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Utilizing Pragmatic Frames as an analytical tool for children's performance during word learning

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***Abstract*—Typically, to assess children's performance in a word learning task, a category coding is applied to the answers given by the children, according to which they can score "1" when correct and "0" when incorrect. This paper extends the current methodology: Following a recently re-introduced theory of Pragmatic Frames, the construct of Pragmatic Frames is proposed as an analytical tool which makes it possible (1) to describe children's performance in more detail and (2) to gain more insight into their pragmatic competencies.**

Keywords— pragmatics, word learning, Pragmatic Frames

I. INTRODUCTION

In a typical experimental word learning situation, a child is first taught a novel word and then tested on performance: In a comprehension test, a child is requested to choose from a selection and to point out the correct referent; in a production test, the child is asked to label an object or picture that the experimenter is showing. In both tasks it is common to apply a category coding to assess the child's performance: For example, children are awarded with "1" for a correct response (saying the novel word or pointing to the referent), while "0" is given to any other response. Thus, usually, the category accounts for the word production or word comprehension only, without giving children credit for their pragmatic behavior, in which their performance is wrapped. More specifically, children's behavior will only be acknowledged, when they succeed in producing the correct word form verbally (for word production) or when children act in an appropriate way, for example by handing over or pointing to the correct referent (or its pictures) out of some possibilities (for word comprehension). This way of assessment focuses on the correct answer by categorizing any other behavior as a failure or not appropriate. Yet, every experimenter will agree that there are many types of failure and it is insightful to analyze the different ways in which children might fail the task. In fact, in many word learning studies, e.g. [1], [2], when looking at individual differences, interpretations for children's failure are offered if their behavior might express some understanding of the interactive requirements. In this paper, we present a new method of analysis that aims to comprise the pragmatic behavior of a child. This is possible, because we utilize the notion of Pragmatic Frames to account for the whole pragmatic task and thus the sequence of behaviors that a child is producing while responding to the request.

A. Pragmatic Frames

The concept of Pragmatic Frames has many roots. One of them can be traced back to the work by Bruner [3], in which he proposes a matrix of routinized interactions that emerges between interactants, consisting of some communicative means with which a deep structure of meaning is realized. Importantly, this matrix is consistent as an order of behaviors corresponding to particular phases. This order allows the matrix to be repeated, and with increasing experience, a child can anticipate each step or the matrix's goal. One important characteristic of this matrix is that it comprises the different roles of the interaction partners. This means that a particular order of behaviors is structured among specific interactional roles of the participants, which they have to fulfill with their behavior. In a peek-a-boo-game, involving face covering and reappearing, Bruner [3] observed that children were increasingly able to take an active role. This increase was recently demonstrated in a longitudinal study following peek-a-boo 'syntax' by Nomikou and colleagues [4]. In this data, it was observed that infants are taking up an active role, but also that the caregivers will assign a role to their child and expect it to be fulfilled. The mastery of a pragmatic frame can be characterized by the ability to fulfill any role in it.

The other root of Pragmatic Frames can be seen in Wittgenstein's language games [5]. In Wittgenstein's work, verbal utterances are tightly linked to a behavioral disposition. For example, if somebody say "give me the apple!", the utterance is considered understood if it accords with the addressee's act of giving the speaker the requested entity. Thus, understanding the utterance results in a disposition of giving. From this example, it becomes obvious that the meaning of an utterance and the effect that it has on the interaction partner is at the fore of Wittgenstein's approach. The nature of the meaning highlights the dependence of interaction partners on each other: The symbol is effective, because it is linked to the behavioral disposition of the interaction partner. While this approach is not concerned with learning, for word learning, it raises the question

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of how the behavioral disposition can be learned and retrieved when hearing a specific utterance.

B. Pragmatic Frames in Language Acquisition

One of the most important frames in language acquisition that is discussed as highly relevant for language acquisition is the frame of labeling. In this situation, the competent speaker is highlighting an object or event (e.g., pointing to an apple) to the learner and naming it (saying "that's an apple!"). In developmental studies, such a pragmatic situation is considered to be the key to word learning because the naming is clearly referential, and the child can easily identify the referent for the mentioned new label. While the pragmatics of this labeling situation certainly address the problem of resolving reference, it should be highlighted that it is a specific frame that limits the process of word learning to the coordination of partners' attention yielding a clear connection between the referent and the word. This very specific context of labeling, however, can be helpful for recognizing the interactional structure that is distributed between the partners according to their roles. Thus, in the following, we will focus on that frame.

Within a socio-pragmatic approach to language acquisition, Tomasello, Akhtar and colleagues, e.g., [6], [7] investigated the frame of reference, i.e., children's ability to infer the referent from the adult's communicative action and to learn words in this context. This frame of reference was dubbed joint attention and characterizes a routinized pattern of attention, in which partners not only coordinate towards an external object or event but are also aware of their mutual engagement towards it. Tomasello and Todd [8] provided evidence for joint attention being advantageous for word learning. From the developmental perspective, it is still intriguing to ask how children come to engage in joint attention. Tomasello [9] proposes the 9-month-revolution—a point in development, from which children are "beginning to understand other persons as goal directed". The solution to the reference problem seems to be the child's ability to recognize other persons as intentional agents [10]. In this view, however, this recognition goes hand in hand with attribution of mental states to others. In fact, Tomasello and colleagues [10] propose intentionality as the key skill that boosts children's ability to participate in frames of reference. There are, however, alternative ways by which children come to engage in frames of reference. Accordingly, not the mental state of recognition of intentionality but rather the scaffolding of children's active role is highlighted.

C. Application of Pragmatic Frames

In a recent work focusing on establishing reference, Heller and Rohlfing [11] identified interactive jobs that constitute this pragmatic frame of labeling. Generally, these jobs stand for units of behavior to achieve a joint goal but are organizationally distributed between partners. The organization functions like an adjacency pair: There is a conditional relevance of one partner to follow (and accept the behavior of) the other. The following four jobs capturing the labeling routine were identified:

1) Establishing visual perception as a relevant resource, which is successful, when the partners agree on the means with which they try to influence each other's attention.

2) Constituting the domain of scrutiny, with which job the partners agree on a space that is relevant for the referent.

3) Locating the target, with the goal to select a target.

4) Construing the referent, with the goal to identify the target as a referent on the basis of the history of the interaction.

Heller and Rohlfing [11] exemplify that depending on the child's participation, at the beginning of establishing a routine, a competent partner can fulfill most of the jobs and thus scaffolds (or constrains) the child's active role. Furthermore, as shown in the longitudinal study of the authors, the elicited response of the child can be supported by the adult signaling its acceptance, or it can be corrected and thus considered an unacceptable response. This way, the child experiences a process of conventionalization, at the end of which she or he will know about the own contribution and can proactively set up the conditional relevancies on her or his own.

In this longitudinal study [11], the jobs as units of a Pragmatic Frame were considered as a product of a dyad, toward which the caregiver was naturally scaffolding the child. In our study (which we describe below), in turn, we asked whether the concept of Pragmatic Frames can also be used to identify pragmatic jobs within an experimental situation, in which the adult's behavior is more restricted and thus less scaffolding. We assumed that for this setting, the notion of Pragmatic Frames encompassing visible behaviors (as assumed in [3] and [5]) has to be extended to cognitive operations, as suggested by Rohlfing and colleagues [12]. In this recently proposed revision of the Pragmatic Frame Theory, cognitive operations that function as an inner behavior that is an integral and necessary part of a sequence of observable actions but performed covertly. However, in [12], these operations remained underspecified. The value of the presentation below is, thus, to offer a more concrete operationalization of possible operations.

D. Using Pragmatic Frames to account for pragmatic competence within an experimental setting

The general idea here is to use Pragmatic Frames to account for pragmatic skills in children. To put it broadly, pragmatic skills are responsible for coping with communicative situations and motivate the kind and manner of communicative actions that are appropriate with respect to the environment, the partner and other contextual circumstances. Pragmatic skills encompass nonverbal skills such as the child's ability to focus attention on a person or an object, and to produce a sequence of gaze and gesture if necessary, e.g., [13]. Usually, assessments of pragmatic skills have a clear target such as testing the children's ability to infer intention from a sequence of actions [14], or to understand irony or metaphors. This clear target is reflected by coding the children's behavior in a binary way. Here, we propose a gradual coding that accounts for both children's interpretation and disposition of an appropriate action within a particular situation. What we mean by pragmatic skills here is a task-specific understanding of a communicative action and the means with which the communication can be achieved. Importantly, it pertains to a specific task that can then be divided into specific jobs gradually building on each other. The gradual way, we argue, is the pragmatic competence of putting a

sequence of behavioral units together in order to join the partner's (verbal and nonverbal) actions meaningfully.

For the assessment, we selected an experimental labeling scenario. It offers several opportunities to test word knowledge after a training, in which within a labeling frame, the child is exposed to a new word for a new referent. Within this labeling scenario, a child's answer consists of several units. These units, following the theory of Pragmatic Frames [12], are assembled from both overt (interactive and communicative behavior) and covert (cognitive operations) behaviors. Below, we derive these concrete units, calling them 'jobs', by micro-analytically looking at the children's performance. We hypothesize that the fulfillment of the third job (Accepting the role of an addressee) marks an important step in the pragmatic development because a child shows the ability to take an active role within a more demanding (because it is less scaffolded) interaction. The study was carried out with two age groups, for which we hypothesized that they will differ in their pragmatic competencies.

II. Method

The word learning study was carried out with two age groups to investigate age-related differences of pragmatic competencies: a younger group of 21-month-old children (N = 21), and an older group of 27-month-old children (N = 26). In the study, *a retention task* was administered tapping into children's ability to produce a new word. This task was followed by *a generalization task*, in which children demonstrated their extended understanding of the new word by singling out a new exemplar of the referent. These two tasks are considered separately because their cognitive complexity is different.

A. Procedure: Retention Task

After a training session, in which an experimenter labeled a novel object, presented together with two other novel objects on a table, the child's knowledge of the new word was tested, i.e. his or her word production. In contrast to the majority of studies focusing on only one word class, e.g. [1], [2], we tested children for nouns, adjectives, and numbers (three items total). In a session, the experimenter called the child by her or his name while pointing to a referent and gazing at the child, she then asked for production ("what is this?" for a noun, "what color is this block?" for an adjective, "how many are there?" for a number). Within this labeling scenario, a child's answer consisted of several units assembled from both cognitive and interactive behavior (specified in section II C). At the end of this sequence, the task required the child to produce the word for the referent (an object's name, a color adjective or a number).

B. Procedure: Generalization Task

Following the retention task, children's generalization of the target word to new exemplars of the referent was tested. The experimenter put the objects known from the training in a non-transparent box under the table, and presented new objects on a tray (e.g. pencils of different colors). While gazing at the child, she asked him or her to pass an object, e.g., for color adjectives: "Can you give me the grey pencil?" Thus, together with children's ability to generalize the target word, we tested her or his word comprehension. Within this scenario, again a child's answer consists of several units, at which end she or he is supposed to pass the correct object.

C. Coding of children's performance: Retention Task

Looking at children's answers, we identified two types of behaviors that reflected their competence (see Fig. 1): on the one hand, *interactive behavior* taking up on what the interaction partner (i.e., the experimenter) initiated; on the other hand, the chosen means of productive behaviors that gave insights into children's *referential disposition* with respect to the task.

Interactive behavior. We identified five jobs that were considered to follow on from each other in a sequence (jobs listed in detail below). The implicit assumption is that these jobs hierarchically depend upon each other, i.e., a child can perform a job only if she or he completed the preceding job. More specifically, a child can only produce a new word if she or he was able to understand the turn and to take it. However, without necessarily having to produce a new word, a child was credited for her or his pragmatic performance. In accordance with this hierarchy, a coding system was developed that captures the fulfilled jobs (see Fig. 1). Each job was coded in a binary way, as either being fulfilled (1 point) or not (0 points).

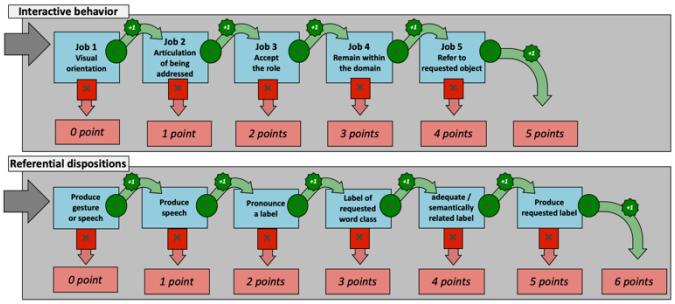

Fig. 1. A coding system capturing the fulfilled jobs and the assessment of the fulfilled requirements in the retention task.

The identification of the following jobs was driven by the previous literature and the focus on the child's pragmatic competence within the frame of labeling a referent.

1) Job 1 *Visual orientation towards the frame*: The child is requested to orient her or himself towards the partner and to respond to her ostensive communication with gaze, eye contact or, at minimum, body orientation. For the coding, the moment at which the experimenter was gazing at the child was crucial. The job was coded as fulfilled as soon as the child shifted his / her gaze between the experimenter and the stimulus before, during or after the experimenter's request. In terms of the taxonomy by Heller and Rohlfing [11], this job concerns the constitution of the domain of scrutiny. All of the children showed visual orientation towards the frame.

2) Job 2 *Articulating an understanding of being addressed*: The child is requested to interpret the situation as a communicative act and to 'activate' a behavioral disposition. In this vein, if a question is asked, the addressee needs to know that she or he is requested to answer, i.e. to provide the requested information. Even if this requested information is not available, the addressee is expected to articulate an understanding of being addressed and to fulfill this answering role. This capability likely relies on a conception of an interaction consisting of behavioral units that are bidirectional, depending on the dialogical role. Such a behavioral disposition

is commonly referred to as a concept of adjacency pairs. Whereas for adults a clear disposition results in an almost reflexive answer, this is not a given in the case of young children, and therefore interesting for the developmental perspective on the pragmatic competence. For the coding, a time-contingent change in the behavior was crucial. If the child articulated any behavior soon after the request, it was interpreted as meeting the interactive requirement of understanding that they were being addressed. Behavior such as handing the turn over to the caregiver, or behavior that displayed a refusal, such as looking somewhere else or turning away, suggests that even though children did not accept the role of the addressee, they understood this interactive role, and thus this behavior was considered as fulfilling the job.

3) Job 3 *Accepting the role of an addressee*: This job accounts for the child's acceptance of her or his communicative role within the task (as opposed to refusing or handing the turn over). This acceptance goes hand in hand with the child's 'willingness' to be (and to stay) a part of a joint communicative endeavor in pursuit of a particular goal [12]. In the coding, any verbal and nonverbal behavior with which the child was attempting to follow the request attested to an ability to fulfill her or his role. Typically, children pointed to an object or produced a verbal utterance related to an object or its features. For this particular job to be coded as fulfilled, it was not necessary to say the appropriate label or to point to the requested referent. Any communicative action of pointing to objects or attempts of labeling (also of other objects or people in the testing room) was sufficient to demonstrate a pragmatically appropriate knowledge of this job. The job was regarded as not fulfilled in cases, for example, in which the child refused to answer or started to explore objects.

The two remaining jobs can be described as jobs at the top of the hierarchy. They both account for the linguistic understanding of the labeling request.

4) Job 4 *Remaining within the domain of scrutiny* assesses whether the child remains within the ongoing frame of labeling, and thus the space in which the objects in the label game were present, or leaves it. A child fails to fulfill the job when her or his gaze (or pointing gesture) refers to an entity outside the domain of scrutiny. This is the case for example if, soon after the experimenter's request articulated by "what is that?" and a pointing gesture to an object on a table, the child points to the camera. In this example, job 3 is fulfilled, because the child articulates the role of being addressed, but Job 4 is not because the child leaves the domain of scrutiny.

5) Job 5 *Referring to the requested object*: The child fulfilled the job if she or he referred to the object requested by the experimenter using nonverbal or verbal behavior.

Referential dispositions. Children's responses differed in terms of how they referred to the referent and thus how they fulfilled the pragmatic requirements of the task. For the coding, we first captured all the ways in which children responded. Then, we ordered them in a way they advance the task requirements. Finally, we assessed what kind of a referential behavior children disposed of. This coding was relevant only when the child fulfilled the fourth interactive job and thus remained within the domain, the labeling frame.

1) We took any speech production (vocalizations, protowords, words and sentences) and gesture use (index finger- as well as hand-points, and conventional gestures) into account to tick children's disposition of *Gesture or speech production*. As an effect, children that favored nonverbal behavior were considered to perform this job as well as children producing speech. For more advanced referential behavior, however, speech production was required.

2) If the child decided to produce speech in form of protowords, vocalizations, or deictic expressions to refer to one of the objects, we coded this way of referential behavior as *Produces speech*. Thus, even though children did not produce a label, they could demonstrate the disposition of verbal means.

3) A criterion for the more advanced task requirement was to *Pronounce a label* that is word-like. For the coding, it was of critical question whether the vocalization comprises a syllabic structure consisting of (a) vowel(s) and consonant(s).

In our further assessment, semantic features of the requested label were important. The following order emerged because some children labeled an entity in a pragmatically correct way but semantically, these labels were wrong or only partly correct. The advantage of our coding is that the selection of the object and the production of the label can be differentiated within the frame of reference.

4) The observation of children's answers that we made (5 answers from 4 children) let us assume that for the production task, it was necessary to *Produce a label of the requested word class* (noun, adjective, or number): In the case when the experimenter asked "How many buttons are there?", the child can dispose of an answer with any number or the ability to count the buttons. Thus, we considered any association with a number to be appropriate but less advanced for the task requirement.

5) A more advanced production of a label is reflected in semantic appropriateness of the chosen label that is expressed in *Produce a semantically adequate label*: For the production of an adjective, it is semantically appropriate when an orange object is labeled as "red". For the production of a number, it is appropriate to say a number without counting or giving more numbers. The production of a noun, in turn, requires a word that is semantically close to the target referent, e.g., "pants" for "belt buckle"—in these examples, obviously, the fast mapping of the phonological form failed but the child's pragmatic action took place because it was based on a semantically similar concept.

6) Finally, with the fulfillment of *Produce the requested label*, the target of the task was reached if the child produced the label that was trained in the training session. The nonverbal orientation to the referent (gazing or pointing to it) was not necessary for it.

In this assessment, a child could obtain a maximum of 6.

D. Coding of children's performance: Generalization Task

Similar to the relevant behavior in the retention task, in generalization task, *interactive behavior* takes up on what the experimenter initiated; the coding of *referential dispositions* reflects children's advance in choosing actions and disposing of cognitive operations that are appropriate to construe the reference in accordance with the task requirements.

Interactive behavior. We identified four jobs, of which the first three are identical to Job 1–3 of the interactive behavior in the retention task (see above).

4) Job 4 *Child follows the conditional relevance* within the adjacency pair: The experimenter's request to pass an object makes it conditionally relevant to transfer an object. Thus, children's actual or clearly recognizable effort of transferring an object was coded as correct.

Note that in the generalization task, the child was also requested to remain within the domain of scrutiny. However, as this task consist of both, comprehension of the new label and generalization to a new exemplar of the referent, this job was coded within the referential behavior (Job 2 and 3).

Referential dispositions. The assessment of whether the task was fulfilled was coded along the following dispositions:

1) In the first step, with *Construing a referent*, we coded whether a child construed any referent following the experimenter's request. The objects on the tray were not necessary for it. We identified this disposition on the observation that some children searched for the original training object that was put in a box under the table. In this case, they showed some understanding for an asked referent.

2) The requirements 2 and 3 are related to one another and helped us to assess whether the child construed the referent within the domain of scrutiny, i.e., the space in which she or he has to look for the referent. Because our experimental setup allowed the experimenter to repeat the request if the child did not look at the tray for the requested object, we coded whether the child was able to *Construe the referent with support (Job 2)*

3) or *Construe the referent independently*. For coding this disposition, children's gaze direction as well as their referent selection was crucial. If a child disposed of the third referential behavior, the disposition 2 was also ticked.

Further cognitive dispositions. In addition to the dispositions described above that can be ordered from 1 to 3 to advance the task, there are further dispositions that need to be considered separately (see Fig. 2). To an extent, they are task-specific.

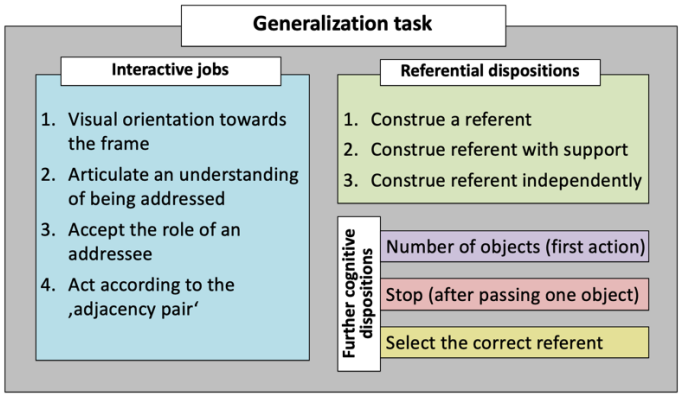

Fig. 2. A coding system capturing the jobs in the generalization task.

1) As first, *Number* captures the requirement to refer to the appropriate number of objects that the child selected. While the experimenter's request required to select or pass only one object, we observed that some children would select several objects at once (e.g., one in each hand). The challenge here is to selected only one object, which disposition is also observable when not the requested object (but only one) was selected.

2) Another challenge is to *Stop* selecting or passing objects once already one is selected. However, we observed that once children started to handle objects over, some children even 'cleared' the tray and thus, continue to give objects until no object was left on the tray.

3) With *Selecting the correct referent*, we assessed whether the child was successful in the generalization task and selected the correct object as the first one. Thus, if a child only passed the correct object without clearing the tray or selecting two objects at the same time, they achieved 3 points. If the first object was the correct one but afterwards, the child selected another object, she or he was awarded two points.

III. Results

In our study, we focused on word learning in different age groups administering retention and generalization tasks, for which we specified concrete jobs that follow the concept of Pragmatic Frames. Because of limited space, we report results from the retention task only. We hypothesized that the job *Accepting the role of an addressee* marks an important step in pragmatic development because a child shows his or her ability to take an active role within the interaction. In both age groups, we observed that some children would perform differently across the three trials, and thus did not use mean values for the analysis. Instead, we looked at how many children in each age group master this job in all of the trials within the retention task. We found that significantly more 27-month-old children were able to master the third job in all of the three trials (N = 10) compared to the 21-month-old children (N = 2; Fisher's exact test, p = .04). Interestingly, most of these children who fulfilled this third job in all three trials also achieved the maximum score of 5 in all trials. This supports our hypothesis that this interactive job is important for pragmatic competence. However, 17 children at the age of 21 months achieved this job once or twice, which means that the majority of children at this age was able and willing to actively interact in our task, but did not do so consistently. Similarly, 7 of the 27-month-old children achieved this job once or twice. Not surprisingly, the score from the scale of interactive behavior highly correlates with the scale of referential requirements (r = .87, p < .001) suggesting that those children who were able to produce some kind of verbal behavior (on their referential disposal) were more likely to receive higher scores for their interactive behavior.

However, what is surprising is that only two children from the 21-month-olds, but nine children from the 27-month-olds did not achieve this job in any of the trials. This could be an indication that the older children are more aware that a certain phonological form is expected: If they did not know this form and were aware of it, they might rather have resigned from tackling this job. This explanation is supported by further analyses of the phonological form showing that the younger children produced more errors than the older children. To put it in other words, older children seem to better estimate/identify the pragmatic demand of the job that consists of both, the communicative act and the disposition of an adequate form.

Younger children, instead, might be more spontaneous about saying something, and control less for the phonological form.

Coding children's performance in the retention task in the binary way leads to the results shown in Table I. Accordingly, none of the 21-month-old children produced a correct verbal label, and depending on the word class, only some or few of the 27-month-olds did so. However, when coding the different jobs, the studied children apparently displayed some knowledge and understanding of the task (see Table II).

TABLE I. Number of children producing the correct verbal response within the retention task (typical binary coding)

	nouns	color adjectives	numbers
21 months	0	0	0
27 months	11	5	4

TABLE II. Number of children achieving particular jobs and dispositions of referential means required within the retention task

		Interactive behavior: Jobs					Referential dispositions					
		1	2	3	4	5	1	2	3	4	5	6
21 months	noun	20	15	9	9	6	11	10	3	1	1	0
	color	21	16	10	9	7	14	12	3	1	0	0
	number	20	16	13	12	8	14	12	5	2	2	0
27 months	noun	26	23	16	16	14	16	14	11	11	11	11
	color	26	18	12	11	10	15	15	11	7	6	5
	number	26	22	13	13	11	14	14	9	9	6	4

The results from the generalization task are provided as supplementary online material: go.upb.de/psylingaom.

IV. Discussion

In this paper, our aim was to suggest a more fine-grained assessment of children's pragmatic competence in experimental word-learning settings by identifying the jobs that the task of labeling requires. Applying the concept of Pragmatic Frames [12] and following interactive jobs that need to be fulfilled to establish reference within naturalistic child-caregiver interactions [11], we identified elements of a sequence (consisting of overt observable behaviors as well as covert cognitive operations) that are necessary to accomplish the word learning task of retention and generalization. This approach allowed us to give children credit for their referential dispositions even if the final goal within this frame, i.e. to produce or comprehend a label, was not yet achieved. Applying this tool to existing data of 21- and 27-month-olds in a labeling setting, we found our hypothesis confirmed that Job 3, i.e., *Accepting the role of an addressee,* marks an important step in pragmatic development. Correspondingly, most of the children who fulfilled this third job in all three trials also achieved the maximum score in all trials. Overall, the results can be considered as the first proof of concept suggesting that this approach might serve as an analytical tool for children's performance during word learning. It also highlights the manifold pragmatics of a task: Firstly, it appears that the visual orientation – what is called 'joint attention' – is only one interactive job within many that needs to be fulfilled. Secondly, two further jobs (*Articulate an understanding of being addressed* and *Accepting the role of an addressee*) have to do with the child's dialogical role, his or her understanding (acceptance), and thus the will to cooperate. Furthermore, the generalization task is more complex as some cognitive requirements pertains to a particular word class. However, the identified task requirements as well as children's referential dispositions need to be confirmed in future work.

We are convinced that this fine-grained presentation of children's performance during word learning can be a first step towards becoming sensitive to different 'jobs' that are interactively accomplished within a task. With this analytical tool, comparisons of different tasks can be more easily achieved. In the future, we envision applying this tool to further investigate and explain how an individual can flexibly switch between different tasks—a flexibility that artificial developmental systems still cannot achieve [15]. For the assessment of individual pathways of learning, a state transition analysis might be a further step revealing whether children may repeat or skip certain jobs. Such an analysis could also reveal more about how young children learn the jobs required in, and thus the pragmatics of, learning tasks.

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