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Social factors in the acquisition of a new word order

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ABSTRACT

Present syntax acquisition tasks are not optimal for studying how children learn a new syntactic constraint and generalize it in sentence production. To address this issue, this study modified Akhtar's production task where novel word orders were learned, so that it was more socially natural. Three- and four-year-old children were tested in this new task and the role of input factors was assessed. The new task was more effective at eliciting the novel word order, but the role of input factors differed from earlier studies. To trace the source of these differences, the study manipulated the social features directly in a second experiment. The results suggest that social knowledge contextualizes the influence of input factors in syntax acquisition.

KEYWORDS

Input; Japanese; learning; sentence production; social knowledge; syntax acquisition

Syntax acquisition is the process whereby children acquire constraints on word sequences from language input. Syntax acquisition researchers using elicited production often test structures that come from the child's native language (Gropen, Pinker, Hollander, Goldberg, & Wilson, 1989; Huttenlocher, Vasilyeva, & Shimpi, 2004). These studies can tell us how children use the constraints and structures that they have already learned, but they do not allow us to manipulate the learning of these constraints. There are also training studies that have manipulated the strength of existing representations (Abbot-Smith, Lieven, & Tomasello, 2004; Childers & Tomasello, 2001), but these studies do not examine how the child acquires the syntactic representation initially. And while there is a large literature that examines the initial learning of syntactic constraints in comprehension (Gomez & Gerken, 2001), the differences in the syntactic behavior in production and comprehension (Naigles, 2002; Tomasello, 2003) suggest that we need tasks that allow us to study directly the production-specific aspects of how children learn syntax.

To address this issue, we adapted a task called the Weird Word Order task (Akhtar, 1999). In this task, children saw a scene with a novel action and then heard a description of that scene with a word order that was different from their native language (this non-native word order is referred to as the 'weird word order', henceforth WWO). For example, an English child might hear 'Tamming Elmo the car' while watching the puppet Elmo do a novel action to a car. The child could learn that the action is called 'tamming' and the order in this structure places the verb 'tamming' before the agent 'Elmo,' and both of these before the patient 'the car.' The child was tested by being shown the same action with novel participants and was asked to describe what happened. The child could describe the scene either with the WWO that they had just learned (e.g., 'tamming Big Bird the house'), or change it to the order of their native language (e.g., 'Big Bird tamming the house'). As the arguments in the input and the test sentences were different, children could not succeed in this task by simply memorizing lexical sequences. Instead, they had to develop an abstract representation that incorporates some kind of word order knowledge instantiated over word classes and these constraints are akin to syntactic constraints in adult language (e.g., verbs go before subjects).

The WWO task is relatively unique among syntax acquisition tasks in that it allows one to manipulate the acquisition of a new word order and its use in production within a controlled meaning-driven communicative situation. Given that this task was originally designed to look at the strength of the child's native syntactic representations, it is not well suited for the study of how children learn a new syntactic constraint. In all of the previous WWO studies, children were reluctant to use the novel WWO structure. For example in Akhtar (1999), even with 80 models of the novel structure, 2-year-olds, 3-year-olds, and 4-year-olds never produced the novel WWO structure more than four times when given 20 elicitation questions (less than 16% novel structure use). Seeing as the researchers gave the children a substantial amount of exposure and opportunities for using the structure, it would seem that there was sufficient input to learn the structure and sufficient opportunities to exhibit that knowledge.

One reason that children might be reluctant to use the WWO in this task is because the child's interlocutor in these studies is often the experimenter and the experimenter speaks the child's native language (i.e., English). Just as bilingual children are sensitive about using the appropriate language for particular interlocutors (Genesee & Nicoladis, 2007), children in this task might find it strange to use a WWO utterance with an interlocutor that prefers English. Another reason that children might be reluctant to generalize in these studies is because the children had to learn several different word orders paired with different verbs. For example, Akhtar (1999) had children learn three verb-structure pairings: SVO structure (e.g., 'Elmo dacking the car'), SOV (e.g., 'Elmo the car gopping'), and VSO (e.g., 'Tamming Elmo the car'). No known language has three verb-conditioned word orders and children may have had difficulty learning these word orders if they thought that they were part of the same language, as was suggested by the use of a single interlocutor for all three conditions. Finally, some of these studies have the children describe a scene to an interlocutor who is present with the child during the viewing of the scene. Therefore, the interlocutor should already know what has happened and it was not informative for the child to tell them what has happened. If the child knew this, they might not have been motivated to use the WWO. These three issues with the earlier studies suggest that the communicative situation was not as natural as it could have been.

These issues are not just important for developing a better method for examining syntax acquisition in the laboratory, but they also relate to a more general question about the role of social knowledge in language acquisition. Social knowledge or factors can refer to a wide variety of situational or interpersonal knowledge. But in this article, the term social knowledge is used to refer to knowledge that the child possesses about what their interlocutor knows. In this case, the child might have social knowledge about what languages their interlocutor prefers or what scenes their interlocutor has already seen. This kind of knowledge has been shown to influence word learning (Baldwin, 1993), the learning of phonological contrasts (Kuhl, Tsao, & Liu, 2003), or the comprehension of requests (Babelot & Marcos, 1999), but a similar influence on the acquisition of syntactic structures in production has not been found. One reason for this gap is that unlike studies of word or phonological learning, production studies rarely use newly learned syntactic constraints. Also, studies that do involve the learning of new syntactic constraints, such as statistical learning studies, do not typically test children in communicative situations with human interlocutors (Gomez & Gerken, 2001) and therefore it is hard to manipulate social constraints in these situations. To fully understand how social knowledge influences syntax acquisition, we need to have tasks where novel structures are learned and generalized in natural communicative situations.

In sum, the tasks used for studying syntax acquisition are not optimal for studying how children learn new syntactic structures that can be used in sentence production. The WWO task can be used to study this issue, but children in the WWO task are reluctant to generalize the newly learned word order, possibly because the task does not take into account the social nature of language use. In the present study, a new, socially appropriate WWO task was developed and used to examine how input factors influence the learning of a new structure.

EXPERIMENT 1: INPUT FACTORS IN A SOCIALLY APPROPRIATE WWO TASK

The WWO paradigm was designed to test the theory that syntactic knowledge is gradually constructed from structural patterns in the child's input (Akhtar, 1999; Tomasello, 2003). This input-driven account would predict that as children get older, their native language syntactic structures should become stronger due to the fact that they are abstracted over a larger number of input utterances. Also, if children are abstracting structural representations from more item-based representations, then early on in development they should have stronger structural representations for frequent familiar verbs than for novel or low frequency verbs. These stronger native language structures should make the child less likely to learn or use the novel WWO structure. Over several studies, evidence has accumulated that supports these predictions (Abbot-Smith, Lieven, & Tomasello, 2001; Akhtar, 1999; Matthews, Lieven, Theakston, & Tomasello, 2005; Matthews, Lieven, Theakston, & Tomasello, 2007). Given that the goal of these studies was to examine how native language structures slowed down the acquisition of the WWO, these studies did not focus on the factors that were needed to insure that novel structures could be learned in the task.

To make the WWO more learnable, we modified the task so that it provided a closer approximation to the situations where children might naturally learn and use a novel word order. First, the child's interlocutor was set to be an individual who seemed to understand the WWO language exclusively. Since a child might have expectations about a person's language preferences from their race, we used a non-human robot dog as the child's interlocutor. Given that children have no language experience with this kind of robot, their expectations about the language that it understands should be completely driven by their experience in the laboratory. In our experiments, the robot dog was shown to understand utterances in a single WWO structure. Since we used only one structure, there was no confusion about which structure was appropriate for the robot and no memory difficulties related to the verb-structure pairing. Interaction with the robot was part of a sticker search game, where the children had to command the robot to perform actions to help them to find stickers in the room. Unlike some of the earlier studies, where the child's utterance was redundant, the robot cannot know which sticker the child is looking for without hearing the child's utterance and therefore the child should be motivated to produce an utterance for the robot. This is especially so because children are quite motivated to find the stickers in our game.

To test this new methodology, we tried to replicate earlier WWO findings within this new task. As in the earlier studies, we manipulated age and verb familiarity. We used 3- and 4-year-old children, because it has been argued that the third year is an important transition point where syntax in production moves from more item-based representations to more abstract representations (Tomasello, 2003). As we tested Japanese children, we used Japanese verbs as familiar verbs and Japanese-like nonce words for the novel verbs.

There are two likely outcomes of this study. One possibility is that input factors have the same effect in this new robot WWO task as in the earlier studies. If that is the case and the robot task also produces more WWO structures, then we will have created a more robust task for studying novel structure use in production. The other possibility is that the changes to the interlocutor and the task could change the way that input factors influence the behavior in the task. If this is the case, then more work will be needed to understand how these changes to the social situation relate to the child's sentence generation behavior.

METHOD

Participants

Forty normally developing monolingual Japanese children participated in the study. The younger children had a mean age of 3;6 (range 3;3–3;8; *n* = 20, 12 females). The older children had a mean age of 4;6 (range 4;4–4;8; *n* = 20, 11 females). Three children were replaced due to experimenter error.

Design and materials

A between-subjects design was used with either familiar or novel verbs for each age group. As our study was conducted with Japanese children, the structures that were tested were different from the previous English studies. Japanese is a verb-final language; therefore a verb-initial WWO structure was used. For example, the robot was able to do two actions: pointing or looking at the location of the sticker. A Japanese command for pointing at an object would be 'OBJECT *yubisashite*' and for looking at an object, 'OBJECT *mite*.' The WWO command structure reversed the order of these two elements and placed the verb first, as in '*yubisashite* OBJECT' or '*mite* OBJECT.' In addition to these two Japanese verbs, two novel verbs were also used (point = 'pate,' look = 'dote'). The Japanese verbs had a command form (ending in *te*). The novel verbs also had this ending and this was done to encourage the children to treat all of the verbs as Japanese verbs that could appear in canonically ordered Japanese utterances. These WWO structures were comparable in complexity to the VERB-SUBJECT stimuli used by Abbot-Smith et al. (2001).

The actions were performed by a Sony Aibo Robot (ERS-7M3) that was controlled by the first author in an adjacent room using the wireless Mind 3 remote control software. The software had a movement controller (walking, turning, sitting, standing) and a built-in set of motion sequences. One built-in sequence was a right-handed pointing gesture (Fig. 1, left). The software also included a head controller system that was used to perform the 'looking' action (Fig. 1, right). The 'looking' action involved a visual search and ended with the robot looking at the sticker location. To clarify that each action was complete, the pointing action ended with a whistle and the looking action with a bark. The experiment room had three cameras to monitor the movements and actions of the robot and the child. It also had microphones for monitoring and recording the speech during the session. The output of the three video cameras was combined with the sound information and was recorded onto digital DVC-pro tapes for offline transcription and coding.

A random set of nine stickers was created for each child, such that no object occurred twice in each set. One sticker was used for the initial warm-up task and was placed on a piece of paper. A sticker card was created with copies of the pictures of the stickers in the child's set. When the sticker card was introduced, the child was asked to name all of the stickers to insure that they could produce the object labels.

Procedure

The experiment was done in Japanese, but an English gloss is used here for utterances in the experiment.

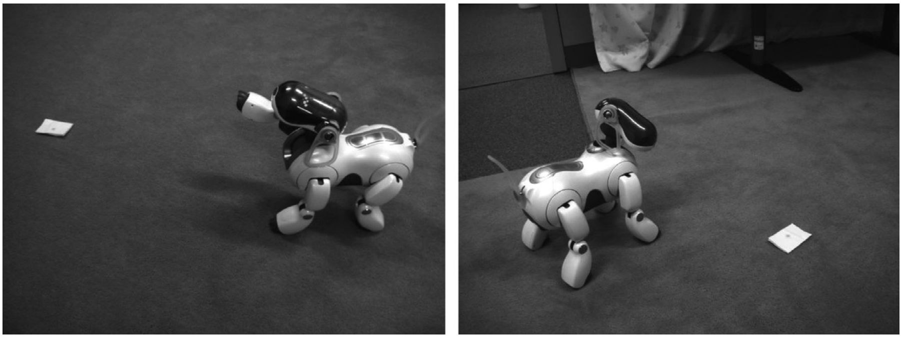

Figure 1 Pointing (left) and looking (right) actions with the robot dog

Warm-up. The experiment began with a warm-up procedure that created the expectation in the child that the robot dog could understand spoken language and the language that it preferred had a WWO structure. First, the experimenter commanded the robot to perform the pointing and looking actions with the warm-up sticker (e.g., lion sticker) and encouraged the child to repeat the commands. This procedure was repeated with both verbs until it was thought that the child understood the actions and could say the phrases (e.g., *yubisashite raion*, point lion; *mite raion*, look lion). In the last few examples, the child was asked which verb they preferred to use (e.g., 'Should we do point or look?') to encourage them to do more than imitate the adult.

Practice search trials. After the warm-up, the next two trials were practice search trials that gave the child experience with the sticker search game as well as the testing situation. The first practice search trial introduced the idea that stickers were hidden in the room, and the second practice search trial tried to encourage the child to control the search process. In the first practice search trial, a sticker was selected from the sticker card and the experimenter commanded the robot to search for that sticker using the point verb. The robot moved halfway to the sticker and then pointed to the location of the sticker. Next, the experimenter commanded the robot to look at the location of the sticker. The experimenter and the child would then search and retrieve the sticker in the place where the robot pointed and looked.

The second practice search trial began with the selection of a sticker (e.g., clothing) and then several prompts. First the child heard the prompt 'Tell the doggie what to do' and after a short pause they heard the second prompt, 'Tell the doggie to do the thing with the clothing.' Then the experimenter commanded the robot with the WWO utterance with the pointing verb (e.g., *yubisashite fuku*, point clothing) and the robot performed the action. The second part of the search trial was the same as the first part, except the looking verb was used (e.g., *mite fuku*, look clothing). Since the prompts in the practice trial were also used in the test trials, hearing them here followed by the target WWO utterance helped to suggest that the WWO utterance was the appropriate response to the prompts in the later test trials.

Test trials. A novel target sticker was selected on the card and the experimenter prompted the child to 'Tell the doggie what to do' (*wanwan-ni oshiete*). Next they were prompted to 'Tell the doggie what to do with X' (X refers to the target sticker, *wanwan-ni X-no-koto oshite*). Next they were prompted with a question that referred to both actions (e.g., 'Should we do pointing or looking?,' *yubisashite ka mite docchi ga ii?*). If the child chose a verb, the child was encouraged to use it with the robot. Then the experimenter prompted the child by saying the verb and pausing for a response; this was repeated three times. If at any point in the test trial the child said either the WWO VERB-OBJECT order (e.g., *yubisashite X*; *mite X*) or the Japanese OBJECT-VERB order (e.g., *X yubisashite*; *X mite*), the robot immediately began to perform the action specified and this part of the trial ended. If the child did not produce anything by the time the three verb repetitions were produced, the experimenter then produced the target WWO structure (e.g., *yubisashite X*; *mite X*) and the robot performed the action. As before, the second part of the test trial involved asking the child if they could use the other word and the same sequence of prompts was repeated until the child or experimenter had commanded the robot to perform the action and the sticker was collected. The test trial procedure was repeated for all of the remaining stickers for a total of six test stickers.

To summarize, the children were shown that the robot could respond to commands with the WWO structure in both the warm-up period and within two practice search trials. Then they were given six test trials to search for novel stickers and for each of the two verbs (pointing, looking) they could hear up to six elicitation prompts. If the child produced either one of the target orders during testing, the experimenter ended that part of the trial, and then continued with the second verb or the next trial. Since the stickers at test were different from those used during warm-up and practice, the children could not succeed by doing pure imitation of learned sequences.

Coding

A transcription of the experimenter's and children's utterances during the experimental trials were made offline by the Japanese experimenter using the recorded tapes. The utterances produced by the children were coded into either VERB-OBJECT or OBJECT-VERB for the target verbs (*yubishashite*, *mite*). We allowed other words to precede and follow a VERB-OBJECT or OBJECT-VERB phrase (e.g., *mite mite fuku*, look look clothing, would be VERB-OBJECT), but we excluded utterances with non-object particles or other material between the verb and the noun (e.g., *fuku yubi-de sashite*, clothing finger-with point). In Experiment 1, 12 utterances were excluded for material between the verb and in Experiment 2, 10 utterances were excluded. The verbs could have a different tense and aspect. We allowed variation in word forms (e.g., *sashite* instead of *yubisashite*) and variation in how the object was named ('the silver shirt,' 'the shirt sticker'). The first author used the transcript to code the categories and these codings were checked by the Japanese experimenter. Eight children were recoded by a second Japanese coder and 96% reliability was achieved. Table 1 presents the means and standard deviations for each of the conditions.

Table 1 Means and standard deviations for the VERB-OBJECT and OBJECT-VERB orders in Experiments 1 and 2

Experiment 1	*Age*	*Verb-type*	*Verb-object*	*Object-verb*
	3;6	Familiar	6.0 (5.1)	0.4 (0.5)
	3;6	Novel	6.0 (6.5)	2.5 (7.2)
	4;6	Familiar	10.7 (5.2)	1.9 (3.6)
	4;6	Novel	11.5 (4.7)	0.1 (0.3)
Experiment 2		*Social*	*Verb-object*	*Object-verb*
		WWO-Match	10.7 (5.2)	1.9 (3.6)
		Native-Match	0.0 (0.0)	3.5 (4.7)
		Both-Match	5.4 (6.3)	4.2 (5.6)

Results

To examine how the input-related factors influenced behavior in the task, a mixed-effect model with age and verb-type crossed was fitted to the mean participant frequency of WWO VERB-OBJECT and Japanese OBJECT-VERB structures produced (Fig. 2) and an analysis of variance was applied to the model. The 4-year-olds produced more VERB-OBJECT structures than the 3-year-olds ($F(1,36) = 8.83$, Cohen $d = 1.02$, $p = 0.005$). There was no difference between familiar and novel verbs ($F(1,36) = 0.05$, $p = 0.81$) and no interaction between age and verb-type ($F(1,36) = 0.05$, $p = 0.82$). For OBJECT-VERB structures, there were no significant effects (age: $F(1,36) = 0.12$, $p = 0.73$; verb-type: $F(1,36) = 0.01$, $p = 0.91$; age*verb-type: $F(1,36) = 2.3$, $p = 0.14$). Therefore, children were producing more of the novel WWO structures as they got older, but age had no effect on the use of the Japanese structure. Familiar Japanese verbs as well as novel verbs were equally likely to occur in either structure.

To examine the choice between these two structures, a second analysis of variance with age and verb-type crossed was applied to the empirical-logit-transformed participant proportions (Agresti, 2002). Again, there was a main effect for age ($F(1,36) = 5.0$, Cohen $d = 0.76$, $p = 0.03$), but no effect for verb-type ($F(1,36) = 0.03$, $p = 0.86$) and no interaction between the two ($F(1,36) = 0.89$, $p = 0.35$). Therefore, older children are more likely to select the novel VERB-OBJECT versus the OBJECT-VERB order as they get older. Previous studies have found the opposite pattern, where the proportion of novel structures produced becomes smaller as children get older (Abbot-Smith et al., 2001; Akhtar, 1999; Matthews et al., 2005).

Since there was an effect of age in structure choice, we examined whether this difference was due to the input to the child (number of WWO model utterances that the child heard) or the opportunities for the child to respond (number of prompts). The 3-year-olds heard an average of nine models per child per verb and the 4-year-olds heard seven models on average. The 3-year-old children required on average 54 prompts per child (two verbs, six test trials) and 23% of these prompts

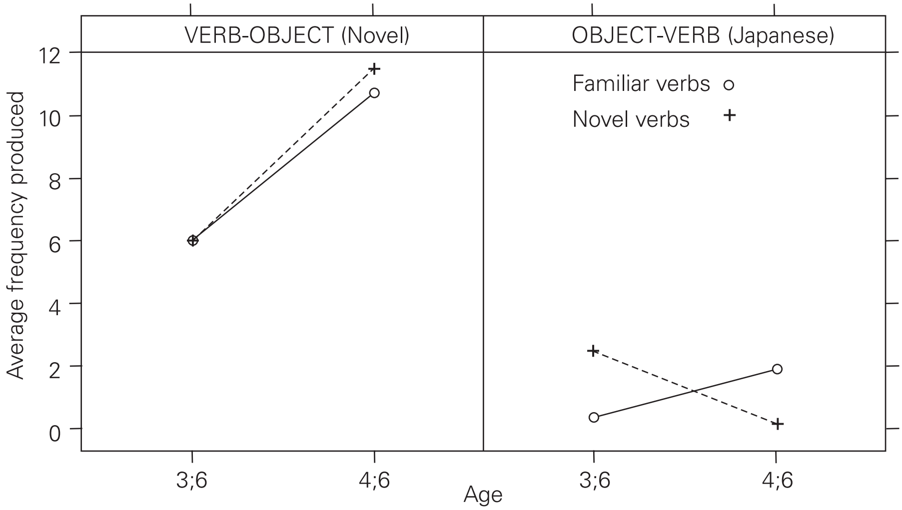

Figure 2 Average frequency of word orders produced by age and verb-type

were isolated verbs (16 prompts/child). The 4-year-old children required only an average of 23 prompts per child with isolated verb prompts making up only 16% (four prompts/child). Thus, the higher production of the novel structure by 4-year-olds occurred even though they heard fewer modeled utterances and fewer prompts (they produced a response mostly within the first three prompts). The faster learning and higher use of the WWO by the older children in this task suggests that the stronger native language representations in these children did not make it harder for them to use the novel WWO structure. This result contrasts with the expectations of the earlier WWO studies.

One goal of this study was to see if it is possible to increase the likelihood that children produce a newly learned WWO by making the task closer to a natural situation where a novel word order would be appropriate. To see if this task is a better means for studying how children learn a new structure, it is necessary to compare this study with previous studies and this comparison needs to control for the different number of models and opportunities for using the target structure in each study. Since the chance of producing the novel structure should go up with the number of models and number of opportunities, we divided the mean frequency of novel structures produced for each participant by the sum of the number of models and opportunities, and this yielded the novel word order generalization quotient. This generalization quotient represents the average increment in the use of the novel word order with each added opportunity or model. The number of models for the previous studies came from the reported number of models per verb. The number of opportunities for the previous studies came from the reported number of elicitation questions per child. For the robot WWO paradigm, the number of models and opportunities depended on how the child responded in the experiment, and hence these numbers were determined from the transcripts. The number of models included both models produced in warm-up and practice, as well as any model utterances produced when the child was unable to produce either target utterance during testing, and this total was divided by 2 to get the number of models per verb. The number of opportunities was the average number of experimenter prompts per child.

Figure 3 shows that the robot WWO task yielded higher generalization quotients than in the other studies. Since different syntactic structures are used in the various studies, the best comparison is between Abbot-Smith et al. (2001) 3;9 children and the robot WWO 3;6 children, because the syntactic structure was of a similar complexity to our stimuli (a verb followed by a single argument). Abbot-Smith et al.'s children matched to the novel structure 1.56 times out of six opportunities with 49 models (prop. = 1.56/(6 + 49) = 0.028). The robot study children yielded six novel structures out of 54 opportunities and nine models (prop. = 6/(54 + 9) = 0.095). Therefore, the slightly younger children in the robot WWO task were three times more likely to produce a novel WWO with each model or opportunity compared to the children in Abbot-Smith et al.'s study. Since the generalization quotient is higher than in all of the previous studies, the robot WWO task seems to be a more robust way to elicit novel word orders.

Although the robot WWO task yields higher use of the novel WWO structure, behavior in the task does not exhibit the same sensitivity to input factors as in earlier studies. In earlier WWO studies, children had more trouble using the novel WWO order as they got older and with familiar verbs. These studies argued that the difficulty in using the WWO was due to competition from the canonical structures in the child's native language. As these native language structures grew in strength as children aged or with native language verbs, children would be more reluctant to use the WWO structure. In contrast to this expectation, the older children in the robot task were more likely to use the WWO. Since the robot WWO task differed from the original WWO task in the social knowledge that the children had about their interlocutor, it is possible that these changes were responsible for the difference in production behavior. In Experiment 2, we test this interpretation by manipulating these social features of the task.

EXPERIMENT 2: THE ROLE OF THE INTERLOCUTOR'S LANGUAGE ABILITIES IN THE WWO TASK

To examine whether social knowledge was influencing structure use, we compared the robot WWO task with two other versions of the task. One version was designed to match the features of the previous studies that we thought were socially unnatural. Therefore, we had the experimenter command the robot to find the stickers and then had the child describe what the robot did to the experimenter. This version of the robot task mimicked two of the features of the previous WWO tasks: (1) the children and their interlocutor share the same dominant language, and (2) the children are asked to describe a scene that their interlocutor has already seen. Since the experimenter produces the target structure in each trial to command the robot, the child actually hears the WWO utterance that they should use and,

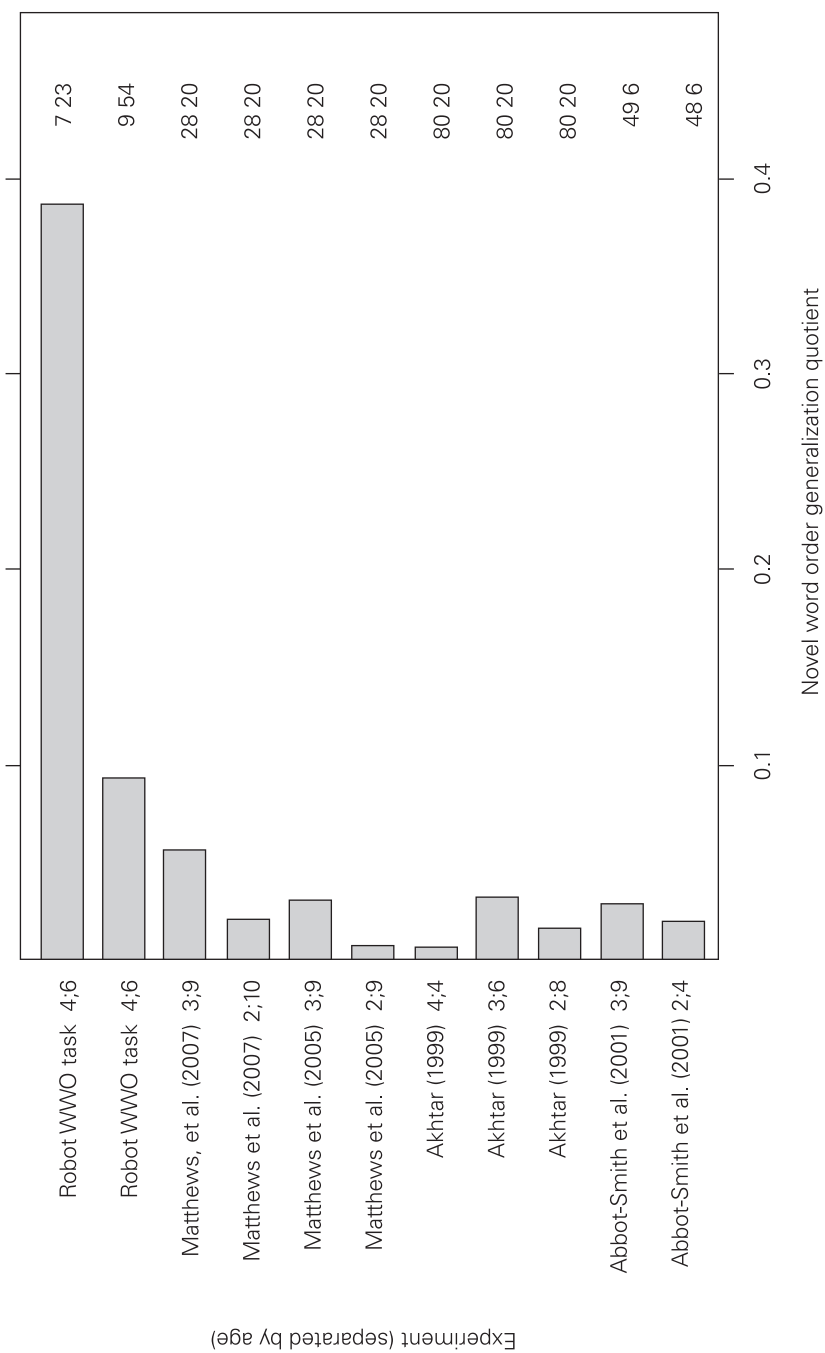

Figure 3 Novel word order generalization quotient for various WWO studies divided by age (the number of models and opportunities are shown on right)

therefore, an input-driven account would predict that the use of the novel structure should rise in this condition. However, if the child is sensitive to the fact that their interlocutor understands Japanese and already knows what the robot has done, then we should expect lower use of the novel WWO structure in this condition. Since this condition mimics the situation where a child speaks with an interlocutor who understands the child's native language, we called this condition the Native-Match condition. On the other hand, the original robot WWO task is a situation where the child must use the WWO structure with an interlocutor who prefers the WWO, and therefore that condition was called the WWO-Match condition.

Since the Native-Match condition changed the context of the interaction in several ways, we also wanted to have a comparison that was more focused on the social knowledge that the child represented about their interlocutor's language abilities. To do this, we created another version of the robot WWO task, which was identical to the original robot WWO task, except that before the experiment began, the robot was shown to understand some utterances in Japanese. Therefore, if the child is sensitive to the language abilities of their interlocutor, they should use the WWO less with a robot that understands both the WWO language and Japanese (we called this condition the Both-Match condition). If the language abilities of their interlocutor are irrelevant for syntactic generalization, then we should see no differences between the Both-Match and the WWO-Match conditions.

Method

Participants

Thirty normally developing Japanese monolingual children participated in the study (15 girls). The children had a mean age of 4;6 (range 4;4–4;8).

Materials

The same two Japanese verbs from Experiment 1 were used (point = *yubisashite*, look = *mite*).

Design and procedure

The experimental condition was manipulated between subjects. Data for the WWO-Match condition came from the 4-year-old familiar verb condition in Experiment 1.

The Native-Match condition was designed to approximate the earlier human-based WWO studies within our sticker search task. Instead of having the child command the robot, the adult commanded the robot with the WWO utterance, and then prompted the child to describe the action with three questions in the child's native language. The prompts were designed to be similar to those in the WWO-Match condition. The first prompt was the question 'What did the doggie do?' (*wanwan nani shita?*). That was followed by the prompt that mentioned the target verb ('What did the doggie point at?,' *wanwan wa nani o yubisashita?*) and then one that mentioned the target object ('What happened to the apple?,' *ringo-no-koto nani shita?*). After each question, the experimenter would wait for a response and respond with approval for any response. The second part of the search trial was the same as the first part except the experimenter would command the robot with the looking verb (e.g., *mite ringo*, look apple). And after the action was complete, the same questions were asked with the verb 'point' replaced with 'look' ('What did the doggie do?,' 'What did the doggie look at?,' 'What happened to the apple?'). The same procedure was used for the practice search trials.

The Both-Match condition was exactly the same as the WWO-Match condition, except before the normal warm-up procedure was done, the child was shown that the robot could also understand some Japanese utterances. The robot was commanded by the experimenter in Japanese to perform five actions. None of the actions used the target verbs 'point' or 'look.' First the robot was commanded to stand (*tatte*) and the robot got up from its sitting position. Next, the robot was asked if he liked apples (*ringo suki?*), and the robot barked in response. Next the robot was told to sit in another location (*koko ni suwatte*). Then the robot was told to hit a pen with its head (*kono pen oshite*). Finally, the robot was told to walk to the location where the warm-up procedure normally started (*asoko ni aruiteitte*). Then the normal WWO-Match procedure began and the child saw that the robot understood WWO utterances with the verbs 'point' and 'look.'

The data were coded in the same manner as in Experiment 1, except for the Native-Match condition. In that condition the experimenter said the target command before asking the questions. Sometimes the children repeated the experimenter's command before the prompt questions were produced. These repetitions were excluded from the analysis because these responses were not answers to the experimenter's questions. All other responses to the experimenter's questions with both verb and object were included in the analysis. A second independent Japanese coder recoded 12 children and 97% reliability was achieved. Table 1 presents the means and standard deviations for each of the conditions.

Results

A mixed-effect model with social condition (WWO-Match, Native-Match, Both-Match) was fitted to the mean participant frequency of WWO VERB-OBJECT and Japanese OBJECT-VERB structures produced and an analysis of variance was applied to the model. As can be seen in Figure 4, there was a significant effect of social condition for VERB-OBJECT structures ($F(2,27) = 13.0$, $p < 0.001$). Contrasts determined that the WWO-Match condition was significantly different from the Native-Match condition ($t(27) = 5.1$, Cohen $d = 3.1$, $p < 0.001$) and the Both-Match condition ($t(27) = 2.5$, Cohen $d = 0.97$, $p = 0.018$). For the OBJECT-VERB condition, there was no effect of social condition ($F(2,27) = 0.63$, $p = 0.54$).

To examine the choice between these two structures, a second analysis of variance with social condition was applied to the empirical-logit-transformed participant proportions. The analysis of variance showed a main effect for social condition ($F(2,27) = 7.02$, $p = 0.004$). The difference between the WWO-Match and the Native-Match conditions was significant ($t(27) = 3.7$, Cohen $d = 2.19$, $p = 0.001$). The difference between the WWO-Match and the Both-Match conditions was only marginally significant ($t(27) = 1.8$, Cohen $d = 0.75$, $p = 0.082$), where the high proportion in the WWO-Match condition was weakened in the Both-Match condition.

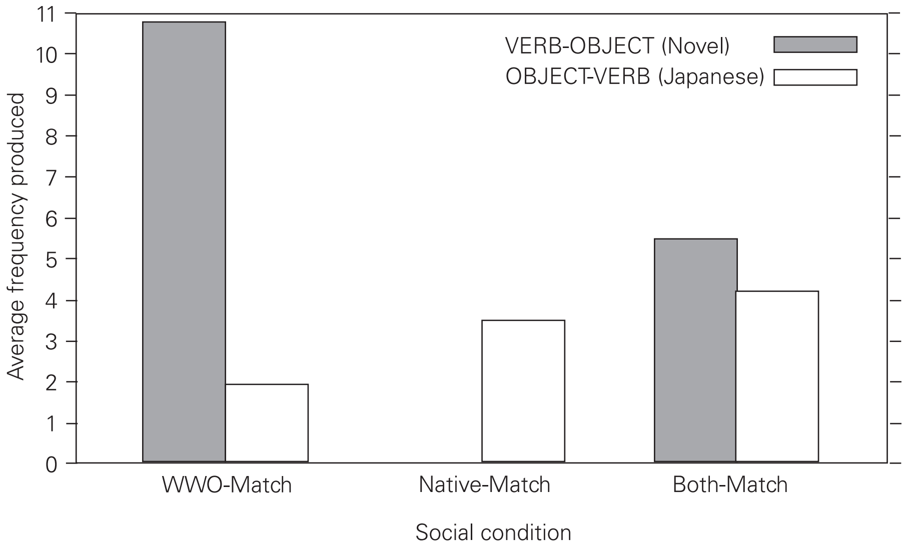

Figure 4 Average frequency of word orders produced by social conditions

Since there was an effect of social condition on structure choice, we examined how the number of WWO models or the number of prompts differed for each condition. On average, the WWO-Match condition children heard seven models, the Native-Match children heard 11 models, and the Both-Match children heard eight models. The WWO-Match children got 18 prompts with four isolated verb prompts, the Native-Match children heard 40 prompts (this condition did not have the isolated verb prompts), and the Both-Match children heard 41 prompts with seven isolated verb prompts. As in Experiment 1, the number of models and prompts did not predict generalization of the WWO structure. The Native-Match children never used the WWO even though they heard more WWO models and they had many chances to respond. The Both-Match children had a similar number of models to the WWO-Match children, but had a much larger number of prompts. The large number of prompts in the Native-Match and Both-Match conditions was due to the fact that the children did not respond to the earlier prompts (prompts were stopped when a response with a target verb and the target object, in either order, was produced). This reluctance to produce a response could be due to the child's uncertainty about which structure was most appropriate for their interlocutor, since in both of these conditions, the child's interlocutor was able to understand both the WWO and Japanese.

Since the number and types of prompts depended on how the child responded, we performed another analysis that removed this variation. For this analysis, we removed any target utterance produced after an isolated verb prompt, since these prompts might encourage the VERB-OBJECT order. We also removed any target utterances with the second verb where the experimenter modeled the VERB-OBJECT order for the first verb in the pair. When an analysis of variance was applied to the empirical-logit-transformed participant proportions, similar results were obtained. There was a main effect for social condition ($F(2,27) = 6.4$, $p = 0.006$). The WWO-Match versus Native-Match contrast was significant ($t(27) = 3.6$, $p = 0.001$) and now the WWO-Match versus Both-Match contrast was also significant ($t(27) = 2.1$, $p = 0.046$). The stronger contrasts might be due to the removal of items that were influenced by the experimenter's prompts, and hence social knowledge might have had a bigger effect on the remaining items. This analysis provides further support that the effect of social knowledge was not due to the differences in the prompts across conditions.

These results demonstrate that children were sensitive to the different social conditions and this sensitivity influenced how often they produced the novel VERB-OBJECT structure as well as the relative likelihood of choosing that structure over the Japanese structure. The difference between the WWO-Match condition and the Both-Match condition suggested that children were taking the language abilities of their interlocutor into account, since these two conditions were identical, except that the Both-Match condition children saw that the robot responded to five Japanese utterances at the beginning of the study. The fact that these utterances, which were irrelevant to the sticker search game, could reduce the number of novel VERB-OBJECT structures by almost half suggests that the knowledge that the robot could understand some Japanese made the children less sure about using the WWO. This suggests that 4-year-old children were sensitive to the language abilities of their interlocutor and were using that social information in deciding how to generate their own utterances.

The difference between the WWO-Match and the Native-Match conditions helps to explain some of the discrepancies between the results in Experiment 1 and the earlier WWO studies. The Native-Match condition was similar to the earlier WWO studies in that the child must describe an action to an interlocutor who speaks the child's native language. In the Native-Match condition, we replicated the reluctance to use the WWO structure that was found in earlier WWO studies. In those studies, the unwillingness of older children to use the WWO was taken as evidence that the canonical word order of their native language was suppressing the use of the WWO. That account would be unable to explain our finding that children at the same age will use the WWO quite often in the WWO-Match condition. Our results suggest that social knowledge might obstruct the influence of input in syntactic generalization.

The unwillingness to use the WWO in the Native-Match condition also addresses several general questions about the robot task. It is possible that the frequent use of the WWO in Experiment 1 is just a property of a freer word-order language like Japanese or the simple nature of ordering two words in commands. The fact that Japanese children are unwilling to use this simple process in the Native-Match condition suggests that children find it hard to order these words when the situation is not appropriate. Several of the earlier studies had the children learn different word orders for different verbs and the complex verb-structure mapping could have been the main reason why children were reluctant to use the newly learned word orders. However, our results suggest that this reluctance is present even when you have only one structure to learn, as long as the structure is inappropriate for one's interlocutor.

Our results suggest a social interpretation of the earlier WWO studies. Rather than assuming that input frequency is instantiated directly in the syntactic structures themselves, our results suggest that input frequency is instantiated in the links between social features and syntactic structures. When a child is interacting with an interlocutor that speaks their native language, input frequency should influence their behavior. But when a child is talking with a speaker who does not speak their native language, their native language representations should be suppressed and should not interfere with their learning or use of the WWO. This contextualization of syntax by situation should come about automatically if children are learning statistical regularities between their language input and extra-linguistic meaning, as is assumed in many models of language learning (Chang, Dell, & Bock, 2006; Gleitman, Cassidy, Nappa, Papafragou, & Trueswell, 2005; Tomasello, 2003). Social knowledge is just another type of meaning that contributes to the language learning process.

CONCLUSION

The study of the acquisition of new syntactic structures in production must balance two demands. The first is that syntax is abstract and, therefore, the best evidence for this knowledge is the ability to generalize these constraints to novel meanings or words. The second is that syntax is learned and the study of this learning requires that we control the conditions in which these structures are learned. It is important to have syntax acquisition tasks that allow us to attend to both of these demands. It is also critical to use tasks where children cannot succeed by imitating the experimenter or by using information from their previous language experience. The WWO task has many of these properties, but was not designed to study the learning of the WWO and children were reluctant to use the WWO in previous studies. The robot WWO task resolves these problems by making the WWO utterance both appropriate and informative for the child's interlocutor. The results with the robot task diverged from earlier studies with respect to input factors like age and verb familiarity. A follow-up study demonstrated that the differences between these studies were most likely due to the social knowledge in each task. These results suggest that children can contextualize their knowledge for different situations, so that knowledge that is appropriate for Japanese interlocutors does not interfere with production of a non-Japanese structure.

In this study, we provide some of the first experimental evidence that children are using information about what their interlocutor knows or prefers to decide about whether to use a newly learned syntactic constraint. Although there is not much research on this particular issue, there are many reasons to think that social knowledge should interact with syntax. First of all, social knowledge often plays a large role in adult language. For example, pronoun use depends on which referents your interlocutor knows or can infer and pronouns can vary in different syntactic contexts (e.g., she, her). Second, many languages have rich systems for marking social relationships. For example, every main clause verb in Japanese marks the speaker's politeness level, which depends on the speaker's relationship with their listener. In addition, syntactic structure can also vary depending on whether the referent is the speaker's interlocutor or a third party. For example, the Japanese version of the sentence 'Tom likes cake' uses different case-marked particles (*ga/wo*) and verb forms (*hoshii/hoshigatteiru*) if Tom is the speaker's interlocutor (*Tom wa keeki ga hoshii*) or if Tom is a third party (*Tom wa keeki o hoshigatteiru*). These types of phenomena suggest that adult syntax can be penetrated by features of the social context.

Second, it seems that young children are sensitive to information about others' knowledge state or preferences (Moll, Carpenter, & Tomasello, 2007; Song, Baillargeon, & Fisher, 2005; Tomasello, Carpenter, Call, Behne, & Moll, 2005). There is also evidence that young children understand some pragmatic constraints on conversation (Eskritt, Whalen, & Lee, 2008). And there are correlations between features of complex syntax and the ability to understand false beliefs in 3- to 5-year-old children, suggesting that syntax might be linked to the ability to represent the mental states of others (Villiers & Pyers, 2002). This evidence suggests that even young children can perform some sophisticated social processing and these social processes seem to be related to language development and use.

Finally, there is evidence that young children can vary features of their language production behavior for their interlocutor. Children in bilingual environments must determine which language to use with which interlocutor, and there is evidence that young children start to differentiate their languages early on using cues like interlocutor identity (Genesee, Boivin, & Nicoladis, 1996; Genesee, Nicoladis, & Paradis, 1995; Nicoladis & Genesee, 1996). There is also evidence that children vary their language use within a language depending on their interlocutor's abilities. For example, 3-year-old and 5-year-old children will vary the length of their utterances appropriately when speaking to an adult or a doll that looks like a toddler (Warren-Leubecker & Bohannon III, 1983); and 4-year-old boys will use more complex syntactic constructions when speaking to a 2-year-old who is considered high verbal compared to a low verbal child (Masur, 1978). Very young children are not adept at adjusting their speech for their listener, but these abilities become more adult-like over development (Dunn & Kendrick, 1982; Mannle, Barton, & Tomasello, 1992; Shatz & Gelman, 1973; Warren-Leubecker & Bohannon III, 1983). If this change in the ability to adjust speech for one's interlocutor is partially due to changes in the ability to represent interlocutor-specific preferences, then it is possible to suggest a common mechanism for the developmental effects in these earlier studies and Experiment 1. The ability to represent social knowledge grows stronger during development and these social representations directly influence structure selection. So instead of simply selecting syntactic structures based on input frequency, children may be trying to select structures that are appropriate for each situation with input strength only becoming relevant within an appropriate context.

In sum, there is evidence that young children are making use of social knowledge about their interlocutors, they can use interlocutor-specific information to help in word learning or language differentiation, and adult syntactic knowledge seems to be sensitive to features of the social situation. In this study, we have brought some of these factors together, by showing that the learning and generalization of a new word order can be influenced by what the child thinks that their interlocutor knows, and this provides some evidence for a direct link between social knowledge and syntax. In addition, we have also provided an experimental paradigm where children can demonstrate their ability to use a newly learned syntactic constraint, and this paradigm could be useful for further study of how various factors, both social and non-social, influence the acquisition of syntactic structures for sentence production.

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