts and colleagues' (2014) finding that, while shy children had lower expressive vocabulary scores than less-shy children, their receptive vocabulary scores were more similar (see also Rubin, 1982). Related work has also found that the differences in vocabulary scores between shy and less-shy children can be explained by unresponsiveness (Spere, Schmidt, Theall-Honey & Martin-Chang, 2004). While the present study found that shy children were less likely to respond correctly when asked to select a familiar object, and to map novel labels onto novel objects, shy children did not simply refuse to respond. In fact, across all participants only three trials (out of a possible 384) were coded as non-responses. The *I know it but won't say it* hypothesis cannot explain why shy children will offer a supposedly incorrect response; their behavior may be better described as "I may know it, but won't say it, *but I will say something anyway*." Therefore, simply eliciting a response from a shy child may not provide an adequate measure of their knowledge. A key assumption of the *I know it but won't say it* hypothesis, as supported by Smith Watts and colleagues (2014), is that receptive language skills are unaffected by shyness at this age, but this is not borne out by the current work.

The present study found that shy children do not show evidence of retaining the (few) word object mappings that they successfully made during referent selection. This clearly demonstrates that shyness does not only impact on the in-the-moment online processes, but also the longer term processes necessary in the acquisition of vocabulary. Beyond demonstrating that receptive language is not immune to the effects of shyness, these findings suggest that previous research reporting poor retention on the group level (Horst & Samuelson, 2008) might be explained by not having controlled for shyness. Again, the failure of shy children to retain mappings cannot be explained by reticence to respond; they offered a response on all retention trials, too.

Apart from *I know it but won't say it*, several alternative explanations have been put forward to account for the differences between shy and less-shy children on measures of language development. One, known as the *lack of practice* hypothesis (Coplan & Evans, 2009), argues that shy children tend to avoid social situations and in doing so limit both their exposure to others' language and an opportunity to practice language while receiving contingent feedback. Empirical support for this hypothesis has been found, for example, in the discovery that shy children speak less than their less-shy peers in experimental settings (Crozier & Perkins, 2002), at home (Reynolds & Evans, 2009) and in non-western cultures (Crozier & Badawood, 2009). This explanation draws heavily on language development as measured in terms of vocabulary size, and in light of the present findings, assumes that children's ability to form and retain object-label mappings can be moderated by experience and practice. To explain our results according to this hypothesis one would have to assume that children's previous experience and interactions are shaped by shyness to such an extent that either shy children miss out on the opportunity to develop the understanding that requests should be responded to correctly, or that they restrict their language input to the extent that they cannot acquire the mechanisms needed to map novel labels onto novel objects. However, while the lack of practice might well explain a lower vocabulary size in young children due to lack of exposure, it is unlikely that it affects the mechanisms of word learning per se., particularly given the shift towards an understanding of the domain-general nature of the processes that support this ability (Samuelson & Smith, 1998).

A third hypothesis is based on findings that older shy children are less likely to take risks (Jones & Thomas, 1994; Levin & Hart, 2003). While it is still unclear whether such an aversion to risk has emerged in shy children at this young age, we argue that it is possible that shy children are less likely to rely on a guess when responding, which also explains the effect of shyness on expressive vocabulary (Coplan & Evans, 2009). The effect may be particularly pronounced in tests of word learning that involve novel words with ambiguous referents, as in the present study where children were required to map the novel word to the novel object using only novelty as a cue. Novelty is inherently ambiguous and does not rule out competitors as potential referents with certainty. Therefore, an aversion to risk is likely to disrupt their use of novelty as a cue to referent selection.

Alongside an aversion to risks, shy children also demonstrate inhibited approach and discomfort in social situations involving novelty (Putnam, Gartstein & Rothbart, 2006). Most experimental settings are fundamentally unfamiliar to a young participant. Tests are typically carried out by a researcher who is unknown to the child, often in an unfamiliar room (Heibeck & Markman, 1987; Horst & Samuelson, 2008; Horst, Samuelson, Kucker, & McMurray, 2011; Horst, Scott, & Pollard, 2010; Spiegel & Halberda, 2011; Zosh, Brinster, & Halberda, 2013). When shy children were certain that their response was correct, they were able to overcome the problems posed by the unfamiliar setting to some extent, because as a group they reliably selected a familiar object when requested. Yet shy children selected the correct familiar object less often than less-shy children, suggesting that an unfamiliar setting can impact on shy children's demonstration of label referents. Furthermore, when asked for a novel label, shy children were just as likely to select a familiar object as the novel one. It is therefore likely that shy children's reluctance to rely on ambiguous cues in responding to requests, alongside their aversion to novelty, produce a familiarity preference on novel label trials.

These effects must, however, be further teased apart in order to better understand how best to tailor the testing environment so as to not disadvantage shy children. Reducing the unfamiliarity of the testing procedure could reduce shy children's preference for familiar objects, and may allow children to feel more comfortable in taking a risk and making use of novelty as a cue to the correct referent on novel label trials. However, shy children's aversion to novelty may affect their responses by restricting their attention to and encoding of the novel label-object mapping, supported by the finding that even on trials where they attended to the novel object enough to select it during referent selection, these mappings were not retained, unlike the mappings formed by the less-shy children. It may be the case that the encoding of the word-object mapping by shy children is different to that of less-shy children, calling for more implicit measures of children's mapping of novel labels to novel objects in order to explore the effect of shyness on attention during the formation of the mappings.

This study has shed further light on previous explanations for the effect of shyness on measures of language development, and examined whether they can account for the effect of shyness on the processes used to form word-object mappings. While researchers have been confident in claiming that this effect can be best explained in terms of shy children's reticence to respond (Smith Watts et al., 2014), the current study found that shy children will respond to questions even when they are posed by an unfamiliar adult. The *lack of practice* argument also offers an inadequate explanation for these findings, given that it is based on the unlikely assumption that lack of practice has impaired the very mechanisms by which shy children map words to objects. The explanation that best fits the present data is that shy children's aversion to risk-taking and novelty serves to enhance their preference for familiar objects on novel label trials, and limits their attention to and encoding of any possible word-object mappings.

Most importantly, this study is a clear demonstration that intrinsic factors related to emerging temperament can affect the acquisition of language by moderating the processes by which shy children disambiguate and retain word meanings. Therefore, variability in early language acquisition must be explored in terms of differences in the mechanisms by which language is acquired, not only differences in the input. The present study has shown that given the same input and cues to word learning, shy children respond differently from their less-shy peers. In further exploring the effect of emerging temperament on the processes involved in word learning, the field can be better informed in identifying children for whom language acquisition is more difficult, or just different.

References

Asendorpf, J. B., & Meier, G. H. (1993). Personality effects on children's speech in everyday life: Sociability-mediated exposure and shyness-mediated reactivity to social situations. *Journal of Personality and Social Psychology*, *64*(6), 1072–1083. http://doi.org/10.1037/0022-3514.64.6.1072

Axelsson, E. L., Churchley, K., & Horst, J. S. (2012). The right thing at the right time: why ostensive naming facilitates word learning. *Frontiers in Psychology, 3*. doi: 10.3389/fpsyg.2012.00088

Axelsson, E. L., Perry, L. K., Scott, E. J., & Horst, J. S. (2016). Near or far: The effect of spatial distance and vocabulary knowledge on word learning. *Acta Psychologica*, *163*, 81–87. http://doi.org/10.1016/j.actpsy.2015.11.006

Behrend, D. A., Scofield, J., & Kleinknecht, E. E. (2001). Beyond fast mapping: Young children's extensions of novel words and novel facts. *Developmental Psychology*, 37(5), 698-705. doi: 10.1037/0012-1649.37.5.698

Booth, A. E, McGregor, K. K., & Rohlfing, K. J. (2008). Socio-pragmatics and attention: Contributions to gesturally guided word learning in toddlers. *Language Learning and Development, 4,* 179-202. doi: 10.1080/15475440802143091

Broberg, A., Lamb, M. E., Hwang, C. P., & Bookstein, F. L. (1990). Inhibition: Its stability and correlates in sixteen to forty-month-old children. *Child Development, 61,* 1153 – 1163. doi: 10.1111/j.1467-8624.1990.tb02849.x

Brooks-Gunn, J., & Duncan, G. J. (1997). The effects of poverty on children. *The Future of Children*, *7*(2), 55–71. doi: 10.2307/1602387

Carey, S., & Bartlett, E. (1978). Acquiring a single new word. *Proceedings of the Stanford Child Language Conference, 15*, 17-29.

Coplan, R. J., & Evans, M. A. (2009). Shyness and Language [Special issue]. *Infant and Child Development, 18(3),* 211-305.

Coplan, R. J., & Weeks, M. (2009). Shy and soft-spoken: shyness, pragmatic language, and socio-emotional adjustment in early childhood. *Infant and Child Development*, *18*(3), 238–254. http://doi.org/10.1002/icd.622

Crozier, W. R. and Badawood, A. (2009), Shyness, vocabulary and children's reticence in Saudi Arabian preschools. *Infant and Child Development, 18,* 255–270. doi: 10.1002/icd.623

Crozier, W. R., & Perkins, P. (2002). Shyness as a factor when assessing children. *Educational Psychology in Practice, 18,* 239-244. doi: 10.1080/0266736022000010267

Dale, P., & Fenson, L. (1996). Lexical development norms for young children. *Behavior Research Methods, Instruments, & Computers, 28*(1), 125-127. doi: 10.3758/BF03203646

Desmarais, C., Sylvestre, A., Meyer, F., Bairati, I., & Rouleau, N. (2008). Systematic review of the literature on characteristics of late-talking toddlers. *International Journal of Language & Communication Disorders, 43*(4), 361-389. doi: 10.1080/13682820701546854

Dixon Jr., W. E., Salley, B. J., & Clements, A. D. (2006). Temperament, distraction, and learning in toddlerhood. *Infant Behavior and Development*, *29*(3), 342–357. http://doi.org/10.1016/j.infbeh.2006.01.002

Evans, M. A. (1996). Reticent primary grade children and their more talkative peers: Verbal, nonverbal, and self-concept characteristics. *Journal of Educational Psychology*, *88*(4), 739–749. http://doi.org/10.1037/0022-0663.88.4.739

Evans, G. W. (2004). The environment of childhood poverty. *American Psychologist, 59*, 77-92. doi:10.1037/0003-066X.59.2.77

Feinstein, L. (2003), Inequality in the early cognitive development of British children in the 1970 cohort. *Economica*, 70, 73–97. doi: 10.1111/1468-0335.t01-1-00272

Fernald, A., Marchman, V. A., & Weisleder, A. (2013). SES differences in language processing skill and vocabulary are evident at 18 months. *Developmental Science*, *16*(2), 234–248. http://doi.org/10.1111/desc.12019

Gazelle, H. (2008). Behavioral profiles of anxious solitary children and heterogeneity in peer relations. *Developmental Psychology*, *44*(6), 1604–1624. http://doi.org/10.1037/a0013303

Halberda, J. (2003). The development of a word-learning strategy. *Cognition, 87,* B23-B24. doi: 10.1016/S0010-0277(02)00186-5

Halberda, J. (2006). Is this a dax which I see before me? Use of the logical argument disjunctive syllogism supports word-learning in children and adults. *Cognitive Psychology, 53,* 310-344.

Hart, B., & Risley, T. R. (1995). *Meaningful differences in the everyday experience of young American children.* Baltimore, MD: Paul H Brookes Publishing.

Heibeck, T. H., & Markman, E. M. (1987). Word learning in children: An examination of fast mapping. *Child Development, 58,* 1021-1034. doi: 10.2307/1130543

Hoff, E., Laursen, B., & Tardif, T. (2002). Socioeconomic Status and Parenting. In M. Bornstein (Ed.), *Handbook of Parenting Volume 2: Biology and ecology of parenting* (pp. 231-252). Mahwah, NJ: Lawrence Erlbaum.

Horst, J. S. and Samuelson, L. K. (2008), Fast mapping but poor retention by 24-

month-old infants. *Infancy*, *13*, 128–157. doi: 10.1080/15250000701795598

Horst, J. S., Samuelson, L. K., Kucker, S. C., & McMurray, B. (2011). What's new? Children prefer novelty in referent selection. *Cognition, 118*(2), 234-244. doi: 10.1016/j.cognition.2010.10.015

Horst, J. S., Scott, E. J., & Pollard, J. (2010). The role of competition in word learning via referent selection. *Developmental Science, 13,* 706-713. doi: 10.111/j.1467-7687.2009.00926.x Hurtado, N., Marchman, V. A., & Fernald, A. (2007). Spoken word recognition by Latino children learning Spanish as their first language. *Journal of Child Language*, *34*(02), 227–249. doi: 10.1017/S0305000906007896

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary growth: Relation to language input and gender. *Developmental Psychology, 27*(2), 236-248. doi: 10.1037/0012-1649.27.2.236

Kagan, J., Reznick, J. S., & Snidman, N. (1987). The physiology and psychology of behavioral inhibition in children. *Child Development*, *58*(6), 1459–1473. http://doi.org/10.2307/1130685

Kagan, J., Reznick, J., & Snidman, N. (1988). Biological bases of childhood shyness. *Science*, *240*(4849), 167–171.

Kelly, D. J. (1998). A clinical synthesis of the `late talker' literature: Implications for service delivery. *Language, Speech & Hearing Services in Schools, 29*(2), 76.

Kucker, S. C. (2013). The role of vocabulary knowledge and novelty biases in word learning: Exploring referent selection and retention in 18- to 24-month old children and associative models. Unpublished doctoral dissertation. University of Iowa, Iowa City, IA.

Landau, B., Smith, L. B., & Jones, S. S. (1988). The importance of shape in early lexical learning. *Cognitive Development, 3*(3), 299-321. doi: http://dx.doi.org/10.1016/0885-2014(88)90014-7

Levin, I. P., & Hart, S. S. (2003). Risk preferences in young children: early evidence of individual differences in reaction to potential gains and losses. *Journal of Behavioral Decision Making, 5,* 397-413. doi: 10.1002/bdm.453

Mareschal, D., Johnson, M. H., Sirois, S., Spratling, M., Thomas, M. S. C., & Westermann, G. (2007). *Neuroconstructivism - I: How the brain constructs cognition*. Oxford, UK: OUP.

Markman, E. M., & Hutchinson, J. E. (1984). Children's sensitivity to constraints on word meaning: Taxonomic versus thematic relations. *Cognitive Psychology, 16*(1), 1-27. doi: http://dx.doi.org/10.1016/0010-0285(84)90002-1

Markman, E. M., & Wachtel, G. W. (1988). Children’s use of mutual exclusivity to constrain the meanings of words. *Cognitive Psychology, 20,* 121 – 157. doi: 10.1016/0010-0285(88)90017-5

Markman, E. M., Wasow, J. L., & Hansen, M. B. (2003). Use of the mutual exclusivity assumption by young word learners. *Cognitive Psychology, 47,* 241-275. doi: 10.1016/S0010-0285(03)00034-3

Markson, L., & Bloom, P. (1997). Evidence against a dedicated system for word learning in children. *Nature*, *385*(6619), 813–815. http://doi.org/10.1038/385813a0

McClelland, G. H., Lynch, J. G., Irwin, J. R., Spiller, S. A., & Fitzsimons, G. J. (2015). Median splits, Type II errors, and false-positive consumer psychology: Don't fight the power. Journal of Consumer Psychology, 25(4), 679-689.10.1016/j.jcps.2015.05.006

McMurray, B., Horst, J. S., & Samuelson, L. K. (2012). Word learning emerges from the interaction of online referent selection and slow associative learning. *Psychological review, 119*(4), 831-877. doi: 10.1037/a0029872

Mervis, C. B., & Bertrand, J. (1994). Acquisition of the Novel Name-Nameless Category (N3C) principle. *Child Development, 65,* 1646-1662. doi: 10.1111/j.1467-8624.1994.tb00840.x

Putnam, S. P., Gartstein, M. A., & Rothbart, M. K. (2006). Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior Questionnaire. *Infant Behavior and Development, 29*(3), 386-401. doi: 10.1016/j.infbeh.2006.01.004

Rubin, K. H. (1982). Social and social-cognitive developmental characteristics of young isolate, normal and sociable children. In K. H. Rubin & Hildy, R. S. (Eds.), *Peer Relationships and social skills in childhood* (353-374). New York, NY: Springer.

Reynolds, K. P., & Evans, M. A. (2009). Narrative performance and parental scaffolding of shy and nonshy children. *Applied Psycholinguistics, 30,* 363-384. doi: 10.1017/S0142716409090158

Quine, W. V. O. (1960). *Word and object*. Cambridge, MA: MIT Press.

Samuelson, L. K., & Horst, J. S. (2007). Dynamic noun generalization: Moment-to-moment interactions shape children's naming biases. *Infancy*, *11*(1), 97–110. http://doi.org/10.1080/15250000709336872

Smith, L. B., & Yu, C. (2013). Visual attention is not enough: Individual differences in statistical word-referent learning in infants. *Language, Learning and Development, 9,* 25-49. doi: 10.1080/15475441.2012.707104

Smith Watts, A. K., Patel, D., Corley, R. P., Friedman, N. P., Hewitt, J. K., Robinson, J. L. and Rhee, S. H. (2014), Testing alternative hypotheses regarding the association between behavioral inhibition and language development in toddlerhood. *Child Development*, 85: 1569–1585. doi: 10.1111/cdev.12219

Spere, K. A., Schmidt, L. A., Theall-Honey, L. A., & Martin-Change, S. (2004). Expressive and receptive language skills of temperamentally shy preschoolers. Infant and Child Development, 12, 1–11. doi: 10.1002/icd.345

Spiegel, C., & Halberda, J. (2011). Rapid fast-mapping abilities in 2-year-olds. *Journal of Experimental Child Psychology, 109,* 132-140. doi: 10.1016/j.jecp.2010.10.013

Twomey, K. E., Ranson, S. L., & Horst, J. S. (2014). That's more like it: Multiple exemplars facilitate word learning. *Infant and Child Development, 23,* 105-122. doi: 10.1002/icd.1824

Vlach, H. A., & Sandhofer, C. M. (2012). Fast mapping across time: Memory processes support children's retention of learned words. *Frontiers in Psychology*, *3*, 46. http://doi.org/10.3389/fpsyg.2012.00046

Whitehurst, G. J., & Fischel, J. E. (1994). Practitioner Review: Early Developmental Language Delay: What. If anything. Should the clinician do about it? *Journal of Child Psychology and Psychiatry, 35*(4), 613-648. doi: 10.1111/j.1469-7610.1994.tb01210.x

Wilkinson, K. M., Ross, E., & Diamond, A. (2003). Fast mapping of multiple words: Insight into when "the information provided" does and does not equal "the information perceived". *Journal of Applied Developmental Psychology, 24,* 739-762. doi: 10.1016/j.appdev.2003.09.006

Xu, F., Cote, M., & Baker, A. (2005). Labeling guides object individuation in 12-month-old infants. *Psychological Science, 16,* 372-377. doi: 10.1111/j.0956-7976.2005.01543.x

Zosh, J. M., Brinster, M., & Halberda, J. Optimal contrast: Competition between two referents improves word learning. *Applied Developmental Science, 17,* 20-28. doi: 10.1080/10888691.2013.748420

Parents as Experimenters: Reducing Unfamiliarity Helps Shy Children Learn Words

Matt Hilton, Katherine E. Twomey and Gert Westermann

Lancaster University

Abstract

Shy children do not demonstrate learning of novel word-object mappings when tested by an unknown experimenter (Hilton & Westermann, Paper 1). This may be due to the unfamiliar context of the task. Two-year-old children (*N* = 24) took part in referent selection trials, with their parent acting as the experimenter. On referent selection trials, children were presented with sets of three objects, one novel and two familiar, and asked for either a familiar or a novel object using a novel word. Children were then tested on their retention of the previously formed novel word-object mappings. Shy and less-shy children showed comparable performance on referent selection trials, but only shy children retained the novel word-object mappings. It was therefore concluded that increased familiarity can modulate intrinsic differences that affect performance on this task.

Parents as Experimenters: Reducing Unfamiliarity Helps Shy Children Learn Words

Children are remarkable word learners. In 18 years children learn around 60,000 words (Anglin, 1993), and they manage to acquire language in vastly different environments, irrespective of culture, upbringing, socioeconomic status and a host of other equally variable factors. Children learn words from the adults around them (Snow, 1972), other children (Senghas & Coppola, 2001), and even from television (Rice & Woodsmall, 1988), storybooks (Horst, Parsons, & Bryan, 2011) and tablet computers (Korat, Shamir, & Arbiv, 2010). This makes for a rich but unpredictably variable input, meaning that the child must very quickly become skilled at engaging with this environment in a way that facilitates the acquisition of language. Scholars have rightly been very interested in how children acquire this language, out of philosophical interest (e.g. Quine, 1960), in order to inform theories of development (e.g. Spencer et al., 2009), or to develop interventions for children with atypical language development (e.g. Gray, 2005). Given the difficulties of rigorously studying the learning of a single word in situ, scholars have typically opted to examine children's learning of previously unknown word-object mappings in the more easily controlled environment of the lab.

Often inspired by Quine's (1960) exploration of the difficulty posed by deciphering the correct referents of words, researchers have examined how children disambiguate the myriad words that they hear. Disambiguation must be speedy because children are frequently required to respond rapidly to requests, often in situations where their interactional partner does not provide an unambiguous cue to the correct referent. Children therefore appear to become skilled in using in-the-moment heuristics to attempt to respond contingently. For example, a parent may point to a fruit bowl containing apples, oranges and a banana and remark on what a bright color the banana is. If the child already knows the words *apple* and *orange*, then from the age of around 18 months, he or she will assume that the yellow object must be the referent of the word *banana* (Halberda, 2003; Mervis & Bertrand, 1994). This behavior, by which a child will rapidly map a word onto a referent is known as *fast mapping*. Studies of fast mapping typically consist of *referent selection* trials in which a novel object is presented alongside one or more familiar competitors. The experimenter then asks for an object using a novel word (e.g., *Can you show me the blicket?*) in order to examine whether children do indeed select the novel object as its referent (Axelsson, Churchley, & Horst, 2012; Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Horst & Samuelson, 2008; Mervis & Bertrand, 1994; Spiegel & Halberda, 2011).

Initially, fast mapping appeared to provide a useful explanation for children's remarkably speedy acquisition of language during the second year of life and beyond (e.g. Golinkoff et al., 1992). However, more recent work demonstrates that succeeding on a referent selection trial does not mean that the word-object mapping is learned. For example, Horst and Samuelson (2008) demonstrated that 24-month-old children who had correctly mapped novel labels to novel objects during referent selection showed no evidence for retention of these mappings after a five-minute delay. More recent empirical work has replicated the finding that accurate referent selection is possible without any evidence of retention (e.g. Axelsson et al., 2012; Twomey, Ranson, & Horst, 2014), and these findings are supported by computational modeling of word learning which shows that selection of the novel object as the referent of the novel label is possible without any learning by the model (McMurray, Horst, & Samuelson, 2012). The discrepancy between initial mapping and longer-term retention has prompted a more detailed exploration of the possible mechanisms underlying referent selection, which has improved our understanding of why successful referent selection does not necessarily support retention of the initial mappings.

Mather and Plunkett (2009) examined children's looking when presented with a familiar and a novel object to better understand the relationship between attentional dynamics and success on referent selection trials. The authors presented twenty-two-month-old children with pairs of objects, one of which was novel and one of which was familiar. Upon hearing a novel label, the children showed no evidence of looking towards the novel object. Instead, looking towards the familiar competitors appeared to be key in supporting the selection of the novel object as the referent of a novel label (see also Halberda, 2006). This work indicates that referent selection, considered as separate from retention, is the result of rejecting familiar competitors as potential referents (Halberda, 2006; Markman & Wachtel, 1988) rather than an a priori implicit drive to map the novel label directly onto the novel object (as suggested by Mervis & Bertrand, 1994). Thus, successful referent selection may require little or no sustained attention to the novel object.

However, a wider reading of the literature suggests that heightened attention to the novel object is required for the word-object mapping to be retained (and thus learned). Horst and Samuelson (2008) found that ostensively naming the object (by pointing at it and labeling it) following referent selection led to retention of the word-object mapping. Similarly, Axelsson and colleagues (2012) found that following referent selection, dampening attention to competitors by partially covering them, and highlighting the novel object by illuminating it, also supports retention.

Many other studies have shown that carefully controlling the context in which novel objects are presented during referent selection can also support retention of the word-object mapping, likely by encouraging children to attend more to the novel object as the trials progress. For example, repeatedly presenting the novel object alongside consistent familiar competitors on referent selection trials leads to retention of the novel word-object mappings, whereas varying the familiar competitors reduces the likelihood that the mappings are retained (Axelsson & Horst, 2014). Repeating familiar competitors means that the child need not rule them out on each trial, which could therefore reduce children's attention to them. Similarly, Horst, Scott & Pollard (2010) found that 24-month-old infants retained mappings formed in the presence of two, but not three or four competitors, which neatly demonstrated that while increased attention to the target was not necessary to form the novel-word object mapping, more competitors led to a decrease in attention to the novel object, meaning children could no longer retain the mapping. Reduced attention to competitors allows more attention to be focused on the novel object and the association between the label and the object can become stronger. Similarly, presenting children with many exemplars of a novel object category across referent selection trials supports retention of the novel word-object mappings, likely because the variability in the novel object draws children's attention to their common features, resulting in a stronger association (Twomey et al., 2014).

These previous findings are in line with theories suggesting that although they are linked, the processes underlying referent selection are different to those required for long term word learning (Bion, Borovsky, & Fernald, 2013; McMurray et al., 2012). Specifically, they suggest that the mechanisms supporting referent selection do not necessarily entail learning. In order to retain the word's meaning, the association between word and object must become stronger than the association formed by referent selection alone (Axelsson et al., 2012).

It is therefore clear that manipulating the external task environment by constructing referent selection trials to draw attention to the novel object supports the learning of the word-object mapping. Equally, however, factors internal to the child may affect word learning: some children may be better able to focus their own attention on the novel object than others. As a consequence, these children may find learning words via referent selection easier than those who look less at the novel object. Interest has therefore turned to intrinsic factors that can affect children's attention during labeling. We know from statistical learning paradigms that children who shift their attention to a target object are more likely to learn the word-object mapping than those children who tend to look more at competitors (Smith & Yu, 2013), yet the mechanisms underlying these differences in attention allocation are not clear.

Differences in children's approach to novelty likely come to bear on their referent selection and retention. Children's approach to novelty in social situations has been typically termed *behavioral inhibition* (Kagan, Reznick, & Snidman, 1988), or *shyness* (Putnam, Gartstein, & Rothbart, 2006), with latency to approach a novel object acting as an early marker for later shyness (Rothbart, 1988) and throughout childhood shy children demonstrate discomfort when faced with novelty (Buss, 1986). A typical lab-based fast mapping task however involves substantial novelty: the room is usually new, the task is unfamiliar, and the experimenter is typically an unfamiliar adult. Lab-based tasks may therefore be more anxiety-provoking for shy children than less-shy children. Shy children could be less likely to focus their attention on the word learning task sufficiently to form and retain word object mappings in the face of such a high degree of novelty, because instead they may focus more on the novel elements of the environment (i.e. the room and/or the experimenter).

Hilton and Westermann (Paper 1) examined whether shyness affected children's word learning performance on a lab-based task. They first presented children with referent selection trials consisting of one novel and two familiar objects. When asked to select an object using a novel word (e.g. "where's the koba?"), shy children did not reliably select the novel object, whereas less-shy children did. On subsequent retention trials consisting of three just-seen novel objects, less-shy children retained the word-object mappings encountered during referent selection above chance while shy children did not. The authors concluded that shy children's aversion to novelty, compounded by a reluctance to rely on a label cue that could feasibly refer to one of the known competitors, disrupted attention to the novel object during referent selection, leading to unsystematic performance and failure to retain any mappings that were formed.

Hilton and Westermann (Paper 1) therefore presented evidence that the in-the-moment processes by which children disambiguate word meaning are affected by shyness. Interestingly, however, some have argued that shy children's receptive language skills are overall not affected by shyness (Smith Watts et al., 2014). Thus, the longer term associative processes supporting word learning outside the lab may be protected from the effects of shyness. This may be because word-object associations are formed across different contexts, some of which may be better suited for shy children to learn from. Understanding which contexts facilitate shy children's attention to novel objects during labeling is therefore critical to our understanding of how they learn words.

Given shy children's marked aversion to novelty, increasing the familiarity of the testing environment should facilitate their attention towards the objects in the task, freeing up their attentional system to disambiguate the novel label and select the correct referent. This increase in available attention may also lead to heightened looking at the novel object, which could in turn support shy children's retention of the novel word-object mapping. The present study therefore examines shy and less-shy children's word learning under conditions of increased familiarity. Children took part in a fast mapping task (as in Hilton & Westermann, Paper 1), with the key difference that each child's parent, rather than an experimenter, presented each array of objects and asked for the target. On referent selection trials, the parent presented their child with two familiar objects and one novel object, and asked either for a familiar object or for the novel object using a pseudoword. After a five-minute delay, children were then tested on their retention of the novel word-object mappings presented during referent selection. If increasing the familiarity of the situation reduces the impact of shyness on the attentional processes that support word learning, shy children should select the novel object as the referent of the novel label, and retain the mapping after the delay. However, if familiarity has no effect on performance, shy children should, like in Hilton and Westermann (Paper 1), fail to select novel targets during referent selection, and fail to retain any mappings that were formed.

Method

Participants

Twenty-four typically developing two-year-old children participated (*M* = 29 m, 6 days, *SD* = 115 days; range = 24 m, 18 days to 35 m, 15 days; 16 girls and 16 boys). All children were monolingual and predominantly from middle-class, Caucasian families living in the North West of England, UK. Families were recruited by contacting parents who had previously indicated interest in participating in child development research. Parents' travel expenses were reimbursed and children were offered a storybook for participating. Data from three additional children were excluded from analyses due to their parent not following the correct procedure (n = 2) and refusal to participate (n = 1).

The Early Childhood Behavior Questionnaire (ECBQ; Putnam et al., 2006) was used to assess children's shyness as an enduring, biologically-based individual difference. The ECBQ asks parents to rate how often their child has demonstrated particular behaviors over the previous two weeks on a scale ranging from 1 (*never*) to 7 (*all the time*). The scale consists of 18 fine-grained subdimensions of temperament. While these subdimensions include areas such as activity level, frustration and high- or low-intensity pleasure, we collected only responses related to the shyness subdimension. The questionnaire also included items measuring a randomly selected subdimension (perceptual sensitivity) to avoid demand characteristics confounding responses. Responses to the perceptual sensitivity items were not input nor analyzed.

The shyness scale consists of 12 items that assess how children react in situations that elicit shy behavior, for example "When approaching unfamiliar children playing, how often did your child watch rather than join?" and "In situations where s/he is meeting new people, how often did your child become quiet?". Each child was scored from 1-7 by averaging their parents' responses to the 12 questions relating to shyness (after correcting for reverse coded questions). A score of 1 is considered the least shy, and a score of 7 is considered the most shy. Once all data was collected, we calculated the median score for all children (3.38). Following the procedure of Hilton and Westermann (Paper 1), children scoring above the median formed the shy group and those scoring less than the median formed the less-shy group. The shy and less-shy group did not significantly differ in age, $t(22) = -1.21$, $p = .24$.

Stimuli

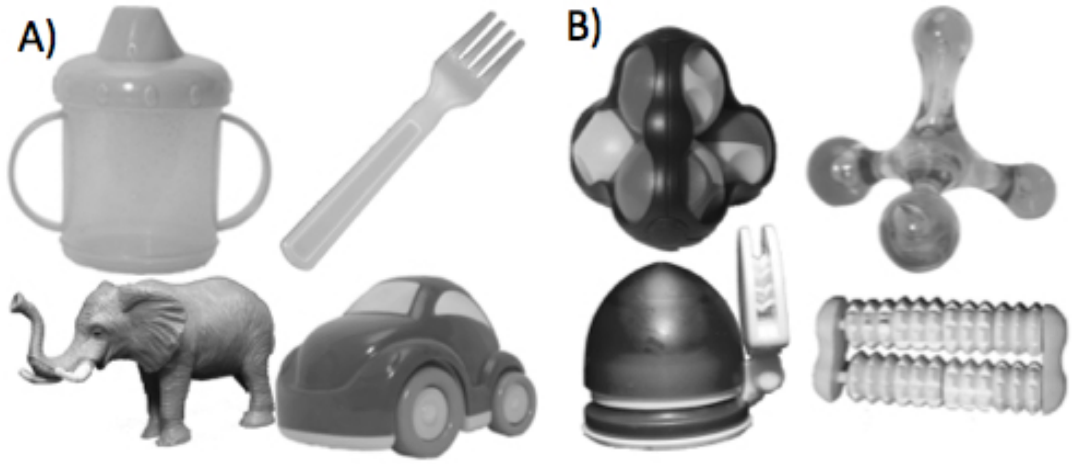


Figure 1. Subset of stimuli used in the experiment. Panel A) shows examples of familiar objects used during referent selection, and Panel B) shows the four novel objects.

All stimuli were used in both conditions. Twelve objects, selected because they are easily named by two-year-old children, acted as familiar objects and consisted of animals (duck, elephant, fish, pig), vehicles (car, motorbike, helicopter) and household objects/toys (spoon, fork, cup, ball and doll). The four novel objects, selected because they are unfamiliar to two-year-old children, were a plastic massager, a deconstructed Rubik's cube, a cocktail strainer and a napkin holder (see Figure 1). Four distinct non-words (*cheem*, *koba*, *sprock*, *tannin*) were used to name the novel objects, and were taken from previous research using similar methodology (Behrend, Scofield, & Kleinknecht, 2001; Halberda, 2006; Horst & Samuelson, 2008; Samuelson & Horst, 2007). Novel names were randomly assigned to objects across participants. All objects were similar in size (approximate mean size 5 cm x 6 cm x 9 cm). The objects were presented on an unpainted wooden tray, divided into three equal compartments.

Procedure and Design

Prior to their visit to the lab each child's parent was emailed a 10-minute training video. The video was a walkthrough of the experiment with commentary explaining the procedure in more detail. Importantly, the video did not explain that novel words or objects would be used in the task. Instead, the video contained only familiar objects and labels. This was to ensure that parents did not practice the task beforehand with their child in order to train them in selecting a novel object as the referent of a novel label. When parents arrived at the lab, they were then informed that some of the labels and objects may be novel, but that they should not react differently to these objects or labels. Parents completed the questionnaire taken from the ECBQ, and the experimenter then explained the procedure once more. When the child was settled and comfortable, the parent and child moved to the testing room and the experiment began.

Word learning task.

Warm up trials. During the task children sat on a high chair across a white table from their parent. The experimenter sat behind the parent, occluded by a screen, ready to organize the stimuli and pass them to the parent through a hidden opening. All trials consisted of three objects being presented to the child on the tray. Warm-up trials consisted of three familiar objects and were designed to introduce the child and parent to the forced-choice task, and to ensure that children understood their parent's instructions. On each trial, the requested object label was displayed on a screen behind the child. The experimenter then passed the tray of objects through the opening to the parent. The parent then placed the tray on the table, out of reach of the child, and asked for the target three times (e.g., "Wow a duck! Can you see the duck? Where's the duck?"). The parent then slid the tray forward into reaching distance for the child, and gave the child the opportunity to retrieve the requested object. If correct, the child was praised, and if incorrect the child was corrected. The order in which the objects were requested was randomly determined prior to training. Warm-up trials continued until children had correctly selected each referent once.

Referent selection trials. Referent selection trials began immediately after warm up trials, and proceeded in the same manner with two exceptions. First, neither praise nor corrections were given following the child's choice. Second, two of the objects were familiar and one was novel. Each novel object was randomly assigned a novel word, and no familiar objects presented during referent selection had been used as warm up stimuli.

Each child was presented with four sets of three objects, and each set was shown three times (12 trials in total). On the first two trials for each set, the parent requested the novel object, and on the final trial the parent requested a randomly selected familiar object. The combination of familiar and novel objects that comprised each set was randomly selected prior to the experiment.

Retention trials. Following referent selection there was a five-minute break, during which the child and parent read storybooks. This break was to ensure that any retention in the following trials was the product of long-term memory (following Horst & Samuelson, 2008). After the five-minute break, the child participated in four retention trials. Now, parents presented children with sets of three just-seen novel objects. Across the four retention trials, each novel object was the target once. The two novel objects presented alongside the target were randomly determined. On presentation of each set, the parent asked their child to select the target three times (i.e. "Wow a koba! Can you see the koba? Where's the koba?"). The parent then slid the tray forward and the child indicated the chosen object. Trial order was randomized across participants.

Results

Word Learning Tasks

For each child, the proportion of correct choices was calculated by dividing the number of correct responses by the total possible (i.e., 4 for familiar trials, 8 for novel trials).

Referent selection task. Each child took part in four familiar and eight novel referent selection trials during referent selection. Overall, selection of the correct familiar object was higher than would be expected by chance (chance: 0.33 for all reported tests; $M = .69$, $SD = .25$), $t(23) = 7.36$, $p < .001$, two-tailed. Furthermore, children selected the novel object significantly above chance on novel label trials ($M = .63$, $SD = .20$), $t(23) = 7.21$, $p < .001$. Overall, children did not select the novel object more often on its first presentation than on its second presentation, $t(23) = 1.41$, $p = .17$. Children were no better at selecting the requested familiar object than the novel object, $t(23) = 1.71$, $p = .10$.

Retention task. One child (less-shy) did not participate in the retention task due to failure to re-engage with the task following the break. Retention trials were only analyzed if the child had selected the novel object on the initial novel label trial. This was to ensure that only memory for initially-formed mappings was tested (following Horst & Samuelson, 2008). Overall, children retained these word-object mappings at levels greater than would be expected by chance, ($M = .42$, $SD = .27$), $t(22) = 2.10$, $p < .05$.

Shyness as a Predictor of Word Learning

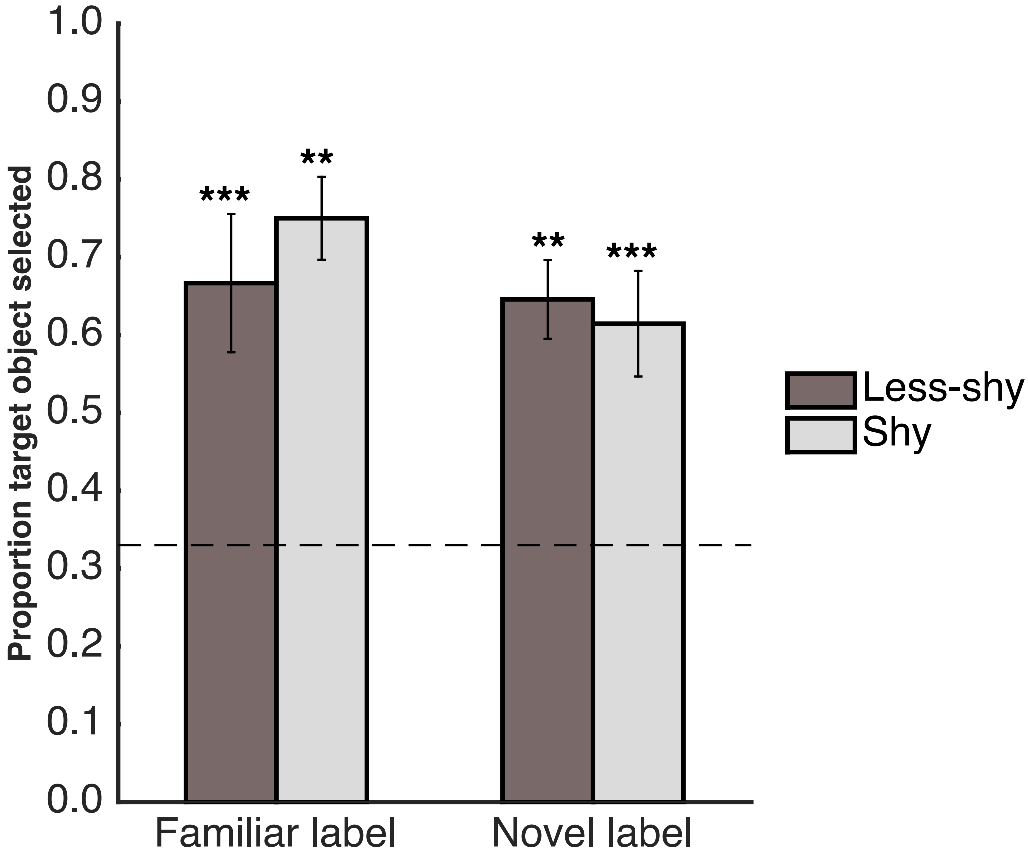


Figure 2. Shy and less-shy children's proportion of target choices on the three types of referent selection trials. Error bars represent 1 SE, and the dashed line represents chance (.33) $^{**}p < .01$, $^{***}p < .001$.

Analysis of referent selection for shy and less-shy children revealed that children in the less-shy group were better than would be expected by chance at selecting the familiar object, $t(11) = 3.79$, $p < .01$; and the novel object $t(11) = 6.18$, $p < .001$. Children in the shy group were also better than would be expected by chance at selecting the familiar object, $t(11) = 7.88$, $p < .001$, and the novel object, $t(11) = 4.15$, $p = .01$. Children's object choices were submitted to a 2 (group: less-shy or shy) x 2 (trial: novel or familiar) mixed analysis of variance (ANOVA). There was no main effect of group, $F(1, 22) = 3.01$, $p = .10$, indicating that there was no evidence that shy children chose the correct object less often that less-shy children. There was also no main effect of trial, $F(1, 22) = 0.10$, $p = .78$, that is, overall, children were no better at selecting the referent on familiar than on novel label trials. There was no interaction between group and trial, $F(1, 22) = 1.62$, $p = .22$.

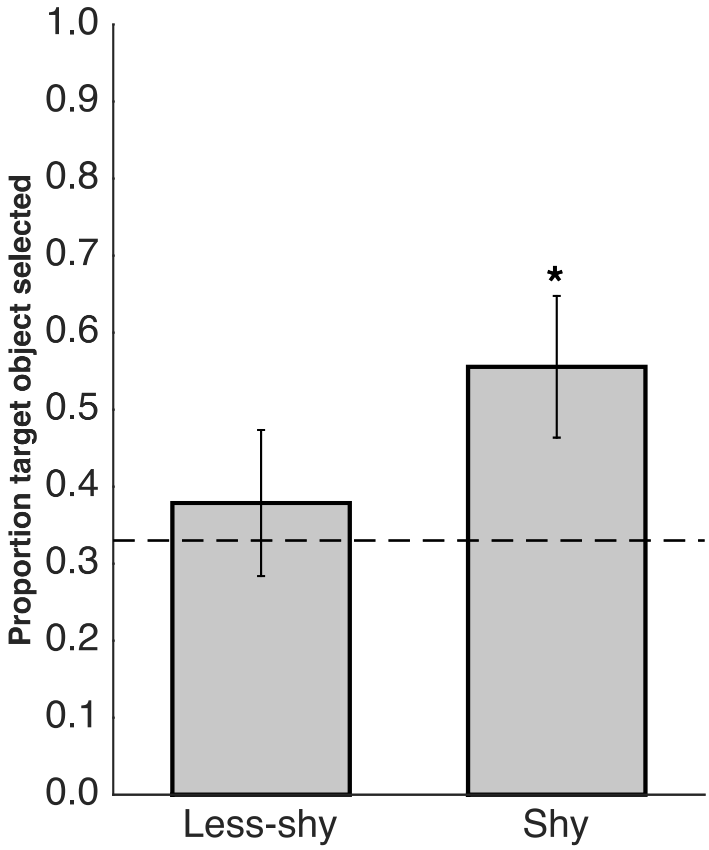


Figure 3. Shy and less children's proportion of retained word-object mappings. Error bars represent 1 SE, and the dashed line represents chance. *p <.05.

However, at test children in the less-shy group did not retain the word-object mappings at levels higher than expected by chance, $t(10) = .51$, $p = .62$. In contrast, children in the shy group did show evidence of retaining the word-object mappings, $t(11) = 2.45$, $p = .03$, as shown in Figure 3. An independent-samples t-test revealed no difference between the groups, $t(21) = -1.34$, $p = .20$.

Discussion

This study provides converging evidence that shyness affects children's word learning (see also Hilton & Westermann, Paper 1), and demonstrates that this effect can be mitigated by increasing the familiarity of the task. Critically, while shy children do not select a novel object as the referent of a novel label when asked by an experimenter, they will do so when requested by their parent. This supports shy children's retention of these word-object mappings formed during referent selection. We argue that shy children's retention is improved when the task is more familiar because their aversion to novelty no longer disrupts the attention allocation that supports disambiguation of the novel label.

Given that shy children exhibit discomfort in the presence of unfamiliar adults (Putnam et al., 2006), they likely struggled in previous studies to attend to the relevant features of the task in the presence of an unfamiliar experimenter. Hilton and Westermann (Paper 1) argued that shy children's aversion to novelty disrupts the attentional processes that support their selection of the novel object as the referent of the novel label: the perceived 'threat' of the novelty of the task and/or experimenter could therefore serve to interrupt shy children's attempts to systematically scan and reject competitors as referents. The current study supports this account: removing one component of the task's novelty by asking a familiar adult to conduct the task frees up shy children's attentional system to attend to the task, demonstrating successful referent selection that leads to retention.

Hilton & Westermann (Paper 1) also offered an interpretation of their results based on shy children's heightened wariness of negative social evaluation (Coplan, Girardi, Findlay, & Frohlick, 2007) and risk-aversion (Levin & Hart, 2003), suggesting that shyness is marked by a reluctance in "hazarding a guess" (Coplan &

Evans, 2009, p. 212). Thus, shy children may judge the potential social cost of being wrong as greater than the potential benefit of learning a new word. That is to say, in this task children typically map novel labels to novel referents, but it is entirely possible that the novel label could refer to one of the familiar objects, for example as a superordinate category label. Referent selection may therefore be impaired in the presence of an unfamiliar experimenter because shy children are reluctant to rely on an ambiguous label cue in determining the correct referent. The current work indicates that reducing the potential for negative social evaluation supports children's disambiguation of the novel label. Such a rich explanation for this effect requires further investigation and confirmation, but it would suggest that shy children make better use of unambiguous cues to referent selection.

Exemplifying the complex and dynamic nature of the relationship between shyness, context and word learning, less-shy children did not retain the word-object mappings when they had been presented by their parent. This surprising result suggests that these children are able to allocate their attention appropriately in order to select the novel object as the referent of the novel label, but their attention is subsequently not sufficiently focused on the novel object to robustly encode the word-object mapping. Alternatively, less-shy children may fail to re-engage with the task after the break. In any case, it is unlikely that less-shy children are unable to learn words from their parent; however, it is possible that increasing the familiarity of the environment may cause less-shy children to lose interest, although their performance on referent selection trials remained constant from beginning to end. Nonetheless, this finding suggests that less-shy children's attention does not support the retention of word-object mappings in highly-structured tasks in a context of high familiarity, and further work is required to support and examine this effect.

While previous research has examined the effect of shyness on language production in older children (Crozier & Badawood, 2009; Crozier & Perkins, 2002; Reynolds & Evans, 2009; Smith Watts et al., 2014), taken together with Hilton & Westermann (Paper 1), the current study is the first to suggest that shyness could drive this effect early in language acquisition by modulating the disambiguation and retention of words. This study therefore builds on recent investigations of the effect of attention during referent selection on the retention of words (Axelsson et al., 2012; Bion et al., 2013; Smith & Yu, 2013) by providing evidence of an intrinsic factor that may affect attention during word learning: shyness. Importantly, the finding that shy children retained word-object mappings when the objects were presented by their parent suggests that the negative impact of shyness on language development (e.g. Smith Watts et al., 2014) does not imply that shy children's language development is somehow problematic or delayed (Coplan & Armer, 2005). Instead, the optimal environment in which children can acquire language varies according to shyness. The finding that shy children learn better in environments that are familiar may explain why shyness is not associated with long-term academic problems (Cameron, 2009), because shy children are able to learn once they have familiarized themselves with the environment.

Finally, the current work also raises important methodological issues. First, parents complied with the instructions necessary to ensure a controlled task when given thorough training, demonstrating the feasibility of controlling the familiarity of the testing environment and laying the groundwork for future, parent-controlled experimental tasks. Second, attrition rates from this study were better than most studies based on similar paradigms run by trained researchers. In the current work, only one child was excluded from analyses due to failure to engage, equal to 4% of the total tested, while previous papers testing the same aged children have reported comparable (or higher) attrition rates (e.g. 11%; Zosh, Brinster, & Halberda, 2013). Children therefore engage well with a task when interacting with their parents.

Since Carey's (1978) seminal work we have come a long way in understanding the complex link between how children establish what the words they hear mean and their learning of these words. We have moved from arguments that children's use of a priori constraints or lexical principles lead to word learning (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Markman & Wachtel, 1988), to the understanding that children's word learning is both emergent and dynamic (Bion et al., 2013; McMurray et al., 2012; Regier, 2003; Samuelson & Smith, 2000; Smith & Samuelson, 2006). The current work highlights the dynamic nature of the processes that support word learning by demonstrating the importance of understanding the interaction between intrinsic and extrinsic factors and their effect on the behaviors that impact on language acquisition.

Importantly, the current work demonstrates that the processes involved in referent selection change across contexts. In line with recent demonstrations that intrinsic factors can come to bear on children's use of word-learning strategies (e.g. Perry & Samuelson, 2011), the current work supports accounts that the flexibility of attentional allocation can also explain the variability in results of previous studies of word learning: Retention is dependent on the interaction between aspects of the environment and – critically – the learner. We must take these interactions into account in attempting to form a more holistic and multidimensional explanation of children's apparent skill in learning words.

References

Anglin, J. M. (1993). Vocabulary development: A morphological analysis. *Monographs of the Society for Research in Child Development*, *58*(10), i–186. http://doi.org/10.2307/1166112

Axelsson, E. L., Churchley, K., & Horst, J. S. (2012). The right thing at the right time: Why Ostensive naming facilitates word learning. *Frontiers in Psychology*, *3*, 88. http://doi.org/10.3389/fpsyg.2012.00088

Axelsson, E. L., & Horst, J. S. (2014). Contextual repetition facilitates word learning via fast mapping. *Acta Psychologica*, *152*, 95–99. http://doi.org/10.1016/j.actpsy.2014.08.002

Behrend, D. A., Scofield, J., & Kleinknecht, E. E. (2001). Beyond fast mapping: Young children's extensions of novel words and novel facts. *Developmental Psychology*, *37*(5), 698.

Bion, R. A. H., Borovsky, A., & Fernald, A. (2013). Fast mapping, slow learning: Disambiguation of novel word–object mappings in relation to vocabulary learning at 18, 24, and 30 months. *Cognition*, *126*(1), 39–53. http://doi.org/10.1016/j.cognition.2012.08.008

Buss, A. H. (1986). A theory of shyness. In W. H. Jones, J. M. Cheek, & S. R. Briggs (Eds.), *Shyness: Perspectives on research and treatment* (pp. 39–46). Boston, MA: Springer US. Retrieved from http://dx.doi.org/10.1007/978-1-4899-0525-3_4

Cameron, C. A. (2009). Associations between shyness, reluctance to engage, and academic performance. *Infant and Child Development*, *18*(3), 299–305. http://doi.org/10.1002/icd.626

Carey, S. (1978). The child as word learner. In M. Halle, J. Bresnan, & G. Miller (Eds.), *Linguistic theory and psychological reality*. Cambridge, MA: MIT Press.

Coplan, R. J., & Armer, M. (2005). Talking yourself out of being shy: Shyness, expressive vocabulary and socioemotional adjustment in preschool. *Merrill-Palmer Quarterly*, *51*(1), 20–41.

Coplan, R. J., & Evans, M. A. (2009). At a loss for words? Introduction to the special issue on shyness and language in childhood. *Infant and Child Development*, *18*(3), 211–215. http://doi.org/10.1002/icd.620

Coplan, R. J., Girardi, A., Findlay, L. C., & Frohlick, S. L. (2007). Understanding solitude: Young children's attitudes and responses toward hypothetical socially withdrawn peers. *Social Development*, *16*(3), 390–409. http://doi.org/10.1111/j.1467-9507.2007.00390.x

Crozier, W. R., & Badawood, A. (2009). Shyness, vocabulary and children's reticence in Saudi Arabian preschools. *Infant and Child Development*, *18*(3), 255–270. http://doi.org/10.1002/icd.623

Crozier, W. R., & Perkins, P. (2002). Shyness as a factor when assessing children. *Educational Psychology in Practice*, *18*(3), 239–244. http://doi.org/10.1080/0266736022000010267

Golinkoff, R. M., Hirsh-Pasek, K., Bailey, L. M., & Wenger, N. R. (1992). Young children and adults use lexical principles to learn new nouns. *Developmental Psychology*, *28*(1), 99–108. http://doi.org/10.1037/0012-1649.28.1.99

Golinkoff, R. M., Mervis, C. B., & Hirsh-Pasek, K. (1994). Early object labels: the case for a developmental lexical principles framework. *Journal of Child Language*, *21*(01), 125–155. http://doi.org/10.1017/S0305000900008692

Gray, S. (2005). Word learning by preschoolers with specific language impairment: Effect of phonological or semantic cues. *Journal of Speech, Language & Hearing Research*, *48*(6), 1452–1467.

Halberda, J. (2003). The development of a word-learning strategy. *Cognition*, *87*(1), B23–B34. http://doi.org/10.1016/S0010-0277(02)00186-5

Halberda, J. (2006). Is this a dax which I see before me? Use of the logical argument disjunctive syllogism supports word-learning in children and adults. *Cognitive Psychology*, *53*(4), 310–344. http://doi.org/10.1016/j.cogpsych.2006.04.003

Horst, J. S., Parsons, K. L., & Bryan, N. M. (2011). Get the story straight: Contextual repetition promotes word learning from storybooks. *Frontiers in Psychology*, *2*, 17. http://doi.org/10.3389/fpsyg.2011.00017

Horst, J. S., & Samuelson, L. K. (2008). Fast mapping but poor retention by 24-month-old infants. *Infancy*, *13*(2), 128–157. http://doi.org/10.1080/15250000701795598

Horst, J. S., Scott, E. J., & Pollard, J. A. (2010). The role of competition in word learning via referent selection. *Developmental Science*, *13*(5), 706–713. http://doi.org/10.1111/j.1467-7687.2009.00926.x

Kagan, J., Reznick, J., & Snidman, N. (1988). Biological bases of childhood shyness. *Science*, *240*(4849), 167–171.

Korat, O., Shamir, A., & Arbiv, L. (2010). E-books as support for emergent writing with and without adult assistance. *Education and Information Technologies*, *16*(3), 301–318. http://doi.org/10.1007/s10639-010-9127-7

Levin, I. P., & Hart, S. S. (2003). Risk preferences in young children: early evidence of individual differences in reaction to potential gains and losses. *Journal of Behavioral Decision Making*, *16*(5), 397–413. http://doi.org/10.1002/bdm.453

Markman, E. M., & Wachtel, G. F. (1988). Children's use of mutual exclusivity to constrain the meanings of words. *Cognitive Psychology*, *20*(2), 121–157. http://doi.org/10.1016/0010-0285(88)90017-5

Mather, E., & Plunkett, K. (2009). Learning words over time: The role of stimulus repetition in Mutual Exclusivity. *Infancy*, *14*(1), 60–76. http://doi.org/10.1080/15250000802569702

McMurray, B., Horst, J. S., & Samuelson, L. K. (2012). Word learning emerges from the interaction of online referent selection and slow associative learning. *Psychological Review*, *119*(4), 831–877. http://doi.org/10.1037/a0029872

Mervis, C. B., & Bertrand, J. (1994). Acquisition of the Novel Name–Nameless Category (N3C) principle. *Child Development*, *65*(6), 1646–1662. http://doi.org/10.1111/j.1467-8624.1994.tb00840.x

Perry, L. K., & Samuelson, L. K. (2011). The shape of the vocabulary predicts the shape of the bias. *Frontiers in Psychology*, *2*. http://doi.org/10.3389/fpsyg.2011.00345

Putnam, S. P., Gartstein, M. A., & Rothbart, M. K. (2006). Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior Questionnaire. *Infant Behavior and Development*, *29*(3), 386–401. http://doi.org/10.1016/j.infbeh.2006.01.004

Quine, W. V. O. (1960). *Word & Object*. The MIT Press.

Regier, T. (2003). Emergent constraints on word-learning: a computational perspective. *Trends in Cognitive Sciences*, *7*(6), 263–268. http://doi.org/10.1016/S1364-6613(03)00108-6

Reynolds, K. P., & Evans, M. A. (2009). Narrative performance and parental scaffolding of shy and nonshy children. *Applied Psycholinguistics*, *30*(2), 363–384. http://doi.org/10.1017/S0142716409090158

Rice, M. L., & Woodsmall, L. (1988). Lessons from television: Children's word learning when viewing. *Child Development*, *59*(2), 420–429.

Rothbart, M. K. (1988). Temperament and the development of inhibited approach. *Child Development*, *59*(5), 1241–1250. http://doi.org/10.2307/1130487

Samuelson, L. K., & Horst, J. S. (2007). Dynamic noun generalization: Moment-to-moment interactions shape children's naming biases. *Infancy*, *11*(1), 97–110. http://doi.org/10.1080/15250000709336872

Samuelson, L. K., & Smith, L. B. (2000). Grounding development in cognitive processes. *Child Development*, *71*(1), 98–106. http://doi.org/10.1111/1467-8624.00123

Senghas, A., & Coppola, M. (2001). Children creating language: How Nicaraguan Sign Language acquired a spatial grammar. *Psychological Science*, *12*(4), 323–328.

Smith, L. B., & Samuelson, L. (2006). An attentional learning account of the shape bias: Reply to Cimpian and Markman (2005) and Booth, Waxman, and Huang (2005). *Developmental Psychology*, *42*(6), 1339–1343. http://doi.org/10.1037/0012-1649.42.6.1339

Smith, L. B., & Yu, C. (2013). Visual attention is not enough: Individual differences in statistical word-referent learning in infants. *Language Learning and Development*, *9*(1), 25–49. http://doi.org/10.1080/15475441.2012.707104

Smith Watts, A. K., Patel, D., Corley, R. P., Friedman, N. P., Hewitt, J. K., Robinson, J. L., & Rhee, S. H. (2014). Testing alternative hypotheses regarding the association between behavioral inhibition and language development in toddlerhood. *Child Development*, *85*(4), 1569–1585. http://doi.org/10.1111/cdev.12219

Snow, C. F. (1972). Mothers' speech to children learning language. *Child Development*, *43*(2), 549–565.

Spencer, J. P., Blumberg, M. S., McMurray, B., Robinson, S. R., Samuelson, L. K., & Tomblin, J. B. (2009). Short arms and talking eggs: Why we should no longer abide the nativist–empiricist debate. *Child Development Perspectives*, *3*(2), 79–87. http://doi.org/10.1111/j.1750-8606.2009.00081.x

Spiegel, C., & Halberda, J. (2011). Rapid fast-mapping abilities in 2-year-olds. *Journal of Experimental Child Psychology*, *109*(1), 132–140. http://doi.org/10.1016/j.jecp.2010.10.013

Twomey, K. E., Ranson, S. L., & Horst, J. S. (2014). That's more like it: Multiple exemplars facilitate word learning. *Infant and Child Development*, *23*(2), 105–122. http://doi.org/10.1002/icd.1824

Zosh, J. M., Brinster, M., & Halberda, J. (2013). Optimal contrast: Competition between two referents improves word learning. *Applied Developmental Science*, *17*(1), 20–28. http://doi.org/10.1080/10888691.2013.748420

Eye Movements During the Learning of Novel Word-Object Mappings in Shy and Less-Shy Children

Matt Hilton, Katherine E. Twomey and Gert Westermann

Lancaster University

Abstract

The current work takes the novel approach of examining the effect of shyness on early word learning using looking time measures. 20- and 26-month old children took part in an eye-tracking task. Each child was presented with images of objects in sets of three, each comprising one novel and two familiar objects, and heard either a label for one of the familiar objects, or a novel word. Shyness affected children's attention to the objects, with less-shy children showing evidence of disambiguation more rapidly following the label and for longer than shy children. Analysis of the relation between looking during labeling and retention provided further evidence that learning of novel word-object mappings only takes place *after* their first exposure.

Eye Movements During the Learning of Novel Word-Object Mappings in Shy and Less-Shy Children

Reports on the development of language usually begin by celebrating children's remarkable ability to learn words. For example, it is often stated that by the time of their second birthday, children have typically acquired a vocabulary of over 300 words (Fenson et al., 1994). While an impressive demonstration of the speed of language acquisition, these summaries often ignore an equally fascinating aspect of early language acquisition– its variability. When examined further, Fenson and colleagues' (1994) data also show that 10% of two-year-old children are able to produce more than 528 different words, while the 10% at the opposite end of the scale produce fewer than 66 different words. Interestingly, the majority of children in the bottom 10% will show no later difficulties with language development (Kelly, 1998).

This variability in early language acquisition is typically examined in terms of effects of the environment on vocabulary size. For example, research on the effects of *socio-economic status* (SES) examines the extrinsic factors that shape language development, exploring why children from more deprived backgrounds have smaller vocabularies (Hoff-Ginsberg, 1991). While Hart and Risley (2003) initially argued that this effect is due to children from low-SES families being exposed to fewer words, Hirsh-Pasek and colleagues (2015) have more recently demonstrated that the quality, alongside quantity, of input is critical. For example, by drawing on previous findings that higher-SES parents elicit more conversation from their child when they speak than lower-SES parents (Hoff, Laursen & Tardif, 2002), it can be argued that children from high-SES backgrounds have larger vocabularies because their language input is easier to learn from.

Recently, there has been an increasing focus on intrinsic factors that can affect language development, specifically the child's emerging biologically-based individual differences (e.g., Stromswold, 2001). One of these factors is temperament which is typically defined as enduring, biologically-based differences in behavioral style that can be assessed across a number of subdimensions (e.g. Putnam, Gartstein & Rothbart, 2006). A subdimension of temperament with a marked effect on language acquisition is shyness. Shyness is defined by Putnam and colleagues (2006, p. 399) as "slow or inhibited approach and/or discomfort in social situations involving novelty or uncertainty," and is stable throughout early childhood (Fox, et al., 2005; Putnam et al., 2006; Sanson, Pedlow, Cann, Prior & Oberklaid, 1996). Shy children speak less (Crozier & Perkins, 2002), have lower productive vocabularies (Smith Watts et al., 2014) and score lower on face-to-face measures of language development (Crozier & Hostettler, 2003).

The predominant explanation for the association between shyness and language acquisition is known as the *I know it but won't say it* hypothesis (Coplan & Evans, 2009), according to which shy children do not acquire language differently from less-shy children, but rather they are reticent to respond. Smith Watts and colleagues (2014) tested this explanation by examining the relations between behavioral inhibition, expressive, and receptive vocabulary. It was found that expressive vocabulary, but not receptive vocabulary, is strongly associated with behavioral inhibition. Despite offering support for the *I know it but won't say it* hypothesis, these findings are based on parental report of children's receptive and productive vocabulary. Stronger evidence for this view could come from examining this effect on other measures of language development, leading to a more multidimensional understanding of the effect (Dockerell, 2001), for example by examining the effect of shyness on the low-level attentional processes used to acquire this language in the first instance. Thus, whether shyness also affects the implicit processes by which children acquire their vocabulary can be better understood through a more fine-grained analysis of the effect of shyness on the in-the-moment processes by which language is learned.

We know that deciphering the meaning of heard words, the critical first step in word learning, is a challenge for the child. As explained in Quine's (1960) seminal work, the number of potential referents for each individual word is theoretically infinite, yet children cannot rely on their interactional partners to disambiguate the meaning of every spoken word for them. We now know that one way that children tackle this disambiguation problem is by narrowing down the potential meaning of words before selecting a referent. These behaviors are systematic, traditionally leading some researchers to describe them as constraints children place upon the potential meaning of the heard word (Markman 1994) or as lexical principles (Golinkoff, Mervis & Hirsh-Pasek, 1994). For example, English learning children's preference for generalizing labels from one object to another of the same shape has been attributed to the *shape bias* (Landau, Smith & Jones, 1988; Samuelson & Smith, 1999). Similarly, monolingual infants' reliable ability to map novel labels to novel objects, when all other potential referents are familiar, has been described as their use of a mutual exclusivity strategy (ME; for an alternative account, see Mervis & Bertrand, 1994).

Use of an ME-type strategy for novel label disambiguation has been reliably demonstrated in children as young as 17 months of age (Halberda, 2003), and has provided the means by which *fast mapping* (Carey, 1978), or children's ability to rapidly link novel labels to novel objects, has typically been investigated. Specifically, in these studies children take part in *referent selection* trials during which they are presented with a set of objects, some of which are familiar, and one of which is novel. They are then asked to select an object using a novel pseudoword (e.g. “can you get the blicket?”). While children are often able to select the novel object when hearing a novel label, whether or not children retain the mappings they form during referent selection has recently been questioned.

Initial reports on fast mapping assumed that correctly selecting the referent led to its retention (Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; see also Zosh, Brinster & Halberda, 2013), giving rise to the reputation of fast mapping as a basic mechanism for word learning (Golinkoff et al., 1992). However, more recent research has cast doubt on this theory. Horst and Samuelson (2008) found that correct selection of the novel target on referent selection trials did not lead to retention in 24-month-old children and, along with subsequent reports supporting this finding (e.g. Axelsson, Churchley & Horst, 2012), these results have led to the conclusion that the processes underlying correct referent selection are separate from the encoding of the mapping into long term memory (McMurray, Horst & Samuelson, 2012; Munro, Baker, McGregor, Docking & Arculi, 2012).

The discovery that referent selection does not automatically lead to retention has inspired a wealth of research into the factors that may moderate the association between the two processes. For example, Horst and Samuelson (2008) found that mappings formed via referent selection were only retained if the mapping was reinforced by ostensive naming (pointing at and labeling an object) immediately after the child selected the referent. Later research showed that dampening attention to competitor objects and heightening attention to the target object following its selection further facilitated children’s retention of the mapping (Axelsson et al., 2012). This research therefore indicated that selecting the novel object as a referent of a novel label does not by itself entail sufficient encoding of the novel word-object association for that mapping to be retained; instead the mapping can only be retained if the child's attention to the target is heightened above levels typically shown during a referent selection task.

While this previous research offers valuable insight into the extrinsic processes that underlie successful retention by varying external input while the mapping is formed, it does not examine whether intrinsic individual differences can affect the formation of the mapping, and whether these differences can in turn serve to modulate children's retention. Recent fine-grained analyses of children's attention to objects during referent selection trials have, however, begun to offer an insight into the nature of these individual differences.

Bion, Borovsky and Fernald (2013) examined whether attention during the disambiguation of novel labels predicted retention of these word-object mappings. When presented with a novel object alongside a familiar object, children above the age of 24 months looked towards a novel object when hearing a novel label, but only from the age of 30 months did children begin to show evidence of retaining the novel word-object mappings that had been previously presented. Importantly, it was found that at 24 and 30 months of age, looking longer towards the novel object during labeling increased the likelihood that the mapping was retained. While not specifically focusing on individual differences, this study suggests that intrinsic factors affecting children's formation of the novel word-object mapping can also affect retention of these mappings.

Hilton and Westermann (Paper 1) investigated whether intrinsic factors traditionally associated with language outcome measures (i.e. shyness) can predict differences between children in their disambiguation of heard words, and the authors also examined whether these differences explain children's difficulty in retaining these mappings. It was found that shy children did not reliably select a novel object as the referent of a novel label. In their study, 24-month-old children were presented with sets of three objects, one of which was novel and two of which were familiar. In contrast with the *I know it but won't say it* hypothesis, shy children showed no reticence to respond, either when asked for one of the familiar objects or for the novel target. Shy children were, however, less likely to select the correct familiar object than their less-shy peers. Shy children also selected objects at chance levels in response to the novel word, while less-shy children reliably chose the novel object. Furthermore, after a five-minute break, shy children did not retain any of the novel-object mappings that they had formed during referent selection, while less-shy children retained these mappings at levels above what would be expected by chance alone.

Beyond supporting previous findings that shyness negatively impacts language growth this study demonstrated that shyness affects the in-the-moment processes by which word-object mappings are formed, as well as longer term retention. Hilton and Westermann (Paper 1) concluded that shy children's aversion to novelty (Kagan, Reznick & Snidman, 1988) and risk-taking (Levin & Hart, 2003) caused them to respond unsystematically when faced with forming a novel word-object mapping on referent selection trials. In order to successfully form and retain a novel word-object mapping on this task, the child must first select the novel object as the referent of a novel label, attending to it sufficiently to encode the mapping. The novel label, however, cannot be disambiguated with certainty: the novel word may in fact refer to one of the familiar objects, and shy children's risk aversion might lead them to avoid this ambiguity. Indeed, shy children were just as likely to select a familiar object as the novel object when asked for a novel word.

Hilton and Westermann's (Paper 1) study provided clear evidence that the effect of shyness on language acquisition cannot be explained solely in terms of shy children's reticence to respond, and furthermore indicates that its influence goes beyond simply affecting children's referent selection. The mechanism by which shyness affects children's retention is likely to be that reduced attention to the target and competitor objects resulted in unsystematic responses during referent selection, thereby affecting the successful encoding of the mapping in long-term memory (cf. Axelsson et al., 2012). This conclusion is supported by existing research: Smith and Yu (2011) tracked children's eye gaze as they were repeatedly presented with a novel word-object mapping. On each trial, the target object was paired with a novel object. Children who shifted their attention away from the novel competitor and toward the target object as trials progressed later retained newly-formed mappings, a clear demonstration that attentional dynamics during referent selection can explain whether word-object mappings are learnt. Thus, the lack of reliable novel referent selection among shy children observed by Hilton & Westermann (Paper 1) could have been caused by different patterns of attention to targets and competitors compared with less-shy children. The current study explores this possibility.

Specifically, we examined whether shyness affects the time course of attention during referent selection, and further, whether such an effect changes across development. We therefore tested 20-month-old children, who have been shown to correctly select novel target objects but do not increase their looking to it during labeling and 26-month-olds, who demonstrate reliable looking to the novel object during labeling (Bion et al., 2013). In doing so, we sought to justify the assertion that shyness exerts its effect on language development by moderating children's implicit attentional processes during the disambiguation of new words.

Method

Participants

A total of 32 typically developing children, aged 20- and 26-months took part in the study. All children were monolingual and were from predominantly white, middle-class families living in the North West of England, UK. There were 16 children in the 20-month age group (*M* = 20 m, 13 days; range = 19 m, 11 days to 21 m, 5 days; 8 girls), and an additional three 20-month-old children were excluded due to fussiness (*n*=2) and experimenter error (*n*=1). There were also 16 children in the 26-month age group (*M* = 26 m, 13 days; range = 25 m, 19 days to 27 m, 0 days; 8 girls), and an additional two 26-month-old children were excluded due to equipment failure (*n*=1) and fussiness (*n*=1). One 20-month-old contributed no retention data because of refusing to participate in retention trials. Families were recruited by contacting parents who had previously indicated interest in participating in child development research. Parents' travel expenses were reimbursed and children were offered a gift of a storybook for participating.

Parents completed the Oxford CDI, a checklist for vocabulary comprehension and production, for their children (Hamilton, Plunkett & Shafer, 2000). Vocabulary scores for three 20-month-old children were not available because their parent failed to return the questionnaire. The 20-month-old group produced a mean of 127 words (range = 17-413 words) and comprehended a mean of 252 words (range = 104-413 words). The 26-month-old group produced a mean of 179 words (range = 158-386 words) and comprehended a mean of 347 words (range = 217-416 words).

Ethical approval for this study was granted by the Lancaster University Research and Ethics Committee.

Stimuli

Visual stimuli for training trials consisted of digital photographs of known and familiar objects (see Figure 1). Novel objects included a plastic tripod, a wooden roller, a wooden dumbbell and a plastic tea-strainer, and were chosen because most children at 26 months of age do not know names for these objects (Fenson et al., 1994). Each picture was of similar size on the screen (approx. 700 x 800 mm).

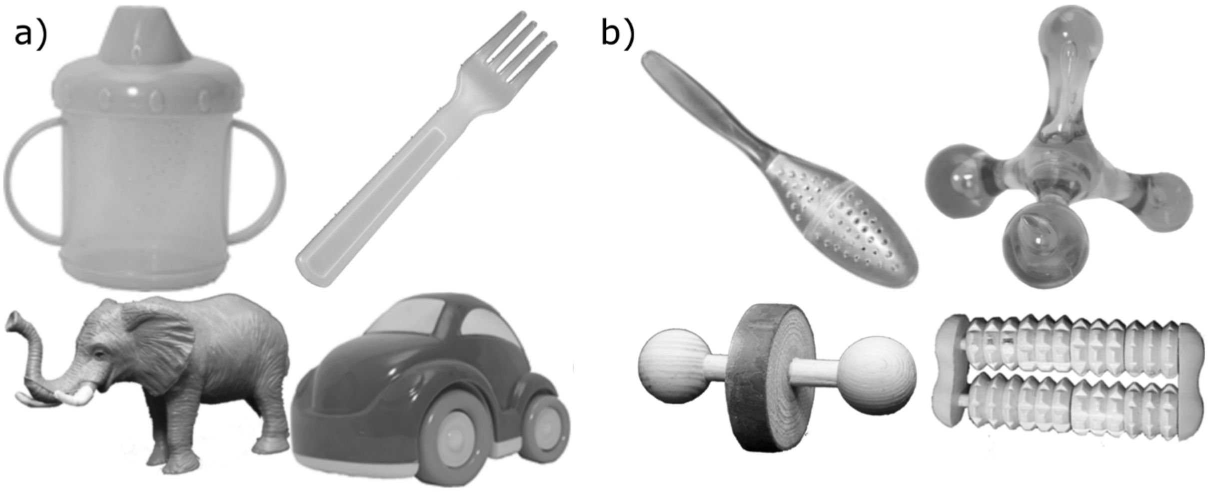


Figure 1. A subset of images used in the experiment. Panel A shows images of familiar objects shown during referent selection. Panel B shows images of the four unfamiliar objects as presented on referent selection trials. The actual unfamiliar objects were then used as stimuli on retention trials.

Audio stimuli consisted of three labeling phrases and object labels spoken by a male native British English speaker in infant-directed speech. The target object label appeared in the final position of each labeling phrase ("Look, there's a ____! Where's the _____? Wow, it's a ____!"). The three labeling phrases were in the same order on all trials. The label was heard 2500 ms after the start of the video as part of the first labeling phrase, 5200 ms after the start of the video as part of the second labeling phrase and 9100 ms after the start of the video as part of the third labeling phrase.

Seven objects were used for retention trials. Three randomly selected familiar objects acted as warm-up stimuli, alongside the four novel objects presented to the child during training.

Procedure

Shyness questionnaire. During their visit, parents completed the shyness scale of the Early Childhood Behavior Questionnaire (ECBQ; Putnam et al., 2006). The ECBQ is a standardized parent report measure of 18- to 36-month-old children's emerging temperament, and the shyness scale asks parents to rate from 1-7 (1 = *never*, 7 = *always*) how often over the past two weeks their child has demonstrated shy-type behaviors (e.g. "when playing with unfamiliar children, how often did your child seem uncomfortable?"). Averaging across the twelve questions results for each child in a score between 1 (*least shy*) and 7 (*most shy*). In order to avoid demand biases in parents' responses, three other questions taken from other temperamental subdimensions were included within the questionnaire, but these additional questions were not analyzed.

During their visit to the lab, children took part in referent selection trials, which were presented on a computer screen, and retention trials based on their selection of the actual 3D objects.

Referent selection trials. Children were seated centrally 50-70 cm in front of a computer screen on their parent's lap. A Tobii X120 eye-tracker, located beneath the screen recorded the child's eye gaze, and a video camera above the screen recorded the parent and child throughout the procedure. Parents were instructed not to look at the screen as the videos were playing to avoid influencing their child's behavior. Prior to the experiment starting, children were calibrated using a 5-point calibration procedure. An attention-grabbing animation was displayed in the four corners and center of a 3x3 grid, and calibration accuracy was checked and repeated if necessary.

All participants took part in all referent selection trials. There were 12 referent selection trials for each child. For each participant, the 12 referent selection pictures were randomly grouped into sets of three, with each set comprising one novel object and two familiar objects, meaning that the objects comprising each set were consistent for each participant but varied across participants. Each novel object was assigned one of four pseudowords (*cheem, koba, sprock, tannin*), chosen to be plausible pseudowords in English and which have been used in previous word learning studies (Halberda, 2006; Markson & Bloom, 1997; Horst & Samuelson, 2008; Samuelson & Horst, 2007). On each trial, a set of pictures bounced onto the screen, accompanied by a short bouncing sound effect, in order to grab children's attention at the beginning of the trial. Once the objects had finished bouncing (2000 ms after the start of the videos), the labeling phrases began. Once the labeling phrases had finished, the objects stayed on the screen for a further 2000 ms, before disappearing ready for the next trial.

Each set of pictures was presented three times; on two trials, the child heard the novel word, and on one trial the child heard one of the two familiar object labels (randomly selected). On each trial, the three objects were displayed stationary side-by-side on the screen for a total duration of 12000 ms. The labeling phrases began playing as soon as the objects had finished bouncing. The first label was heard at 2500 ms and the final label finished at 10000 ms.

Eye-gaze analyses. The sampling rate for each participant was 60 Hz, and the raw data files were exported from Tobii studio and analyzed in Matlab (version 2015a). For each participant, the data file showed, for each refresh of the screen, the time from the beginning of the trial, the trial number, and the xy co-ordinates of the child's gaze on the screen.

Based on the threshold approach of Yu and Smith (2011), three rectangular Areas of Interest (AOIs) were defined as the three areas of the screen where the stimuli were displayed. All AOIs measured 385 by 408 pixels. AOI1 covered the object on the left-hand side of the screen, AOI2 covered the object in the middle, and AOI3 covered the object on the right. AOIs did not overlap and there was a margin of 107 pixels between AOIs. Continuous gaze within an AOI was counted as a fixation. If continuous gaze within an AOI was interrupted for less than 60ms, this interruption was recoded as a continuation of that fixation, because this was most likely due to accidental eye-tracking errors rather than the child rapidly re-orienting their attention.

Retention trials. After the 12 referent selection trials, children took a five minute break, during which they played in an adjacent room. Children then took part in retention trials during which they sat on their parent's lap at a table opposite the experimenter. Prior to the retention test trials, a series of warm-up trials were presented to ensure that children understood the task and were responding appropriately to the experimenter's requests. On each warm up trial, children were presented with three familiar objects side-by-side on a tray divided into three sections (cf. Horst & Samuelson, 2008). After allowing children to look at the objects for three seconds the experimenter slid the tray towards the child and requested one of the objects (e.g. "where's the duck?"), before allowing the child to make their choice by pointing or retrieving the object. On the next trial, the objects were rearranged out of sight of the child, and another object was requested. These trials continued until the child had correctly selected the target object on three consecutive trials. Across the initial three trials, each object was requested once, and the target object was in each location on the tray once. On any further trials, the position of the target was randomly determined. In order to encourage participation, children's correct responses were praised and corrections were offered when the child did not at first select the correct object.

Following the warm up trials, the retention trials began. The procedure for retention trials was identical to the warm up trials, except no praise or corrections were offered. Instead, once the child had selected an object, the experimenter replied "thank you" in a neutral tone, replaced the object and then began the next trial. Across the four retention trials, each novel object seen during referent selection acted as the target, and two other randomly selected previously seen novel objects acted as competitors. The experimenter requested the target object using the novel word with which it had been presented during referent selection. The order of trials and the position of the target on the tray were randomly determined.

Results

For each trial, the time spent looking in each AOI was calculated for the two seconds preceding the onset of the label (pre-labeling), and from 233ms after the onset of the label (to ensure children had time to process the label; Haith, Hazan & Goodman, 1988; Canfield & Haith, 1991) to three seconds following the onset of the label (post-labeling). For each of these time intervals, the proportion of time spent looking at the target was calculated for each trial by dividing the time spent looking at the target AOI by the sum of time spent looking in all AOIs. For each child and for each time interval, the proportion of time spent looking at the target object on familiar object trials, the first novel label trial, and the second novel label trial was calculated, as well as the mean for each age group.

Referent Selection Trials: Overall

Figure 2 shows the mean looking time towards the target for each age group, time interval and trial type.

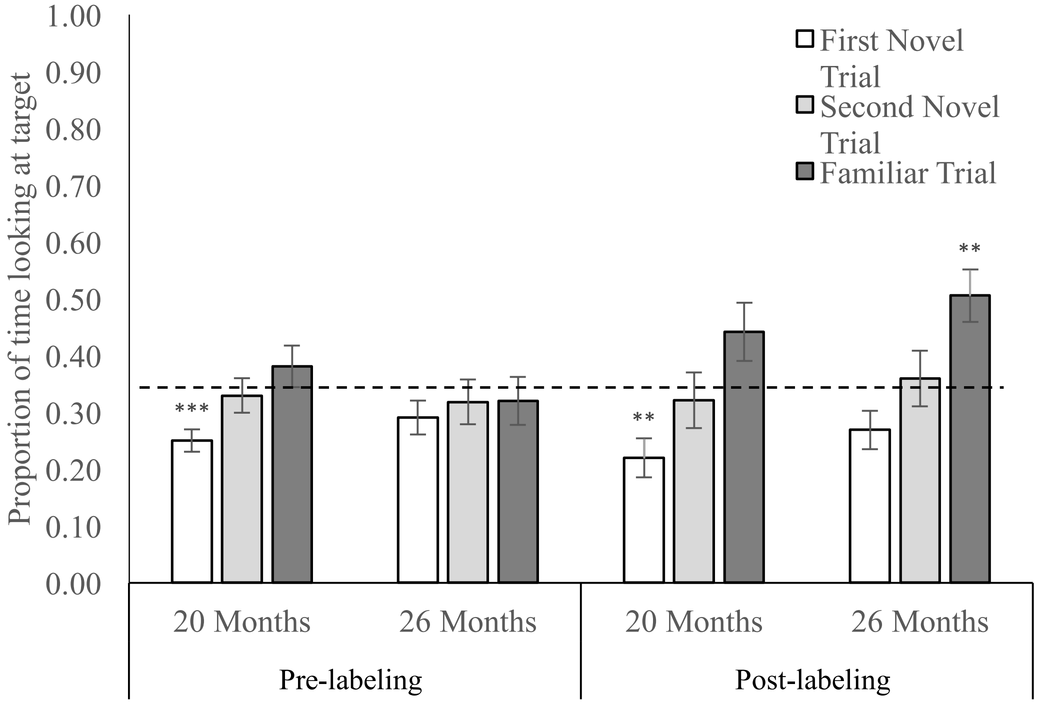


Figure 2. The proportion of time spent looking at the target object for the 2500 ms prior to the onset of the label (pre-labeling) and the 3000 ms following the onset of the first label (post-labeling). Error bars represent 1 SE. The dashed line represents chance (.33). ** $p < .01$, *** $p < .001$ indicate difference from chance.

Two-tailed one-sample t-tests were performed for each age group and trial in order to examine whether children's looking was different from what would be expected by chance (.33). In the pre-labeling interval, children did not look at any of the three objects more than would be expected by chance, except for 20-month-old children who looked away from the novel object on the first novel label trial, $t(15)$ =

-4.25, p = .001. In the post-labeling interval, 20-month-old children looked away from the novel target after hearing the novel label for the first time, $t(15) = -3.35$, $p = .004$, and the older children looked towards the familiar object when it was labeled $t(15) = 3.71$, $p = .002$. 20-month-old children tended to look towards the familiar object when it was labeled, $t(15) = 2.10$, $p = .053$, and 26-month-old children tended to look away from the novel object when it was labeled for the first time, $t(15) = -1.90$, $p = .07$. There was no evidence that children responded systematically to the label on the second novel label trial.

Shyness and Looking During Referent Mapping

A shyness score was calculated for each child by averaging their parent's responses to questions relating to shyness on the questionnaire. The lowest possible score was 1, meaning that the child was not shy at all. The maximum possible score was 7, meaning that the child was extremely shy. The mean shyness score for the 20-month-old group was 3.12 (range = 1.92 – 5.17, SD = 1.03). The mean shyness score for the 26-month-old group was 3.19 (range = 1.58 – 4.67, SD = .99). The two age groups did not differ on shyness score, $t(30) = -.21$, $p = .83$, *ns*. Furthermore, there was no correlation between shyness and receptive vocabulary in the 20-month-old group, $r(12) = -.11$, $p = .719$, or in the 26-month-group, $r(15) = .29$, $p = .28$. There was also no correlation between shyness and productive vocabulary in the 20-month-old group $r(12) = -.01$, $p = .98$, or in the 26-month-old group $r(15) = .33$, $p = .22$.

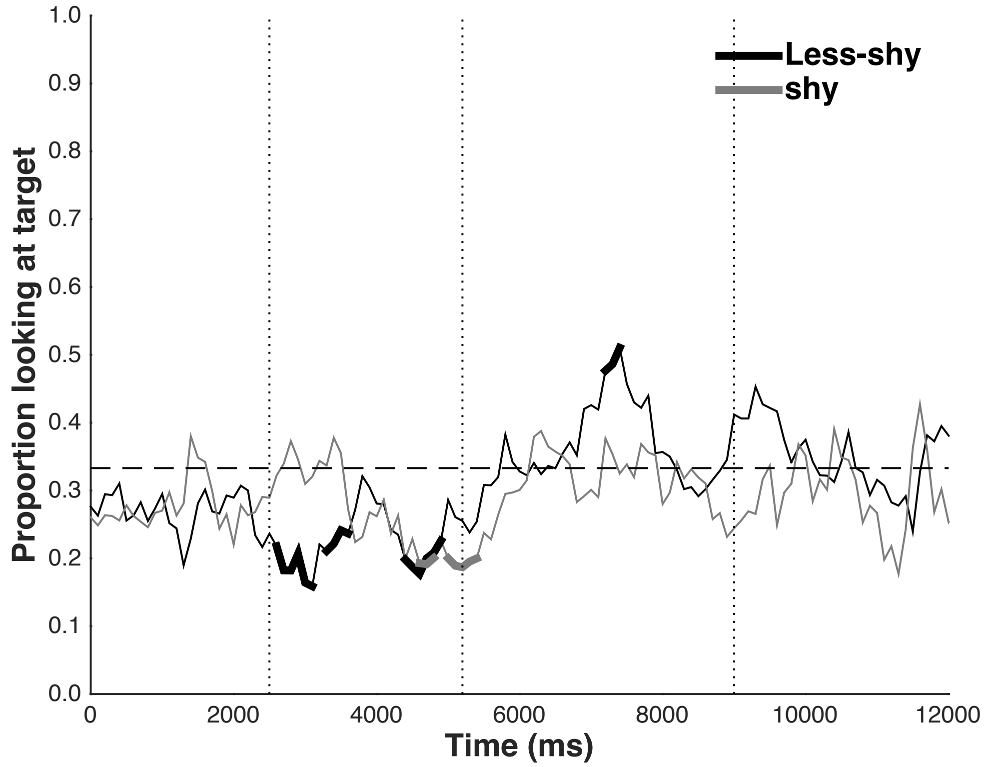
A 2 (interval: pre-labeling, post-labeling) x 3 (trial: first novel, second novel, familiar) x 2 (age: 20 months, 26 months) mixed analysis of covariance (ANCOVA) was performed with shyness as the covariate in order to investigate the looking patterns of the two age groups before and after hearing the label. According to the Delaney-Maxwell Method (Delaney & Maxwell, 1981), the shyness covariate was mean-centered by subtracting the mean shyness score from each score, to avoid distorting any main effects. As expected, shyness predicted looking behavior, F (1, 29) = 7.86, p = .009, η_p^2 = .21.

A main effect of interval confirmed that children looked less at the target before labeling (M = .32, SD = .02, range = .15 - .52) than after labeling (M = .35, SD = .02 range = .16 - .54), F (1, 29) = 5.40, p = .029, η_p^2 = .15. There was also a main effect of trial type, F (1, 29) = 11.29, p < .001, η_p^2 = .28, and Bonferonni corrected post-hoc tests indicated that children looked less at the target on first novel label trials (M = .26, SD = .02, range = .11 - .51) than second novel label trials (M = .33, SD = .03, range = .14 - .58; p = .022), and that children looked at the target more on familiar label trials (M = .41, SD = .3, range = .17 - .70) than first novel label trials (p < .001), but there was no difference between second novel label trials and familiar trials (p = .137). There was no main effect of age (20 months: M = .32, SD = .02, range = .23 - .45; 26 months: M = .35, SD = .02, range = .19 - .50), F (1, 29) = .73, p = .400, nor an interaction between age and trial type, F (1, 29) = .21, p = .809, and no interaction between age and interval, F (1, 29) = 3.74, p = .063. There was a significant interaction between interval and trial type, F (1, 29) = 6.61, p = .003, η_p^2 = .19, and an examination of the simple main effects indicated that on familiar label trials, children looked more at the familiar target object following the familiar label, F (1, 29) = 15.62, p <.001, η_p^2 = .35, while looking did not differ pre- and post- label on first novel label trials, F (1, 29) = 1.23, p =.277, nor second novel label trials, F (1, 29) = .26, p = .616. These data thus show that children's attention to the novel object is not heightened on hearing a novel label.

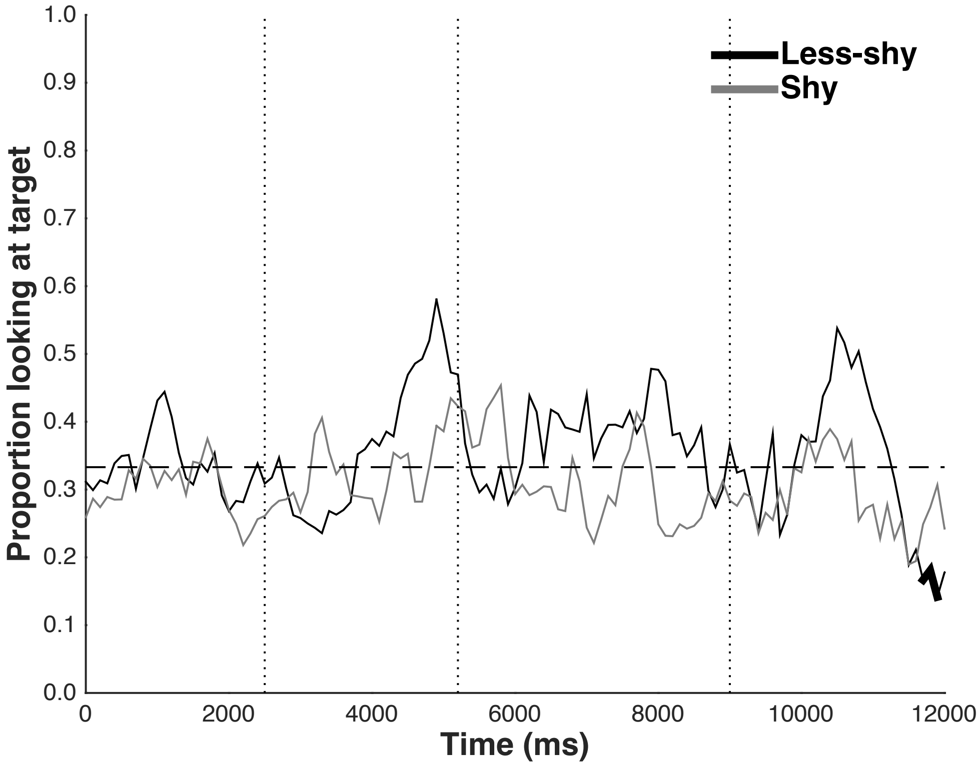
Time Bin Analyses

To enable a more fine-grained analysis of how shyness affected children's attention to the objects throughout the entire labeling time course, looking time was analyzed for each trial in 100 ms time bins across for the entire duration that the objects were stationary on the screen. The proportion of looking time to the target was calculated by dividing the time looking to the target AOI by the total time looking to all AOIs for each 100ms time bin. Given that initial analyses found an effect of shyness, but not age, looking times were collapsed across age groups. Children with a shyness score above the median (3.04) formed a *shy* group (*n* = 16), and those with a score below the median formed a *less-shy* group (*n* = 16).

A)



B)


Less-shy
Shy
Proportion looking at target
Time (ms)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2000
4000
6000
8000
10000
12000

C)

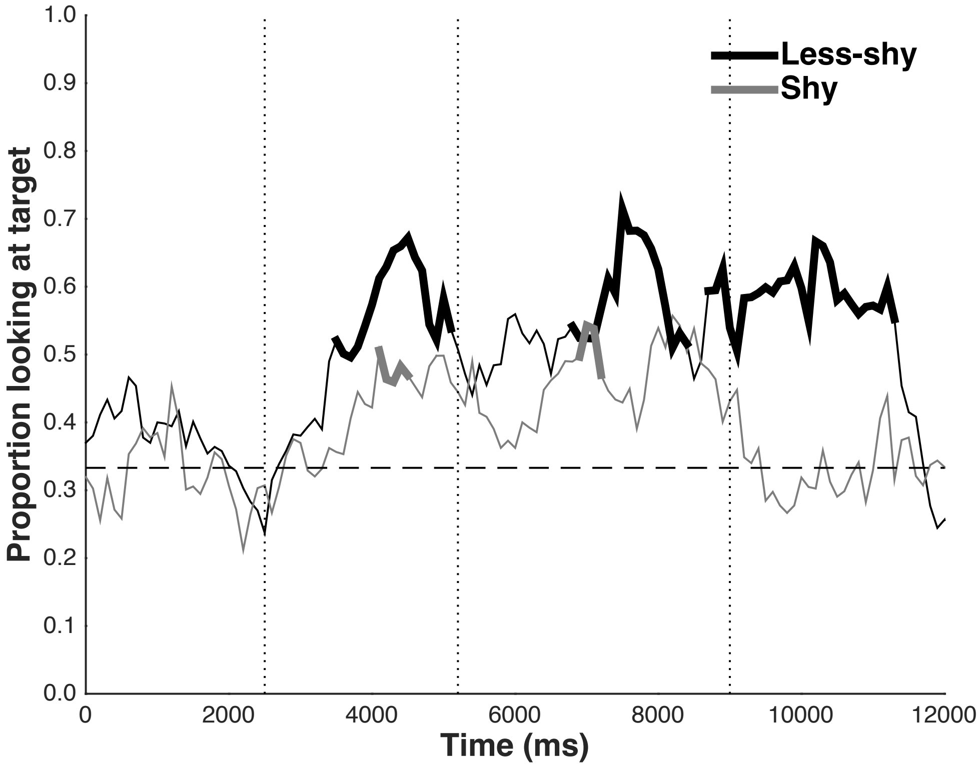

Less-shy
Shy
Proportion looking at target
Time (ms)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2000
4000
6000
8000
10000
12000

Figure 3. Shy and less-shy children's proportion of time looking to the target object from appearance to disappearance of object images calculated in 100ms time bins. Panel A shows children's looking towards the target on first novel label trials. Panel B shows children's looking towards the target on second novel label trials. Panel C shows children's looking toward the target on familiar label trials. Thicker lines indicate proportion of looking towards target significantly different from chance for at least three consecutive time bins, $p <.05$. Dashed horizontal line represents chance (.33) and vertical dotted lines identify the times at which the label was heard.

The average proportion of time spent looking at the target object for each 100 ms time bin was calculated for both groups, and is depicted in Figure 3. As seen in Figure 3A, neither shy nor less-shy children showed any looking towards the novel object before the label was heard. Less-shy children looked away from the novel object from 2600 ms (100 ms after the first label was heard) for a period of 600 ms, and from 3300 ms for a period of 400 ms and then again from 6500 for a period of 600 ms. This looking away from the novel object upon hearing a novel label is evidence that children were disambiguating the label by eliminating the familiar competitors as referents (Halberda, 2006). These children then looked towards the novel object at 7200 ms for a period of 300 ms, which could be evidence that these children were beginning to form the mapping. Shy children also showed evidence of disambiguating the novel label, but later than less-shy children, and for less time. They looked away from the novel object at 4600 ms (2100 ms after the onset of the first label) for a period of 300 ms, and then again at 5000 ms for a period of 500 ms.

As seen in Figure 3B, neither less-shy nor shy children looked towards or away from the novel object on the second novel label trial. Their looking was at chance, except that less-shy children looked away from the novel object from 13700 ms until the end of the trial.

As seen in Figure 3C, less-shy children looked more towards a familiar target following its label than shy children. Specifically, less-shy children looked towards the target object more often and for longer than shy children

Predicting Retention

Each child was tested on their retention of all four novel word-object mappings presented during referent selection. Each object was assigned a retention score: Mappings that were retained were scored a 1, and those that were not retained were scored a 0. The proportion of word-object mappings retained was calculated for each child by dividing the number of mappings retained by the total possible (i.e. 4). Overall, 20-month-old children did not retain the novel word-object mappings above levels expected by chance ($M = .37$, $SD = .23$), $t(14) = 0.57$, $p = .58$. Similarly, 26-month-old children did not retain the mappings above levels expected by chance ($M = .41$, $SD = .26$), $t(15) = 1.44$, $p = .27$.

Each child's retention score was then correlated with the average proportion of looking time to the novel object in the three seconds following the onset of the label on the first and second novel label trials. As expected, there was no relation between mean looking towards the novel object on the first novel label trial and mean retention score at 20 months, $r\ (14) = .11$, $p = .697$ or 26 months, $r\ (15) = .04$, $p = .886$. Mean looking towards the novel object on the second novel label trial was not related to mean retention score at 20 months, $r\ (14) = .01$, $p = .969$, but there was a positive relation at 26 months, $r\ (15) = .54$, $p = .029$, indicating that 26-month-old children who on average looked more towards the novel object on the second presentation of the novel label retained more of the novel word-object mappings. Nevertheless, novel object looking on these trials was at chance, suggesting that although children who were better able to direct their attention to the novel object after the first exposure to the novel word and object retained more mappings, these increases in attention were overall small.

Discussion

The current work examined 20- and 26-month-old children's looking patterns during word learning on a typical referent selection task, and the effects of shyness as an aspect of intrinsic individual differences on these looking patterns. We found that looking patterns were affected by shyness, but not by age. As the first fine-grained analysis of children's looking on a typical fast mapping task with two competitors, the current work revealed that children's mapping of a novel label onto a novel object does not require focus on the novel object. We know that two-year-old children typically select the novel object as the referent of a novel label (Axelsson, et al., 2012; Horst & Samuelson, 2008), but children in the current study overall looked away from the novel object when they heard a novel label. This finding may be counterintuitive, because infants and children are expected to show increased looking to labeled objects, but it highlights the complex relations between attention, referent selection and word learning. Our results also suggest that learning of the novel word-object mapping does not begin to take place until at least the second presentation of the mapping.

The finding that children look away from the novel object upon hearing a novel label is clear evidence against earlier theories that posited children at this age automatically map novel labels onto nameless objects (e.g. Mervis & Bertrand, 1994). The current work is however somewhat at odds with the recent report that by 24 months of age children look toward a novel object when hearing a novel label (Bion et al., 2013). However, this finding could be explained by the discrepancy between looking time measures of word learning where only one familiar competitor is presented (e.g. Bion et al., 2013; Mather & Plunkett, 2009), and the current work that examined looking on a more typical stimulus array for this age group (Axelsson et al., 2012; Horst & Samuelson, 2008). Increasing the cognitive load of the task by increasing the number of competitors to be ruled out as in the current work likely meant that children could not demonstrate reliable looking to the novel object on these trials, because more cognitive resources must be directed towards ruling out the competitors.

The suggestion that formation of novel word-object mappings can be achieved despite reduced attention to the target also sheds light on why children's retention of these mappings is so poor (e.g. Horst & Samuelson, 2008) – because retention requires increased looking to the target. This result then supports the thesis that the mechanism by which ostensive naming enhances retention on this task is by increasing attention to the object (e.g. Axelsson et al., 2012). Furthermore, such an explanation would explain the finding that children's retention of novel mappings is reduced when the number of familiar competitors presented on referent selection trials is increased (Horst, Scott & Pollard, 2010): When children must rule out more competitors, their attention to the novel object is reduced, which weakens the association between word and object.

It is possible that such a counterintuitive finding was due to task difficulty or an unidentified issue with stimuli. This explanation is however unlikely, because children reliably looked towards a familiar object when it was labeled. Therefore, children's lack of attention to the referent was specific to novel object trials. Interestingly, this finding shows that attention is directed differently, according to whether a novel or familiar label is heard, but we know that when tested behaviorally, children of this age will select the target referent on both novel and familiar trials (Horst & Samuelson, 2008). This discrepancy between looking and object selection must therefore be carefully considered.

The current work also examined children's looking during labeling and whether this could predict retention. A positive association was found between looking at the novel object on its second presentation and retention of the novel word-object mapping. This finding suggests that some children are beginning to learn on the second exposure of the novel word and object. McMurray and colleagues' (2012) computational model of word learning suggests that selection of the correct novel object on novel referent selection trials is possible without any learning taking place, and this suggestion was supported by the finding that looking towards the novel object on the second presentation of the novel label, but not the first presentation, was associated with learning. Importantly, this looking behavior on the second exposure was unrelated to their looking on the initial exposure to the word and object. It can therefore be concluded that the first exposure to a novel word-object mapping does not entail any learning.

Based on previous work (Hilton & Westermann, Paper 1), the current work also aimed to investigate whether shyness affects children's attention to the objects during labeling. The present study found that the effect of shyness on word learning is already visible in children's eye movements during the presentation of word-object mappings. Upon hearing a novel label for the first time, shy children were slower than less-shy children to begin the process of disambiguation, and looked to the competitor objects for less time. This reduced looking at competitors might diminish shy children's ability to reject them as potential referents of the novel label. Importantly, this could explain shy children's random referent selection on a tabletop referent selection task with the actual objects (Hilton & Westermann, Paper 1).

These results thus extend our understanding of the effects of shyness on language development. First, these findings are further evidence for the limitations of the predominant explanation of the effect of shyness on early language development, that shy children are reticent to respond (Smith Watts et al., 2014). The present study took the novel approach of examining the association between shyness and eye movements as an implicit measure of language processing, requiring no response from the child, and revealed differences that suggest shy children's attention during novel labeling does not support successful disambiguation. Thus, the differences in behavior between shy and less-shy children observed by Hilton and Westermann (Paper 1) likely stems from low-level attentional factors rather than a reluctance to engage with the task.

These findings also add to previous literature that has explored how shyness can affect children's attention to and scanning of features in their environment. This previous work has typically explored shy children's attention via manipulation of the perceived threat of the stimuli. For example, LoBue and Pérez-Edgar (2014) found that shy children more quickly identify threatening social stimuli (an angry face) than less-shy children at 4-7 years of age. Similarly, Dodd and colleagues (2015) used eye tracking to examine anxious 3-4-year-old children's attention to threatening and non-threatening faces, and found that anxious children look less at faces overall. These studies offer a clear indication that shyness can affect children's scanning of their social environment. The present study extends these findings to non-social stimuli (i.e. the objects presented on-screen during referent selection) and to substantially younger age groups, demonstrating effects of shyness possibly as early as 20 months.

We argue that an aversion to novelty, a key component of shyness in children (Kagan et al., 1988), may explain shy children's unsystematic looking patterns. In the context of our study this finding suggests that the novel object disrupts the essential process of disambiguation, that is, ruling out competitors as referents. While intuitively it could be concluded that shy children look away from stimuli to which they are averse, recent evidence has supported a hyper-vigilance explanation, by which children attend more to stimuli to which they are averse when presented on a screen (Brunet, Heisz, Mondloch, Shore & Schmidt, 2009). Support for this effect comes from analysis of shy children's face scanning. When measured behaviorally, shy children show an aversion to direct eye-contact (Cheek & Buss, 1981), yet when presented with pictures on a screen, shy children actually attend more to the eyes in comparison to the mouth than less-shy children (Matsuda, Okanoya & Myowa-Yamakoshi, 2013). Therefore, shy children's aversion to novelty could mean that they are more vigilant to the novel object because it provokes a level of anxiety, and this finding may explain why shy children are unable to disengage from the novel object enough to rule out the competitors as potential referents.

Our results also indicate that even when a familiar object is labeled the presence of the novel object could disrupt shy children's scanning of the array: compared with their less-shy peers they are slower to orient to and quicker to look away from the familiar object when they hear its label. Here again we argue that shy children's aversion to novelty means that they have difficulty scanning the objects in a systematic manner. It is important to note, however, that the present study found no evidence that shy children look towards the novel object more than would be expected by chance on familiar label trials.

Overall, the present study highlights the complex link between shyness, attention during disambiguation and retention of novel word-object mappings. This fine-grained approach to examining children's implicit learning about novel word-object mappings shows that while intrinsic individual differences can affect children's initial disambiguation of word meaning, what matters for learning of these meanings is attention after the initial disambiguation. Importantly, it has been shown that shyness affects the very earliest stage of language acquisition – that is, working out the meaning of heard words.

References

Axelsson, E. L., Churchley, K., & Horst, J. S. (2012). The right thing at the right time: Why ostensive naming facilitates word learning. *Frontiers in Psychology*, *3*, 88. http://doi.org/10.3389/fpsyg.2012.00088

Bion, R. A. H., Borovsky, A., & Fernald, A. (2013). Fast mapping, slow learning: Disambiguation of novel word–object mappings in relation to vocabulary learning at 18, 24, and 30 months. *Cognition*, *126*(1), 39–53. http://doi.org/10.1016/j.cognition.2012.08.008

Brunet, P. M., Heisz, J. J., Mondloch, C. J., Shore, D. I., & Schmidt, L. A. (2009). Shyness and face scanning in children. *Journal of Anxiety Disorders*, *23*(7), 909–914. http://doi.org/10.1016/j.janxdis.2009.05.009

Canfield, R. L., & Haith, M. M. (1991). Young infants' visual expectations for symmetric and asymmetric stimulus sequences. *Developmental Psychology*, *27*(2), 198–208. http://doi.org/10.1037/0012-1649.27.2.198

Carey, S., & Bartlett, E. (1978). Acquiring a single new word (Vol. 15, pp. 17–29). Presented at the Proceedings of the Stanford Child Language Conference.

Cheek, J. M., & Buss, A. H. (1981). Shyness and sociability. *Journal of Personality and Social Psychology*, *41*(2), 330–339. http://doi.org/10.1037/0022-3514.41.2.330

Coplan, R. J., & Evans, M. A. (2009). At a loss for words? Introduction to the special issue on shyness and language in childhood. *Infant and Child Development*, *18*(3), 211–215. http://doi.org/10.1002/icd.620

Crozier, W. R., & Hostettler, K. (2003). The influence of shyness on children's test performance. *British Journal of Educational Psychology*, *73*(3), 317–328. http://doi.org/10.1348/000709903322275858

Crozier, W. R., & Perkins, P. (2002). Shyness as a factor when assessing children. *Educational Psychology in Practice*, *18*(3), 239–244. http://doi.org/10.1080/0266736022000010267

Delaney, H. D., & Maxwell, S. E. (1981). On using analysis of covariance in repeated measures designs. *Multivariate Behavioral Research*, *16*(1), 105–123. http://doi.org/10.1207/s15327906mbr1601_6

Dockrell, J. E. (2001). Assessing language skills in preschool children. *Child & Adolescent Mental Health*, *6*(2), 74–85.

Dodd, H. F., Hudson, J. L., Williams, T., Morris, T., Lazarus, R. S., & Byrow, Y. (2014). Anxiety and attentional bias in preschool-aged children: an eyetracking study. *Journal of Abnormal Child Psychology*, *43*(6), 1055–1065. http://doi.org/10.1007/s10802-014-9962-x

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., … Stiles, J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, *59*(5), i–185. http://doi.org/10.2307/1166093

Fox, N. A., Nichols, K. E., Henderson, H. A., Rubin, K., Schmidt, L., Hamer, D., … Pine, D. S. (2005). Evidence for a gene-environment interaction in predicting behavioral inhibition in middle childhood. *Psychological Science*, *16*(12), 921–926.

Golinkoff, R. M., Hirsh-Pasek, K., Bailey, L. M., & Wenger, N. R. (1992). Young children and adults use lexical principles to learn new nouns. *Developmental Psychology*, *28*(1), 99–108. http://doi.org/10.1037/0012-1649.28.1.99

Golinkoff, R. M., Mervis, C. B., & Hirsh-Pasek, K. (1994). Early object labels: the case for a developmental lexical principles framework. *Journal of Child Language*, *21*(01), 125–155. http://doi.org/10.1017/S0305000900008692

Haith, M. M., Hazan, C., & Goodman, G. S. (1988). Expectation and anticipation of dynamic visual events by 3.5-month-old babies. *Child Development*, *59*(2), 467–479.

Halberda, J. (2003). The development of a word-learning strategy. *Cognition*, *87*(1), B23–B34. http://doi.org/10.1016/S0010-0277(02)00186-5

Hart, B., & Risley, T. R. (2003). The early catastrophe: The 30 million word gap by age 3. *American Educator*, *27*(1), 4–9.

Hirsh-Pasek, K., Adamson, L. B., Bakeman, R., Owen, M. T., Golinkoff, R. M., Pace, A., … Suma, K. (2015). The contribution of early communication quality to low-income children's language success. *Psychological Science*, *26*(7), 1071–1083.

Hoff, E., Laursen, B., & Tardif, T. (2002). Socioeconomic status and parenting. In M. H. Bornstein (Ed.), *Handbook of Parenting* (Vol. 2). Mahwah, NJ: Lawrence Erlbaum Associates.

Hoff-Ginsberg, E. (1991). Mother-child conversation in different social classes and communicative settings. *Child Development*, *62*(4), 782–796. http://doi.org/10.1111/j.1467-8624.1991.tb01569.x

Horst, J. S., & Samuelson, L. K. (2008). Fast mapping but poor retention by 24-month-old infants. *Infancy*, *13*(2), 128–157. http://doi.org/10.1080/15250000701795598

Horst, J. S., Scott, E. J., & Pollard, J. A. (2010). The role of competition in word learning via referent selection. *Developmental Science*, *13*(5), 706–713. http://doi.org/10.1111/j.1467-7687.2009.00926.x

Kagan, J., Reznick, J., & Snidman, N. (1988). Biological bases of childhood shyness. *Science*, *240*(4849), 167–171.

Kelly, D. J. (1998). A clinical synthesis of the "late talker" literature: Implications for service delivery. *Language, Speech, and Hearing Services in Schools*, *29*(2), 76–84. http://doi.org/10.1044/0161-1461.2902.76

Landau, B., Smith, L. B., & Jones, S. S. (1988). The importance of shape in early lexical learning. *Cognitive Development*, *3*(3), 299–321. http://doi.org/10.1016/0885-2014(88)90014-7

Levin, I. P., & Hart, S. S. (2003). Risk preferences in young children: early evidence of individual differences in reaction to potential gains and losses. *Journal of Behavioral Decision Making*, *16*(5), 397–413. http://doi.org/10.1002/bdm.453

LoBue, V., & Pérez-Edgar, K. (2014). Sensitivity to social and non-social threats in temperamentally shy children at-risk for anxiety. *Developmental Science*, *17*(2), 239–247. http://doi.org/10.1111/desc.12110

Markman, E. M. (1994). Constraints on word meaning in early language acquisition. *Lingua*, *92*, 199–227. http://doi.org/10.1016/0024-3841(94)90342-5

Markson, L., & Bloom, P. (1997). Evidence against a dedicated system for word learning in children. *Nature*, *385*(6619), 813–815. http://doi.org/10.1038/385813a0

Mather, E., & Plunkett, K. (2009). Learning words over time: The role of stimulus repetition in mutual exclusivity. *Infancy*, *14*(1), 60–76. http://doi.org/10.1080/15250000802569702

Matsuda, Y.-T., Okanoya, K., & Myowa-Yamakoshi, M. (2013). Shyness in early infancy: approach-avoidance conflicts in temperament and hypersensitivity to eyes during initial gazes to faces. *PLoS ONE*, *8*(6), 1–7.

McMurray, B., Horst, J. S., & Samuelson, L. K. (2012). Word learning emerges from the interaction of online referent selection and slow associative learning. *Psychological Review*, *119*(4), 831–877. http://doi.org/10.1037/a0029872

Mervis, C. B., & Bertrand, J. (1994). Acquisition of the Novel Name–Nameless Category (N3C) principle. *Child Development*, *65*(6), 1646–1662. http://doi.org/10.1111/j.1467-8624.1994.tb00840.x

Munro, N., Baker, E., McGregor, K., Docking, K., & Arciuli, J. (2012). Why word leaning is not fast. *Frontiers in Psychology*, *3*, 1–10. http://doi.org/10.3389/fpsyg.2012.00041

Putnam, S. P., Gartstein, M. A., & Rothbart, M. K. (2006). Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior Questionnaire. *Infant Behavior and Development*, *29*(3), 386–401. http://doi.org/10.1016/j.infbeh.2006.01.004

Quine, W. V. O. (1960). *Word & Object*. The MIT Press.

Samuelson, L. K., & Horst, J. S. (2007). Dynamic noun generalization: Moment-to-moment interactions shape children's naming biases. *Infancy*, *11*(1), 97–110. http://doi.org/10.1080/15250000709336872

Samuelson, L. K., & Smith, L. B. (1999). Early noun vocabularies: do ontology, category structure and syntax correspond? *Cognition*, *73*(1), 1–33. http://doi.org/10.1016/S0010-0277(99)00034-7

Sanson, A., Pedlow, R., Cann, W., Prior, M., & Oberklaid, F. (1996). Shyness ratings: stability and correlates in early childhood. *International Journal of Behavioral Development*, *19*(4), 705–724.

Smith Watts, A. K., Patel, D., Corley, R. P., Friedman, N. P., Hewitt, J. K., Robinson, J. L., & Rhee, S. H. (2014). Testing alternative hypotheses regarding the association between behavioral inhibition and language development in toddlerhood. *Child Development*, *85*(4), 1569–1585. http://doi.org/10.1111/cdev.12219

Stromswold, K. (2001). The heritability of language: a review and metaanalysis of twin, adoption, and linkage studies. *Language*, *77*(4), 647–723. http://doi.org/10.2307/3086845

Yu, C., & Smith, L. B. (2011). What you learn is what you see: using eye movements to study infant cross-situational word learning. *Developmental Science*, *14*(2), 165–180. http://doi.org/10.1111/j.1467-7687.2010.00958.x

Zosh, J. M., Brinster, M., & Halberda, J. (2013). Optimal contrast: Competition between two referents improves word learning. *Applied Developmental Science*, *17*(1), 20–28. http://doi.org/10.1080/10888691.2013.7484

The Effect of Shyness on Children's use of Eye-gaze to Determine the Referents of Words

Matt Hilton, Katherine E. Twomey and Gert Westermann

Lancaster University

Abstract

Previous research has shown that shyness affects children's attention during the disambiguation of novel words (Hilton, Twomey & Westermann, Paper 3). The current study examines whether shyness also affects children's use of eye gaze as a means to novel label disambiguation. Children's ($N = 32$) gaze was recorded as they viewed videos in which an onscreen actor sat at a table on which three objects appeared. The actor looked at and labeled one of the objects. Overall, shy children looked more than less-shy children at the face of the actor as she was looking at and labeling the referent. Shy children did not look more at the target object relative to the competitor objects, while less-shy children followed the actor's gaze and attended to the referent. This suggests that shy children's heightened attention to faces may reduce their use of referential cues to referent selection.

The Effect of Shyness on Children's use of Eye-gaze to Determine the Referents of Words

Shyness as an individual difference in childhood already received attention from Darwin in *The Expression of the Emotions* (1872). Although his characterization of shyness as an 'odd state of mind' is now thankfully outdated, he observed its emergence in early childhood, reporting that his two-year-old child showed "a trace of what certainly appeared to be shyness… by the eyes being for a few minutes slightly averted from me. (p. 137)". Even during an era of Victorian ideals of children's deferential behavior, a shy child was worthy of note, and noticeable due to their aversion to meeting an adult's gaze.

While an aversion to eye contact continues to be considered characteristic of shyness (Cheek & Buss, 1981; Putnam, Gartstein & Rothbart, 2006; Pilkonis, 1977), the diversity of children's shy behaviors has led to multiple definitions of this trait. Briggs and Smith (1986), for example, offered the general definition of "discomfort and inhibition in the presence of others" (p. 629) while others such as Buss (1985) typified shyness with a wider range of behaviors: reticence, social withdrawal, inhibition of speech and gesture, and low self-esteem. While a detailed discussion of the differences between the various definitions are beyond the scope of the current work (see the introduction of this thesis for a more in-depth discussion), most interpretations agree that shyness is characterized by a discomfort in social situations that affects children's behavior. Furthermore, there is agreement that the main behavioral markers of shyness are anxiety and withdrawal in novel social situations (Crozier, 1979; Kagan, Reznick & Snidman, 1988; Putnam et al., 2006).

Work from Rothbart and colleagues examining children's emerging temperament has proved influential, and the authors consider shyness as the result of biologically-based and enduring constituents of children's emerging temperament (Putnam, et al., 2006). Putnam et al.'s (2006) Early Childhood Behavior Questionnaire (ECBQ) measures children's temperament across a range of dimensions, of which 12 items measure the child's shyness. On these items parents are asked to rate their child's overall aversion to novel social events, their latency to approach during these events, and their clinginess during the event, and these differences in behavior are measurable from the age of 18 months.

In addition to the behaviors measured in the ECBQ, shy individuals are characterized by reduced verbal interaction (Crozier, 2001), which prompted research into the effects of shyness on language development (e.g. Spere, Schmidt, Theall-Honey & Martin-Chang, 2004). Traditionally research into the role of shyness in language development has been concerned with the receptive and productive vocabulary of the child (Coplan & Armer, 2005; Crozier & Badawood, 2009; Smith Watts et al., 2014; Spere et al., 2004), and this research has broadly suggested that shyness restricts children's vocabulary size.

There have been a number of explanations put forward to account for the effect of shyness on children's vocabulary size, and recently, Smith Watts and colleagues (2014) have argued that the most likely explanation is that shy children are more reticent to respond than less-shy children. A reticence to respond thus restricts shy children's expressive language growth, but not their receptive language growth. Such a conclusion however does not account for findings that shyness can also exert an effect on children's receptive language (Spere et al., 2004) and importantly, it does not account for recent findings that shyness affects the cognitive processes by which language is acquired (Hilton, Twomey & Westermann, Paper 3).

In a series of studies, Hilton and colleagues have found that shyness can affect children's word learning, which may in part explain the relation between shyness and verbal ability (e.g. Hilton & Westermann, Paper 1). Recent advances suggest that early word learning operates on two related, but distinct processes: in-the-moment, rapid disambiguation of word meaning (often known as *fast mapping*; Carey & Bartlett, 1978), followed by reinforcement of these mappings over repeated encounters via associative learning (Smith & Yu, 2008). Children eventually then show evidence of retaining the mapping by using the word in a new context or after a delay, and at this point, the word has been *learned* (McMurray, Horst & Samuelson, 2012). Hilton and colleagues (Paper 1) have examined the effect of shyness on both the processes related to word disambiguation and the processes that support retention.

Children initially disambiguate the meaning of words in a number of ways, sometimes making rapid initial judgments about the correct referent of a word before selecting it. For example, a child will rapidly work out that a novel label must refer to a novel object when the only other possible referents are familiar (Horst & Samuelson, 2008), by eliminating the familiar objects as potential referents. While some have argued that these judgments can be based on innate or learned heuristics (or lexical principles) that guide the child to the most likely referent (Markman, 1994; Golinkoff, Mervis & Hirsh-Pasek, 1994; see Halberda, 2006 for a review), more recent evidence suggests that this seemingly skilled and complex behavior can be driven by low-level attentional processes (McMurray et al., 2012; Samuelson & Smith, 1998). At the same time, it has been shown that unlike less-shy children, shy children do not map a novel word onto a novel object in this way (Hilton and Westermann, Paper 1).

Hilton and Westermann (Paper 1) presented children with *referent selection* trials, in which the child was presented with one novel and two familiar objects and was asked to select one using a novel word. Shy children on average did not select the novel object as the referent of a novel label and subsequently showed no evidence of retaining any of the mappings that they had formed (Hilton & Westermann, Paper 1). This was taken as evidence that shyness impacts on both the in-the-moment processes that support referent selection, and the longer-term associative processes that lead to retention of the novel word-object mappings formed via referent selection.

Hilton and Westermann (Paper 1) argued that the mechanism by which shyness affects children's referent selection and retention was attention. Specifically, based on existing research demonstrating that attention during referent selection is critical in determining whether label-object associations will be retained (e.g. Axelsson, Churchley & Horst, 2012), the authors concluded that shyness reduced attention to the novel object because shy children's aversion to novelty (Kagan, Reznick & Snidman, 1987) disrupted their systematic scanning of the objects on display, given that the task is marked by a high degree of novelty. This conclusion was supported by a related study which found that reducing the novelty of the task by asking the parent to conduct the study (rather than a researcher) led to shy children being able to retain the novel word-object mappings presented during referent selection (Hilton, Twomey & Westermann, Paper 2).

However, Hilton & Westermann's (Paper 1) original behavioral task leaves open the question of precisely how shyness might affect children's attention allocation during referent selection. Thus, Hilton, Twomey and Westermann (Paper 3) tracked children's gaze as they were forming these mappings on a 2D object looking time task. Children heard a novel label as they saw an array of three objects on the screen, one of which was novel and the other two were familiar. Less-shy children looked towards the familiar competitors upon hearing the novel label, supporting accounts of referent selection which assume that children rule out known objects as referents of novel words via a mutual-exclusivity-type process (Halberda, 2006). In contrast, the novel label led shy children to look away from the novel object later and for less time than their less-shy peers, suggesting that their failure to retain novel word-objects mappings in Hilton and Westermann (Paper 1) could have been due to unsuccessful disambiguation of the novel label.

Taken together, these studies have important implications for our understanding of the link between shyness and language acquisition. First, Hilton and colleagues (Paper 2) showed that the familiarity of the interactional partner can modulate the relation between shyness and word learning. Second, the authors showed that this effect is exerted by modulating the attentional processes that serve to support this word learning (cf. Axelsson et al., 2012). Third, and most importantly, the authors clearly demonstrated that shyness impacts on the low-level attentional processes serving word learning, rather than only affecting higher-level responses (Coplan, Wichmann & Lagacé-Séguin, 2001; Crozier & Perkins, 2002; Smith Watts et al, 2014).

The previous body of work clearly calls for a greater exploration of the effect of shyness on children’s attention during word learning. Hilton and Westermann (Paper 1) argued that apart from affecting attentional processes, shy children's risk aversion (Addison & Schmidt, 1999; Levin & Hart, 2003) could also impact on their ability to form the novel word-object mappings. Older children who self-report as shy are less likely to offer a response to a teacher’s question in class (Jones & Gerig, 1994), which is taken as evidence that shy children weigh the costs of getting a question wrong more highly than the benefits of contributing an answer (Coplan & Evans, 2009). Shy children's reluctance to be wrong could thus affect their referent selection: if they cannot be certain that the novel label maps onto a novel object they likely will not rule out the familiar competitors as potential referents. A risk-averse explanation for shy children's differential performance on this task would therefore predict that shy children benefit more from cues to word meaning that are unambiguous, such as eye-gaze.

Despite clearly affecting children's referent selection, shyness appears to have no long-term effects on early receptive vocabulary development (Smith Watts et al., 2014). Thus, shy children may make use of different cues during disambiguation than less-shy children. Indeed, a careful reading of the extant literature would suggest that shy children could make more use of eye-gaze as a cue to word meaning. Despite shyness being characterized by discomfort in novel social situations, shy individuals tend to concentrate more on faces and specifically, eyes (Wieser, Pauli, Alpers & Mühlberger, 2009). This has led to the *hyper-vigilance hypothesis*: shy individuals' aversion to novel interaction and increased self-consciousness (Crozier, 1979) means that they seek out social cues and intentions faster than less-shy individuals. More recent work has replicated this finding in children (Brunet, Heisz, Mondloch, Shore & Schmidt, 2009) and in young infants (Matsuda, Okanoya & Myowa-Yamakoshi, 2013). Hyper-vigilance to social cues, specifically gaze, could lead shy children to capitalize on this cue during referent selection. This may be one mechanism by which children's receptive vocabulary is protected from the effects of shyness.

The current study therefore sets out to examine whether the effect of shyness on children's word learning is present when children are offered eye-gaze cues alongside novelty cues as to the referent of the words that they hear. We know that shy children show a pattern of attention incongruent with referent selection when there is no interactional partner (Hilton, et al., Paper 3), and the present study aimed to examine the effect of shy children's heightened sensitivity to social cues on their attention during word learning from an unfamiliar adult.

Specifically, we extended the design of Hilton et al. (Paper 3) to a more social context by showing an onscreen actor who looks at and labels the target object. As in Hilton et al. (Paper 3), the current study examined the looking of 20- and 26-month old children in order to examine any developmental trajectory of the effects of shyness on the use of eye-gaze in referent selection. Finally, we examined whether any individual differences in looking can explain children's retention of the novel-word object mappings presented during referent selection.

Method

Participants

A total of thirty-two typically developing children aged 20 and 26 months old took part in the study. All children were monolingual and were from predominantly white, middle-class families living in the North West of England, UK. There were 16 children in the 20-month age group (*M* = 20 m, 11 days; range = 19 m, 19 days to 20 m, 25 days; 7 girls) and 16 children in the 26-month age group (*M* = 26 m, 14 days; range = 25 m, 8 days to 27 m, 8 days; 4 girls). An additional five 20-month-old children were excluded due to fussiness (*n*=4) and equipment error (*n*=1), and an additional three 26-month-old children were excluded from this group due to fussiness (*n*=2) and equipment error (*n*=1). Families were recruited by contacting parents who had previously indicated interest in participating in child development research. Parents' travel expenses were reimbursed and children were offered a gift of a storybook for participating.

Parents completed the Oxford CDI for their children (Hamilton, Plunkett & Shafer, 2000). Questionnaire data for one 26-month-old child were missing due to their parent not returning the questionnaire. The 20-month-old group had a mean productive vocabulary of 107 words (range = 7-413 words) and a mean receptive vocabulary of 245 words (range = 45-414 words). The 26-month-old group had a mean productive vocabulary of 259 words (range = 58-372 words) and a mean receptive vocabulary of 357 words (range = 232-414 words).

Ethical approval for this study was granted by the Lancaster University Research Ethics Committee.

Stimuli

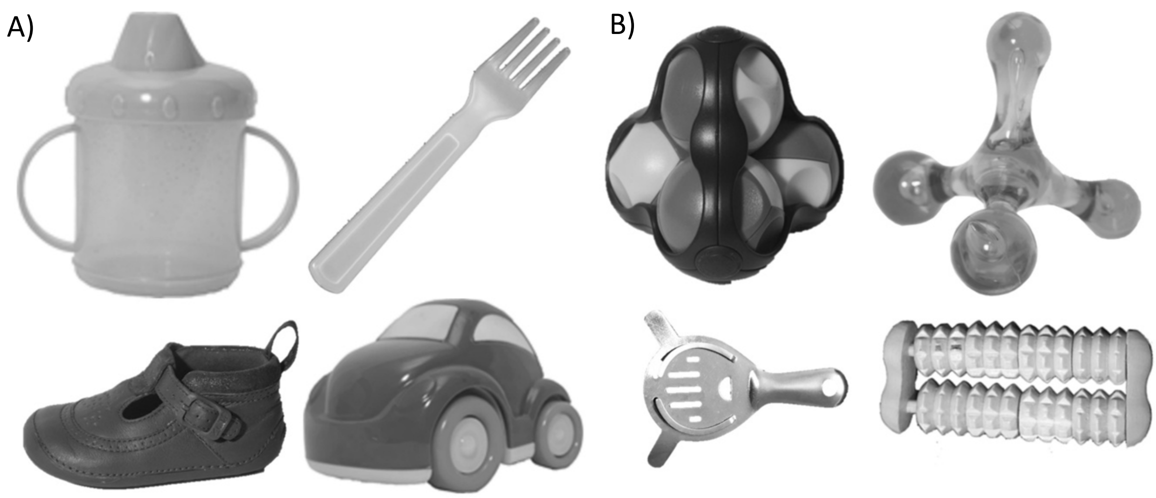


Figure 1. Subset of stimuli presented during experiment. Panel A shows example familiar stimuli, and panel B shows the four novel objects.

Visual stimuli for learning trials consisted of pictures of eight familiar objects (e.g. cup, shoe, car) and four novel objects (e.g. a plastic hand massager; see Figure 1). Each picture was of similar size (approx. 700 x 700 mm) onscreen. Retention trials consisted of 3D objects. These were three familiar objects (helicopter, duck, fork) used as warm-up items, and the novel objects that had been seen during learning trials. These objects were all of a similar size (approx. 950 x 715 x 515 mm).

Procedure and Design

Shyness and Vocabulary Questionnaires. Parents completed the shyness scale of the Early Childhood Behavior Questionnaire (ECBQ; Putnam et al., 2006) during their visit. The ECBQ is a standardized parent report measure of 18- to 36-month-old children's emerging temperament. 12 items measure the child's shyness, and each item asks parents to rate from 1-7 (1 = *never*, 7 = *always*) how often over the past two weeks their child has demonstrated shy-type behaviors (e.g. "when playing with unfamiliar children, how often did your child seem uncomfortable?"). Averaging across the twelve questions yields for each child a score between 1 (*least shy*) and 7 (*most shy*). In order to avoid demand biases in parents' responses, three other questions taken from other temperamental subdimensions were included within the questionnaire, but parents' responses to these questions were not included in any analyses.

Referent Selection trials. Children sat on their parent's lap approximately 60cm from a computer monitor mounted above a Tobii x120 eye-tracker, which recorded children's gaze data from both eyes at a sampling rate of 60 Hz. Before the trials began, the gaze of each child was calibrated using a 5-point procedure. An attention grabber was displayed in the four corners and middle of a 9x9 grid, and the experiment began when all points were calibrated successfully.

Figure 2. Example still from disambiguation trial video.

Each trial consisted of a video of a female actor sitting at a table and looking at the camera. After 600 ms pictures of three objects then “bounced” onto the table in front of the actor, one to the left, one in the middle, and one on the right (see Figure 2 for an example still). The actor then looked at the target object (approx. 3000 ms after the trial onset) and labeled it three times, embedded within a consistent script: “Look, it’s a___! Can you see the___? Wow, it’s a___!”. After she finished speaking (10400 ms after she began), the actor looked back at the camera, and the objects disappeared ready for the next trial to begin.

For each participant, the objects were randomly grouped into sets of three, with each set consisting of one novel and two familiar objects. Each novel object was randomly assigned a novel pseudoword, taken from previous research and known to be plausible English non-words and novel to children (Halberda, 2006; Horst & Samuelson, 2008; Markson & Bloom, 1997; Samuelson & Horst, 2007). Each set was presented three times. On the first two presentations, the novel object acted as the target, and on the final presentation a randomly selected familiar object acted as the target. The order in which the sets were presented was pseudorandomized, with the constraint that no set was presented more than twice successively. Across the three presentations of a given set, the target appeared once on the left, once in the middle and once on the right. After every fourth trial, a four-second long animation with accompanying sound effect was played in order to keep children's attention on the screen. After all referent selection trials were completed, children took a five-minute break.

Eye-gaze analyses. The raw data files were exported from Tobii Studio and analyzed in Matlab (version 2015a). For each participant, the data file showed for each refresh of the screen the time from the beginning of the trial, the trial number, and the xy coordinates of the child's gaze on the screen.

Based on the threshold approach of Yu and Smith (2011), three rectangular object Areas of Interest (AOIs) were created in the areas of the screen where the stimuli were displayed. All AOIs measured 400 by 400 pixels. Object AOI 1 covered the object on the left-hand side of the screen, Object AOI 2 covered the object in the middle, and Object AOI 3 covered the object on the right. There was a gap of 100 pixels between object AOIs. A margin of 20 pixels separated AOIs from the left and right edge of the screen, and a margin of 40 pixels separated the AOIs from the bottom of the screen. A further Face AOI measuring 400 by 400 pixels covered the area of the screen containing the face of the actor. AOIs did not overlap. Continuous gaze within an AOI was counted as a fixation. If continuous gaze within an AOI was interrupted for less than 60ms, this interruption was recoded as a continuation of that fixation, because this was most likely due to blinking or eye-tracking errors rather than the child rapidly re-orienting their attention.

Retention trials. Retention trials began with a warm-up task. Children were seated on their parent's lap opposite the experimenter. The experimenter presented the three familiar objects to the child on a tray specially divided into three sections, initially out of reach of the child. Children were then asked to select one of the objects (e.g. "Where's the duck?"), the tray was pushed forward into the child's reach, and their response was recorded. If the child selected the correct object, both the experimenter and parent praised the child, or if the child selected an incorrect object, the experimenter and parent encouraged the child to select the correct one. If the child failed to respond after two further prompts, the tray was removed and the next trial began. On each subsequent trial, the three objects were rearranged out of sight of the child, and children were asked for a different object. The warm-up task continued until children selected the correct object three times in a row. Across the warm-up task, a target object appeared in each section of the tray at least once. Retention trials continued in the same manner as the warm-up task, with two differences. First, no praise or encouragement was offered following the child's response: the experimenter simply replied with a neutral "thank you." Second, retention trials consisted of previously-seen novel objects. On each trial the child was presented with a target alongside two other randomly selected objects, and was asked for the target using the appropriate novel pseudoword. There was one retention trial for each novel object; each child therefore participated in four retention trials. The order of retention trials was randomly determined, as was the location of the target on the tray.

Results

Shyness and Parent-Report Language Measures

There was no association between shyness and receptive vocabulary in the 20-month group, *r* (15) = -.120, *p* = .66, or in the 26-month group, *r* (14) = -.13, *p* = .66. There was also no association between shyness and productive vocabulary in the 20-month group, *r* (15) = -.34, *p* = .20, or in the 26-month group, *r* (14) = -.04, *p* = .90.

Looking towards the Target Object

In order to examine whether the actor's gaze led to increased looking at the target, the proportion of time spent looking at the target object was calculated by dividing time looking at the target object AOI by the total time looking in all Object AOIs from the time the actor looked towards the target (3000 ms) until the time the actor looked away from the object (11000 ms). The proportion of time looking at each competitor object was also calculated. These proportions were then averaged across first novel label trials, second novel label trials, and familiar label trials. Data from an extreme outlier who exclusively looked towards the face for all novel label trials were excluded from subsequent analyses.

Proportion looking was submitted to a 3 (Object: Target, Competitor 1, Competitor 2) x 3 (Trial: First Novel, Second Novel, Familiar) x 2 (Age) Analysis of Covariance (ANCOVA) with the shyness scores included as a covariate. The shyness score was mean-centered prior to analysis by subtracting the mean score from each individual score to avoid any distortion of main effects (Delaney and Maxwell, 1981). Children looked differently across the three objects, F (2, 56) = 12.00, $p < .001$, η_p^2 = .30. Bonferonni corrected post hoc tests indicated that children looked more at the target object (*M* = .41, *SD* = .10, range = .19 - .66) than both the first competitor (*M* = .28, *SD* = .08, range = .07 - .47; *p* < .001) and the second competitor (*M* = .31, *SD* =

.08, range = .13 - .51; *p* = .01). Children looked equally at both competitors (*p* = .36). Follow up analyses showed that children looked at the target more than would be expected by chance (0.33; *t* (30) = 4.33, *p* < .001, *d* = 1.6). Trial type did not affect looking to the target, *F* (2, 56) = .00, *p* = .88. There was no main effect of age, *F* (1, 28) = 0.33, *p* = .60, and shyness was not a significant covariate *F* (1, 28) = 0.473, *p* = .50.

The proportion of mappings retained was calculated by dividing the number of correct responses on retention trials by the total possible (i.e., 4). No relationship was found between retention and proportion of looking to the target on either the first novel label trial, *r* (30) = .22, *p* = .24, or the second novel label trial, *r* (30) = -.16, *p* = .41.

Shyness and Looking to the Face

The proportion of time spent looking at the face on each trial was calculated by dividing looking time to the Face AOI by total time spent looking to all AOIs. This measure was then submitted to a stepwise multiple regression with main effects of age and shyness. Age lacked predictive power and was thus removed from the regression equation, while shyness was retained, *F* (1, 29) = 4.49, *p* = 0.03, R^2 = 15%. In line with the hyper-vigilance hypothesis (Brunet et al., 2009), a unit increase in shyness score produced an increase in proportion of looking towards the face of .09, meaning that shyer children looked more at the face.

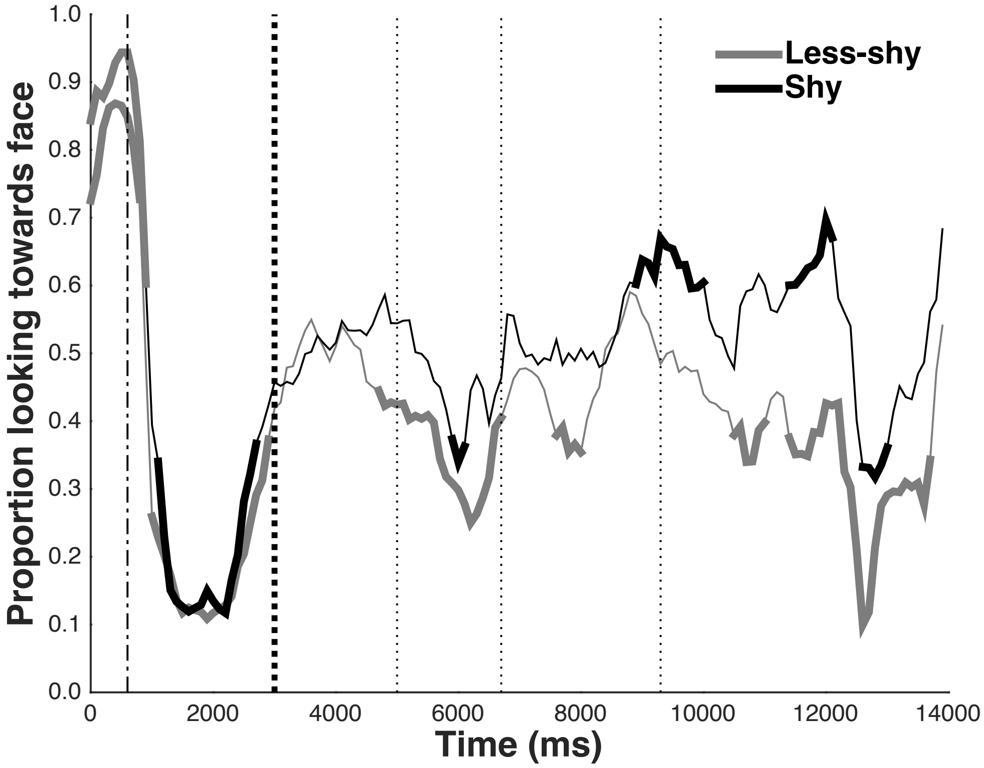


Figure 3. Shy and less-shy children's mean proportion of looking time towards the face in 100 ms time bins throughout display of video. Colored lines are thicker when the looking towards the objects and face are significantly different for three or more consecutive time bins ($p < .05$). Vertical dot-dash line denotes the time at which the objects appear on the screen. Thick vertical dashed line denotes the time at which the actor turns to look at the target object. Other vertical dashed lines denote the time at which the actor spoke the object label.

We then examined how shy children's heightened attention to the face affected their attention to the objects, and how this unfolded during labeling. We performed a median split on shyness score (Mdn = 3.25), assigning children with a score greater than median to the *shy* group (n = 13), and children with a score less than the median to the *less-shy* group (n = 15). Children who scored the median (n = 3) were excluded from analyses. Figure 3 depicts the proportion of time spent looking at the face in 100 ms time bins across trials. Less-shy children showed sustained looking away from the face and towards the objects following their appearance on the screen. They looked equally towards the face and the object when the actor turned her head to look at the target object, and 1800 ms afterwards, they looked away from the face and towards the array of objects, with maximum looking at approximately 6000 ms. Following the second label, less-shy children showed a second period of looking away from the face and towards the objects (7700 ms to 8100 ms). Looking returned to chance levels until the third label when less-shy children once more directed their attention away from the face and towards the objects (from 10600 ms to 11100 ms and from 11500 ms until the end of the trial).

Shy children showed a different pattern of looking. They did not look away from the face and towards the objects until 3000 ms after the actor had turned to look at the target, and this looking towards the objects lasted only for a duration of 300 ms. Interestingly, this is the same time-window in which less-shy children's looking towards the objects peaked, and thus suggests that this time-window is important. Unlike the less-shy children, following this 300 ms period, shy children did not again look towards the objects more than the face. Instead, shy children showed two further periods of looking towards the face, as the label was heard for a third time (from 9000 ms to 10100 ms, and from 11500 ms until the end of the trial).

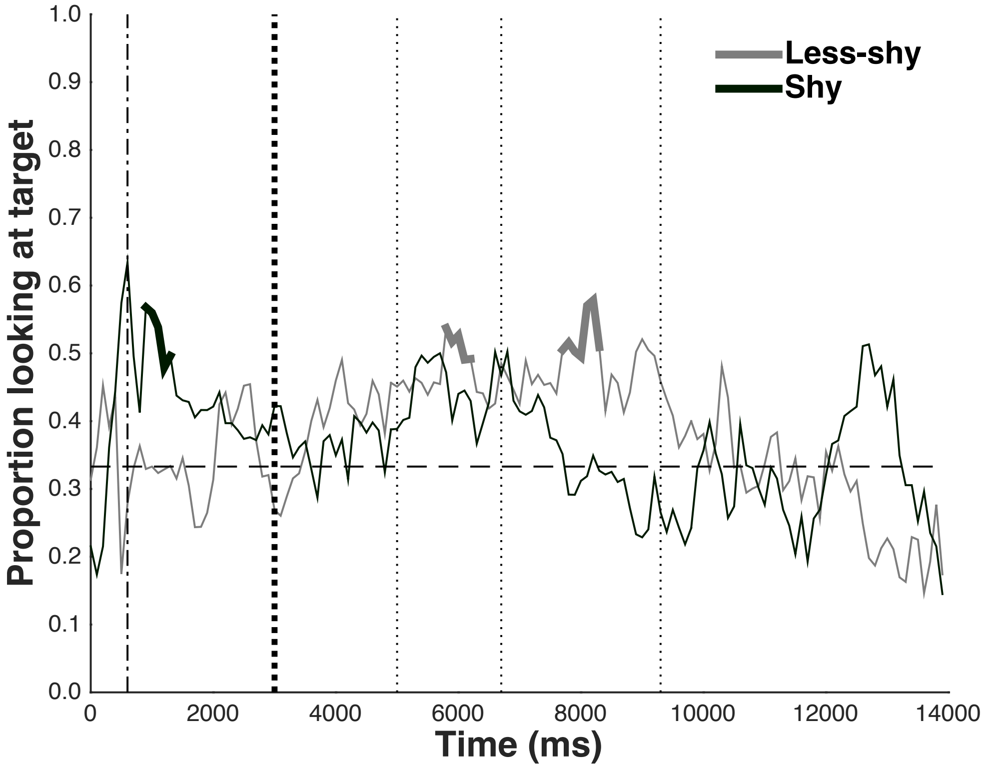


Figure 4. Shy and less-shy children's mean proportion of looking time towards the target and in 100 ms time bins throughout display of video. Vertical dot-dash line denotes the time at which the objects appear on the screen. Thick vertical dashed line denotes the time at which the actor turns to look at the target object. Other vertical dashed lines denote the time at which the actor spoke the object label. Horizontal dashed line represents chance (.33). Colored lines are thicker when the looking towards the objects and face are significantly different from chance for three or more consecutive time bins ($p < .05$).

Figure 3 demonstrates that shyness affected the fine-grained temporal dynamics of looking towards the face and the objects, but does not tell us whether shyness also affected looking towards the target. Therefore, in order to examine whether shyness affected their attention to the target object as it was being labeled, the proportion of time spent looking at the target object was calculated by dividing the time spent looking in the target AOI by the total time looking in the three objects AOIs for each 100 ms time bin (see Figure 4). Shy children did not look at at the target object more than would be expected by chance, yet less-shy children showed two periods of looking towards the target, after the label was heard for the first and second time.

Retention

The proportion of word-object mappings retained was calculated for each child by dividing the number of correct responses on retention trials by the total possible (i.e., 4). 20-month-old children did not retain the mappings above levels expected by chance alone (M = .36, SD = .24), $t(15) = 0.44$, p = .67. 26-month-old children also did not retain the mappings above levels expected by chance (M = .39, SD = .18), $t(15) = 1.27$, p = .22.

Discussion

The current work examined whether looking to faces during object labeling could explain differences in shy and less-shy children's word learning. When an unknown actor labeled novel and familiar objects, shy children looked more towards the face than to the objects. Conversely, less-shy children looked more at the objects than the face during labeling. Importantly, less-shy children, but not shy children, showed a distinct period of heightened looking to the target in comparison to competitors. We suggest that this may explain why shy children perform poorer than less-shy children on word learning tasks (Hilton & Westermann, Paper 1).

Shy children's hyper-vigilance to faces has previously been reported (e.g. Brunet et al., 2009), but it was unclear whether this increased looking to faces impairs or enhances shy children's use of gaze as a cue to word meaning. It could have been argued that a bias to attend to faces would mean a more rapid and accurate use of gaze to determine the intended referent of speech. Instead, the current work showed that shy children's bias to attend to faces meant that they disengaged from the face later and for less time than less-shy children. Furthermore, likely because their attention to the object array was reduced, shy children showed no increased looking to the referent in comparison to competitor objects.

We know that shy children learn words differently from less-shy children. Shy children failed to form and retain novel word object mappings when presented by an unfamiliar adult (Hilton & Westermann, Paper 1). Given that attention across all competitors is key in forming the novel word-object mapping (e.g., Halberda, 2006), and that subsequent heightened attention to the target referent is critical in retaining the mapping (e.g. Axelsson et al., 2012), shy children's increased looking at the face of the interactional partner may explain their lack of word learning from an unfamiliar adult.

Why shy children of this age should attend more to the face than less-shy children is not yet clear. Previous work has focused on adults (Wieser et al., 2009) or older children (Brunet et al., 2009). This work concluded that shy individuals are hyper-vigilant to faces because their heightened self-consciousness (e.g. Crozier & Perkins, 2002), means that they more rapidly seek out cues to negative self-evaluation which are conveyed by the face and more specifically the eyes. Whether such an explanation holds for 20 to 26-month-old children remains to be seen, and more work is thus required.

In any case, the current work has shown that shy children's hyper-vigilance to faces is strong enough to interfere with word learning processes, which demonstrates that temperament can have a profound impact on children's word learning, meaning that these individual differences must be taken seriously in accounts of word learning and language acquisition. This conclusion is in line with other recent evidence that shyness affects children's attention during word learning. Hilton, Twomey & Westermann (Paper 3) were the first to examine the effect of shyness during word learning using eye-tracking technology. The authors presented an identical task to that presented in the current study, except that the objects were presented on a blank screen without an actor, so children heard the objects labeled but saw no interactional partner. Hilton et al., (Paper 3) found that less-shy children demonstrated a pattern of attention congruent with our understanding of the formation of novel-word object mappings in the absence of social cues (Axelsson et al., 2012): Less-shy children first looked towards familiar competitors and then towards the target. In contrast, shy children showed random looking across all objects. The authors argued that shy children's random looking was driven by their aversion to novelty (Kagan et al., 1988), and their reluctance to rely on an ambiguous cue (Coplan & Evans, 2009), which impacted on the ruling out of familiar competitors as potential referents.

When viewed in light of this previous research, the current work thus demonstrates that shy children's attention pattern during object labeling is not optimal for the formation and retention of any novel word-object mappings, both when social and non-social cues can be used to determine the correct referent. This would suggest that shy children might be slowed in acquiring language, that is to say their receptive vocabulary skills are limited in comparison to less-shy children. This suggestion contradicts one of the predominant explanations for shy children's differential language acquisition – that they are reticent to respond (Smith Watts et al., 2014).

Unlike some previous work (e.g. Spere et al., 2004), however, the current study found no association between receptive language and shyness, despite differences in shy and less-shy children's behavior and attention during word learning tasks (Hilton, Twomey & Westermann, Paper 2; Paper 3; Hilton & Westermann, Paper 1). This finding remains a critical focus for future work: given such marked differences in attention during object labeling, we are yet to discover the mechanisms by which shy children's overall receptive vocabulary size might be protected from the effects of shyness. It is possible that shy children require more exposure to the word and object together before they begin to form an association between them, possibly because increased attention to a particular adult's face extinguishes over time, or because the mappings are subsequently presented across different contexts.

Unlike Hilton & Westermann's (Paper 1) study, the current work found that neither shy nor less shy children retained the mappings that were presented. Similarly, there was no association found between looking during labeling and retention. We argue that this finding is likely due to the greater demands of the task: attending to the face reduces all children's attention to the objects to some extent (in comparison to previous studies that only present the objects on a blank screen; Bion, Borovsky & Fernald, 2013; Hilton, Twomey & Westermann, Paper 3). While this finding demonstrates that forming a mapping does not necessarily lead to retention (Horst & Samuelson, 2008; McMurray et al., 2012), nonetheless in the context of previous studies one would expect a relationship between successful target looking and retention of the corresponding label-object mapping. A possibility here is that children struggled to transfer their learning from the 2D pictures of the objects to the actual 3D objects, known as the *video deficit effect* (Krcmar, Grela & Lin, 2007; Robb, Richert & Wartella, 2009, see Barr, 2010 for a review), although children have shown no difficulty with this transfer in other studies (e.g. Zosh, Brinster & Halberda, 2013).

A further contribution to the field of the current work was that it examined children's attention while presented with eye-gaze and novelty cues to referent selection, and these findings have implications for our understanding of these processes overall. Importantly, this study found no main effect of object familiarity: Children attended equally to the labeled object regardless of whether it was novel or familiar. This is in contrast to the findings of Hilton and colleagues (Paper 3), who found that children look away from the novel object on novel label trials in order to rule out competitors as referents, but look towards the familiar object on familiar label trials because they already know this mapping. This finding would therefore suggest that children do not use both novelty *and* gaze cues when they are presented simultaneously. In the current work they made use of only one cue: gaze. Use of eye gaze and not novelty would make sense given that the gaze cue is less ambiguous (a novel label could also refer to a familiar object), meaning that children did not need to further disambiguate the word. This explanation may also explain recent findings that increasing the number of cues presented simultaneously does not increase retention (Brady & Goodman, 2014), likely because shy children will make use of the least ambiguous cue.

In conclusion, the current work found that shyness affected children's attention to objects when they are being labeled by an unfamiliar adult, a finding that has profound implications for our understanding of the effect of shyness on language development. Shy children's increased looking to the face meant that they were unable to attend to the target object during labeling, while less shy children did. This is further evidence that shy children's differential language acquisition is unlikely to be due only to their reluctance to respond as has previously been suggested (Smith Watts et al., 2014). Fine-grained analyses of shy children's looking during referent selection when a familiar adult is labeling the objects is the next step to understanding how shy children come to disambiguate and learn words during early childhood.

References

Addison, T. L., & Schmidt, L. A. (1999). Are women who are shy reluctant to take risks? behavioral and psychophysiological correlates. *Journal of Research in Personality*, *33*(3), 352–357. http://doi.org/10.1006/jrpe.1999.2249

Axelsson, E. L., Churchley, K., & Horst, J. S. (2012). The right thing at the right time: Why ostensive naming facilitates word learning. *Frontiers in Psychology*, *3*, 88. http://doi.org/10.3389/fpsyg.2012.00088

Barr, R. (2010). Transfer of learning between 2D and 3D sources during infancy: Informing theory and practice. *Television and Toddlers: The Message, the Medium, and Their Impact on Early Cognitive Development*, *30*(2), 128–154. http://doi.org/10.1016/j.dr.2010.03.001

Bion, R. A. H., Borovsky, A., & Fernald, A. (2013). Fast mapping, slow learning: Disambiguation of novel word–object mappings in relation to vocabulary learning at 18, 24, and 30 months. *Cognition*, *126*(1), 39–53. http://doi.org/10.1016/j.cognition.2012.08.008

Brady, K. W., & Goodman, J. C. (2014). The type, but not the amount, of information available influences toddlers' fast mapping and retention of new words. *American Journal of Speech-Language Pathology*, *23*(2), 120–133.

Briggs, S. R., & Smith, T. G. (1986). The measurement of shyness. In W. H. Jones, J. M. Cheek, & S. R. Briggs (Eds.), *Shyness* (pp. 47–60). New York, NY: Plenum.

Brunet, P. M., Heisz, J. J., Mondloch, C. J., Shore, D. I., & Schmidt, L. A. (2009). Shyness and face scanning in children. *Journal of Anxiety Disorders*, *23*(7), 909–914. http://doi.org/10.1016/j.janxdis.2009.05.009

Buss, A. H. (1985). Two kinds of shyness. In R. Schwarzer (Ed.), *Self-related cognitions in anxiety and motivation* (pp. 65–75). Hillsdale, NJ: Erlbaum.

Carey, S., & Bartlett, E. (1978). Acquiring a single new word (Vol. 15, pp. 17–29). Presented at the Proceedings of the Stanford Child Language Conference.

Cheek, J. M., & Buss, A. H. (1981). Shyness and sociability. *Journal of Personality and Social Psychology*, *41*(2), 330–339. http://doi.org/10.1037/0022-3514.41.2.330

Coplan, R. J., & Armer, M. (2005). Talking yourself out of being shy: Shyness, expressive vocabulary and socioemotional adjustment in preschool. *Merrill-Palmer Quarterly*, *51*(1), 20–41.

Coplan, R. J., & Evans, M. A. (2009). At a loss for words? Introduction to the special issue on shyness and language in childhood. *Infant and Child Development*, *18*(3), 211–215. http://doi.org/10.1002/icd.620

Coplan, R. J., Wichmann, C., & Lagacé-Séguin, D. G. (2001). Solitary-active play behavior: a marker variable for maladjustment in the preschool? *Journal of Research in Childhood Education*, *15*(2), 164–172. http://doi.org/10.1080/02568540109594957

Crozier, W. R. (1979). Shyness as anxious self occupation. *Psychological Reports*, *44*(3), 959–962. http://doi.org/10.2466/pr0.1979.44.3.959

Crozier, W. R. (2001). Shyness, self-perception and reticence. In R. J. Riding & S. G. Rayner (Eds.), *Self Perception* (pp. 53–77). Westport, CT: Ablex.

Crozier, W. R., & Badawood, A. (2009). Shyness, vocabulary and children's reticence in Saudi Arabian preschools. *Infant and Child Development*, *18*(3), 255–270. http://doi.org/10.1002/icd.623

Crozier, W. R., & Perkins, P. (2002). Shyness as a factor when assessing children. *Educational Psychology in Practice*, *18*(3), 239–244. http://doi.org/10.1080/0266736022000010267

Darwin, C. (1872). *The expressions of the emotions in man and animals*. London: John Murray.

Golinkoff, R. M., Mervis, C. B., & Hirsh-Pasek, K. (1994). Early object labels: the case for a developmental lexical principles framework. *Journal of Child Language, 21*, 125-155. http://dx.doi.org/10.1017/S0305000900008692

Halberda, J. (2006). Is this a dax which I see before me? Use of the logical argument disjunctive syllogism supports word-learning in children and adults. *Cognitive Psychology*, *53*(4), 310–344. http://doi.org/10.1016/j.cogpsych.2006.04.003

Hamilton, A., Plunkett, K., & Schafer, G. (2000). Infant vocabulary development assessed with a British communicative development inventory. *Journal of child language, 27*(03), 689-705.

Horst, J. S., & Samuelson, L. K. (2008). Fast mapping but poor retention by 24-month-old infants. *Infancy*, *13*(2), 128–157. http://doi.org/10.1080/15250000701795598

Jones, M. G., & Gerig, T. M. (1994). Silent sixth-grade students: characteristics, achievement, and teacher expectations. *The Elementary School Journal*, *95*(2), 169–182.

Kagan, J., Reznick, J., & Snidman, N. (1988). Biological bases of childhood shyness. *Science*, *240*(4849), 167–171.

Kagan, J., Reznick, J. S., & Snidman, N. (1987). The physiology and psychology of behavioral inhibition in children. *Child Development*, *58*(6), 1459–1473. http://doi.org/10.2307/1130685

Kindt, M., Bierman, D., & Brosschot, J. F. (1997). Cognitive bias in spider fear and control children: assessment of emotional interference by a card format and a single-trial format of the stroop task. *Journal of Experimental Child Psychology*, *66*(2), 163–179. http://doi.org/10.1006/jecp.1997.2376

Krcmar, M., Grela, B., & Lin, K. (2007). Can toddlers learn vocabulary from television? An experimental approach. *Media Psychology*, *10*(1), 41–63. http://doi.org/10.1080/15213260701300931

Levin, I. P., & Hart, S. S. (2003). Risk preferences in young children: early evidence of individual differences in reaction to potential gains and losses. *Journal of Behavioral Decision Making*, *16*(5), 397–413. http://doi.org/10.1002/bdm.453

Markman, E. M. (1994). Constraints on word meaning in early language acquisition. *Lingua*, *92*, 199–227. http://doi.org/10.1016/0024-3841(94)90342-5

Markson, L., & Bloom, P. (1997). Evidence against a dedicated system for word learning in children. *Nature*, *385*(6619), 813–815. http://doi.org/10.1038/385813a0

Matsuda, Y.-T., Okanoya, K., & Myowa-Yamakoshi, M. (2013). Shyness in early infancy: Approach-avoidance conflicts in temperament and hypersensitivity to eyes during initial gazes to faces. *PLoS ONE*, *8*(6), 1–7.

McMurray, B., Horst, J. S., & Samuelson, L. K. (2012). Word learning emerges from the interaction of online referent selection and slow associative learning. *Psychological Review*, *119*(4), 831–877. http://doi.org/10.1037/a0029872

Pilkonis, P. A. (1977). The behavioral consequences of shyness. *Journal of Personality*, *45*(4), 596.

Putnam, S. P., Gartstein, M. A., & Rothbart, M. K. (2006). Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior

Questionnaire. *Infant Behavior and Development*, *29*(3), 386–401. http://doi.org/10.1016/j.infbeh.2006.01.004

Robb, M. B., Richert, R. A., & Wartella, E. A. (2009). Just a talking book? Word learning from watching baby videos. *British Journal of Developmental Psychology*, *27*(1), 27–45. http://doi.org/10.1348/026151008X320156

Samuelson, L. K., & Horst, J. S. (2007). Dynamic noun generalization: Moment-to-moment interactions shape children's naming biases. *Infancy*, *11*(1), 97–110. http://doi.org/10.1080/15250000709336872

Samuelson, L. K., & Smith, L. B. (1998). Memory and attention make smart word learning: An alternative account of Akhtar, Carpenter, and Tomasello. *Child Development*, *69*(1), 94–104. http://doi.org/10.1111/j.1467-8624.1998.tb06136.x

Smith, L. B., & Yu, C. (2008). Infants rapidly learn word-referent mappings via cross-situational statistics. *Cognition*, *106*(3), 1558–1568. http://doi.org/10.1016/j.cognition.2007.06.010

Smith Watts, A. K., Patel, D., Corley, R. P., Friedman, N. P., Hewitt, J. K., Robinson, J. L., & Rhee, S. H. (2014). Testing alternative hypotheses regarding the association between behavioral inhibition and language development in toddlerhood. *Child Development*, *85*(4), 1569–1585. http://doi.org/10.1111/cdev.12219

Spere, K. A., Schmidt, L. A., Theall-Honey, L. A., & Martin-Chang, S. (2004). Expressive and receptive language skills of temperamentally shy preschoolers. *Infant and Child Development*, *13*(2), 123–133. http://doi.org/10.1002/icd.345

Wieser, M. J., Pauli, P., Alpers, G. W., & Mühlberger, A. (2009). Is eye to eye contact really threatening and avoided in social anxiety?—An eye-tracking and psychophysiology study. *Journal of Anxiety Disorders*, *23*(1), 93–103. http://doi.org/10.1016/j.janxdis.2008.04.004

Yu, C., & Smith, L. B. (2011). What you learn is what you see: using eye movements to study infant cross-situational word learning. *Developmental Science*, *14*(2), 165–180. http://doi.org/10.1111/j.1467-7687.2010.00958.x

Zosh, J. M., Brinster, M., & Halberda, J. (2013). Optimal contrast: Competition between two referents improves word learning. *Applied Developmental Science*, *17*(1), 20–28. http://doi.org/10.1080/10888691.2013.748

The Role of Shyness in Early Word Learning: A Discussion

Matt Hilton

Lancaster University

The Role of Shyness in Early Word Learning: A Discussion

Summary

The current thesis set out to explore whether shyness can affect children's referent selection, and whether any variability in referent selection caused by shyness can also come to bear on retention. Paper 1 found that shyness affected 24-month-old children's referent selection and retention. Shy children on average did not map a novel label to a novel object when the only other possible referents were familiar, and shy children did not retain the few mappings that they did form.

Papers 2, 3 and 4 then sought to examine the mechanisms that explain the findings of Paper 1. Paper 2 found that unfamiliarity in the environment plays a key role in modulating the effect of shyness on children's referent selection and retention. When each child's parent ran the experiment, rather than an unfamiliar experimenter, shy children reliably selected the novel object as the referent of a novel label. Shy children also retained the novel word-object mappings made during referent selection. Paper 2 suggested that increasing the familiarity of the testing environment may have supported shy children's retention because it allowed them to better focus on the array of objects, rather than aspects of the environment that they found aversive. Papers 3 and 4 followed this suggestion up by examining whether shyness affected children's looking during referent selection.

Paper 3 presented referent selection trials on a screen with a blank background and tracked 20 to 26-month-old children's eye-gaze as they heard novel and familiar labels. Overall, it was found that shyness affected children's attention across the three objects depending on whether they heard a novel or a familiar label. Children overall looked away from the novel object upon hearing a novel label, likely reflecting their elimination of the familiar competitors as potential referents, and children looked towards a familiar object upon hearing its label. However, shyness affected these looking patterns. Shy children were slower to look away from the novel object, and looked away from it for less time than less-shy children on novel label trials, but were slower to look towards the familiar object, and looked at it for less time than less-shy children on familiar label trials. These findings suggest that shyness affects children's referent selection by impacting on the low-level attentional processes that support the formation of novel word-object mappings. Tests of retention also showed that 26-month-old children's looking to the novel object the second time a novel label was heard was positively correlated with the number of word-object mappings retained.

Paper 4 explored the hypothesis that shy children's increased sensitivity to the environment, and specifically to social cues (Brunet, Heisz, Mondloch, Shore, & Schmidt, 2009), would confer an advantage on shy children in their use of eye-gaze as a cue to referent selection. Thus, children's eye-gaze was recorded as they were presented with referent selection trials by an onscreen actor looking at and labeling the target object on each trial. Contrary to expectations, however, shy children's increased attention to the actor's face delayed their looking towards the array of objects as the target was labeled, and also reduced the time that they spent looking at the target in comparison to competitor objects. This finding suggested that shy children might not have demonstrated correct word-object mappings in Paper 1 because they looked more at the experimenter's face and less at the objects in comparison to less-shy children.

Overall, this thesis found that shyness affects children's referent selection. This finding suggests that errors on typical referent selection tasks (typically 25% of trials; e.g. Wilkinson, Ross, & Diamond, 2003) may be due more to intrinsic trait-based individual differences than transient trial-based effects. That is, a few children struggle on many referent selection trials, rather than many children struggling on a few trials. This argument indicates that referent selection may not be as automatic and robust for all children as first thought (e.g. Horst & Samuelson, 2008). The current thesis also presented evidence that shyness can modulate the relation between referent selection and retention.

Shyness and Referent Selection

Shyness is operationalized as discomfort and inhibition in novel social situations (Putnam, Gartstein, & Rothbart, 2006), and Paper 1 consequently argued that shy children performed poorly on referent selection trials because the context of the lab-based task inhibited their engagement with the objects during labeling. Increasing the familiarity of the task by asking the parent to act as experimenter led to equivalent performance on referent selection trials between shy and less-shy children (Paper 2).

The current thesis presented evidence that shy children's poor performance on referent selection trials in unfamiliar environments was due to their reduced attention to potential referents. While behaviorally, shy children tend to look away from unfamiliar adults (Fox, Henderson, Rubin, Calkins, & Schmidt, 2001), more fine-grained eye-tracking analyses have shown that shy children are actually hyper-vigilant to others' faces (Brunet et al., 2009). Paper 4 showed that shy children's attention to faces was also heightened in the context of referent selection, which meant that shy children attended less to the potential referents and to the inability to learn the word-object mapping. The suggestion that shy children's increased attention to the face disrupts their referent selection was also supported by the finding that shy children showed no systematic looking pattern across the three potential referents, while less-shy children, who attended less to the face, looked more at the target object than the two competitor objects.

The current thesis is the first to demonstrate that referent selection itself may also be affected by variability in attention brought about by factors intrinsic to the child. This demonstration extends previous work that has shown attention to be crucial in determining whether a novel word-object mapping will be learned (e.g. Axelsson, Churchley, & Horst, 2012; Horst, Scott, & Pollard, 2010), suggesting that variability in attentional processes affects all stages of the word learning process.

The current work also found that the effect of shyness on referent selection may not be solely due to shy children's hyper-vigilance to an unfamiliar experimenter's face (Brunet et al., 2009). Even when the referent selection task was presented via a computer monitor, with no facial stimulus present, differences in the scanning pattern of shy and less-shy children across the objects were evident. Paper 3 found that shy children failed to disengage from the novel object during labeling in comparison to less-shy children, and this failure to disengage meant that shy children did not rule out competitors as potential referents of the novel label.

We know that children who are better able to look away from the target object during labeling are better at forming the novel word-object mapping, a suggestion in line both with Halberda's (2006) work and with findings based on adult populations that initial looking towards competitor objects during labeling leads to better word learning (Fitneva & Christiansen, 2011). Paper 3 however showed that unlike less-shy children, shy children had difficulty disengaging from the novel object. This finding would thus indicate that shy children do not form the novel mappings presented on each trial because they fail to eliminate competitors as potential referents. Children in general have a bias to attend to stimuli that they find aversive

(Field, 2006), so shy children's increased looking to the novel object can be explained in terms of their aversion to novel objects (Kagan, Reznick, & Snidman, 1987; Rothbart, 1988).

A second behavior associated with shyness is an aversion to risk (Levin & Hart, 2003). This means that shy children are less likely to respond based on a guess (Coplan & Evans, 2009). This behavior also likely comes to bear on children's referent selection as the cue to the correct referent is inherently ambiguous, because the novel word may be an alternative label for one of the familiar competitors. Thus, solving the referent selection task presents children with the risk of choosing the wrong object. Therefore, shy children's risk aversion may mean that they do not so readily reject the familiar competitors as potential referents. This risk aversion could have also been reflected in shy children's unsystematic scanning of the familiar objects in comparison to less shy children on hearing a novel label.

Shy children's aversion to novel stimuli and to risk may therefore disrupt their ability to reject familiar objects as potential referents of the novel label. The specific mechanisms that underlie the rejection of familiar competitors and selection of the novel object are still not fully understood. Recent advances have however demonstrated that instead of an inference-based process, the formation of a novel word-object mapping can be explained in terms of activation of potential word meanings (McMurray, Horst, & Samuelson, 2012). This means that shyness likely does not interrupt an inference-based approach to determining the referent of a novel word. Instead, shyness may reduce the pattern of activation and inhibition of potential word meaning during labeling. Whereas we know that activation can be affected by in-the-moment factors (e.g. social dynamics; Kucker, McMurray, & Samuelson, 2015), in this thesis I have shown that longer-term intrinsic factors may also impact on these processes. Shy children's aversion to novelty may therefore mean that the strength of activation of the novel object may be reduced in comparison to less-shy children. Conversely, shy children's reluctance to hazard a guess may reduce the suppression of activation of the familiar competitors. Both of these effects could therefore explain why children did not select the novel object as the referent of the novel label in Paper 1, and they could also explain the children's unsystematic looking pattern on referent selection trials in Paper 3.

Shyness and Retention

Attention to the target object during labeling is key in determining whether the word-object mapping will be retained (Axelsson et al., 2012; Horst & Samuelson, 2008). Therefore, any individual differences that lead to an increase in attention to the target during labeling are also likely to lead to increased retention. Given that shy children attend much more to the experimenter's face than to the array of objects (Paper 4), it is therefore likely that shy children's poor retention of the few word-object mappings that they did form was due to insufficient attention to the target object during referent selection. This argument would also explain why shy children were able to learn the novel word-object mappings when they were presented by their parents: Shy children were not hyper-vigilant to their parent's face, so were able to sufficiently attend to the novel object to retain the word-object mapping.

However, given that increased target looking leads to increased retention, an aversion to (and thus bias to attend to) the novel object (Rothbart, 1988) could have led to better retention by shy children for the few correctly selected referents (which were no better than baseline), but this was not the case. It is likely that the optimal attention pattern for word learning from referent selection would be to first disambiguate the novel label by ruling out familiar competitors (Halberda, 2006;

Zosh, Brinster, & Halberda, 2013), followed by a focusing of attention on the novel object (Axelsson et al., 2012). Therefore, while shy children's attention to the novel object may be increased in comparison to less-shy children's, shy children did not demonstrate retention because they did not first rule out competitors as referents. Again, in light of McMurray and colleagues' (2012) explanation of word learning in terms of referent activation, an increase in activation to the novel object during referent selection will increase the likelihood that the novel word-object mapping is retained. Inhibition of the familiar competitors must be necessary for the activation of the novel object to be strong enough to form a robust association. Shy children's failure to attend to the familiar objects may therefore indicate that activation is not sufficiently concentrated at the novel object to retain the mapping. This speculation is supported by Paper 3, which showed that less-shy children initially began the disambiguation process by looking away from the novel object upon hearing the novel label, and then attempted to consolidate this novel word-object mapping by briefly focusing on the novel label towards the end of the labeling window.

The conclusions of Paper 2 and Paper 3 require more discussion in light of each other. Paper 3 showed that shy children scanned the array of objects less systematically (in comparison to less-shy children), they disengaged from the novel object later and scanned the competitor objects for less time than less-shy children. This difference in looking patterns was argued as a likely mechanism of shy children's poor performance on referent selection trials in Paper 1. Yet these findings do not explain why shy children retained word-object mappings when referent selection trials were presented by their parent (Paper 2). If, as suggested, shy children's aversion to the novel object meant that they failed to reject the competitors as referents, this effect should still be present when the parent acted as the experimenter, because the effects are object-related rather than context-related.

It is possible that shy children's reluctance to hazard a guess (Coplan & Evans, 2009) comes to bear more on retention than their aversion to the novel object. This reluctance to guess may only be present when interacting with an unfamiliar experimenter, because shy children may be less wary of answering incorrectly in front of a trusted caregiver. This explanation could account for shy children's improved retention when their parent acts as the experimenter, and it fits with our understanding of shy children's heightened self-consciousness (Crozier, 1995).

Of course, one key limitation of the current work is that both Paper 3 and Paper 4 showed no effects of shyness on retention. The conclusions about the link between looking during referent selection and retention are therefore somewhat speculative. That retention was no better than chance for both shy and less-shy children suggests that the retention task may have been unsuitable. The sample may simply have been too young to show any effects (half of the children were 20 months old). It is also likely that the *video deficit effect* played a role (Krcmar, Grela, & Lin, 2007), which means that children may have been unable to extend their learning about the objects presented on the screen during referent selection to the actual 3D objects presented during retention. In order to strengthen the conclusions of Paper 3 and Paper 4 in terms of the effect of shyness on retention, future research should present both referent selection and retention trials in the same medium. This extension of the current methodology would likely then offer a sensitive enough measure to examine a direct effect on retention.

Insights into Word Learning

In examining the relation between shyness and word learning, the current thesis has also offered an insight into word learning more generally. First, it builds on previous work that demonstrated the complex link between attention, referent selection and retention (Axelsson et al., 2012; Bion, Borovsky, & Fernald, 2013; Horst & Samuelson, 2008; McMurray et al., 2012). Paper 3 was the first to examine the link between referent selection and retention by recording children's gaze during a typical fast-mapping task in which two familiar competitors were presented on each trial. All previous investigations (to the author's knowledge) have only examined looking to the target and one competitor (Bion et al., 2013; Halberda, 2006; Mather & Plunkett, 2009; Zosh et al., 2013), which has meant we cannot be sure how their findings generalize to table-top behavioral studies that typically present children with the target alongside at least two competitors (e.g. Axelsson et al., 2012; Horst & Samuelson, 2008). Paper 3 found that upon hearing a novel label, children's looking was characterized by a shift towards the familiar competitors and away from the novel target, in line with others' accounts (Axelsson et al., 2012; Halberda, 2006; Horst et al., 2010).

That selection of the novel target as the referent of the novel word is the result of *reduced* looking to the target may initially seem counterintuitive, especially to those who are familiar with infant preferential looking paradigms which conclude that children look *towards* the object to which they are mapping the word (Houston-Price et al., 2010; Mather & Plunkett, 2011; Schafer & Plunkett, 1998; Swingley & Aslin, 2000). However, looking away from the target is in line with the account that mapping the novel word to the novel object follows the rejection of familiar competitors as referents (Halberda, 2006; Horst et al., 2010). Increasing the number of competitors to two, as was the case in Paper 3, thus allowed a clear demonstration that children’s referent selection is possible with minimal attention to the novel target object. Furthermore, Paper 3 found that children looked at the familiar target when it was labeled, suggesting that looking away from the target is characteristic of novel word learning, and not familiar word recognition.

Paper 3 thus presents further evidence that children's referent selection on typical fast mapping tasks is supported by a disjunctive-syllogism style mechanism. In other words, children must rule out familiar competitors as potential referents before mapping the novel label onto the novel object. The mechanisms behind this process-of-elimination approach however remain under discussion.

Halberda (2006) argued that children's selection of the novel object as the referent of a novel label was the result of inference-based logical reasoning (Halberda, 2006), driven by the assumption that the novel label does not refer to one of the familiar competitors that are presented. Although this reasoning need not be conscious or explicit, an a priori assumption must be present and driving children's object choice. The emergence of children's ability to select the novel object as the referent of a novel label during the second year of life (Halberda, 2003) may reflect the successful acquisition of this assumption.

Recent work reporting on computational modeling of children's referent selection has, however, suggested that such an a priori assumption may not be necessary to lead children to reject familiar competitors as potential referents. Instead, McMurray and colleagues' (2012) computational model demonstrated reliable referent selection with no need for an algorithm that imposed any process-of-elimination computations on input. Critically, however, the model's chosen referent on each referent selection trial was deemed to be the object with the highest activation, but given that attention to familiar competitors is crucial in supporting referent selection, more work must be done to ascertain whether such a measure accurately reflects children's actual referent selection.

The current work aims to inform the ongoing debate. Critically, the main finding of Paper 1, that shy 24-month-old children do not map a novel label onto a novel object, demonstrates there are marked individual differences in children's referent selection. We must therefore begin to further examine the mechanisms that underlie children's rejection of familiar competitors as referents of a novel label. A useful approach in addressing this question could be to examine children's looking pattern on referent selection trials in which all objects are novel, but competitors are pre-familiarized novel objects for which a label is not yet known (i.e. an extension of Horst, Samuelson, Kucker & McMurray, 2011). This would allow a better understanding of the role of known words in children's rejection of competitors as potential referents.

One further strength of the current work is that both Paper 3 and Paper 4 employed fine-grained and dynamic analysis of children's looking during labeling, rather than relying solely on average looking time. This allowed an examination of the key points in time that drive the effect of shyness on attention during word learning. As argued by Balas and Oakes (2015), children's looking time must be considered as a dynamic measure, and the time bin analyses presented in the current thesis neatly demonstrate how these dynamics can be presented and assessed.

Methodological Issues

The current work also raises methodological issues about the study of word learning. While lab tasks are specifically designed to maximize control over confounding variables, this control may inhibit some children's ability to engage with the task, which suggests that individual differences must be taken into account when drawing conclusions from these experiments. Shy children were able to form and retain the word object mappings when presented in an environment constructed to be more familiar (Paper 2), while they did not form and retain the word object mappings in the more unfamiliar environment of a typical lab-based task (Paper 1). This sort of task thus seems to inhibit shy children's learning; their less robust performance may be due to environmental familiarity, rather than any additional independent variable under consideration.

The importance of understanding the interaction between individual differences and the context of the experimental task has been demonstrated for intrinsic factors other than shyness. Unsurprisingly, for example, distractible children learn fewer words in the presence of distractions than their less-distractible peers (Dixon Jr., Salley, & Clements, 2006). Beyond being a further example of individual differences that impact on word learning, Dixon Jr. and colleagues' (2006) finding suggests that the straightforward answer to the concerns of the current work – that children could simply be tested at home to reduce any inhibition of shy children – may then fail to account for differences in distractibility in the likely more cluttered home environment. While this example highlights the difficulty in controlling for the interaction between individual differences and task context (because there are so many to be borne in mind), it is essential that individual differences are taken seriously in developmental science. It could therefore become best practice to routinely take measures of children's shyness via a parent-report questionnaire (e.g. Putnam et al., 2006) in all word learning studies, so that the shyness score can be included in analyses as a covariate. Indeed, some labs routinely already ask all parents to complete a temperament questionnaire (e.g. Altvater-Mackensen & Grossmann, 2015) so that relevant scales can be included in analyses.

Unless temperament is taken into account, developmental research runs the risk of only being applicable to *good research babies*, that is to say those who are best suited to learn in the environment in which the task is presented. This practice calls into question the validity of the findings that are produced from the field. For example, 14% of infants in looking-time studies are excluded due to fussiness (Slaughter & Suddendorf, 2007), and this fussiness may be due to infant temperament (Wachs & Smitherman, 1985), leading to biased samples used for final analyses. Recently, it was shown that participants excluded from EEG studies were more likely to be higher in negative reactivity than those children whose data is included (Marshall, Reeb, & Fox, 2009). These studies, alongside the present work, are a clear demonstration that temperament can predict how children will engage with experimental tasks.

Shyness and Language Acquisition

This thesis began by discussing the variability in children's early language acquisition, and by outlining the two novel aims of this research program: first, to extend research beyond the many investigations into the extrinsic factors that may explain this variability, such as socioeconomic status (e.g. Rowe, 2008) or parental language use (e.g. Rowe, Özçalışkan, & Goldin-Meadow, 2008), by examining intrinsic factors that can affect language acquisition; and second, to examine how variability in children's language acquisition may emerge from the processes involved in word learning.

The current thesis argues that an effect of shyness on looking during labeling is driven by shy children's aversion to unfamiliarity in the environment, aversion to the novel object and an aversion to risk. This effect of looking during labeling means that shyness comes to bear both on referent selection and retention, which suggests that these components of shyness must also be incorporated into future theoretical approaches to shy children's language development. Recent research, however, has suggested that differences in referent selection are not necessarily reflected in children's longer-term language development. This is because in-the-moment referent selection is governed by different processes to the associative mechanisms that support the long-term retention of word meaning (McMurray et al., 2012). McMurray and colleagues' (2012) account argues that learning word-object mappings is gradual across many exposures to the co-occurrence of word and object. When applied to the noisy, cluttered environment outside of a lab task, such a system is advantageous for the child because it allows the pruning of any false associations learned via referent selection. Only when the strength of the association is increased e.g. by reinforcing it with ostensive naming (Horst & Samuelson, 2008) or when it is presented across contexts (Smith & Yu, 2008), will the word-object mapping be learned.

At first sight, it would therefore seem that individual differences in children's referent selection should not influence their language acquisition. The current thesis, however, found that by modulating the strength of the association between the word and the object, shyness may indeed explain variability in language learning. Clearly, any set of circumstances that reduces the strength of association between the novel word and novel object during disambiguation could prevent that association from being retained. Critically, however, shyness is an enduring character trait that modulates the strength of the association across subsequent exposures to the word and object, thus possibly hindering the cross-situational learning of word-object associations. Importantly, however, Paper 2 showed that shy children formed a strong enough association between the novel object and label when it was presented in a context that was familiar. Thus, as development progresses, situations will become more familiar, and words initially presented in an unfamiliar setting are likely to be repeated somewhere more well-known, allowing shy children to learn the words. This account offers an explanation for the time-course of variability in children's language acquisition during early childhood: Variability begins to increase from the age at which children are beginning to produce multiple words (Fenson et al., 1994), but this variability wanes again at around the age of 30 months.

Contribution to Existing Theories

Existing theories of the relation between shyness and language development have largely been based on measures of children's language production (e.g. Asendorpf & Meier, 1993; Coplan, 2000; Crozier & Perkins, 2002; Evans, 1987; Reynolds & Evans, 2009). This focus means that differences in the processes by which language is acquired are not well accounted for by traditional accounts of shy children's language acquisition. Importantly, we cannot know from these previous reports whether children's receptive language skills are also affected by shyness. Reports by Smith Watts and colleagues (2014) and Spere and colleagues (2004) are key because they examined the receptive vocabulary of children.

Smith Watts and colleagues (2014) argued that shy children's lower language scores are best explained in terms of a reticence to respond. This argument suggests that shyness does not affect children's language acquisition, but rather that shy children are reluctant to respond. This account neatly explains Smith Watts and colleagues' (2014) finding that expressive, but not receptive, vocabulary is affected by shyness, but this finding is contradicted by Spere at al., (2004) who found that receptive vocabulary is also affected by shyness. Similarly, a reticence to respond model cannot account for the findings of the current thesis that shyness affected children's word learning. Paper 1 could not rule out the possibility that children were forming and learning the novel word-object mappings presented during referent selection, because shy children may simply have been reluctant to demonstrate that they had learned the association. Yet Paper 3 and Paper 4 showed that there were marked differences in the attention patterns of shy and less-shy children during referent selection. Therefore, even when measured implicitly, with no response necessary, this thesis has shown that shyness affected the low-level attentional processes that we know are key in supporting the disambiguation of new words. This is a clear indication that shy children's differential language development cannot be solely explained in terms of a reticence to respond.

An alternative account, outlined by Evans (1996), has suggested that shy children are less linguistically competent (Coplan and Evans, 2009). On this view shy children's reduced verbal participation (e.g. Crozier, 1995) means that they have fewer opportunities to practice and engage with language, which impacts on their ability to acquire it. Importantly, Evans' (1996) explanation would suggest that shy children's reduced exposure to language can impact on their receptive language skills, and is therefore more in line with the findings of the current thesis than a reticence to respond explanation. Importantly however, the supposed mechanism behind Evans' (1996) explanation is that any differences in these cognitive processes are a result of shy children's reduced engagement with language.

We do know that children's language experience can affect their behavior on referent selection trials. Houston-Price, Caloghiris and Raviglione (2010) found that bilingual children did not reliably map a novel word to a novel object, and they explained this behavior with the children's experience of having more than one label for an object. There has been no plausible mechanism put forward to explain why shy children's differential language experience in comparison to less-shy children delays their ability to map the novel label to the novel object. Therefore, the lack-of-practice explanation for the relation between shyness and language development cannot yet fully account for the findings of the current thesis. That shy children's language experience means that they are unable to form novel word-object mappings is also not supported by the finding that shy children's referent selection is above chance when their parent ran the experiment. Instead, the current evidence suggests that the effects of shyness on children's language development are more complex and multidimensional than suggested by previous theoretical approaches. Shy children's lower language scores can be in part accounted for by their differential looking during referent selection.

Insights into shyness

The current research has also offered an insight into our understanding of shyness. This work has shown that overt behavior is a poor predictor of children's attention, because although children will select a novel object as the referent of a novel label, they actually look less at the novel object than the familiar competitors. Shyness is characterized in terms of a turning away from unfamiliar people (Putnam et al., 2006) and an avoidance of eye-contact (Fox et al., 2001), yet Paper 4 found that shy children attended more to faces when presented on a screen. This finding built on previous similar findings that shy children are hyper-vigilant to faces (Brunet et al., 2009) by demonstrating shy children's heightened attention to faces even when there is something else to look at (in this case the array of objects). Paper 4 argued that this increased attention is due to children's attentional bias to aversive stimuli (Kindt, Bierman, & Brosschot, 1997).

Furthermore, Paper 3 showed that shyness can affect children's attention in the absence of any social interaction, which suggests that shy children's aversion to novelty extends to novel objects. An aversion to novel objects has previously been reported as a core dimension of shyness (Kagan et al., 1987), or a correlate of it (Rothbart, 1988). It is unclear why shy children show such an aversion. It is possible that shy children worry that the novel object increases the likelihood that adults around them will want to engage with them about it, but such an idea does not explain the finding that the association between shyness and an aversion to novel objects is present as early as 6 months (Rothbart, 1988), given that it is unlikely that such young infants have such a sophisticated understanding of social interaction. Also, given the important role that novelty plays not just in word learning research, but also much of cognitive research more generally (i.e. novelty preference research; Snyder, Blank, & Marsolek, 2013), it would be beneficial to examine the mechanisms behind differences in children's approach to novelty.

Importantly, Paper 3 and Paper 4 showed that shyness can affect low-level attentional processes as well as children's explicit behavior. This is in line with Rothbart's (1981) argument that attention is a key component of children's emerging temperament. Importantly, this suggests that the effects of shyness on behavior are linked to certain implicit attentional biases and differences (Paper 3 & Paper 4); whether shyness or attentional differences emerge first is an important question for future research.

On a further methodological note, the current study has supports the *predictive validity* (i.e., one scale being able to predict scores on another; Cronbach & Meehl, 1955) of the Early Childhood Behavior Questionnaire (Putnam et al., 2006) by finding an association between children's shyness scores and looking during labeling

(Paper 3 & Paper 4) and choices on referent selection tasks (Paper 1 & Paper 2). These findings further support the use of the ECBQ in developmental research. Parental questionnaires remain the best method of measuring children's temperament, because parents have the greatest insight into the enduring behaviors of their child. While some experiments have used lab-based measures of children's shyness (e.g. Rubin, Nelson, Hastings, & Asendorpf, 1999), unless shyness is measured across different time points and in different contexts it is impossible to understand whether the measure is a reflection of a trait-based individual difference, or more transient state-based factors.

Implications of the Current Work

Recent years have seen the development of a number of computational models of referent selection, offering new insights into the mechanisms underlying children's word learning (McMurray, 2007; McMurray et al., 2012; Samuelson, Smith, Perry, & Spencer, 2011; Twomey, Morse, Cangelosi, & Horst, 2016). The current work has sought to engage with the conclusions of this computational work to further inform our understanding of the link between shyness and language. Learning in these models is typically simulated via a dynamic associative model (e.g., McMurray et al., 2012), which frames word learning in terms of strength of connections between paired inputs. In this case, auditory inputs (words) are linked to visual inputs (potential referents) via an intermediate layer of lexical units. Put simply, as a label and object are presented together, the strength of the connection between the two increases, while at the same time spurious connections are gradually pruned or inhibited.

McMurray et al. (2012) outlined how their dynamic associative model can explain both referent selection and retention. The novel object is selected as the referent of a novel label because the activation to the corresponding object is strongest, and over time this activation increases the strength of the connection between label and object until it can be considered learned. As with empirical work, computational modeling has begun to examine individual differences in language development by investigating how differences in training stimuli input to the model can affect the model's learning outcome. Notably, Thomas, Forrester & Ronald (2013) were the first to examine whether real-world effects of socioeconomic status on language development can be captured by a computational model.

Future work could thus attempt to model the findings of the current thesis computationally. A *shy* model could have inbuilt biases that increase the processing of novel information in order to examine whether this reduces novel word learning in comparison to a *less-shy* model that process familiar competitors more readily. This work could demonstrate that shyness modulates the strength of connections formed on presentation of the word and object. This suggestion offers a potential explanation for the findings of the current thesis in terms of our understanding of computational modeling, and offers a potential variable that can be considered in future models to better reflect real-world word learning.

This work also has important implications beyond the lab. The findings that shy children have difficulty disambiguating and retaining words when they are presented by an unfamiliar adult (Paper 1 & Paper 4) are particularly notable. Given the high turnover of staff in childcare and early education (OECD, 2006) children are potentially encountering many unfamiliar adults in these settings. The current work suggests that this could hinder shy children’s word learning in nursery settings from new staff. Shy children may therefore benefit from learning words in more structured tasks with unfamiliar adults, such as storybook reading, because the task may be familiar when the adult is not. Future work should focus on whether manipulating the familiarity of the task itself can support shy children's learning.

Importantly, in understanding the interactions between contexts and individual differences in early language acquisition, we can begin to understand when language development is just slowed, or when there may be a cause for concern. Prediction of language difficulties in later childhood is still not possible because the vast variability in early language development (Fenson et al., 1994) means that typical language development is difficult to define (Desmarais, Sylvestre, Meyer, Bairati, & Rouleau, 2010). Even children in the bottom 10% for productive vocabulary will go on to acquire language normally (Kelly, 1998; Whitehurst & Fischel, 1994). If we can begin to control for individual differences that can explain variability in early language acquisition, we can then work towards identifying children at risk for later language difficulties.

Concluding Remarks

Humpty Dumpty sat on a wall.
Humpty Dumpty had a great fall.
All the king's horses and all the king's men
Couldn't put Humpty together again.

Oakes (2009) described the current state of the art in developmental psychology, and asked us to think of the study of cognitive development as Humpty Dumpty. Oakes argued that decades of research into the development of cognitive domains (e.g. word learning) in isolation have tipped poor Humpty Dumpty over the edge, meaning that our understanding of development is now fractured and scattered. How, then did Mr. Dumpty fall?

The drive to study domains of cognitive development in isolation was likely the result of the perceived need to understand the processes by which development unfolds that are common to all children. Such ideas are far from old-fashioned: Bloom (2001) asserts that until we fully understand the universal processes that lead to language acquisition, any examination of individual differences is futile. Such a stance, however, ignores our current understanding of development as emergent and dynamic and therefore interconnected (e.g. Spencer et al., 2006). In stark contrast to Bloom's (2001) argument, a dynamic systems approach would argue that we can *only* understand children's language development fully by examining how it interacts with other developmental systems –for example, attention. Similar ideas form the cornerstone of Mareschal and colleagues' (2007) theory of neuroconstructivism, which explicitly argues for a greater examination of the intrinsic factors that serve to modulate developmental systems. This thesis embraces these theoretical concerns, and it is an example of a series of studies that specifically set out to examine the relations between two typically disparate domains of research: temperament and word learning.

Despite decades of research into children's ability to work out that the novel word *blicket* likely refers to the most novel referent object, this work is the first to explicitly examine how temperament can influence this ability. While many had come to the conclusion that the ability to map novel objects onto novel labels is a key behavior that emerges by the end of the second year of life (Halberda, 2003), the current thesis has found that shy children do not form word-object mappings in this way, and has shown that taking a mechanistic approach to the study of individual differences in language acquisition can help us better understand the processes by which this language is learned. Specifically, the enduring nature of shyness means that it is an individual difference that may affect word learning via its consistent influence on referent selection. Thus, while some argue that referent selection underpins language acquisition (e.g. Mayor & Plunkett, 2010), and others argue that it does not (e.g. Bion et al., 2013), the current work tells a more nuanced story: learning from one exposure to a word and object may play more of a role in language acquisition for some children than for others.

The finding that shyness affects children's attention during referent selection makes clear that temperament exerts an effect on word learning via the low-level processes by which children form word-object associations. Shy children's reduced verbal ability cannot be explained solely in terms of a reticence to respond. We must therefore begin to explore if and how shy children overcome these differences in word learning, in order to examine whether these differences are a cause for concern. Such an investigation strikes at the heart of one of the main difficulties inherent in running research studies with children: reliably measuring children's responses as a true measure of their knowledge.

In summary, the current thesis should stand as a demonstration that drawing together typically separate domains within the study of cognitive development can offer key insights into children's development, as suggested by Oakes (2010). Such insights have been in part the result of a move towards a more mechanistic understanding of language acquisition (McMurray et al., 2012), which has been accompanied by an increased interest in how individual differences come to bear on these mechanisms (e.g. Smith & Yu, 2013). Specifically, variability in children's emerging behavioral style can correspond to individual differences in children's word learning, further demonstrating that word learning is the result of a dynamic, emergent system.

References

Altvater-Mackensen, N., & Grossmann, T. (2015). Learning to match auditory and visual speech cues: social influences on acquisition of phonological categories. *Child Development*, *86*(2), 362–378. http://doi.org/10.1111/cdev.12320

Asendorpf, J. B., & Meier, G. H. (1993). Personality effects on children's speech in everyday life: Sociability-mediated exposure and shyness-mediated reactivity to social situations. *Journal of Personality and Social Psychology*, *64*(6), 1072–1083. http://doi.org/10.1037/0022-3514.64.6.1072

Axelsson, E. L., Churchley, K., & Horst, J. S. (2012). The right thing at the right time: Why ostensive naming facilitates word learning. *Frontiers in Psychology*, *3*, 88. http://doi.org/10.3389/fpsyg.2012.00088

Balas, B. & Oakes, L. (2015). Modeling infant visual preference as perceptual oscillation. In Proceedings of the Joint IEEE International Conference on *Development and Learning and Epigenetic Robotics (ICDL-EpiRob), 2015* (pp. 26–32). http://doi.org/10.1109/DEVLRN.2015.7345451

Bion, R. A. H., Borovsky, A., & Fernald, A. (2013). Fast mapping, slow learning: Disambiguation of novel word–object mappings in relation to vocabulary learning at 18, 24, and 30 months. *Cognition*, *126*(1), 39–53. http://doi.org/10.1016/j.cognition.2012.08.008

Bloom, P. (2001). Précis of how children learn the meanings of words. *Behavioral and Brain Sciences*, *24*(06), 1095–1103. http://doi.org/10.1017/S0140525X01000139

Brunet, P. M., Heisz, J. J., Mondloch, C. J., Shore, D. I., & Schmidt, L. A. (2009). Shyness and face scanning in children. *Journal of Anxiety Disorders*, *23*(7), 909–914. http://doi.org/10.1016/j.janxdis.2009.05.009

Coplan, R. J. (2000). Assessing nonsocial play in early childhood: Conceptual and methodological approaches. *Play Diagnosis and Assessment (2nd Ed.)*, 563–598.

Coplan, R. J., & Evans, M. A. (2009). At a loss for words? Introduction to the special issue on shyness and language in childhood. *Infant and Child Development*, *18*(3), 211–215. http://doi.org/10.1002/icd.620

Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin*, *52*(4), 281–302.

Crozier, W. R. (1995). Shyness and self-esteem in middle childhood. *British Journal of Educational Psychology*, *65*(1), 85–95. http://doi.org/10.1111/j.2044-8279.1995.tb01133.x

Crozier, W. R., & Perkins, P. (2002). Shyness as a factor when assessing children. *Educational Psychology in Practice*, *18*(3), 239–244. http://doi.org/10.1080/0266736022000010267

Desmarais, C., Sylvestre, A., Meyer, F., Bairati, I., & Rouleau, N. (2010). Three profiles of language abilities in toddlers with an expressive vocabulary delay: Variations on a Theme. *Journal of Speech, Language, and Hearing Research*, *53*(3), 699–709. http://doi.org/10.1044/1092-4388(2009/07-0245)

Dixon Jr., W. E., Salley, B. J., & Clements, A. D. (2006). Temperament, distraction, and learning in toddlerhood. *Infant Behavior and Development*, *29*(3), 342–357. http://doi.org/10.1016/j.infbeh.2006.01.002

Evans, M. A. (1987). Discourse characteristics of reticent children. *Applied Psycholinguistics*, *8*(02), 171–184. http://doi.org/10.1017/S0142716400000199

Evans, M. A. (1996). Reticent primary grade children and their more talkative peers: Verbal, nonverbal, and self-concept characteristics. *Journal of Educational Psychology*, *88*(4), 739–749. http://doi.org/10.1037/0022-0663.88.4.739

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., … Stiles, J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, *59*(5), i–185. http://doi.org/10.2307/1166093

Field, A. P. (2006). Is conditioning a useful framework for understanding the development and treatment of phobias? *Anxiety of Childhood and Adolescence: Challenges and Opportunities*, *26*(7), 857–875. http://doi.org/10.1016/j.cpr.2005.05.010

Fitneva, S. A., & Christiansen, M. H. (2011). Looking in the wrong direction correlates with more accurate word learning. *Cognitive Science*, *35*(2), 367–380. http://doi.org/10.1111/j.1551-6709.2010.01156.x

Fox, N. A., Henderson, H. A., Rubin, K. H., Calkins, S. D., & Schmidt, L. A. (2001). Continuity and discontinuity of behavioral inhibition and exuberance: psychophysiological and behavioral influences across the first four years of life. *Child Development*, *72*(1), 1–21. http://doi.org/10.1111/1467-8624.00262

Halberda, J. (2003). The development of a word-learning strategy. *Cognition*, *87*(1), B23–B34. http://doi.org/10.1016/S0010-0277(02)00186-5

Halberda, J. (2006). Is this a dax which I see before me? Use of the logical argument disjunctive syllogism supports word-learning in children and adults. *Cognitive Psychology*, *53*(4), 310–344. http://doi.org/10.1016/j.cogpsych.2006.04.003

Horst, J. S., & Samuelson, L. K. (2008). Fast mapping but poor retention by 24-month-old infants. *Infancy*, *13*(2), 128–157. http://doi.org/10.1080/15250000701795598

Horst, J. S., Samuelson, L. K., Kucker, S. C. & McMurray, B. (2011). What's New? Children prefer novelty in referent selection. *Cognition*, 118(2) 234-244. http://doi.org/10.1016/j.cognition.2010.10.015

Horst, J. S., Scott, E. J., & Pollard, J. A. (2010). The role of competition in word learning via referent selection. *Developmental Science*, *13*(5), 706–713. http://doi.org/10.1111/j.1467-7687.2009.00926.x

Houston-Price, C., Caloghiris, Z., & Raviglione, E. (2010). Language experience shapes the development of the mutual exclusivity bias. *Infancy*, *15*(2), 125–150. http://doi.org/10.1111/j.1532-7078.2009.00009.x

Kagan, J., Reznick, J. S., & Snidman, N. (1987). The physiology and psychology of behavioral inhibition in children. *Child Development*, *58*(6), 1459–1473. http://doi.org/10.2307/1130685

Kelly, D. J. (1998). A clinical synthesis of the "late talker" literatureimplications for service delivery. *Language, Speech, and Hearing Services in Schools*, *29*(2), 76–84. http://doi.org/10.1044/0161-1461.2902.76

Kindt, M., Bierman, D., & Brosschot, J. F. (1997). Cognitive bias in spider fear and control children: assessment of emotional interference by a card format and a single-trial format of the stroop task. *Journal of Experimental Child Psychology*, *66*(2), 163–179. http://doi.org/10.1006/jecp.1997.2376

Krcmar, M., Grela, B., & Lin, K. (2007). Can toddlers learn vocabulary from television? an experimental approach. *Media Psychology*, *10*(1), 41–63. http://doi.org/10.1080/15213260701300931

Kucker, S. C., McMurray, B., & Samuelson, L. K. (2015). Slowing down fast mapping: Redefining the dynamics of word learning. *Child Development Perspectives*, *9*(2), 74–78. http://doi.org/10.1111/cdep.12110

Levin, I. P., & Hart, S. S. (2003). Risk preferences in young children: early evidence of individual differences in reaction to potential gains and losses. *Journal of Behavioral Decision Making*, *16*(5), 397–413. http://doi.org/10.1002/bdm.453

Mareschal, D., Johnson, M. H., Sirois, S., Spratling, M., Thomas, M. S. C., & Westermann, G. (2007). *Neuroconstructivism - I: How the Brain Constructs Cognition*. Oxford: OUP Oxford.

Marshall, P. J., Reeb, B. C., & Fox, N. A. (2009). Electrophysiological responses to auditory novelty in temperamentally different 9-month-old infants. *Developmental Science*, *12*(4), 568–582. http://doi.org/10.1111/j.1467-7687.2008.00808.x

Mather, E., & Plunkett, K. (2009). Learning words over time: The role of stimulus repetition in mutual exclusivity. *Infancy*, *14*(1), 60–76. http://doi.org/10.1080/15250000802569702

Mather, E., & Plunkett, K. (2011). Mutual exclusivity and phonological novelty constrain word learning at 16 months. *Journal of Child Language*, *38*(05), 933–950. http://doi.org/10.1017/S0305000910000401

Mayor, J., & Plunkett, K. (2010). A neurocomputational account of taxonomic responding and fast mapping in early word learning. *Psychological Review*, *117*(1), 1–31. http://doi.org/10.1037/a0018130

McMurray, B. (2007). Defusing the childhood vocabulary explosion. *Science*, *317*(5838), 631–631. http://doi.org/10.1126/science.1144073

McMurray, B., Horst, J. S., & Samuelson, L. K. (2012). Word learning emerges from the interaction of online referent selection and slow associative learning. *Psychological Review*, *119*(4), 831–877. http://doi.org/10.1037/a0029872

Oakes, L. M. (2009). The "Humpty Dumpty Problem" in the study of early cognitive development: Putting the infant back together again. *Perspectives on Psychological Science*, *4*(4), 352–358.

OECD. (2006). *Starting strong II: Early childhood education and care*. Paris, France: OECD. Retrieved from http://www.unicef.org/lac/spbarbados/Implementation/ECD/StartingStrongII_OECD_2006.pdf

Putnam, S. P., Gartstein, M. A., & Rothbart, M. K. (2006). Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior Questionnaire. *Infant Behavior and Development*, *29*(3), 386–401. http://doi.org/10.1016/j.infbeh.2006.01.004

Reynolds, K. P., & Evans, M. A. (2009). Narrative performance and parental scaffolding of shy and nonshy children. *Applied Psycholinguistics*, *30*(2), 363–384. http://doi.org/10.1017/S0142716409090158

Rothbart, M. K. (1981). Measurement of temperament in infancy. *Child Development*, *52*(2), 569–578. http://doi.org/10.2307/1129176

Rothbart, M. K. (1988). Temperament and the development of inhibited approach. *Child Development*, *59*(5), 1241–1250. http://doi.org/10.2307/1130487

Rowe, M. L. (2008). Child-directed speech: relation to socioeconomic status, knowledge of child development and child vocabulary skill. *Journal of Child Language*, *35*(01), 185–205. http://doi.org/10.1017/S0305000907008343

Rowe, M. L., Özçalışkan, Ş., & Goldin-Meadow, S. (2008). Learning words by hand: Gesture's role in predicting vocabulary development. *First Language*, *28*(2), 182–199.

Rubin, K. H., Nelson, L. J., Hastings, P., & Asendorpf, J. (1999). The transaction between parents' perceptions of their children's shyness and their parenting styles. *International Journal of Behavioral Development*, *23*(4), 937–957.

Samuelson, L. K., Smith, L. B., Perry, L. K., & Spencer, J. P. (2011). Grounding word learning in space. *PLoS ONE*, *6*(12), e28095. http://doi.org/10.1371/journal.pone.0028095

Schafer, G., & Plunkett, K. (1998). Rapid word learning by fifteen-month-olds under tightly controlled conditions. *Child Development*, *69*(2), 309–320. http://doi.org/10.1111/j.1467-8624.1998.tb06190.x

Slaughter, V., & Suddendorf, T. (2007). Participant loss due to "fussiness" in infant visual paradigms: A review of the last 20 years. *Infant Behavior and Development*, *30*(3), 505–514. http://doi.org/10.1016/j.infbeh.2006.12.006

Smith, L. B., & Yu, C. (2008). Infants rapidly learn word-referent mappings via cross-situational statistics. *Cognition*, *106*(3), 1558–1568. http://doi.org/10.1016/j.cognition.2007.06.010

Smith, L. B., & Yu, C. (2013). Visual attention is not enough: Individual differences in statistical word-referent learning in infants. *Language Learning and Development*, *9*(1), 25–49. http://doi.org/10.1080/15475441.2012.707104

Smith Watts, A. K., Patel, D., Corley, R. P., Friedman, N. P., Hewitt, J. K., Robinson, J. L., & Rhee, S. H. (2014). Testing alternative hypotheses regarding the association between behavioral inhibition and language development in toddlerhood. *Child Development*, *85*(4), 1569–1585. http://doi.org/10.1111/cdev.12219

Snyder, K. A., Blank, M. P., & Marsolek, C. J. (2013). What form of memory underlies novelty preferences? *Psychonomic Bulletin & Review*, *15*(2), 315–321. http://doi.org/10.3758/PBR.15.2.315

Spencer, J. P., Clearfield, M., Corbetta, D., Ulrich, B., Buchanan, P., & Schöner, G. (2006). Moving toward a grand theory of development: In memory of Esther Thelen. *Child Development*, *77*(6), 1521–1538. http://doi.org/10.1111/j.1467-8624.2006.00955.x

Spere, K. A., Schmidt, L. A., Theall-Honey, L. A., & Martin-Chang, S. (2004). Expressive and receptive language skills of temperamentally shy preschoolers. *Infant and Child Development*, *13*(2), 123–133. http://doi.org/10.1002/icd.345

Swingley, D., & Aslin, R. N. (2000). Spoken word recognition and lexical representation in very young children. *Cognition*, *76*(2), 147–166. http://doi.org/10.1016/S0010-0277(00)00081-0

Thomas, M. S. C., Forrester, N. A., & Ronald, A. (2013). Modeling socioeconomic status effects on language development. *Developmental Psychology*, *49*(12), 2325–2343. http://doi.org/10.1037/a0032301

Twomey, K. E., Morse, A. F., Cangelosi, A., & Horst, J. S. (2016). Children's referent selection and word learning: insights from a developmental robotic system. *Interaction Studies*.

Wachs, T. D., & Smitherman, C. H. (1985). Infant temperament and subject loss in a habituation procedure. *Child Development*, *56*(4), 861–867. http://doi.org/10.2307/1130098

Whitehurst, G. J., & Fischel, J. E. (1994). Practitioner Review: Early developmental language delay: What. If anything. Should the clinician do about it? *Journal of Child Psychology and Psychiatry*, *35*(4), 613–648. http://doi.org/10.1111/j.1469-7610.1994.tb01210.x

Wilkinson, K. M., Ross, E., & Diamond, A. (2003). Fast mapping of multiple words: Insights into when "the information provided" does and does not equal "the information perceived." *Journal of Applied Developmental Psychology*, *24*(6), 739–762. http://doi.org/10.1016/j.appdev.2003.09.006

Zosh, J. M., Brinster, M., & Halberda, J. (2013). Optimal contrast: Competition between two referents improves word learning. *Applied Developmental Science*, *17*(1), 20–28. http://doi.org/10.1080/10888691.2013.748420