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The Flexibility of 12-Month-Olds' Preferences for Phonologically Appropriate Object Labels

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We explored 12-month-olds' flexibility in accepting phonotactically illegal or ill-formed word forms in a modified associative-learning task. Sixty-four English-learning infants were presented with a training phase that either clarified the purpose of a sound–object association task or left the task ambiguous. Infants were then habituated to sets of Czech words with onsets that are illegal in English (e.g., *ptak*), consonantal sounds (e.g., /l/), or novel functionlike words (e.g., *iv*). When infants were provided with a training phase that highlighted the purpose of the task, they associated the phonotactically illegal Czech words, but not the consonantal sounds or novel functionlike words, with objects. Thus, English-learning 12-month-old infants' flexibility in associating various sound forms with novel objects is limited to labels that share the structural shape of well-formed nounlike words.

Keywords: associative learning, word learning, referential training, word forms

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By the end of the first year of life, infants can proficiently identify and track those sound combinations that make up the word forms in their native language and map these forms onto different concepts (for reviews, see Saffran, Werker, & Werner, 2006; Waxman & Lidz, 2006). Furthermore, infants' refined sensitivity to the linguistic properties of their native language guides the types of word forms they are willing to accept as labels for objects (Graf Estes, Edwards, & Saffran, 2011; Hochmann, Endress, & Mehler, 2010; MacKenzie, Curtin, & Graham, 2012a, 2012b). Here, we investigate the parameters of 12-month-old infants' established preferences for specific word forms as object labels. Across two experiments, we ask whether 12-month-old English-learning infants' preferences for specific word forms will be overridden in a sound–object association task when provided with referential cues that indicate that a linguistic form is intended to be a label for an object.

Recent research has documented early emerging constraints on word–object associations. That is, English-learning 12-month-olds will associate novel English words (i.e., words containing legal speech sounds, in allowable combinations [phonotactically legal], and syllable structures appropriate for English; e.g., *fep*) with novel objects. In contrast, 12-month-olds will not form mappings between communicative sounds (e.g., *ooh*; *ssh*) or single consonantal sounds (e.g., /l/) and objects (MacKenzie, Graham, & Curtin, 2011). Furthermore, 12- and 18-month-olds will not map words to objects when these forms violate native phonotactics (e.g., *ptak*; Graf Estes et al., 2011; MacKenzie et al., 2012b), providing further evidence that infants have begun to acquire knowledge about what an appropriate word form is in their native language. Finally, studies have also demonstrated that 12- and 17-month-olds will map contentlike words (meaningful items, such as nouns and verbs), but not functionlike words (grammatical items, such as determiners), to objects (Hochmann et al., 2010; MacKenzie et al., 2012a). That is, infants do not map functionlike words, which are forms that are marked by syllable reduction, reduced vowels, and simplified syllable structure with minimal, if any, onsets and codas. Also, these forms are highly subject to coarticulation (i.e., articulatory influence of one segment on another segment) by adjacent words (Morgan, Shi, & Allopenna, 1996). Together, these results suggest that by their first birthday, infants have become attuned to the specific characteristics of their native language and apply their knowledge about the nature of appropriate object–word sound forms when making word–object mappings.

The research described above provides compelling evidence that infants have developed a bias for the types of word forms they will accept as labels for objects through experience with their native language. At the same time, young infants can be flexible in the range of symbolic forms that they will accept as naming objects when tested in interactive contexts (e.g., Hollich, Hirsh-Pasek, & Golinkoff, 2000; Namy, Campbell, & Tomasello, 2004; Namy & Waxman, 1998; Woodward & Hoyne, 1999). In these studies, researchers have demonstrated that younger infants are willing to accept both words and nonlinguistic forms as labels for objects. For example, Namy (2001) demonstrated that when 17-month-olds

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were presented with a range of different symbols (i.e., word, gesture, nonverbal sounds, and pictograms) paired with objects in an interactive word-learning task (i.e., provided with attentional and social referential cues), infants successfully mapped these symbols to the objects. Interestingly, however, this general symbolic openness begins to narrow toward the end of the second year of life when infants begin to accept only words as object names (e.g., Graham & Kilbreath, 2007; Namy & Waxman, 1998; Woodward & Hoyne, 1999).

This seeming discrepancy between infants' preference for particular word forms and their apparent symbolic openness raises the question of whether this symbolic flexibility may be contingent upon the presence of social-referential cues in the word-learning task. In the typical interactive tasks used in the studies described above, the use of referential cues such as pointing and eye gaze highlight that the experimenter's intention is to treat a specific nonlinguistic symbol as an object name (e.g., Campbell & Namy, 2003; Hollich et al., 2000; Woodward & Hoyne, 1999). Thus, infants' attention to these social-referential cues may lead them to override a bias to privilege specific word forms over other types of stimuli when establishing word–object mappings. When social-referential cues are stripped away, as in the word–object association tasks described above, infants' default preferences about appropriate forms for object names become evident (MacKenzie et al., 2012a, 2012b, 2011).

In the present studies, we explore the possibility that referential cues will lead English-learning infants to overlook their preferences for particular linguistic forms. Specifically, we ask whether infants' knowledge about the form of linguistically appropriate object labels can be overridden with minimal referential cues or whether learned biases constrain their label–object mappings regardless of the cues provided. To address this question, we draw on research demonstrating that infants' performance in the word–object association task can be modified by providing the infant with information about the referential status of a to-be learned label (e.g., Fennell & Waxman, 2010). For example, 14-month-olds' inability to map phonetically similar words (i.e., minimal pairs such as *bin* and *din*; e.g., Pater, Stager, & Werker, 2004; Stager & Werker, 1997; Werker, Fennell, Corcoran, & Stager, 2002) to objects in a word–object association task is altered when the referential status of these words is highlighted by syntactic and pragmatic cues (Fennell & Waxman, 2010). When infants were habituated to a single novel word–object pairing (i.e., *bin* + Object A) embedded within a familiar naming phrase (e.g., "*Look. It's the* ___), or given a training phase in which they received three familiar word–object pairings (e.g., car, cat, shoe) prior to habituation to the single word–object pairing presented without a naming phrase, 14-month-olds were now able to detect a switch in the pairing (i.e., *din* + Object A) at test.

In the present experiments, we used the modified word–object association task to examine whether infants will accept linguistic forms that deviate from their preference for well-formed phonotactically legal word forms. Here, we examine sounds that are contained within the native language sound system but that occur in illegal combinations (e.g., nonnative phonotactics), sounds that occur in isolation (e.g., individual phonemes), and sounds that occur as grammatical elements (e.g., functionlike words). Specifically, we ask whether English-learning infants' preference for word forms that possess the phonological properties of nounlike words of their native language can be overridden when provided with additional referential clarity for the task. To address this question, we contrasted 12-month-olds' mappings of three different types of forms to objects in a modified referential Switch task (Fennell & Waxman, 2010): phonotactically illegal CCVC words (where C is consonant and V is vowel; e.g., nonnative phonotactics), consonantal sounds (e.g., individual phonemes), and novel functionlike words. This age range was chosen as infants will only associate novel well-formed, phonotactically legal words with objects in an associative-learning task at 12 to 14 months of age (e.g., Curtin, 2011; MacKenzie et al., 2011; Werker, Cohen, Lloyd, Casasola, & Stager, 1998), and infants around this age will associate a variety of symbols (e.g., gestures, nonlinguistic sounds, pictograms) to objects when provided with contextual support (e.g., Hollich et al., 2000; Woodward & Hoyne, 1999).

Experiment 1

In Experiment 1, we examined whether 12-month-olds' preference for well-formed, phonotactically legal words as object labels can be shifted when the goal of the word–object association task is clarified. That is, when English-learning infants are provided with a training phase that highlights that this is a labeling task, will infants map phonotactically illegal word forms to objects? We decided to use CCVC Czech words that contain illegal sound combinations for English (i.e., violate English phonotactics) because previous research has demonstrated that 12-month-olds will not map these forms to objects in an associative-learning task (MacKenzie et al., 2012b).

To examine the influence of referential cues on word–object associations, two groups of infants were tested with a modified Switch task (Werker et al., 1998) that included a training phase that either increased the referential clarity of the task (e.g., familiar objects paired with their labels) or maintained the lack of clarity in the task (e.g., familiar objects paired with exclamations). The two training phases were adapted from previous research (e.g., Fennell & Waxman, 2010; Namy & Waxman, 2000) demonstrating that infants will map novel words presented in isolation to novel objects when provided with a training phase that pairs familiar objects with their familiar basic-level names. Following training, both groups of infants were habituated to two sets of CCVC Czech word–object pairings (e.g., *svet* paired with Object A and *ptak* paired with Object B) and then were tested on these word–object mappings by comparing their looking time during the same trial versus the switch trial.

If 12-month-old infants' bias for preferred word forms is flexible, then when presented with information about what the task entails, infants should broaden their acceptance of potential word forms. Thus, infants should successfully map the illegal word forms to the objects when provided with a training phase that increases the referential clarity of the task (i.e., name-training group) and not when the task remains ambiguous (i.e., exclaim-training group). The findings from this experiment will help clarify the contexts in which infants will apply their established preferences for specific word forms as object labels and the role that referential information has in shifting infants' tendency to link phonotactically illegal word forms with objects in an associative-learning context.

Method

Participants. Data from 32 English-learning 12-month-old infants were included in the final sample. An additional nine infants were tested but were excluded from the sample for the following reasons: did not complete the task ($n = 4$), failed to habituate ($n = 2$), excessive fussiness ($n = 2$), and parental interference ($n = 1$). Infants were randomly assigned to one of two groups: the name-training group ($n = 16$; mean age = 12.68; range = 12.36–13.00; seven girls) or the exclaim-training group ($n = 16$; mean age = 12.56; range = 12.23–12.95; eight girls). Infants were from homes in which English was the primary language spoken (i.e., exposure to English was 80% or greater) and were recruited through pamphlets at child-related trade shows and health clinics within the Calgary, Alberta, area. Infants in the two groups did not differ significantly in age, $F(1, 30) = 2.82$, $\eta_p^2 = .08$, $p = .10$, or in productive vocabulary size, $F(1, 30) = 0.01$, $\eta_p^2 = .00$, $p = .91$, as measured by the MacArthur-Bates Communicative Development Inventory (MCDI; Fenson et al., 2000) short form. Information on ethnicity, race, cultural background, and family socioeconomic status was not collected.

Stimuli. See Figure 1 for an overview of the design. A female, bilingual Czech–English speaker recorded all the auditory stimuli using infant-directed speech in a soundproof booth. The pretest and posttest stimuli consisted of a white plastic waterwheel accompanied by the novel word (i.e., *wug*), similar to procedures used in previous switch-task experiments (e.g., Werker et al., 1998).

During the training phase, infants in both groups were shown four stationary images of a car, cat, baby, and shoe. The auditory stimuli presented during this phase, however, varied according to a group assignment. During the name-training phase, English basic-level names (i.e., *kitty*, *shoe*, *baby*, *car*) were paired with the corresponding familiar object. During the exclaim-training phase, familiar exclamations (i.e., *whee*, *wow*, *yay*, *oooh*) were paired with the familiar object.

During the habituation and test phases, all infants were presented with the same videotapes of two novel objects: a black and blue molecule-shaped object (*Object A*) and a pink, yellow, and blue spiky-shaped object (*Object B*) and the same auditory stimuli: eight exemplars of each of two phonotactically illegal CCVC Czech words: /ptak/ and /svɛt/. The acoustic measurements of both the training and habituation auditory stimuli (i.e., duration and pitch mean) are available in the supplementary materials online.

Apparatus. Testing took place in a quiet and dimly lit soundproof room. Infants sat on their parent's lap or in a high chair facing a 122-cm high by 91.5-cm wide video monitor. Each parent wore headphones while listening to music. The auditory stimuli were delivered at 65 dB, ± 5 dB from a speaker located directly

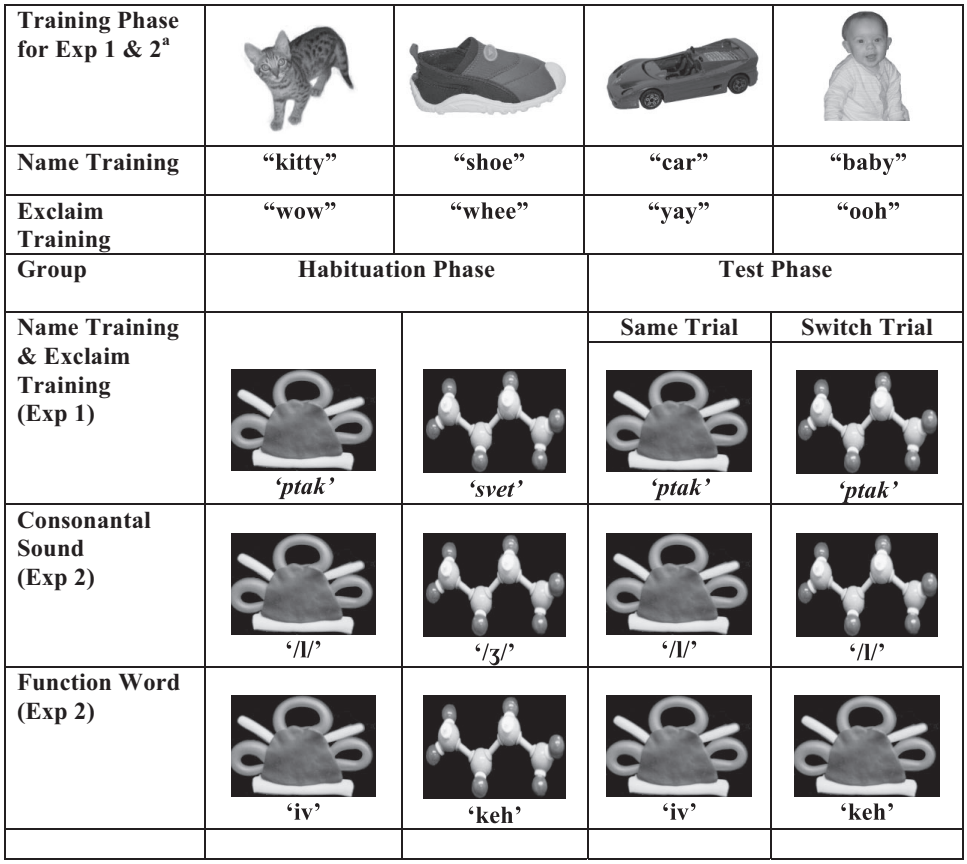

Figure 1. Schematic of testing conditions and phases. [a] Photos are not the exact photos shown to infants. Exp = Experiment.

above the monitor. Infants were recorded using a digital video camera with the lens peeking out of the cloth covering the electronic equipment. The video was used for frame-by-frame primary coding reliability. The experiment was controlled by the Habit X 1.0 program (Cohen, Atkinson, & Chaput, 2004). The visual and audio stimuli were played from digitized files on a computer, which were transmitted to the monitor and speaker in the testing room.

Procedure. Infants were tested using a modified version of the habituation paradigm known as the Switch Task (Werker et al., 1998). The procedure was identical for both groups—all that varied were the auditory stimuli presented during the training phase. Each trial was 20 s in duration. To begin, infants were presented with one of two training phases: (a) *name-training phase*, which included four familiar objects (i.e., a car, a cat, a baby, a shoe), presented sequentially, each paired with its appropriate basic-level name (e.g., "car!"; "kitty!"); or (b) *exclaim-training phase*, which included four familiar objects (i.e., a car, a cat, a baby, a shoe), presented sequentially, each paired with familiar exclamations (e.g., "whee"; "wow"; "yay"). During the habituation phase, infants were presented with two sets of phonotactically illegal Czech word–object combinations presented alternately (e.g., *ptak* paired with Object A and *svet* paired with Object B). Both groups were presented with these auditory stimuli–object pairings in a semirandom order until looking time decreased to a set criterion (65%) or until a maximum of 24 trials were completed (see below).

Following the habituation phase, infants were presented with two test trials in counterbalanced order: the *same* trial and the *switch* trial. During the same trial, infants were presented with a familiar object–sound pairing (e.g., *ptak* + Object A). During the switch trial, infants were presented with a familiar object and sound but with the familiar pairing violated (e.g., *ptak* + Object B). To control for whether the infant became fatigued or uninterested in the test stimuli, a novel auditory stimuli–object pairing was presented once as a pretest trial before the habituation phase and then again as the posttest trial, following the test phase (i.e., *wug* + waterwheel).

The particular auditory stimulus (e.g., *ptak* and *svet*) that was associated with a particular object (Object A or Object B) and the order of the switch and same trials was counterbalanced across children in all groups. The habituation criterion was met if an infant decreased his or her looking time to at least 65% (a 35% decrement) of that of the first block of four trials during any of the following five blocks of four trials. If the infant reached the habituation criterion before the sixth block of four trials, then the test phase would begin. Infants who did not reach the habituation criterion were excluded from the final analyses ($n = 2$).

After completion of the task, all parents completed the MCDI short form (Fenson et al., 2000). All infants comprehended the basic-level name for at least one training object, as measured by the MCDI short form.

Coding. Online coding was used only to determine whether infants were habituating to the word–object pairings. For the critical trials (i.e., pretest, four training trials, last four habituation trials, two test trials, and the posttest), infants' looking times to the object were coded on a frame-by-frame basis from the videotapes. To establish interrater reliability, 20% of the data ($n = 6$ infants) was coded by a second coder. Intraclass correlations (ICCs) coefficients for looking time responses were .98 (all ps $< .001$).

Results

To ensure that any differences found on test trials were not a result of fatigue, we compared infants' looking time during the pre- and posttest trial to determine whether infants regained attention at the end of the task. See Table 1 for mean looking times by group for the pretest, the posttest, the last habituation block, as well as the average number of habituation trials. Results of a 2 (group) × 2 (trial: pretest vs. posttest) analysis of variance (ANOVA) indicated that infants' looking times on the pretest and posttest trials did not differ significantly between groups, $F(1, 30) = 0.11$, $\eta_p^2 = .00$, $p = .75$, or between the pretest trial ($M = 17.11$, $SD = 3.20$) and the posttest trial ($M = 16.62$, $SD = 3.88$), $F(1, 30) = 0.31$, $\eta_p^2 = .01$, $p = .58$. Further analyses indicated that infants in both groups looked significantly longer during the posttest trial ($M = 16.62$, $SD = 3.88$) than during the last habituation block ($M = 7.66$, $SD = 2.69$), indicating that they recovered from habituation, $t(31) = 7.16$, $d = 2.70$, $p < .0001$. The average number of habituation trials did not differ significantly between the name-training group and the exclaim-training group, $F(1, 30) = 0.35$, $\eta_p^2 = .01$, $p = .56$. Furthermore, the amount of looking time during the habituation phase did not differ significantly between the name-training group and the exclaim-training group, $F(1, 30) = 0.06$, $\eta_p^2 = .00$, $p = .80$. These latter analyses indicated that attention to the word–object pairings during the habituation phase was similar across groups.

The primary analyses compared infants' looking times during the same and switch test trials across groups. See Figure 2 for mean looking times by test trial and group. Recall that if infants have established word–object associations, their looking time should be significantly longer during the switch trial than the same

Table 1
Mean Looking Times in Seconds by Group for Pretest, Posttest, Last Habituation Block, and Average Number of Habituation Trials

Group	Pretest	Posttest	Last habituation block	Average number of habituation trials
English training (Exp. 1)	16.92 (3.68)	17.11 (3.60)	7.94 (2.35)	10.50 (3.54)
Exclaim training (Exp. 1)	17.30 (2.75)	16.14 (4.23)	7.38 (3.06)	11.25 (3.64)
Function word (Exp. 2)	17.19 (2.58)	15.69 (3.73)	8.21 (2.84)	9.75 (2.52)
Consonantal sound (Exp. 2)	16.82 (3.27)	12.70 (5.19)	7.94 (3.35)	11.25 (2.62)

Note. Exp. = Experiment. Standard deviations appear in parentheses.

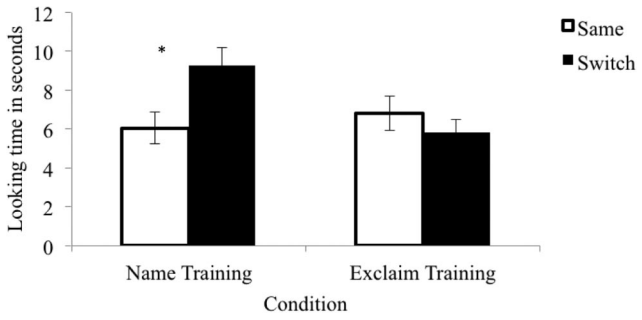

Figure 2. Mean looking times in seconds during same and switch trials as a function of group in Experiment 1. Error bars denote standard error. * $p < .05$.

trial. A 2 (group) × 2 (trial: same, switch) ANOVA yielded a significant Group × Trial interaction, $F(1, 30) = 9.65$, $\eta_p^2 = .24$, $p = .004$. Pairwise comparisons indicated infants in the name-training group looked significantly longer during the switch trial ($M = 9.27$, $SD = 3.67$) than during the same trial ($M = 6.04$, $SD = 3.48$), $t(15) = 3.56$, $d = .90$, $p = .003$. In contrast, infants in the exclaim-training group did not differ in their looking times during the switch ($M = 5.83$, $SD = 2.71$) and same trials ($M = 6.79$, $SD = 2.72$), $t(15) = 0.97$, $d = .35$, $p = .34$. These results demonstrate that when the referential status of phonotactically illegal words was highlighted by the use of an English word-referent training phase, 12-month-olds did associate Czech words with novel objects in an associative-learning task.

To investigate whether infants' performance on the switch task was related to their knowledge of the names of the objects presented during the training phase, we tallied the number of training words comprehended by each infant (zero to four) and correlated this measure with infants' success on the switch task (i.e., difference score that represented looking time to the switch trial minus looking time to the same trial). Results indicated that infants' knowledge of the names of objects in the training phase did not correlate with success in the English name-training condition, $r(14) = .20$, $p = .46$, nor with performance in the exclaim-training condition, $r(14) = -.05$, $p = .85$. These findings suggest that increased comprehension of training words did not directly relate to infants' performance in the name-training condition, suggesting that knowledge of at least one training word (i.e., minimum requirement) was sufficient to understand the purpose of the switch task.

In the final analysis, we examined whether infants responded similarly to the two Czech words. Note that the "pt" cluster in *ptak* is illegal only in onset position in English. It surfaces in word-final position in forms such as "kept." In contrast, the "sv" cluster is illegal in both onset and coda positions. To ensure that infants' success in the English name-training group was not influenced by a preference for one of the two Czech words, we compared the performance of infants who received a switch trial with each Czech word (i.e., *ptak* or *svet* name switch) using a same-switch difference score. Results indicated that infants who received the *ptak* switch ($M = 2.53$, $SD = 3.50$) did not differ significantly from those infants who received the *svet* switch ($M = 3.94$, $SD = 2.65$), $F(1, 15) = 2.2$, $\eta_p^2 = .13$, $p = .16$. As demonstrated by the positive-difference scores, infants looked longer at the switch trial than at the same trial, regardless of the word presented.

Discussion

Our results demonstrate that English-learning infants will associate word forms that violate the phonotactics of their native language to objects when the referential role of these to-be-learned novel words is clarified. However, when the referential role of these phonotactically illegal words remains ambiguous (i.e., exclaim-training group), infants fail to make these word–object mappings. These findings suggest that when infants are presented only with the linguistic information from a to-be-learned label in the word-learning task, their language-specific preferences guide their word–object mapping. However, when infants are provided with additional information that clarifies the referential nature of the switch task, 12-month-old infants' bias for phonologically appropriate object labels is overridden.

The findings from Experiment 1 demonstrate that infants will map phonotactically illegal words to objects when provided with a short training phase. These word forms, however, are well-formed nouns. Although the onsets are phonotactically illegal in English, the individual sounds and the CCVC syllable structure (e.g., *play*, *sleep*) are both legal in English. In the next experiment, we further examine infants' acceptance of various word forms in the modified switch task. That is, we ask whether infants' flexibility is limited to well-formed nounlike words or whether it extends to other types of sound forms.

Experiment 2

Here, we investigated 12-month-olds' ability to establish linkages between objects and either consonantal sounds or novel functionlike words when the referential clarity of these labels is highlighted by a name-training phase. Previous work has demonstrated that 12-month-olds will not map these forms to objects in the traditional switch task (e.g., MacKenzie et al., 2012a, 2012b). If infants are flexible in the types of linguistic forms they will accept as object labels when provided with information that clarifies the referential nature of the task, infants should successfully establish these mappings, as they did with the illegal word forms in Experiment 1. That is, infants in Experiment 2 should demonstrate similar performance to infants in the name-training group in Experiment 1. If, however, infants fail to map these forms to objects, this would suggest that even when the referential role of these labels is highlighted by additional cues provided in the word-learning task, infants' understanding of what an appropriate label is for an object is limited to well-formed words that share the appropriate phonological properties of nounlike words.

Method

Participants. Thirty-two English-learning 12-month-old infants were included in the final sample. An additional 11 infants were tested but were excluded from the sample for the following reasons: did not complete the task ($n = 6$) and failure to habituate ($n = 5$). Infants were randomly assigned to two conditions: consonantal sound group ($n = 16$; mean age = 12.42 months, range = 11.97–12.95; eight girls) and function word group ($n = 16$; mean

age = 12.58, range = 12.10–13.00; eight girls). Infants were from homes in which English was the primary language spoken (i.e., exposure to English was 80% or greater) and were recruited as described in Experiment 1. Information on ethnicity, race, cultural background, and family socioeconomic status was not collected. Infants in both groups did not differ significantly in age, $F(1, 30) = 1.45$, $\eta_p^2 = .05$, $p = .24$, or in productive vocabulary size, $F(1, 30) = 0.19$, $\eta_p^2 = .00$, $p = .94$, as measured by the MCDI short form (Fenson et al., 2000). Infants also did not differ in age, $F(3, 60) = 2.23$, $\eta_p^2 = .00$, $p = .09$, or vocabulary size, $F(3, 60) = 1.03$, $\eta_p^2 = .05$, $p = .70$, from those tested in Experiment 1.

Stimuli. The auditory and visual stimuli presented to both groups of infants in the training phase were identical to those presented in the name-training group in Experiment 1. The visual stimuli presented during the habituation and test phases were also identical to those used in Experiment 1. The auditory stimuli presented during the habituation and test trials, however, varied according to group (i.e., consonantal sound or function word). Within each group, the same native English female speaker recorded the name-training words and the test stimuli. These auditory stimuli were the same auditory stimuli used in previous switch task studies (MacKenzie et al., 2012a, 2012b). Acoustic measurements of auditory stimuli are available in the supplementary materials online.

Infants in the consonantal sound group were presented with exemplars of each of the following linguistic sounds: /l/ and /ʒ/, paired with an object (i.e., Object A or Object B). These consonantal sounds were chosen as they are phonetically distinct from one another (i.e., /l/ is a voiced, alveolar, lateral approximant, whereas /ʒ/ is a voiceless, postalveolar fricative) and can be produced without a vowel (in contrast to a stop consonant). This allowed us to assess infants' potential mappings of single sounds to objects. Previous research has demonstrated that infants will not map these sounds to objects in a switch task (MacKenzie et al., 2011).

Infants in the function word group were presented with exemplars of each of the following words: two novel functionlike words: *keh* (/kə/) and *iv* (/ɪv/), paired with an object (i.e., Object A or Object B). The novel functionlike words (i.e., *keh* and *iv*) were chosen for inclusion in this experiment because they are analogous to frequently used English function words, *the* and *is*. That is, these novel function words and their familiar counterparts (i.e., *iv*/*is* and *keh*/*the*) share similar vowel placement. This similarity allows our novel functionlike words to capture key phonological characteristics of frequent function words. Furthermore, we produced these novel functionlike words in sentences that captured the acoustic characteristics of frequent English function words (e.g., "*Keh* hog ran away" and "The stove *iv* hot to touch") and spliced them out to create the individual tokens. All stimuli were recorded in adult-directed speech to ensure we captured the prosodic and acoustic characteristics of natural sounding function words. Previous research has demonstrated that infants will not map these functionlike words to objects in a switch task (MacKenzie et al., 2012a).

For presentation during the pre- and posttest trials, *und* (/ʌnd/ function word group) and /n/ (consonantal sound group) were recorded.

Apparatus and procedure. The apparatus and procedure used were identical to that of the name-training group in Experiment 1; the only difference was the auditory stimuli presented during the habituation and test phases. All infants comprehended the basic-level name for at least one training object, as measured by the MCDI.

Infants' looking times for the critical trials were coded on a frame-by-frame basis. Interrater reliability for 20% of the data ($n = 6$) was high (ICCs = .98, $ps < .001$).

Results and Discussion

To ensure that infants were not fatigued or generally disinterested in the task, we compared infants' looking time during the pre- and posttest trial. See Table 1 for mean looking times by group for the pretest, the posttest, the last habituation block, as well as the average number of habituation trials. Results of a 2 (group) × 2 (trial: pretest vs. posttest) ANOVA indicated that infants looked significantly longer during the pretest trial ($M = 17.00$, $SD = 2.91$), compared with the posttest trial ($M = 14.20$, $SD = 4.70$), $F(1, 30) = 13.43$, $\eta_p^2 = .31$, $p = .001$. These results suggest that infants may have become disinterested or fatigued in the task, which could have in turn impacted their willingness to map these forms to objects. However, results of a 2 (group) × 2 (trial: last habituation block vs. posttest trial) ANOVA indicated that infants looked significantly longer during the posttest trial ($M = 16.78$, $SD = 3.73$) compared with the habituation block ($M = 7.11$, $SD = 2.42$), $F(1, 30) = 77.35$, $\eta_p^2 = .72$, $p = .0001$. Overall, these results confirm that infants in both groups recovered from habituation, which suggests that infants' decreased looking time from pretest to posttest most likely did not affect their performance on the task. Finally, the average number of habituation trials for infants in the consonantal sound group did not differ significantly from infants either in the function word group in Experiment 2 or the name-training group or exclaim-training group in Experiment 1, $F(3, 60) = 0.85$, $\eta_p^2 = .04$, $p = .47$. Furthermore, infants' proportion of looking time during the habituation trials did not differ across groups, $F(3, 60) = 0.32$, $\eta_p^2 = .04$, $p = .81$. These findings suggest that attention to the word–object pairings during the habituation phase was similar across groups.

The primary analyses compared the looking times on the test trials for infants in the function word and consonantal sound group with that of infants in the name-training group in Experiment 1, who were presented with phonotactically illegal word forms during the mapping phase. A 3 (group) × 2 (same vs. switch) ANOVA yielded a significant Group × Trial interaction, $F(2, 45) = 4.64$, $\eta_p^2 = .17$, $p = .02$. Follow-up comparisons indicated that only infants in the name-training group from Experiment 1 looked significantly longer during the switch trial ($M = 9.27$, $SD = 3.67$) than during the same trial ($M = 6.04$, $SD = 3.48$), $t(15) = 3.56$, $d = .90$, $p = .003$. Infants in the consonantal sound and function word group did not look significantly longer during the switch trial ($M = 7.93$, $SD = 4.91$; $M = 7.12$, $SD = 4.25$) than during the same trial ($M = 7.97$, $SD = 3.27$; $M = 8.02$, $SD = 3.49$), $t(15) = 0.04$, $d = .01$, $p = .97$; $t(15) = 0.96$, $d = .23$, $p = .35$, respectively (see Figure 3). These results demonstrate that when provided with a word-referent training phase, infants successfully mapped phonotactically illegal words to objects; however, they did not map consonantal sounds or functionlike words to objects.

Finally, we tallied the number of training words comprehended by each infant (zero to four) in Experiment 2. This measure was

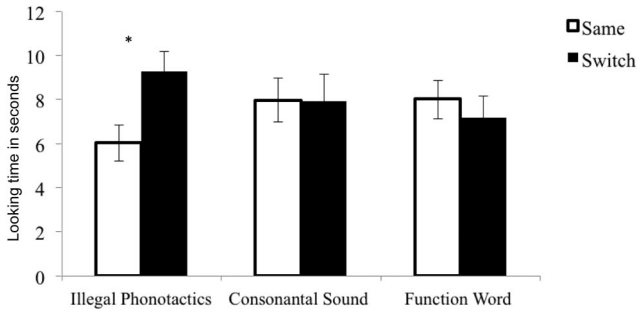

Figure 3. Mean looking times in seconds during same and switch trials as a function of group in Experiment 2. Error bars denote standard error. * $p < .05$.

not significantly correlated with performance in the consonantal sound condition, $r(14) = .15$, $p = .59$, nor performance in the function word condition, $r(14) = -.05$, $p = .86$.

Overall, these results demonstrate that when infants are provided with the same word-referent training phase as in Experiment 1, 12-month-olds will not map isolated consonantal sounds or functionlike words to objects in an associative-learning task.

General Discussion

Together, these findings clarify English-learning infants' flexibility in linguistic form–object mappings in an associative-learning context. In particular, our findings demonstrate that by 12 months of age, English-learning infants will limit their word–object mappings to words that share the phonological properties of contentlike words, even when provided with referential training that adds clarity to the task.

In Experiment 1, 12-month-olds were flexible in accepting word forms that violated the phonotactics of their native language when the referential role of these to-be-learned novel words was clarified with a word-referent training phase. That is, infants in the name-training condition, who were provided with contextual evidence that object labeling was the goal of the task, mapped words that contained illegal sound combinations to objects. Infants' failure to map these phonotactically illegal words to objects in the exclaim-training condition provides critical evidence that simply presenting infants with familiar attention-directing words is not sufficient to promote these word–object mappings. Thus, in order for infants to map words that contain illegal sound combinations to objects, infants require contextual cues in the switch task that indicate that the unusual sounding label is meant to refer to an object.

Our findings extend previous work that has demonstrated that clarifying the ambiguous referential status of words leads infants to map words to objects in isolation (Fennell & Waxman, 2010; Fulkerson & Waxman, 2007; May & Werker, 2012; Namy & Waxman, 2000). Our findings are also consistent with recent research by May and Werker (2013), who investigated how the presence of a referential training phase influenced English-learning 14- and 20-month-olds' mapping of nonnative speech sounds (i.e., clicks) to objects. These sounds fall well outside of any native-English sound categories and therefore cannot be assimilated into any native speech sound category. Results indicated that when infants were provided with a referential training phase, 14-month-olds, but not 20-month-olds, mapped the unassimilable clicks to objects. These findings suggest that when young infants are provided with an additional cue that clarifies the nature of the switch task, 14-month-olds will map labels that contain an illegal phoneme to novel objects. Interestingly, however, 20-month-olds failed to map the clicks regardless of whether the referential training phase was provided, suggesting that a developmental narrowing is occurring between 14 and 20 months of age in infants' awareness of what an appropriate label may be in their native language and their willingness to accept forms that contain illegal sounds as labels for objects. Although our findings are consistent, we have found that forms that are legal in the native language (i.e., function words) are not acceptable object labels, suggesting that some lexical knowledge about the phonological structures specific to object labels exists at 12 months. This is further supported by the finding that our infants also rejected individual legal sounds (i.e., phonemes) as potential labels. Accepting both illegal sound combinations (Experiment 1) and nonnative sounds (May & Werker, 2013) when provided with additional support to the task is potentially very useful. That is, it suggests a certain degree of willingness to learn about sound patterns that have not been experienced in appropriate contexts.

These results raise the question as to whether older infants would fully narrow their acceptance of word forms that contain illegal onset sound combinations as object labels. Given previous work demonstrating that by 20 months of age, infants begin to narrow their acceptance of a variety of symbolic forms as labels (e.g., nonnative sounds, nonlinguistic sound, and gestures), we would predict that infants would demonstrate a similar decrease in flexibility in accepting phonotactically illegal word forms around 20 months of age even when provided with referential support (e.g., Graham & Kilbreath, 2007; May & Werker, 2013; Namy & Waxman, 1998; Woodward & Hoyne, 1999). This, of course, remains an empirical question.

In Experiment 2, infants demonstrated a limited flexibility in mapping ill-formed words to objects. That is, infants did not map consonantal sounds or functionlike words to objects even when the referential intention of these labels was clarified through a name-training phase. Of course, it remains to be seen whether additional contextual or referential cues may lead infants to accept even the poor forms as labels for objects. Why will infants capitalize on the referential training provided in the switch task to map phonotactically illegal words to objects, yet fail to apply this cue when mapping ill-formed words to objects? We propose that although the Czech words contained an onset sound cluster that is illegal in the English language (i.e., /pt/ or /sv/), the structural shape of these words may share more similar characteristics to words that infants typically learn as labels for objects early in the acquisition of language, namely, nounlike words. The illegal Czech words were composed of four sound segments, as opposed to the consonantal sounds and functionlike words, which were composed of a single sound and two-sound segments, respectively. The simplified structure of the functionlike words can be viewed as sharing similar sound structures commonly found in frequent function words in English (i.e., CV, VC, V structure), whereas the Czech words have a complex sound structure that is commonly found in frequent English content words (e.g., CVC, CCVC). Thus, when infants are provided with information that indicates that the to-be-learned linguistic form is intended to be a label, infants may weigh aspects

of what an appropriate word form is differently and thus be less flexible with accepting word forms that are structurally poor (i.e., C, CV, or VC structure) as compared with word forms that contain illegal sound combinations.

In support of this argument, research has demonstrated that young infants are sensitive to not only the structural shape of words but also their phonological properties, which, in turn, permit them to distinguish between grammatical and lexical word forms (Shi & Werker, 2001; Shi, Werker, & Morgan, 1999). Thus, it may be the case that infants' developing sensitivity to the structural shape of words may then subsequently constrain possible labels infants are willing to map to objects. That is, as infants begin to further develop their lexicon, expectations form regarding which word forms constitute an appropriate label for an object, based on several linguistic cues, including the sound structure of word forms. Consequently, even when infants are presented with cues within a word-learning context that indicate that an ill-formed word is intended to be an object label (i.e., word-referent training), infants may be less flexible in mapping these linguistic forms to objects. When precisely this preference for well-formed words develops is unclear. Infants younger than 12 months of age may be willing to accept function words and consonantal sounds as labels for objects. However, given neonates' ability to discriminate content and function words on the basis of their phonological and acoustic cues (Shi et al., 1999) and 6-month-olds' preference for listening to content words over function words (Shi & Werker, 2001), infants between 6 and 12 months of age may have already begun establishing preferences about the particular shape of an object label.

Why do infants in our experiment fail to map function words when previous work has demonstrated that 17-month-olds will map word forms with similar properties to function words (e.g., short vowel, open syllable) to objects (e.g., Werker et al., 2002)? Werker and colleagues demonstrated that 17-month-olds mapped minimally different words with short vowels and an open-syllable structure to objects in the switch task (e.g., *bih* and *dih*). This study, however, differs in several ways methodologically from our study. First, the infants tested were significantly older, which may account for this difference in performance in that the computational demands involved in learning new words, learning about new objects, and linking these words to objects may be more strenuous for young 12-month-olds who are in the early stages of word learning. This argument parallels previous work by Stager and Werker (1997), who found that unlike 17-month-olds, 14-month-olds failed to map minimally different words with short vowels and an open-syllable structure to objects in the switch task. Second, differences in how the auditory stimuli were produced may account for the difference in findings. That is, unlike our function words, which were spliced from a sentence to ensure the forms were not stressed in production, the word forms used in Werker et al.'s study were produced in isolation and with infant-directed speech. Thus, although the stimuli from both studies shared an open-syllable structure, the difference in speech style may account for the way in which the infants processed these different word forms. Future research investigating older infants' acceptance of function words as object labels would help clarify the extent to which 12-month-olds' inability to map these forms to objects is impacted by the structure of these word forms or by their stage in development (i.e., age).

Overall, our findings demonstrate that infants are sensitive to both the linguistic properties of potential labels as well the context in which the labels are presented. That is, infants' language system allows for a certain degree of flexibility in that they will use information that clarifies the switch task to guide their mapping of unusual sound patterns to objects. This flexibility, however, is tempered by the phonological shape of these labels. More specifically, if the forms do not structurally conform to what is considered to be a reasonable syllable pattern (CVC, CCVC) for a label, infants will not accept these labels. It remains an open question whether providing additional contextual or referential information will lead infants to accept these "poor" forms.

These results parallel previous work demonstrating that infants will demonstrate a limited flexibility in the types of auditory stimuli they will accept as labels for objects depending on the cues, which are presented in the word-learning task (Campbell & Namy, 2003; Hollich et al., 2000). For example, Hollich and colleagues (2000) investigated the context in which 12-month-olds will accept linguistic sounds (e.g., mouth sounds) and nonlinguistic sounds as object labels. Results indicated that when infants were provided with attentional cues, including a naming phrase and eye gaze, they accepted the mouth noises but not the nonlinguistic sounds as labels for objects. When perceptual salience of the target object was added as an additional cue in the task, infants accepted the nonlinguistic sound as a label for an object. Further support for the influence of referential cues on word learning comes from work by Campbell and Namy (2003), who demonstrated that both 13- and 18-month-olds will map both verbal (e.g., *foppick*) and nonverbal symbols (e.g., two-tone beep) to object categories when presented within a referential context, but not when the referential context is absent (i.e., when the word or the nonverbal sound was emitted from a baby monitor when the infants looked at the object). Together, these findings suggest that when infants are presented within a rich social interactive task with several referential cues indicating the intent of the speaker, infants will demonstrate a symbolic openness regarding the types of labels they will map to objects (e.g., Campbell & Namy 2003; Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999). However, when referential cues are limited or absent from the word-learning task, infants will constrain the types of forms they will map to objects (e.g., Graf Estes et al., 2011; Hollich et al., 2000; MacKenzie et al., 2012a, 2012b, 2011). Thus, infants have not only emergent preferences for what constitutes an object label but also a certain degree of flexibility within the system, which allows for these preferences to be overridden by other factors, such as referential information.

In summary, our findings add to the growing body of literature on infants' acquired knowledge about their native language sound system and their willingness to apply this knowledge when making word–object mappings (Fennell & Waxman, 2010; Hochmann et al., 2011MacKenzie et al., 2012a, 2012b, 2011; Werker & Fennell, 2004). Indeed, we have shown that English-learning infants will exhibit flexibility in the types of linguistic forms they will map to objects; however, this flexibility appears to be constrained to structurally well-formed words that share the syllabic properties of nounlike words, even when the referential role of these labels are clarified. Thus, our results demonstrate that by their first birthday, infants' ability to make word–object mappings is sophisticated in that infants will weigh the relevance of the linguistic properties of

potential labels and contextual information provided in the task to determine what an appropriate word is for an object label.

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