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Word-learning heuristics in bilingual vocabulary acquisition:
A longitudinal study of a Bulgarian-English child in the US

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Abstract. The early stages of lexical development in children pose various questions about the selection and application of word-learning heuristics. In many proposals these processes are assumed to be facilitated by a specific lexical bias that differs in strength in monolingual and bilingual populations, namely, the Mutual Exclusivity (ME) bias (Markman & Wachtel 1988; Houston-Price et al. 2010). The present study analyzes the role and operation of ME bias in the bilingual vocabulary acquisition of a child who is acquiring Bulgarian and English from birth in the US. The analysis focuses on the child production of translation equivalents (TEs) at three measurement points: 18, 24 and 30 months. The findings reveal a flexible use of the ME bias modulated by the child bilingual linguistic experience and his emerging understanding of word-concept mappings in different contexts.

Keywords. Mutual Exclusivity bias; translation equivalents; word-learning heuristics; word-object mappings; categorization

1. Introduction. How do children learn words? How do they perform the complex operation of mentally connecting the object with its label if this relationship is purely arbitrary? Investigations of the learnability problem, also known as the problem of referential indeterminacy, has led to proposals that early learning is facilitated by lexical biases, which take the form of violable assumptions or good first guesses that could be overridden under certain circumstances. A prime example of such word-learning heuristics is the Mutual Exclusivity (ME) bias, i.e., the use of novel labels for unfamiliar referents (Markman & Wachtel 1988). It has been suggested that the ME bias and particularly, children's rejection of a second label for a familiar referent is based on a form of a disjunctive syllogism, known also as disjunctive elimination in propositional logic: A or B, not A, therefore B (see Houston-Price et al. 2010 for a discussion). This foundational construct of the ME bias is further augmented by contextual, linguistic and referential cues as part of the complex process of word learning.

The view of the ME bias as a violable assumption rather than a rigid constraint allows for some flexibility in interpreting its effects or even its suspension due to the presence of richer contextual and referential information (Kalashnikova et al. 2016a), larger vocabulary size (Houston-Price et al. 2010) or language experience (Markman et al. 2003; Rowe et al. 2015; Kandhadai et al. 2017). Importantly, continuous and systematic experience with two languages has been found to predict the operation of ME bias in children's bilingual vocabulary acquisition. Particularly, the richer their language experience with two (or more) languages, the more likely a weaker ME will apply or not apply at all (Byers-Heinlein & Werker 2009, 2013; Houston-Price et al. 2010; Kalashinikova et al. 2018; Rocha-Hidalgo et al. 2021).

2. Mutual Exclusivity (ME) bias and translation equivalents (TEs). The specific use of the ME bias in early vocabulary development has prompted debates about the possibility of such bias inhibiting the production and comprehension of translation equivalents (TEs) in child's

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lexicon. TEs are pairs of words that have the same general meaning in each language and could substitute each other in a wide range of contexts, for example, the English *train* and the Bulgarian *vlak* 'train'. Knowledge and use of TEs by bilingual children are interpreted as resulting in a many-to-one word-concept mapping, which stands in contrast to monolingual one-to-one mapping (Byers-Heinlein & Werker 2013). The empirical record of TEs is mixed: some studies reported lack of TEs (Volterra & Taeschner 1978; Vihman 1985; Clark 1993), while others found variable proportions of TEs, sometimes reaching up to 50% of the lexicon of bilingual children (Pearson et al. 1995; De Houwer et al. 2006; Sheng et al. 2011). Likewise, the way TEs influence word learning is not fully understood due to conflicting findings, i.e., when the number of TEs is smaller, children tend to adhere to the ME bias and disambiguate (i.e., use novel labels for novel referents) more frequently (Byers-Heinlein & Werker 2013). On the other hand, when there is a higher proportion of TEs, children do not disambiguate at all (Byers-Heinlein & Werker 2009; Houston-Price et al. 2010). In sum, the results of the cross-sectional studies do not provide definitive answers about the role of TEs in bilingual vocabulary acquisition and the effect of ME bias on word-object mappings across two languages.

3. The present study. The variable ME profile of bilingual children and the mixed findings of their production of TEs motivate investigating bilingual vocabulary acquisition in more depth and over a period of time. Thus, my research draws on longitudinal bilingual vocabulary production data with the aim to complement the existing cross-sectional studies of word-learning heuristics in bilingual children (Kalashnikova et al. 2018; Repnik et al. 2021; Rocha-Hidalgo et al. 2021). Despite the limitations in the effect size, longitudinal investigations of one subject are ecologically valid and offer the opportunity to identify the time and manner of bilingual vocabulary acquisition in more detail, potentially revealing some hidden aspects of word-learning heuristics.

The subject of the study is Adam (a pseudonym), a bilingual child who is acquiring Bulgarian and English from birth in the United States and as such, falls under the category of a "future heritage speaker", as defined by Polinsky (2016). These speakers are child bilinguals who receive daily input in two languages: the heritage language spoken at home (in this case, Bulgarian) and the societal language (English), also spoken at home and in public spaces, such as American daycare and Kindergarten. In their language development, speakers like Adam represent the initial stage of adult heritage language grammars.

Adam's mother is a balanced Bulgarian-English bilingual who is also a researcher of bilingualism. Adam's father is a monolingual English speaker born and raised in the US. He spends a fairly good amount of time away from home due to work-related travel, which results in Adam's greater exposure to Bulgarian during those periods. When the father is home, parents try to adhere to the one-parent one-language principle (OPOL) but with frequent bilingual input from the mother as well. At six months, Adam was in the care of an English-speaking babysitter three days a week, and at the age of one was enrolled in an American private daycare (6 hours/day, 5 days/week). Bulgarian continued to be spoken at home by the mother and the monolingual Bulgarian-speaking grandmother, who visited frequently for long periods of time during the first three years of Adam's life.

My investigation of Adam's bilingual vocabulary production aims to determine whether he uses ME as lexically-based heuristic as represented through his production of TEs. For this purpose, I analyzed naturalistic data from Adam's vocabulary production in a home environment based on daily observations and audio and video recordings of him made by his parents. In

addition, his mother recorded his expressive vocabulary using the Toddler Form of the MacArthur-Bates Communicative Development Inventory (CDI), a vocabulary checklist filled out by the parents/guardians on a daily basis. This form documents vocabulary production from 16 to 30 months and is a widely-used instrument for assessing vocabulary development in young children. Originally developed for English (Fenson et al. 2007), it has been since adapted for over 40 languages, which allows for cross-linguistic comparison based on the same collection method.

For the purposes of this study, Adam's parents used the original English Toddler Form and its official Bulgarian adaptation (Andonova 2015), which allowed for documenting of all cases of TEs from the period 18-30 months after Adam was born. Data from participants of the same age range (18 to 30 months) showed that bilingual children can assign novel labels to new objects in ambiguous word-learning situations as early as 18 months of age (Byers-Heinlein & Werker 2009; Kalashnikova et al. 2018; Repnik et al. 2021). Adam's bilingual mother documented not only the production of TEs, but also the contexts of their use, thus, providing information about possible over- or underextension of the meaning of the words (see Pearson et al. 1995 for a discussion on early lexical production). In my study of Adam's word-learning heuristics, I focused on three measurement points: 18 months (when Adam produced his first TEs), 24 months (when he experienced vocabulary spur), and 30 months (shortly after he started translating between Bulgarian and English in a more systematic way). The fluctuations in his English-Bulgarian vocabulary ratio reflect the dynamics of his input resulting from the job-related absences of the English-speaking father and the long visits of a Bulgarian-speaking grandmother (two or three months in duration).

4. Translation equivalents (TEs) in Adam's production. My study is informed by considerations of the facilitatory effect of the many-to-one mapping manifested in bilingual children's knowledge and use of TEs, a result of the weakening or suspending the operation of the ME bias in their lexicon (Pearson et al. 1995; Pettito et al. 2001; Byers-Heinlein & Werker 2013; Rowe et al. 2015). Given his extensive and diverse experience with two languages from birth, as well as the flexible OPOL strategy of his caregivers, Adam is predicted to produce and understand TEs soon after he starts producing words in both languages, Bulgarian and English. I hypothesize that the diversity and richness of his linguistic contexts, as well as his interaction with different caregivers, will enhance his emerging categorizations, as manifested in his knowledge and use of TEs.

Adam's vocabulary production started around 16 months of age when he was exposed to more intensive Bulgarian input during a family visit to Bulgaria in the summer of 2015. His first three words were *tata* (a modified version of the Bulgarian word *topka* 'ball') and the universal *mom* and *dada*. He started producing TEs around 18 months, and they gradually increased in number (as shown in Table 1). The proportion of his TEs was calculated by dividing the number of the TEs by the total number of words in both languages, as extracted from the CDI checklists (see Pearson et al. 1995; Poulin-Dubois et al. 2010; Repnik et al. 2021 for similar approach).

Measurement Points	# Total vocabulary	Translation Equivalents
18 months	11 (7 ENGL; 4 BULG)	1 pair
24 months	140 (63 ENGL; 77 BULG)	16 pairs (11.4% of total vocabulary)
30 months	520 (270 ENGL; 250 BULG)	135 pairs (26% of total vocabulary)

Table 1. English-Bulgarian CDI data

An important milestone in regard to differentiating between his two languages occurred around 30 months, when Adam started producing TEs upon demand from his parents. From this point on, he seemed to be aware that an object can have two labels and that, while his father and his daycare teachers only understand one of them (English), his mother understands both, and his grandmother, only Bulgarian. This realization had a facilitatory effect on the communication with his caregivers and the rapid development of his bilingual lexicon.

One of the interesting aspects of his early vocabulary acquisition was his pattern of use of TEs before 30 months of age when he used TEs in specific domains that reflected some of the properties of his input, i.e., who says what in what context. Table 2 shows some of the most widely used TEs around 24 months.

English	Bulgarian
Baby	Bebe
Ball	Topka
Big	Goljam
Car	Tata
Door	Tata[1]
Down	Dolu
House	Kăšta
More	Ošte
Trash	Bokluk
Truck	Ton

Table 2. Translation equivalents (c. 24 months)

Adam initially used the Bulgarian word *bokluk* 'trash' to designate exclusively trash on the floor (a word mostly heard from the bilingual Bulgarian-English speaking mother), while the English word was used for trash in the dumpster in conversations with the English-speaking father. After a while, Adam started using 'trash' to refer also to trash on the floor, while *bokluk* became less frequent in use (unless specifically reinforced by the mother) and more restricted to specific contexts, such as breadcrumbs or other pieces of food on the kitchen floor.

Another example of his word-learning strategy was the production of the word for 'down/downstairs'. He used the Bulgarian word *dolu* only when he referred to the first floor of his house, whereas he used 'down' mostly when he was carried and wanted to be put down. This division in the domains reflects the more frequent use of the Bulgarian word by the bilingual mother in reference to his playroom on the first floor. It has to be noted that the Bulgarian word alone is not felicitous in the context of directionality, as it is the case with the English word 'down' and thus, has not been used in such contexts by his Bulgarian-speaking caregivers, which could have precipitated the use of 'down' in those contexts.

Adam's production of other TEs also points to a domain-restricted use of both words in each pair. He used the English word for 'baby' to refer to a tiny toy truck and the Bulgarian word for human babies. The word 'big' was used by Adam as a kind-based property, whereas the Bulgarian one designated a property of big vehicles. Similar conceptualization was present in his use of the English word for 'truck' to designate garbage or fire truck, while all other trucks were "covered" by the Bulgarian word. He extended the meaning of 'car' to more contexts, reserving the Bulgarian word only to refer to his mother's car. Similarly, the word for 'house' was more

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[1] The word *tata* is the form Adam used to refer both to *kolata* 'the car' and *vratata* 'the door'.

widely used, while the Bulgarian one was reserved only for his tent. In contrast, the Bulgarian word for 'more' was dominant because both parents used it (the English-speaking father has learned that word and used it in a playful manner with Adam). Finally, a true domain-specific use of TEs is manifested in Adam's use of the English word for 'door' to designate vehicles' doors, whereas he used the Bulgarian word for doors of buildings.

Adam's domain-specific use of TEs resembles the mechanism of semantic underextension in monolingual vocabulary acquisition, i.e., the failure to recognize a prototypical member of a category (White 1982). However, underextension in bilingual acquisition proves to be a more complex process. For example, if we take Adam's TEs for 'trash', which one should we consider his prototype – the trash on the floor or the trash in the dumpster? It is quite challenging for children to sort out the categorical boundaries between different exemplars, a process that is further complicated by semantic representations that need to be mapped to two labels in the language systems of bilingual children.

5. Emerging categorizations and word-learning heuristics. Developmental psychology views early categorization as a dynamic process that takes place in specific task contexts (Bornstein & Arterberry 2010). As soon as children become familiar with the objects in a task, they can change their categorizations. During this process, children are guided by the distribution of exemplars they are exposed to. This model could explain to a certain extent Adam's use of TEs across different domains that goes beyond basic-level object representation and taxonomical hierarchies. In fact, Adam's domain-specific TEs could be described as 'many (words)-to-many (objects) mapping', in a way compartmentalizing his emerging bilingual vocabulary as a result of a more flexible use of the ME bias. I argue that such mapping presented an advantage to him in making the semantic properties of each word more transparent, thus facilitating the distinctions between categories and exemplars.

However, this word-learning heuristic appeared to be temporary, and he went through another phase before full mastery of TEs. During this transition, Adam stopped using one of the members of the TE pair for a while. Particularly, the Bulgarian word *motor* 'motorcycle' was first used to refer to a motorcycle, but after a while when the English word was introduced, it became the dominant one, and the Bulgarian word faded away. Months later, the Bulgarian word re-emerged in his production but this time used as a full-fledged synonym to the English one. Once Adam acquired a good amount of bilingual vocabulary and developed better awareness of the structure of the lexicon, his TEs became fully synonymous in all domains, thus reflecting a complete absence of ME bias.

Domain-specific use of TEs had been previously reported only in two other studies. Volterra & Taeschner (1978) analyzed the bilingual Italian-German vocabulary production of two children who used TEs in different contexts, for example, the Italian word *là* 'there' was initially used for things that were not visible to the children at the time of speaking, while the German word *da* 'there' referred to things that were present and visible to them. The authors suggest that the children did not consider these doublets exact equivalents, because for them, they denoted different concepts. Similarly, Pearson et al. (1995) found that some of their Spanish-English bilingual subjects used *barco* for sailboats but *boat* for all other boats; *zapatos* was reserved for one special pair of sneakers, while *shoes* were used for all others. The authors treated such cases as exceptions and argued that they showed lack of true equivalency between Spanish and English.

Taken together, these findings suggest that domain-specific use of TEs is not an exception but appears to be a word-learning heuristic that characterizes a transitional stage in the lexical development of bilingual children. In the case of Adam, the diverse quality and sources of input, as well as the distinctive domains of language use, could have contributed to a more flexible use of ME reflected in his domain-specific use of TEs. For example, if his parents and caregivers adhered strictly to the OPOL principle, this might have affected the strength of his ME bias, at least initially. On the other hand, a more flexible use of OPOL means more flexibility in regard to the ME bias. At the same time, Adam's sources of input (parents, grandparents and babysitters) and their language practices presented him with some ambiguities in mapping words to concepts. For example, the Bulgarian word for 'car' was used only by his mother and in fairly restricted domains, namely, to refer to her own vehicle, *na mama kolata* (Bulg., 'mommy's car'). On the other hand, both parents used the English word to refer to cars in a more general sense, but also to designate the mother's car when the father was present. This might have led Adam to generalize the meaning of 'car' to most contexts and to limit the scope of the Bulgarian word only to specific references to his mother's car as part of the possessive expression *na mama kolata*. Since his father owns a truck, the word 'car' was never used in reference to his vehicle. Instead, both parents used the mixed Bulgarian-English phrase *tati's truck* 'daddy's truck'. Thus, the representation of 'car' in Adam's mental lexicon could have been reinforced by the division of the domains of use of the English and the Bulgarian word made more transparent by the properties of his input.

6. Linguistic and cognitive factors in the ME bias. New findings about the causes and mechanisms of the operation of the ME bias in monolingual and bilingual populations have informed proposals, in which linguistic and cognitive factors interact in intrinsic ways. Rowe et al. (2015) found that bilingual children have a lower threshold than monolingual children for accepting second labels for familiar objects. However, this threshold does not necessarily mean that bilingual children do not observe ME or other word-learning heuristics. In their study, they found that additional information about the familiar and novel labels, as well as increased exposure to these labels, facilitated the acceptance of a second label for a familiar object by both the monolingual and bilingual group. In other words, the differences between monolingual and bilingual children in regard to the ME bias appear to be gradient rather than categorical.

Other studies emphasize the connections between the underdeveloped cognitive capacities of young children and the high cognitive demands of lexical overlap in the case of production of TEs. Word learning requires the allocation of cognitive resources with maximum efficiency in order to identify new words, determine their referents, recognize their context, etc. This might be a daunting task at early age. For example, Kalashnikova et al. (2016b) found that general attentional biases could contribute to children' tendency to apply ME in certain tasks.

Piccin & Blewitt's (2007) *Resource Conservation View* captures the dynamics in the cognitive cost and benefits associated with word-learning heuristics and the ME bias, in particular. According to the authors, monolingual children would try to avoid lexical overlap because storing and manipulating overlapping labels would come at a greater processing cost. However, if the lexical overlap is required to achieve successful communication, children are fully capable of overriding the ME bias and accepting second labels. The application of this account could be extended to bilingual vocabulary acquisition and, particularly, to the findings of the present study. The fluctuations in Adam's production of TEs through different stages could be analyzed as ways to maximize his communication benefits. Particularly, his domain-specific use of TEs

could have been guided by a more flexible ME bias, a result of resources' conservation efforts. Such word-learning heuristics would have been beneficial for Adam, not only in terms of processing and communicative efficiency, but also as an affective factor in the development of a strong bond between him and his caregivers, as discussed earlier.

7. Conclusions. The present study analyzed naturalistically occurring longitudinal data part of the bilingual lexical production of Adam, a Bulgarian-English simultaneous bilingual from birth residing in the US. The analysis of the data at 18, 24, and 30 months of age revealed Adam's domain-specific use of TEs that featured increased salience of the semantic properties of each member of the TE, suggesting more transparent distinctions between categories and exemplars. Such distinctions would have presented Adam with an advantage in his vocabulary acquisition and could have perhaps alleviated the cost of managing overlapping lexical labels in two languages.

By identifying transitional stages in the vocabulary acquisition of a Bulgarian-English child, my study illuminated specific bilingual word learning heuristics possibly resulting from a flexible use of the ME bias. The study's findings support the view that lexical biases are violable assumptions that could undergo changes when the child is presented with richer contextual and referential information. Future longitudinal investigations of the operation of word-learning heuristics in a bigger cohort of bilingual children would deepen our knowledge of the nature and strength of lexical biases, as well as their impact on domain-general and domain-specific mechanisms of early bilingual vocabulary acquisition.

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