WHAT IS A WORD: UNDERSTANDING DEVELOPMENTAL CHANGES IN THE SOUNDS INFANTS ACCEPT AS POSSIBLE LABELS

by

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ABSTRACT

Language is a conventional system: the use of words is shared within a language community. Even further, each language community has conventions regarding what “forms” may serve as words. A form (the phonological sounds or hand movements that make up a word) used in one community may not be proper in another. It is therefore important that when young language learners acquire a language, they adhere to both the general conventionality of language and the word-form conventions of their particular language(s).

Previous research has demonstrated a developmental narrowing in the word-forms that infants are willing to accept as conventional labels. Younger word-learning infants view a wider range of symbols as potential labels than do older infants. The present study takes this research further, and specifies the nature of this developmental narrowing. Two potential word-learning constraints are explored: a Linguistic word-learning constraint, in which infants limit the symbols they view as potential labels according to whether the label-form consists of components that occur in at least one of the world’s languages, versus a more restrictive Native Language Assimilation constraint, in which infants limit symbols according to whether the components within the label-forms assimilate into native language speech categories. In addition, this research probed whether the development of such constraints is related to infants’ vocabulary acquisition.

In the present study, I explored infants’ ability to learn unassimilable yet linguistic click words as object labels. In Experiment 1, I first established the effectiveness of the novel two-object Referential Switch paradigm, demonstrating that 14-month-old infants succeed in learning unassimilable click words as object labels in this task. In Experiment 2, I then tested 20-month-old infants to investigate the development of a Linguistic versus Native Language Assimilation. I found that while 20-month-old infants with smaller vocabularies were able to learn the unassimilable click words as labels, infants with larger vocabularies were not. These results suggest that the narrowing that occurs between 14 and 20 months of age in
infants’ awareness of word-form conventions is best explained by the development of a Native Language Assimilation word-learning constraint.
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CHAPTER 1 INTRODUCTION

The concept of shoe—the object that is worn on a foot—is given many names across different languages. It may be the English “shoe,” the French “chaussure,” the Russian “bashmak,” or the Swahili “kiatu.” Across all languages, what remains consistent is that the object shoe has no special relationship to the sounds that make up these words: not the sounds of “shoe,” “chaussure,” “bashnuk,” or “kiatu.” This is because language is an arbitrary system. Proficient language users operate under the principle that for most concepts, there is a single appropriate language form (the physical phonological sounds or hand and body movements that make up a word) that is shared among the competent members of a linguistic community (Clark, 1993). Hence, concepts are linked to labels due to the conventional nature of language.

As young infants and children begin to acquire language, they must understand that it is conventional. When a word is used by one speaker to label a concept in one situation, an effective language learner must realize that the same word can also be used to label that same concept in a novel situation by a new speaker. However, while an understanding of language conventionality is important for language acquisition, infants and children must also practice “skeptical trust” (Clement, Koenig, & Harris, 2007) rather than accepting that all labels provided to them are conventional. There are several ways in which young language learners must utilize skeptical trust with regard to provided labels. One critical step is to apply what they know about the forms of words used conventionally in their community. A proficient language learner should be able to ascertain whether a novel sound or symbol used in a labeling situation is likely to be a word, on the basis of whether the novel form itself conforms to the conventional system of word-forms in their language.

How novice language learners make judgments as to whether a newly provided label is conventionally appropriate in their native language is not fully understood. Do hearing infants expect that all linguistic symbols (symbols that are
made up of components that are used in at least one of the world’s languages) are appropriate labels? Or, might infants instead expect that conventionally appropriate labels use sounds that are similar to the sounds that they often encounter in already known words from their native language? The present research seeks to tease apart these possibilities, by investigating the types of symbols that infants will accept as potential object labels.

### 1.1 Conventionality

The principle of conventionality in language was first articulated by Ferdinand de Saussure, who stated that “every type of expression accepted in a community rests in principle on a collective habit or, what comes down to the same thing, in convention” (1916/1968). Saussure pioneered the idea that what ties a concept to the language form that labels it is the fact that members in a community have agreed upon a shared form for the concept. Language is thus a series of bonds between community members, linking form to concept. An understanding of these bonds and the notion that language is shared is of paramount importance to a language learner.

In the early 1980s, Eve Clark first postulated that language conventionality is one of several principles utilized by infants and children as they assemble a lexicon (Clark, 1983; 1993). Clark supported her theory by pointing to the fact that while young children often initially coin their own novel labels for concepts (such as “climber” for ladder, or “spyer” for spy), they eventually abandon these self-made forms in favour of the conventionally accepted forms in their language community. In addition, research has shown that once children have acquired the conventional forms for a concept, they will either correct other speakers when they use an incorrect term, or will look longer at incorrect versus correct speakers (Koenig & Echols, 2003).

Without an understanding of conventionality in language, it would be difficult for language learning to get off the ground. Conventionality allows for
language learners to achieve linguistic common ground with other speakers in their language community, and to apply labels learned in one context to future situations. As such, it might be expected that an understanding of language conventionality is present early in development. Indeed, recent research has demonstrated that young infants appear to employ conventionality in acquiring labels for objects. Henderson, Graham, and colleagues have conducted word-learning studies with both 19- (Graham, Stock, & Henderson, 2006) and 24-month-old infants (Henderson & Graham, 2005). In these studies, infants were initially taught a novel label for a novel object by an experimenter. After learning this novel label, the first experimenter then left the room and a previously absent second experimenter entered. The second experimenter requested the previously labeled object, using the same label as the first experimenter despite not being present when the first experimenter had used this term. Henderson and Graham found that both 19- and 24-month-old infants correctly provided the experimenter with the requested item, suggesting that infants 19 and 24 months of age have an understanding that language labels are shared across speakers. Henderson and Graham also investigated whether infants appeared to overextend an understanding of conventionality to domains that adults do not view as shared, such as personal preference for objects. It was found that infants did not view object preference as conventional, as they failed to extend a first experimenter’s preference for a target object to a second experimenter.

Furthermore, research by Buresh and Woodward (2006) has suggested that an understanding of language conventionality is present even earlier in development. Using a habituation paradigm, Buresh and Woodward found that 13-month-old infants generalized linguistic labels from one speaker to a second speaker, but did not generalize goals across agents. However, Buresh and Woodward also demonstrated that younger (nine-month-old) infants did not generalize linguistic labels across speakers using an identical experimental procedure. This research would thus suggest that infants’ understanding of language conventionality develops between nine and 13 months of age, at around the same time in which infants are thought to be beginning to understand and...
produce words (Fenson et al., 2000; Hollich et al., 2001; Werker, Cohen, et al., 1998; Woodward, Markman, & Fitzsimmons, 1994).

1.2 “Skeptical Trust” in Novel Labels

While utilizing the principle of language conventionality is extremely important for a proficient language learner, there are often occasions in which accepting all provided labels as conventional would be misguided. The vast majority of the times in which a language learner is provided with a label for a concept, it is likely to be the correct conventional term shared within the language community, but this is certainly not always the case. When providing a label, speakers may make a speech error, deliberately mislead or lie to a listener, or be ignorant about the correct conventional term for a concept. Therefore, it is important that a most effective language learner use “skeptical trust” (Clement, Koenig, & Harris, 2004) when accepting provided labels as conventional.

When a speaker provides a novel label for a concept, they are essentially providing testimony that this new label is the form that is used conventionally in their language community to name the concept. In turn, a listener is faced with a choice of whether to accept the speaker’s testimony, and alter their previous belief in the battery of known conventional forms. In 1981, Jaccard put forth a theory highlighting three factors that influence whether an individual is likely to accept a novel testimony and alter their original beliefs. The three variables Jaccard found to contribute to belief change are: the discrepancy between a novel testimony and the receiving individual’s original beliefs, the confidence and knowledge that the receiving individual has in their original beliefs, and the confidence that the receiving individual has in the source of the novel testimony.

More recently, Jaswal and Malone (2007) have argued that Jaccard’s framework for belief change can be used to help understand when infants are willing to change their original beliefs about an object’s category membership. In studies by Jaswal and colleagues (Jaswal, 2004; Jaswal & Malone, 2007; Jaswal &
Markman, 1997; see also Gelman & Markman, 1986; Koenig and Echols, 2003), infants are presented with a novel object that appears to fit into a category already familiar to the infant (such as a novel animal that appears cat-like). They are then given a familiar label for this object that does not match the apparent category membership (such as being told that the cat-like object is in fact a “dog”). The research question is whether infants will attribute properties to the labeled object that are consistent with the category membership that the object appeared to belong to, or to the category named by with the given label (i.e., whether the cat-like object labeled as “dog” would be likely to meow or to bark).

A battery of previous research has illustrated that the three factors thought to influence testimony acceptance and belief change—discrepancy, confidence, and source—contribute to whether infants and children are likely to alter their belief in an object’s category membership when provided testimony of the object’s label. Discrepancy is important in children’s category judgments: research has shown that the further an object appears to be from the labeled category, the less likely it is that infants will adjust their belief to accept that the object has properties of the labeled category. For instance, Koenig and Echols (2003) found that when 16-month-old infants were presented with objects that looked completely like members of one category (such as a cat), but were told that the name for the objects was the label for an entirely different category (such as “shoe”), the infants objected to the provided labels. On the other hand, Jaswal and Markman (2007) presented two year old children with computerized hybrid objects designed to appear to be potential members of two categories, but which leaned more towards being perceived as members of one of the two categories (i.e., a dog-like cat). When these hybrid objects were given the label that corresponded to the less-likely category (“dog”), children were willing to accept that the hybrid objects had properties associated with the labeled category. Jaswal and colleagues (2004; Jaswal & Malone, 2007) have argued that the reason that the infants in Jaswal and Markman’s (2007) study were willing to alter their belief in an object’s category membership while the children in Koenig and Echols’s (2003) study failed to do so is that the discrepancy
between the perceived category of the target object and the category of the provided label was far greater in the Koenig and Echols study.

Jaswal and colleagues have also found that confidence and source appear to contribute to whether infant are willing to adjust their belief in an objects category membership when provided with a new label. In one study (Jaswal, 2004), three year olds were shown to be far more willing to accept speakers' label testimony than were four year olds. The researchers reasoned that the older children were more confident in their knowledge about all the exemplars belonging to the familiar categories employed in the study. In an additional study examining the impact of source on infants’ categorization, Jaswal and Malone (2007) found that three year old children were even more likely to accept a speaker’s label when the speaker was certain in their testimony (“This is a spoon”) than when the speaker appeared uncertain (“I think this is a spoon”).

Given previous findings from Jaswal and colleagues in the domain of category reasoning, it is evident that Jaccard’s three factors impacting belief change and testimony acceptance are indeed germane to young learners’ responses to speaker testimony. Thus in the present study, I apply Jaccard’s model of three factors that influence belief change to infant label learning in order to identify contexts in which young language learners are and are not willing to accept a novel provided label-form as potentially conventional.

According to Jaccard’s framework of belief change, infants’ acceptance of labels should be sensitive to the three factors of discrepancy, confidence, and source. With regard to source, Jaccard’s framework indicates that an infant must see the provider of a novel label as reliable in order to accept the label possibly conventional. As for discrepancy, infants’ acceptance of a novel label-form should be influenced by the similarity between a novel form and the forms of conventional labels already known to the infant. The confidence an infant has in his or her knowledge of the types of label-forms that are used conventionally in his or her language community should also impact whether a label is accepted. However, as infants’ confidence in their knowledge of conventional labels is difficult (if not impossible) to assess, for the purposes of the present study I will use infants’ age
and vocabulary size as a proxy for confidence. It is presumed that as infants grow and develop a sizeable lexicon, their experience with the forms of conventional labels leads them to greater confidence in their knowledge about the types of forms that are typically used in their language.

1.3 Source in Label Learning

Young children are attentive to the source of a provided label. One manner in which children take note of the source of provided labels is in choosing to accept labels from reliable sources versus unreliable sources. Birch, Vauthier, and Bloom (2008) demonstrated that three- and four-year-old children spontaneously track speaker accuracy, and importantly, appear to prefer learning labels from previously accurate speakers as opposed to previously inaccurate speakers (see also Koenig, Clements, & Harris, 2004; Scofield & Behrend, 2008). Moreover, young children are additionally skeptical in accepting labels when a speaker appears ignorant or unconfident. Sabbagh and Baldwin (2001) found that three-year-old children were less likely to learn a label from a speaker who appeared uncertain when naming an object (“Maybe this one’s a blicket”) than from a speaker who showed no signs of uncertainty during naming (“This one’s a blicket”). It would thus appear that by at least three years of age, young children are attentive towards whether the source of a label appears reliable when accepting a provided label as conventional.

1.4 Discrepancy and Confidence in Label Learning

Using the discrepancy between a novel symbol-form and the forms of known labels in order to judge whether a potential label is likely to be a word is an important skill for a language learner to have. For instance, if a speaker is intending to provide a language label (and is giving all the proper referential cues that they are doing so—pointing, eye contact, etc.), but then happens to cough instead of providing a label, a proficient language learner will reject the idea that the cough is a
label based upon the fact that the sounds of a cough are not at all similar to other labels conventionally used in the language community. Adult language users instantaneously use discrepancy to accurately gauge whether provided symbol forms might be a word by using a lifetime of acquired knowledge about the phonotactic rules governing their native language (Brown & Hildum, 1956). However, research has indicated that at the onset of word learning, young infants may initially be willing to accept a broader range of forms as object labels than adults do.

Namy and Waxman (1998) first investigated whether hearing infants aged 18 and 26 months could learn gestures as object labels. Infants were placed in a face-to-face word-learning situation with an experimenter, and were taught either a word label or a gesture label. In the word condition, infants were presented with a target object and told, “we call this one [word].” They were then asked to find the target object, using the taught word. Infants in the gesture condition participated in an identical procedure, except that instead of a word, a gesture was produced by the experimenter as a label for the object. The infant was told, “we call this one [gesture].” Namy and Waxman found that 18-month-old infants succeeded in learning both the word and gestures as object labels, correctly selecting the target object when asked. However, the 26-month-old infants were only successful in the word condition and not in the gesture condition, suggesting that they had become more discerning as to what may serve as possible labels.

Woodward and Hoyne (1999) also examined the types of symbol forms that infants accept as labels, comparing infants’ learning of word labels and non-linguistic sound labels. Infants were given either a word label for an object, or a sound label produced by a noisemaking toy. The researchers found that 14-month-old infants were successful in learning both the word and toy sound labels, but that older 20-month-old infants only learned the word label.

This research by Namy and Waxman as well as by Woodward and Hoyne has revealed a developmental trajectory in infants’ notion of what types of symbol forms are appropriate as object labels: younger word-learning infants (up to 18 months of age) are willing to accept a wide range of symbols as object labels, but older word-
learning infants (older than 20 months) are not. It appears as though infants older than 20 months will only accept linguistic symbols as object labels. Namy and colleagues have continued to explore this issue, and have discovered that the range of symbols that younger infants will accept as labels is indeed quite broad: 18-month-old infants have been shown to accept not only gestures and toy noises, but also digital noises and pictograms (Namy, 2001). In addition, Sheehan, Namy, and Mills (2007) have illustrated a similar developmental narrowing in infants' notions of what may be a word using ERP methodology. In response to known words, 18-month-old as well as 26-month-old infants showed an N400 congruency effect (traditionally demonstrated in responses to known words). However, only 18-month-old infants and not 26-month-old infants showed an N400 congruency effect in response to known gestures.

While work by Namy and colleagues as well as by Woodward and Hoyne has consistently shown that younger infants will accept non-linguistic symbols as object labels, it is important to note that their research does not address whether young infants meaningfully distinguish between linguistic and non-linguistic sounds in language learning. There is a great deal of research showing that infants in fact do respond differently to language than to non-language. For instance, Waxman and colleagues (Balaban & Waxman, 1997; Ferry, Hespos, & Waxman, 2010; Fulkerson & Waxman, 2007) have repeatedly demonstrated that infants are able to use words, but not non-linguistic tones, as invitations to form categories. Yet, there are important differences to note between the Waxman studies and the word-learning studies by Namy and colleagues as well as those by Woodward and Hoyne. First and foremost, the focus of the Waxman studies does not involve infants learning a sound as a label. Moreover, in these studies, infants are given few perceptual and social signals during the task, while in both Namy’s and Woodward’s studies, there were clear perceptual and social cues that both the linguistic and non-linguistic stimuli were referring to objects. As past research has indicated that providing infants with perceptual (Hollich, Hirsh-Pasek, & Golinkoff, 2000) as well as social and referential cues (Namy & Campbell, 2001) can boost infants’ ability to learn novel labels, this difference may also help explain why linguistic words are treated differently than
non-linguistic forms in the Waxman experiments. Furthermore, researchers have argued that while all infants are easily able to recognize the difference between linguistic and non-linguistic stimuli, once younger word-learning infants are placed into a communicative word-learning situation, they begin to weigh more heavily the communicative cues provided to them than the form of the stimuli (Hollich et al., 2000; Woodward & Hoyne, 1999; see also Graham et al., in press).

For the purposes of the present study, what is important to conclude from past research focused on the symbol-forms that infants accept as labels is that when word-learning infants are placed in contexts in which there are sufficient social, referential, and perceptual cues, younger word-learning infants aged 12-18 months are willing to accept a speaker’s implied testimony that non-linguistic symbols may serve as conventional object labels, while infants older than 20-month-olds are not (Hollich, Hirsh-Pasek, & Golinkoff, 2000; Namy, 2001; Namy, Campbell, & Tomasello, 2004; Namy & Waxman, 1998; Woodward & Hoyne, 1999).

There thus appears to be interplay between discrepancy and confidence in whether young language learners accept a speaker’s testimony that a novel provided label is conventional. As infants develop, it is likely that they become more confident in their knowledge about the forms of conventional labels as they encounter more label-forms in their daily experience. Thus the fact that younger infants (12-18 months) are readily willing to accept a speaker’s testimony that a non-linguistic label is conventional, even when there is a sizeable discrepancy between the form of a provided label and the forms of known conventional labels, can be interpreted as a lack of confidence in their own knowledge of word-form conventions. Conversely, the unwillingness of older infants (20+ months) to accept non-linguistic label-forms that are greatly dissimilar from known conventional labels can be explained by increased confidence in word-form conventions.

However, there are several questions that remain open as to how discrepancy and confidence may impact whether an infant language learner is willing to accept a speaker’s testimony that a provided label is conventional. First, how great a discrepancy between the form of a novel provided label and the forms of already known conventional labels are confident language learners ready to accept?
Previous studies have focused primarily on whether infants of different ages are able to learn linguistic versus non-linguistic symbols, but what remains to be illuminated is the specific scope of the developmental narrowing that occurs between 12-18 months of age and 20-26 months of age in infants’ idea of potential words. Do older word-learning infants judge all linguistic stimuli as appropriate labels while rejecting all non-linguistic stimuli, or is the scope of the narrowing perhaps more precise?

Another question that remains unanswered is what aspect of development leads older word-learning infants to become more confident in their knowledge of word-form conventions, and hence to accept less of a discrepancy between the form of provided labels and known conventional word-forms. Is it simply increasing age? Or might it be that greater experience with language, and the building of a more sizeable lexicon leads language learners to greater confidence in their knowledge about the forms of labels used conventionally in their language community?

The present study explores both of these unanswered questions: 1) What is the extent of the discrepancy between the form of a novel presented label and the forms of known conventional labels that word-learning infants will accept in order to view the novel label as potentially conventional, and 2) Does this change solely as a function of age, with older infants becoming more selective in what they will accept as a label? Or, is specific knowledge about conventional forms (as measured through vocabulary growth) important in this developmental change? In order to investigate the symbol-forms that older infants are likely to view as acceptable labels, I compare two hypotheses describing how older word-learning infants may constrain their notion of acceptable labels. The first is a Linguistic word-learning constraint (LING), postulating that older word-learning infants will limit the symbols they view as appropriate conventional labels according to whether symbols are linguistic versus non-linguistic. Alternatively, the more restrictive Native Language Assimilation word-learning constraint (NAT) hypothesizes that older word-learning infants judge symbols as appropriate labels not simply on the basis of whether the forms are linguistic in nature, but according to whether the individual components of the symbols assimilate into native language phonological categories.
To investigate the impact of vocabulary on the type of symbol forms that word-learning infants are willing to accept as conventional, vocabulary was measured for all infants tested.

1.5 Linguistic Word-Learning Constraint

The Linguistic (LING) word-learning constraint holds that older word-learning infants limit the label forms that they view as potentially conventional according to whether these forms are linguistic in nature. Previous research has demonstrated that from early infancy, there appears to be a heightened attention towards and preference for linguistic forms over similar non-linguistic forms (Jusczyk & Bertonici, 1988). For instance, Vouloumanos and Werker (2004) found that both two- and seven-month-old infants preferred natural speech to a matched sine-wave analog. This preference has even been found a few hours after birth (Vouloumanos & Werker, 2007), but is not as specific at birth as by three months of age (Vouloumanos et al., 2010; see also Krentz & Corina, 2008). The LING constraint hypothesizes that the demonstrated preference for linguistic over non-linguistic forms is carried through into word learning, such that older word-learning infants are willing to accept any linguistic forms as potentially conventional labels.

1.6 Native Language Assimilation Word-Learning Constraint

The Native Language Assimilation (NAT) word-learning constraint postulates that for older word-learning infants (20+ months), labels are viewed as potentially conventional only if all the individual components within a possible word assimilate into native language phonological categories.

The notion that the assimilability of heard sounds into native language phonological categories has functional consequences was first articulated by Catherine Best and colleagues as part of the Perceptual Assimilation Model of speech perception (PAM; Best & McRoberts, 2003; Best, McRoberts, & Goodell,
2001; Best, McRoberts, & Sithole, 1988). Best and colleagues proposed this model to explain the development of speech sound contrast discrimination during infancy. In 1984, Werker and Tees had illustrated that while six- to eight-month-old infants can successfully discriminate speech sound contrasts from both native (the English /ba/ versus /da/ contrast) and non-native (the Thompson Salish /k'i/ versus /q'i/ contrast, and the Hindi retroflex-dental /Ta/ versus /ta/ contrast) languages, ten- to 12-month-old infants only discriminate the native language contrast. This finding suggested a decline in older infants’ ability to discriminate sound contrasts not used meaningfully in their own language. However, in 1988 Best, McRoberts, and Sithole found that ten- to 12-month-old infants as well as adults were surprisingly successful at discriminating non-native click consonant contrasts. Thus, Best and colleagues proposed PAM as a theory to explain the development of speech contrast discrimination.

In its essence, PAM argues that once a language learner has begun to acquire the phonological system of their native language (at around 10-12 months of age), they make use of native language speech sound categories when processing speech. Further, as each of the world’s languages has its own set of speech sounds that are used meaningfully, individuals with different native languages have distinct sets of native language speech sound categories that they apply to speech perception. PAM asserts that when a listener perceives a speech sound (either native or non-native), the sound will be assimilated into the most similar native language speech sound category whenever possible. Most of the time, heard sounds will successfully assimilate into a native language speech sound category. The assimilation of a sound into a native language category means that the sound will then be processed by the listener as a member of the category to which it assimilated, and importantly, take on the linguistic, phonemic characteristics that the listener associates with this category. This means that discrimination will be enhanced for those sounds that fit into different phonemic categories, and attenuated (or not evident at all) for sounds that are perceived different instances of the same phonemic category (Harnad, 1987).
Take as an example of speech sound assimilation a situation in which an English-proficient listener hears the Hindi retroflex /T/ as well as native English /t/ sound. As both of these sounds are similar to the native English /t/ category, both /T/ and /t/ assimilate to the /t/ category. With both /T/ and /t/ processed as members of the /t/ category, the listener then cannot distinguish these two sounds, despite the fact that they are acoustically different. Given these predictions of PAM, Best and colleagues hypothesized that it was this sort of assimilation that occurred in the work by Werker and Tees (1984) showing a developmental decline in non-native speech contrast discrimination. The sound contrasts used by Werker and Tees (/T/ vs. /t/, and /k'/ vs. /q'/) are thought to assimilate into a single native language category for English-speaking older infants and adults, which then results in the decreased discrimination shown.

PAM also reasons that there are cases in which a heard speech sound differs too drastically from any native language speech sound categories to assimilate. Speech sounds that are “unassimilable” are not encompassed into any native language speech sound category, and hence listeners are able to detect perceptible acoustic differences between the sounds similarly to young infants who have not yet acquired knowledge of native language phonological categories. Best and colleagues theorized that non-native click consonants remained discriminable by older infants and adults due to the fact that these click consonants are unassimilable for English-proficient listeners. As the sounds are not similar to any native language category, the English-speaking listeners processed these sounds in acoustic terms and were able to differentiate the contrast.
Illustration 1.1 Visual depiction of speech sound assimilation according to PAM.

Illustration 1.1: When sounds assimilate into native language categories (the arrows fit into the boxes), a listener will perceive the heard sound according to the linguistic, phonemic characteristic of the native language category. When sounds do not assimilate (arrows do not enter any box), a listener will perceive the sound according to the non-linguistic, acoustic characteristics of the sound.

The NAT word-learning constraint proposed in the present study takes the assimilation framework laid out in Best’s PAM model, and applies it to word learning in infancy. If the NAT constraint holds true, older word-learning infants should only be willing to accept novel labels as potentially conventional when the sounds that make up the labels are all able to assimilate into native language sound categories.

1 || is the notation for a lateral post-alveolar click, which sounds similar to the “tchick” noise that English speakers may make when spurring on a horse.

2 ! is the notation for a central post-alveolar click, which sounds similar to the noise that English speakers often produce to imitate the sounds of a chicken clucking.

3 While the PAM model describes sound assimilation according to articulatory gesture similarity, the NAT constraint does not attempt to claim that it is gesture similarity that causes heard speech sounds to assimilate to certain native language categories. Instead, it may simply be overall acoustic similarity between sounds, or other perceptual factors driving assimilation. The cause of assimilation is not essential to the theory of the NAT constraint in its present iteration.
1.7 Unassimilable Click Consonants

Click consonants are language sounds found primarily in languages spoken in southern Africa. They are prominent in the Khoisan family of languages, and are used occasionally in Bantu languages as well as a select few East African languages (Ladefoged & Maddieson, 1996). In the Khoisan languages, clicks make up an important part of the phonological sound inventory: Traill (1994) reported that over 70% of the words in dictionary of !Xóö (a Khoisan language spoken in Botswana and Namibia) dictionary begin with a click consonant. As such, it can be seen that click sounds are certainly used as linguistic symbols by many language learners and speakers. However, click sounds are thought not to occur in any language outside of Africa (Ladefoged & Maddieson, 1996).

The manner in which click consonant sounds are articulated by speakers differs significantly from the way non-click consonants are formed. Essentially, non-click sounds have only one place of articulation (defined as the place in which an obstruction is created in the vocal tract by an articulator, such as the tongue tip, tongue body, or larynx) when formed, but click consonants are created with both an anterior (forward in the mouth) and posterior (backward in the mouth) place of articulation (Miller, 2009). The production of a click consonant was described by Miller (2009) thusly:

These two constriction locations [anterior and posterior] form the boundaries of a lingual cavity that is expanded to create a negative pressure air pocket. When the anterior constriction is released, air rushes into this pocket with a distinctive “popping” sound. The auditory impression of the burst is determined by the exact shape of the cavity, as well as the speed and channel (central or lateral) of the release.

Different types of click sounds can be made given the cavity formed from the anterior and posterior constriction locations. Traditionally, click types have been
named based on the posterior constriction: bilabial [ʘ]⁴, dental [||]⁵, central alveolar [!], lateral alveolar [‖], and palatal [ǂ]⁶.

**Illustration 1.2** From Ladefoged and Maddieson (1996), an illustration of the articulatory sequence used to produce an alveolar click.

Best’s Perceptual Assimilation Model explained the continuing discrimination of click consonants by English adults and older infants on the basis that the click consonants failed to assimilate into any native language speech category for English-proficient listeners (Best, McRoberts, & Sithole, 1988). Further evidence for this claim came from the finding that when adults were asked to describe the click consonants used in discrimination studies, they overwhelmingly described the sounds in non-linguistic terms, such as “plops,” “finger snaps,” or “tongue clucking.” Hence, it was argued that English speakers did not perceive the click consonants as fitting into any native speech category, and were instead processing the click sounds as non-linguistic.

⁴ Sounds similar to a kissing noise.

⁵ Sounds similar to a “tsk, tsk” noise.

⁶ Sounds similar to a “tick, tock” noise.
Best and Avery also investigated whether the neural response of adults listening to click consonants differed from the neural response to other language stimuli. While a left-hemisphere bias is traditionally found when adults process language stimuli, it was found that English-speaking adults showed no hemispheric bias when listening to click consonants (Best & Avery, 1999). This was taken as further evidence that click consonants do not assimilate to any native phonological category for English language speakers and are perceived as non-speech.

The NAT word-learning constraint proposed in the current study predicts that for older word learning infants (over 20 months of age), words containing unassimilable sounds should not be considered appropriate object labels. While words containing click consonants are fully linguistic and used in several languages in the world, to speakers and learners of many other languages, such as English, these click words are at least partially unassimilable. The NAT constraint thus suggests that for English learners (as well as other language learners for whom clicks are also unassimilable), click words are processed as non-linguistic and will be treated as non-language by older word-learning infants.

1.8 Goals and Hypotheses of the Present Study

The present set of experiments was designed to explore the scope of the developmental narrowing that occurs during infancy as to what labels are judged to be conventionally appropriate. To do so, the ability of infants to learn novel labels containing unassimilable click consonants was examined. As click consonants are used linguistically in several of the world’s languages, but have been found to be unassimilable to native language categories for English language learners, these sounds constitute ideal stimuli to investigate the breadth of symbols older infants will accept as labels. If older word-learning infants limit the symbol-forms they view as conventional labels according to the LING word-learning constraint, both younger (14-month-old) and older (20-month-old) infants should be able to successfully learn the unassimilable click labels. However, if older infants limit their
acceptance of conventional labels according to a NAT constraint, then while younger infants should succeed in learning the unassimilable click labels, older infants are predicted to reject these labels as potentially conventional and hypothesized to fail in learning the unassimilable click labels.

The novel labels containing click consonants chosen for the present study are words selected from the language N|uu. N|uu is an endangered language spoken in the Northern Cape Province of South Africa, and is part of the Tuu language family. The Tuu language family is notable for its extensive inventory of speech sounds: N|uu itself has 73 consonants, 45 of which are clicks (Miller, 2009). N|uu was chosen for the present study given that its phonological complexity has recently been documented by Miller (2009). In addition, the click word recordings collected by Miller were of excellent quality, and hence were used in the current study. The click words used in the present study were [!a], meaning “hartebeest” and containing a central post-alveolar click consonant, and [||u], meaning “grasshopper” and containing a lateral post-alveolar click consonant.

To investigate infants’ learning of unassimilable click labels, the present study employed a referential version of the Switch word-learning task. The Switch task, designed by Werker, Cohen, and colleagues (1998), has been used extensively to examine infants’ ability to map novel words to novel objects (Fennell, Byers-Heinlein, & Werker, 2007; MacKenzie, Graham, & Curtin, 2010; Werker et al., 2002). In the Switch task, infants are habituated to two novel word-object associations: the first object is paired with one novel word, and the second object is paired with a second novel word. After the infant has habituated to the two word-object pairings, he or she is tested on whether he or she detects a violation of the pairings, wherein a familiar object and familiar word from habituation are presented in a novel pairing. If an infant has detected the pairing between words and objects during the task, they should then dishabituate during the test, and look longer to the test trial containing the novel pairing (called the “Switch” trial). Although learning links between sounds and objects in this task may not be equivalent to learning the full referential meanings of words, previous research has generally regarded infants’
success in this task as evidence of at least a rudimentary ability to learn words (Graf-Estes et al., 2007; Werker et al., 2002).

In the present study, the Switch task was made more referential by applying a “referential training” modification. This alteration to the original Switch task was designed by Fennell & Waxman (2010), with the goal of exploring whether 14-month-old infants are able to better learn minimally different words when provided with an increased referential context. Fennell and Waxman modified a one-object version of the Switch task (where infants are habituated to a single label-object association, and are then tested on the object with a minimally different label to assess whether they detect a change in label form). In this “Referential Switch” task, infants were provided with a pre-training phase prior to habituation, in which objects familiar to the infant were paired with their conventional labels, also likely to be known to the infant. This modification is thought to help indicate to infants that the words played are intended to refer to the object being shown. Fennell and Waxman found that adding the referential training helped infants to succeed in minimal pair word learning. However, the referential training modification has thus far not been used in a two-object Switch task.

Two experiments were conducted in the present study. Experiment 1 tested a novel two-object version of the Referential Switch task, with the goal of establishing an experimental paradigm appropriate for examining infants’ willingness to learn unassimilable click words as object labels. It was expected that given sufficient referential cues, 14-month-old infants should succeed in learning the click labels as infants of this age have been shown to learn a wide range of symbols as labels (Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999). Experiment 2 then turned to investigating the development of NAT and LING word-learning constraints in older infancy, in asking whether 20-month-old infants tested in the same experimental paradigm as used in Experiment 1 are also willing to accept unassimilable click words as labels.

In addition, both Experiments 1 and 2 explored whether infants’ knowledge of language forms is related to the developmental narrowing in the types of symbols accepted as possible labels. Vocabulary measures were taken for both groups of
infants in order to examine whether an increased knowledge of the conventional forms of language (as measured by the proxy of vocabulary size) is related to the developmental narrowing in the types of symbols infants accept as conventional labels. In Experiment 1, the infant Level I form of the MacArthur-Bates Short Form Vocabulary Checklist was used to measure vocabulary size (Fenson et al., 2000), while in Experiment 2 the toddler Level II Form A was used. If familiarity with labels themselves is likely to contribute to the shift in types of labels viewed as conventional, it is expected that there should be a difference in whether infants are willing to accept click words as labels between infants with low vocabularies and those with higher vocabularies.
CHAPTER 2 EXPERIMENT 1

2.1 Introduction

The goal of Experiment 1 was to modify the Switch word-learning procedure into an experimental paradigm appropriate for investigating the types of symbols that infants view as potentially conventional labels. Recent research by Graham, Curtin, and MacKenzie (2010) has demonstrated that in the traditional two-object Switch task, 12-month-old infants do not successfully learn either communicative non-word sounds (such as “aah,” “mmm,” or “lll”) or phonotactically illegal non-native words as labels. This finding is in contrast to the battery of previous research showing that younger word-learning infants are indeed able to learn a variety of both linguistic and non-linguistic symbols as object labels (Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999). It is thought that the critical difference between these sets of findings is the social and referential cues available to the infant during word learning: in studies by both Namy and Woodward studies, infants were tested in a face-to-face interaction where they saw the labeling experimenter focus on the labeled object in a didactic and referential manner, while in the basic Switch task infants are seated in a room with no labeling experimenter present and few cues to the referential status of the labels provided. As previous research has demonstrated that social and referential signals are important in order for infants to attend to non-linguistic symbols as labels (Hall & Waxman, 2004; Hollich, Hirsh-Pasek, & Golinkoff, 2001; Namy & Campbell, 2001; Waxman & Lidz, 2006), it is likely that the dearth of overt social and referential cues in the original Switch method makes this a task in which young word-learning infants are unable to view a wide range of symbols as object labels. Experiment 1 thus attempted to modify the two-object Switch task through the addition Fennell & Waxman’s referential training phase.

Experiment 1 provides the first assessment of the two-object Referential Switch task, and the first test of this task as a method for examining the types of
symbol-forms infants will accept as labels. Specifically, in Experiment 1, I investigate whether 14-month-old infants are able to learn unassimilable click words as labels. As younger word-learning infants (aged 12-18 months) have been shown to accept a wide variety of symbols as object labels in referential word-learning tasks (Namy & Waxman, 1998; Hollich, Hirsh-Pasek, & Golinkoff, 2000; Namy, 2001; Woodward & Hoyne, 1999), it is expected that if the Referential Switch task is an appropriate paradigm with which to explore the types of symbols infants view as potentially conventional labels, 14-month-old infants tested in this task should successfully learn click words as object labels.

In addition, Experiment 1 also explored whether infant vocabulary size is related to the acceptance of click words as labels. Infants’ vocabulary was measured using the infant Level I form of the MacArthur-Bates Short Form Vocabulary Checklist.

2.2 Method

2.2.1 Participants

Participants were 16 full-term infants (eight male, eight female) with a mean age of 14 months and 0 days (range: 13 months 21 days to 14 months 14 days). Infants were recruited by contact with new parents at the local maternity hospital, and by community flyers and referrals. Infants were contacted for the study through the UBC Early Development Research Group database. All infants came from English-speaking homes, and parents indicated that infants were hearing English at least 80% of the time. 14 additional infants were tested but excluded from the analyses: 11 due to fussiness, 1 due to experimenter error, 1 due to the parent reporting the child having an ear infection at the time of test, and 1 due to the infant failing to habituate (defined as looking the maximum 20 seconds at the last habituation trial and both test trials).
2.2.2 Stimuli

Visual stimuli consisted of brightly colored objects that were presented in isolation. The referential training objects moved either horizontally or vertically across the screen (two vertical: car, dog; 2 horizontal: baby, kitty). Habituation objects moved only horizontally across the screen, while the pre/posttest object was a waterwheel that stood stationary while the wheel rotated. The referential training objects were visual images of a cat, a dog, a baby, and a car, and were identical to those used by either Fennell & Waxman (2010), or Yoshida et al., (2009) (See figure 2.1). The habituation objects were a novel object that somewhat resembled a crown, and a novel object that looked similar to a molecule, as used in previous work (Werker, Cohen, et al., 1998; Byers-Heinlein, Fennell, & Werker, 2009; see figure 2.2). All objects were presented against a black background.

Auditory stimuli were recorded in two phases. The habituation stimuli consisted of the CV words [!a] and [||u] from the Khoisan language N|uu. The stimuli were recorded by Ouma Katrina Esau, a native speaker of N|uu, for Miller (2009). Both stimuli words selected were actual words in N|uu, [!a] and [||u] translating respectively to the English “hartebeest” and “grasshopper.” Three female native speakers of English recorded the referential training and pre/posttest stimuli. The referential training stimuli consisted of labels that conventionally named the familiar objects: “kitty,” “dog,” “baby,” and “car.” One speaker (AG) recorded the first two tokens, while a second speaker (JW) recorded the second two tokens. The pre/posttest stimulus was the novel label “gee,” recorded by the third English speaker (KD). Multiple speakers were used in the recording of the referential training and pre/posttest auditory stimuli in order to encourage generalization to the N|uu stimuli, which were produced by a different speaker as well. All auditory stimuli were recorded in adult-directed speech as part of the sentence “Now I say the word [word]” (or the translation equivalent in N|uu), and were set to a mean intensity of 68 dB.
2.2.3 Procedure

The word-learning procedure took place in a dimly-lit, sound-attenuated room. Infants were seated on a parent’s or caregiver’s lap, approximately 46 inches
in front of a 42” plasma television screen onto which visual stimuli were projected (see figure 2.3). Auditory stimuli were relayed to a NAD Electronics 3020E Stereo Amplifier and played through two Bose 101 Music Motion speakers situated on either side of the television monitor and hidden from view by a black curtain. To avoid parental interference or influence during the study, parents wore headphones and listened to music during the task. The experimenter controlled the study by using a computer running the Habit 2002 program (Cohen et al., 2002) in a remote room, and recorded infants’ looking time onto a Canon ZR950 digital video camera. While controlling the task, the experimenter was blind to trial type.

Each trial was 20 seconds long, and began when the infant fixated on an onscreen attention getter. During the trial, the visual object moved continuously, and the auditory stimulus was played a total of 13 or 14 times per trial with approximately 1 second in between each stimulus presentation. (14= “baby,” “kitty”; all other stimuli were played 13 times per trial). Audio and visual presentations of the stimuli intentionally asynchronous, as per previous research (Werker, Cohen, et al., 1998).

In the initial “referential training” phase of the experiment, infants were presented with four referential training trials consisting of familiar objects and labels. Two orders of referential training trials were counterbalanced across participants. Infants were then presented with the pretest waterwheel, accompanied by the sound “gee.” After the pretest, the habituation phase began. During habituation, multiple blocks of four habituation trials (a semi-random order of two tokens of each type per block) were presented until infant looking time decreased to at most 50% of the longest looking block or until 24 trials were presented. At this point, the test trials began. There were two test trials: a “Same” trial and a “Switch” trial. In the Same trial, a familiar pairing from the habituation phase was presented. In the Switch trial, a familiar visual stimulus and a familiar auditory stimulus were presented, but in a new combination (e.g., Object A with Word B). For half the infants the visual object was consistent in both test trials, and for half the infants the auditory stimuli was consistent in both test trials. There were
eight test orders in total, which were counterbalanced across infants. Finally, infants were presented with the posttest trial.

After completing the word-learning task, parents or caregivers filled out the infant Level I form of the MacArthur-Bates Short-Form Vocabulary Checklist (Fenson et al., 2000).

Illustration 2.1 Study room during word-learning procedure

![Illustration 2.1 Study room during word-learning procedure](image)

2.2.4 Analyses

Videos of infant word-learning sessions were digitized into Quicktime videos from the digital videotapes using a iMac 24” (Model A1225) running FinalCut Pro. Looking time was then coded frame-by-frame (29.97 frames per second) by an experienced coder who was blind to condition assignment. For each infant, total looking time to the pretest and posttest trials, the first and last habituation trials, and the two test trials were coded.

Data was analyzed to compare pre- to posttest looking, first habituation trial to last habituation trial looking, and Same versus Switch test trial looking. Data was first analyzed in three three-way repeated measures ANOVA exploring infant
gender, test order, and looking time to each of these three comparisons of interest. Following non-significant effects and interactions with gender and test order, three paired t-tests were conducted to focus on pre- versus posttest looking, first habituation trial to last habituation trial looking, and test trial looking. It was expected that infants would look equally at pre- and posttest trials, suggesting that they remained engaged in the task throughout the procedure. Additionally, it was also expected that infants’ looking time would be greater to the first habituation trial than to the last habituation trial, reflecting that infants habituated to the stimuli. The analysis of primary interest was the comparison between Same and Switch test trials: if infants are able to map the click words to objects during the habituation phrase, their looking time to the Switch trial should be greater than to the Same trial.

To examine the impact of vocabulary size on infants’ performance, scores on the MacArthur-Bates Short-Form Vocabulary checklist were also analyzed. Infant comprehension and productive vocabulary scores were divided according to a median split. Two-way repeated measures ANOVAs were then conducted to examine the relationship between vocabulary and looking time to test trials.

### 2.3 Results

#### 2.3.1 Looking Time

No main effects or interactions with gender or test order were found \((ps > .10\), so the following analyses are presented across gender and order.

Three separate paired t-tests were conducted to examine infant looking time. Looking time was compared in the pre- versus posttest trials, the first habituation versus last habituation trials, and the Same versus Switch test trials. As predicted, infants showed no difference in looking to the pre- versus posttest trials, \(t(15)= .046, p > .50\), confirming that infants did remain engaged in the task throughout the testing procedure. Additionally, infants looked significantly longer to the first
habituation trial than to the last habituation trial, $t(15)= 4.154, p= .001$, confirming that infants did habituate during the procedure.

Of particular interest, infants looked significantly longer to the Switch test trial than to the Same test trial, $t(15)= 2.425, p= .028$. This pattern of results suggests that infants were able to learn the click word-object associations and dishabituated to the novel pairing in the Switch trial.

**Figure 2.3** 14-month-old infants’ average looking time to same versus switch test trials

![Graph showing the average looking time for same and switch test trials](image)

### 2.3.1 Vocabulary Data

The mean comprehension score on the MacArthur short-form CDI for infants was 33.56 words ($SD= 16.61$), while the mean production score was 5.19 words.
To examine the relationship between vocabulary scores and infants’ looking time to test trials, a median split was performed on both infants’ comprehension ($Md=31$ words) and productive ($Md=4$ words) vocabulary scores. For comprehension vocabulary, half of the infants ($n=8$) were classified into a low comprehension vocabulary group (mean comprehension vocabulary score = 22.00 words, $SD=2.11$), while the other half of the infants ($n=8$) were classified into a high comprehension vocabulary group (mean comprehension vocabulary score = 45.13 words, $SD=15.82$). For productive vocabulary, half of the infants ($n=8$) were classified into a low productive vocabulary group (mean productive vocabulary score = 1.75, $SD=1.17$), while the other half of the infants ($n=8$) were classified into a high productive vocabulary group (mean productive vocabulary score = 8.63, $SD=2.07$). Two two-way repeated measures ANOVA (test trial type X vocabulary group) were then conducted to examine the impact of both comprehension and productive vocabulary score on test trial looking. No significant interactions with looking time were found, $ps>.05$.

### 2.4 Discussion

The primary goal of Experiment 1 was to determine whether the Referential Switch task (Fennell & Waxman, 2010) is an appropriate paradigm with which to examine infants’ ability to learn non-native or non-linguistic label-object associations. While Fennell and Waxman found that adding referential training trials to the one-object Switch word-learning task improved infants’ performance in learning minimally different words, prior to the present study the referential training modification had not been used either in a two-object version of the Switch task or to investigate the types of symbols infants will accept as labels.

The results of Experiment 1 illustrate that the two-object Referential Switch task is a suitable experimental paradigm to explore the type of symbols that infants view as potential labels. Consistent with previous research showing that infants aged 12- to 18-months are able to learn a wide range of symbols as object labels
(Woodward & Hoyne, 1999; Namy & Waxman, 1998; Hollich et al., 2001), 14-month-old infants tested in Experiment 1 learning unassimilable click word labels. This finding indicates that in the Referential Switch task, 14-month-old infants are willing to accept a range of symbols as labels that includes at least word-forms containing unassimilable sounds.

The success of young word-learning infants in learning unassimilable click word labels in Experiment 1 contrasts with the results of Graham, Curtin, and Mackenzie (2010; Mackenzie, Graham, & Curtin, 2010). Graham and colleagues found that when tested using the original Switch word-learning task (without any referential training trials), English-learning 12-month-old infants did not succeed in associating objects with labels consisting of either non-word communicative sounds or phonotactically illegal Czech words. The contrast in results between Graham and colleagues’ studies and Experiment 1 suggests that providing infants with a referential context to the Switch word-learning task allows infants to view a wider range of symbol-forms as labels.

The finding that the presence of referential cues boosts young word-learning infants’ willingness to view a variety of symbols as object labels is consistent with previous research. In the previously noted Namy and Campbell (2003) study, both 13 and 18-month-old infants were able to successfully learn native language-like word labels as well as non-linguistic digital sound labels for objects when the labels were produced by an experimenter as part of a familiar naming routine (“Look at what you have [label]. You see that? [label] Do you like that one? [label]”). However, in a second condition in which word labels and sound labels were presented by a baby monitor placed near the infant, 13 and 18-month-old infants failed to learn either the word or sound labels. This research has been taken as evidence that a referential context is important in order for infants to view provided symbols as potentially conventional forms. While younger word-learning infants might be willing to presume that native language-like forms are likely to be object labels without a referential context (as has been shown in many previous studies; see Dietrich, Swingley, & Werker, 2007; Werker, Cohen, et al., 1998), in order to view a wider range of forms as labels, language learners rely on the presence of referential
signals. It would thus appear that in Experiment 1, adding the referential training modification to the Switch task provided younger word-learning infants with sufficient referential cues to allow them to view the click words as potential labels.

However, while Experiment 1 illustrated that the Referential Switch task is an appropriate experimental method to examine the types of symbol forms that word-learning infants view as potentially conventional labels, Experiment 1 does not address the critical question raised in the present study: distinguishing between the development of LING and NAT word-learning constraints. While it can be seen that in the Referential Switch task, younger word-learning infants (14 months) are able to successfully form unassimilable click word-object associations, Experiment 1 does not address whether older word-learning infants, who have previously been shown to become more selective in the symbol-forms they will accept, are willing to view unassimilable sounds as components of object label-forms. This question will be examined in Experiment 2.
CHAPTER 3 EXPERIMENT 2

3.1 Introduction

In Experiment 1 of the present study, I demonstrated that the Referential Switch word-learning paradigm (Fennell & Waxman, 2010) is an appropriate task to explore infants developing notion of the types of symbols that may be accepted as conventional labels. In addition, results from Experiment 1 also indicate that English-learning 14-month-old infants can successfully learn word-object associations in which the word stimuli contained unassimilable click consonants.

Experiment 2 addresses the question of whether older word-learning infants at 20 months of age are also willing to accept object labels that contain unassimilable click consonants. If older word-learning infants limit the symbol-forms they view as potentially conventional labels according to the LING word-learning constraint, by judging symbol-forms as labels only when the forms consist of linguistic components, then it is expected that in Experiment 2, 20-month-old infants should succeed in learning click word labels similar to the 14-month-old infants tested in Experiment 1. However, if the NAT constraint instead limits the symbol-forms that older word-learning infants view as potentially conventional according to whether the sounds within a provided symbol-form all assimilate into native language categories, then it is expected in Experiment 2 that 20-month-old infants should fail to learn the click word labels.

3.2 Method

3.2.1 Participants

Participants were 24 full-term infants (12 male, 12 female) with a mean age of 19 months and 27 days (range: 19 months 16 days to 20 months 11 days). Infants were again recruited by contact with new parents at the local maternity hospital,
and by community flyers and referrals. Infants were contacted for the study through the UBC Early Development Research Group database. All infants came from English-speaking homes, and parents indicated that infants were hearing English at least 80% of the time. 16 additional infants were tested but excluded from the analyses: ten due to fussiness, and six due to parental interference.

### 3.2.2 Stimuli and Procedure

The stimuli and word-learning procedure were identical to those used in Experiment 1. After completing the word-learning task, parents completed the toddler Level II-A form of the MacArthur-Bates Short-Form Vocabulary Checklist (Fenson et al., 2000).

### 3.2.3 Analyses

Analyses were identical to those conducted in Experiment 1.

### 3.3 Results

#### 3.3.1 Looking Time

As in Experiment 1, no main effects or interactions with gender or test order were found ($ps > .10$), so the following analyses are presented across gender and order.

Three separate paired $t$-tests were conducted to examine infant looking time. Looking time was again compared in the pre- versus posttest trials, the first habituation versus last habituation trials, and the Same versus Switch test trials. Infants showed no difference in looking to the pre- versus posttest trials, $t(23) = 1.022$, $p > .25$. This result indicates that infants did remain engaged in the task throughout the testing procedure. Additionally it was found that infants looked
significantly longer to the first habituation trial than to the last habituation trial, $t(23)= 9.026, p< .001$, confirming that infants did habituate during the procedure.

The primary analysis of interest was to compare infant looking time to the Same and Switch test trials. Overall, infants did not look significantly longer to the Switch versus Same trials, $t(23)= 1.238, p>.20$. This pattern of results indicates that as a group, 20 month-old infants failed to dishabituate to the novel pairing in the Switch test trial.

**Figure 3.1** 20-month-old infants’ average looking time to same versus switch test trials

![Graph showing average looking time to same and switch test trials](image)

### 3.3.2 Vocabulary Data

The mean score of the 20-month-old infants on the MacArthur short-form CDI (Form II-A) vocabulary measure was 27.33 words ($SD=19.33$). To examine the impact of vocabulary scores on infants’ looking time to test trials, a median split ($Md= 26$ words) was performed on infants' vocabulary scores (in reminder, only
productive vocabulary is assessed by the CDI at this age). Half of the infants ($n=12$) were classified into a low vocabulary group (mean vocabulary score= 12.50 words, $SD=7.18$), while the other half of the infants ($n=12$) were classified into a high vocabulary group (mean vocabulary score= 42.17 words, $SD= 15.82$). A two-way repeated measures ANOVA (test trial type X vocabulary group) was conducted to examine the relationship between vocabulary score and looking to test trials. The ANOVA yielded a significant interaction, $F(1,22)= 4.479, p= .046$. Two follow-up paired t-tests were conducted to examine looking time to the Same versus Switch test trials for infants in the low and high vocabulary groups. For infants in the low vocabulary group, it was found that looking time to the Switch trial was significantly greater than to the Same trial, $t(11)= 2.366, p= .037$. For infants in the high vocabulary group, there was no significant difference in looking times to the Same and Switch looking trials, $t(11)= .575, p> .20$.

Overall, vocabulary results indicate that the 20-month-old infants with lower vocabularies accepted the click words as object labels and learned the click word-object pairings, while the 20-month-old infants with higher vocabularies failed to link the unassimilable click words with objects.
3.4 Discussion

Looking time results from Experiment 2 suggest that 20-month-old infants as a group failed to learn the unassimilable click words as object labels. Furthermore, the interaction between vocabulary score and looking time to test trial suggests that it may be the acquisition of a sizeable lexicon that is driving this result. Twenty-month-old infants with smaller vocabularies looked longer to the Switch trial than to the Same trial, implying that they were able to link the unassimilable click words with objects. However, 20-month-old infants with larger vocabularies did not look differently to the Switch versus Same trials. It appears as though infants with higher vocabulary scores failed to learn the unassimilable click words as labels.

Results from Experiment 2 provide two critical discoveries. First, Experiment 2 illustrates that older word-learning infants are not willing to accept unassimilable click sounds in object labels. This finding supports the notion of a NAT word-
learning constraint that develops in infancy, such that older word-learning infants are only willing to accept novel potential labels if the sounds within these labels all assimilate into native language speech sound categories. In addition, data from Experiment 2 show that the NAT constraint becomes functional for older word-learning infants only once a sufficiently sized lexicon is established. Having learned to produce and understand a greater number of words and having become more familiar with the forms of known conventional labels, infants with larger vocabularies are better able to judge that unassimilable novel symbol-forms are unlikely to serve as conventional labels. This finding lends credence to the hypothesis that infants’ confidence in their knowledge of the types of word-forms used in their language is a factor that drives infants’ understanding of word-form conventionality.
CHAPTER 4 GENERAL DISCUSSION AND CONCLUSIONS

The knowledge that language is conventional is essential information for a budding language learner. Realizing that language is shared by all members of a language community allows language users to refer to the same concepts, using the same forms, across different times and situations. However, while it is imperative to adhere to the general notion that language is conventional, it is also essential that language learners be prudent when accepting that language provided to them is conventionally used. One indispensable way in which language learners must be vigilant about accepting language is by judging whether the language form itself—the physical sounds or movements that make up the language stimulus—is likely to be conventional.

In the current set of experiments, I hypothesized that while language learners operate under a broad-spectrum understanding of language conventionality when they first begin to acquire words, as older word-learning infants become better acquainted with the forms of conventional labels in their native language(s), a constraint emerges limiting the types of symbol-forms they view as potentially conventional labels. To test this hypothesis, I examined the specificity of an emerging word-form constraint asking whether older word-learning infants view all linguistic forms as potentially conventional (the LING word-learning constraint), or if older word-learning infants are more selective, and view novel symbol-forms as potentially conventional only when these forms consist of language sounds similar to those used in their native language (the NAT word-learning constraint).

A new version of the Referential Switch word-learning task (Fennell & Waxman, 2010) was used in the present study. In this version, two novel words and novel objects were shown to the infant during habituation, such that infants were habituated to two word-object pairings. Experiment 1 demonstrated that in the two-object version of the Referential Switch task, 14-month-old infants are able to learn unassimilable click word-object associations. Given that previous research has also
demonstrated that infants aged 12-18 months learn a wide variety of symbols as labels when supplied with sufficient referential cues, 14-month-olds’ success in Experiment 1 illustrated that the Referential Switch task is an appropriate experimental paradigm to examine infants’ willingness to view non-native language symbol-forms as potentially conventional labels. Experiment 2 then used the Referential Switch task to explore the development of a NAT versus a LING word-learning constraint in older word-learning infants.

My work in the present study was situated within Jaccard’s (1981) three-factor model of testimony acceptance and belief shift. I explored how Jaccard’s factors of discrepancy, confidence, and source can be applied to explaining situations in which a young language learner is likely to accept a novel provided label as conventional. To investigate the discrepancy in symbol form that word-learning infants are prepared to accept between a novel symbol-form and known conventional label-forms, I tested a LING word-learning constraint versus a NAT constraint. Results from Experiments 2 support the claim that a NAT word-learning constraint develops during infancy, revealing that 20-month-old word-learning infants with larger vocabularies do not learn unassimilable click words as object labels. In contrast, both younger infants (14 months; Experiment 1) and 20-month-old infants with smaller vocabularies were successful in learning the click words in the same experimental task. To test the impact of confidence on infants’ acceptance of novel symbol-forms as labels, I examined the role of vocabulary size in older word learning infants’ ability to learn unassimilable words. Results from Experiment 2 indicated that productive vocabulary size is related to older word-learning infants’ success in viewing unassimilable click words as labels. In addition, while source was not explicitly manipulated in the current set of experiments, the methods used in the present study may also have impacted infants’ judgments of the provided labels’ source. These primary conclusions of my research are each elaborated further below.
4.1 Discrepancy in Label Learning

In Experiment 2, I explored how much of a discrepancy between a novel provided symbol-form and known conventional label-forms older word-learning infants are willing to accept. To examine this issue, I compared two hypotheses for the type of symbol-forms that older word-learning infants are willing to accept as potential labels. The LING word-learning constraint postulates that older word-learning infants limit the forms they view as conventional according to whether the forms consist of linguistic versus non-linguistic components. In contrast, the NAT word-learning constraint theorizes that older-word learning infants limit the forms viewed as potentially conventional according to whether the components within these labels are all possible to assimilate into native language speech categories.

In the present study, older word-learning infants (20 months of age) with high vocabularies did not succeed in learning unassimilable click word-object pairings. However, 20-month-olds with low vocabularies and 14-month-old infants (in Experiment 1) were able to form the click word-object associations in the same task. These findings support the development of a NAT word-learning constraint, suggesting that despite the fact that the unassimilable click words are made of linguistic sounds, 20-month-olds with high vocabularies are either unable or unwilling to learn these words as labels. Experiment 2 therefore provides the first evidence of just how discrepant a novel provided label can be from known labels in order to be seen as potentially conventional by young language learners.

While the present study lends credence to the development of a NAT word-learning constraint in older word-learning infants with larger vocabularies, it is still unknown whether discrepancy has an impact on the form of labels younger word-learning infants are willing to accept. Research has consistently demonstrated that when they are provided with appropriate perceptual, social, and referential cues, younger word-learning infants accept a wide range of symbol forms as object labels (Hollich, Hirsh-Pasek, & Golinkoff, 2001; Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999). Twelve to 18-month-old infants have been shown to learn digital toy noises, mouth noises, gestures, and pictograms as labels. In
Experiment 1 of the present study, I additionally found that 14-month-old infants succeeded in learning unassimilable click word as labels. Although my results from Experiment 1 when taken alone may suggest that 14-month-old infants use a LING constraint, when taken in the context of others’ work, it can be presumed that younger word-learning infants are using neither a LING nor a NAT word-learning constraint, but are instead open to a wider range of symbols as labels. However, the maximum discrepancy that younger infants are willing to accept between a new label and known labels has not been established. It is still unknown whether 12- to 18-month-old infants in a referential word-learning situation will truly regard any provided form as a potentially conventional label.

4.2 Confidence in Label Learning

Data from Experiment 2 in the present study suggest that confidence is also connected to older infants’ unwillingness to accept a wide range of symbols as labels. As a proxy for infants’ confidence in their knowledge of conventional label-forms, I assessed infant vocabulary size. In examining the impact of vocabulary size on infants’ learning of unassimilable symbol forms, I found that that only 20-month-old infants with larger productive vocabularies did not view unassimilable click words as labels. In contrast, 20-month-old infants with smaller productive vocabularies succeeded in learning the click words. These results are consistent with the theory that infants’ confidence in their knowledge about the forms of conventional labels used in their native language(s) interacts with discrepancy in determining whether they will accept novel symbol-forms as labels.

Ideally, it would have been of interest in Experiment 2 to explore the relative contributions of both vocabulary and age to 20-month-old infants’ success in learning unassimilable click words as labels. However, the sample of infants tested did not allow for meaningful analyses. There was no significant correlation between age and looking time different to Same versus Switch test trials ($p > .10$), most likely due to the limited age range of infants tested (19 months, 16 days to 20 months, 11
days). Furthermore, a significant portion of the sample clustered within 2-3 days of the median, making analyses based upon a median split uninformative. In future research, it will be imperative to examine whether increased age is related to older infants’ scrutiny of possible labels over and above the influence of increased vocabulary.

4.3 Source in Label Learning

In addition to demonstrating that the factors of discrepancy and confidence impact label learning, previous research has shown that language learners are sensitive to the reliability of the source when judging whether a novel label is likely to be used conventionally (Birch, Vauthier, & Bloom, 2008; Scofield & Behrend, 2008). In the current set of studies, the reliability of the label source was held constant, but it is possible that the experimental method used influenced infants’ view of the provided labels’ source. In the Referential Switch procedure employed, infants were first presented with familiar objects correctly labeled by their familiar labels. While the voices presenting the correct labels for the familiar objects were distinct from the voice presenting the unassimilable click labels during the word-learning task, it is possible that correct labeling of familiar objects could have created a context that boosted infants’ confidence in the reliability of the source of the novel labels.

Added confidence in the source of the labels in the present set of experiments may aid in explaining differences in findings from Experiment 1 and recent studies by Graham, Curtin, and MacKenzie (2010; MacKenzie, Graham, & Curtin, 2010). Graham and colleagues used a standard Switch procedure, and thus did not have training trials with named familiar objects. In their studies, 12-month-old infants did not learn either communicative sound labels or phonotactically illegal labels. It may be that the difference between the two sets of results is that the infants participating in Experiment 1 had more confidence in the source of the labels than did infants in Graham and colleagues’ studies. However, at the present time it is
difficult to entangle whether increased source confidence or increased referential context in the present study is driving the difference in results. This is a question to be addressed by future study.

4.4 Implications for Theories of Word Learning

Several theories describing the way in which infants master word learning have attempted to account for why older infants appear to limit the types of symbol-forms they view as potentially conventional labels. One family of theories is that of learned association (Colunga & Smith, 2003; Smith, 2000). According to this set of theories, as infants gain information about the statistical regularity of language forms, they ascertain the types of symbol forms that are likely to occur simultaneously with objects. This learning leads to those forms being preferentially learned as labels while other forms that are not often paired with objects are not. This family of theories holds that younger word-learning infants are able to view gestures and digital toy noises as object labels due to the fact that younger infants have not yet learned that these sorts of symbols are not usually paired with objects. However, older word-learning infants have picked up on the statistics of language forms, and reject gestures and toy noises as labels due to the fact that they rarely occur simultaneously with objects. In support, a study by Colunga and Smith (2003) demonstrated that older word-learning infants (20-26 months) successfully learned animal noises produced by a tape recorder as labels for animals. The researchers then argued that even though animal noises are clearly non-linguistic and not similar to familiar, conventional labels, the noises often occur simultaneously alongside animal objects, and this statistical co-occurrence allows infants to accept animal sounds as animal labels.

In contrast to a learned association account of word learning are constraint-based theories (Clark, 1993; Markman, 1994; Woodward, 2001; Woodward & Hoyne, 1999). According to this type of theory, infants employ word-learning constraints to delimit the types of possible forms that can serve as potentially
conventional labels. While some researchers have argued that certain word-learning constraints are inbuilt (Hall & Waxman, 1993; Markman, 1994), other research has shown that constraints are likely to arise as infants gain experience learning words (Byers-Heinlein & Werker, 2010). For the purposes of the present study, it is presumed that both inbuilt and experience-based constraints may aid in word learning. In general, the notion of word-learning constraints can be thought of as “constraining the problem space” (Woodward, 2001). When young infants begin the process of learning words, they encounter an enormous problem space of possible symbol-forms and concepts that must be narrowed in order for effective and efficient word learning to occur. In an infant’s environment there are unlimited concepts and symbol forms, yet for the majority of these symbol-forms and concepts, there is only one correct pairing between them. In order to correctly assemble these symbol-concept correspondences and begin the process of learning words, infants are undoubtedly helped by associative and social cues in their learning environment. But even given this assistance, many theorists have hypothesized that word-learning infants are likely to be equipped with several word-learning constraints that help to restrict the possible range of symbol-concept correspondences (Hall & Waxman, 1993; Markman, 1994; Woodward, 2001).

The NAT word-learning constraint proposed and supported by the present study was originally conceived as adhering to a constraint-based theory of word learning. While the current set of experiments did not explicitly test a constraint-based versus learned association account of word learning, inferences about a theory of word learning can be still made based on the present results. In the present set of experiments, younger word-learning infants (14 months) and older word learning infants (20 months) with smaller vocabularies succeeded in learning the novel click word-object pairings in the Referential Switch task. This is in contrast to previous findings by Graham, Curtin, and MacKenzie (2010; MacKenzie, Graham, & Curtin, 2010), wherein younger word-learning infants (12 months) failed to learn phonotactically illegal word-object pairings as well as communicative non-word-object pairings in a non-referential version of the Switch task. The divergence in results between the present study and Graham and colleagues’ work implies that
infants in the current set of experiments are doing more than simply pairing sound stimuli with visual stimuli. Instead, it appears as though the infants in the present study are engaging in a deeper process than pure association. This line of reasoning would then suggest that the narrowing of what is considered a possible label form in infancy is not based purely on learned association.

Past research conducted within a constraint-based model of word-learning has focused mainly on examining the constraints that may help young infants to limit the concepts that are likely to pair with a novel label-form. These constraints are those such as the whole-object constraint (the notion that a novel label is likely to correspond to a whole object and not part of an object), the taxonomic constraint (the notion that words apply to a kind), and the mutual exclusivity constraint (the notion that concepts have only one label) (Markman, 1994). However, while limiting the concepts that are likely to correspond to a novel label is essential to word learning, it is also important to understand which symbol forms that are likely to correspond to a novel concept. It is this sort of constraint that I argue also develops during infancy, along the lines of the NAT word-learning constraint supported by the results of Experiment 2.

4.5 Future Studies

Several questions remain open for future research. While the results of Experiment 2 provide evidence for the development of a NAT word-learning constraint over a LING constraint in older infancy, it is still unknown just how restrictive the NAT constraint is. In order to provide further elucidation of a NAT constraint, it will be essential to explore whether older infants might instead be using a more specific constraint than the NAT constraint outlined in the present study. To further test the NAT constraint as it has been hypothesized, future research must determine whether older infants are willing to view novel symbol forms containing assimilable non-native sounds as conventional, even when these non-native sounds differ markedly from speech sounds used meaningfully in the
native language. Such research should also be able to provide a further test of both a constraint-based view of word-learning or a learned association account, in ascertaining whether older word-learning infants are able to learn non-native words that include non-native sounds that infants are not likely to have heard in association with objects.

A related question that arises regarding the NAT constraint is whether older word learning infants consistently reject unassimilable sounds in novel word-forms, even if these sounds are not the initial sound in a word-form or if these sounds make up the minority of sounds in a word form. In order to fully flesh out the NAT constraint as it is laid out in the present study, these questions must be addressed.

4.6 Conclusions

We live in a conventional world. What side of the road we drive on, how we greet others, how meetings are conducted, and how we use objects are all guided by shared conventions in our community. Even the words we use to describe things are dictated by convention.

Conventionality of language goes even deeper than words themselves: it influences the form of the words we use. Each language community has its own preferred forms of language conventions: while the word-form in English may be the sound “shoe,” in Polish it is the sound “trzewik”, and in American Sign Language it is the motion of two closed hands gently struck together twice. While all of these word forms are appropriate in their own language community, they would not necessarily be appropriate forms in another community. It can therefore be seen what while it is essential for language learners to employ an understanding of language conventionality early in development, it is also critically important that young language learners be skeptical in accepting all language forms provided to them as potentially conventional. Language learners must judge whether provided forms are appropriate in their language community. This is the essence of the NAT word-learning constraint proposed in the present study.
The current set of experiments critically expands our understanding of how and when infants are skeptical in accepting language labels as conventional. I demonstrated that once word-learning infants develop a sufficiently sized lexicon and are more familiar with the types of conventional language-forms used in their community, they become more resistant to accepting novel labels that differ in form. When presented with novel labels that are fully linguistic and that constitute proper labels in one of the world's languages, I found that older word-learning infants are not able to learn word-forms as labels when the sounds within the novel form differ dramatically from the sounds used in known conventional labels. This research suggests that even before two years of age, young language learners are sensitive not only to the conventionality of language in general, but also to the fact that the form of language is also steered by the shared conventions of their language community.
REFERENCES


Namy, L.L. (2001). What’s in a name when it isn’t a word? 17-month-olds’ mapping on nonverbal symbols to object categories. *Infancy, 2*(1), 73-86.


APPENDIX A: Copy of UBC Research Ethics Board’s Certificate of Approval

The University of British Columbia
Office of Research Services
Behavioural Research Ethics Board
Suite 102, 6190 Agronomy Road, Vancouver, B.C. V6T 1Z3

CERTIFICATE OF APPROVAL - MINIMAL RISK AMENDMENT

PRINCIPAL INVESTIGATOR: Janet F. Werker
DEPARTMENT: UBC/Arts/Psychology, Department of
UBC BREB NUMBER: H95-80023

INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:

<table>
<thead>
<tr>
<th>Institution</th>
<th>Site</th>
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<tbody>
<tr>
<td>UBC</td>
<td>Vancouver (excludes UBC Hospital)</td>
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<td>N/A</td>
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</tbody>
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Other locations where the research will be conducted:

N/A

CO-INVESTIGATOR(S):

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Judit Gervain
Ladan G. G. Hamadani

SPONSORING AGENCIES:

Natural Sciences and Engineering Research Council of Canada (NSERC) - "Perceptual tuning and language acquisition"

PROJECT TITLE:

Linking Speech Perception to Language Acquisition: Biases, Mechanisms and Products

Expiry Date - Approval of an amendment does not change the expiry date on the current UBC BREB approval of this study. An application for renewal is required on or before: November 26, 2010

AMENDMENT(S): |

AMENDMENT APPROVAL DATE: |
The amendment(s) and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human subjects.

Approval is issued on behalf of the Behavioural Research Ethics Board and signed electronically by one of the following:

Dr. M. Judith Lynam, Chair  
Dr. Ken Craig, Chair  
Dr. Jim Rupeli, Associate Chair  
Dr. Launo Ford, Associate Chair  
Dr. Anita Ho, Associate Chair