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How infants perceive the toy robot Pleo. An exploratory case study on infant-robot-interaction

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Abstract. In order to develop robot systems that can interact with untrained, naïve human users, it is important to understand how people – from different age groups – perceive a given robot system and which features might be relevant for this. While existing studies generally use questionnaires/interviews and/or coding schemes rendering either abstract categories or single features of individual behaviour towards a robot, we suggest to use a different methodological approach: to use the concepts and methodological tools from Ethnomethodological Conversation Analysis (EM/CA). Investigating video data from a study in which users – here: infants 3 to 8 years old – play with the toy robot Pleo, we show that and how (1) a user's perception, categorization and re-interpretation of a robot system emerges step by step during and from the interaction with the system, and (2) how the user's attempts to establish coordinated 'sequences of action' play a central role in this. The results of our initial exploratory case analysis are discussed in the light of studies which suggest that, in infants, robotic pets seem to blur foundational ontological categories, such as animate vs. inanimate.

1 INTRODUCTION

Over the last years, an increasing body of research has aimed towards developing sociable robot companions that might assist people with their daily routines in domestic environments or provide various sorts of services (such as guidance, entertainment etc.) to the public. As such systems are geared towards untrained, naïve users, it is important to design the interaction between robot and human in a way that users can intuitively interact with a system. In order to do so, it is crucial to understand how people – from different age groups – perceive a given robot system and which features of the system might be relevant for this.

While existing studies have mostly investigated the users' general attitudes towards and perceptions of robot systems using questionnaires and/or interviews [1, 2, 3], Kahn et al. [4] demonstrate that children's *reasoning about* robots (e.g. the robotic dog AIBO) and their *behavioural interaction with* these systems differ.[3] Most importantly, Kahn et al.'s study suggests that robotic pets seem to blur foundational ontological categories, such as animate vs. inanimate. They conclude that "the […] question for the future may not be, "Do young children treat such new technologies as either X or Y?" […] Rather, what may be needed is a more nuanced psychology of human-robotic interaction that can uncover emergent categories in children's understanding of and relationships with this potentially new technological genre" [4: 1451f.].

In this paper, we take up Kahn et al.'s call for methodological innovation and suggest to use the ideas and methodological tools from Ethnomethodological Conversation Analysis (EM/CA) to investigate – on the basis of videotaped data – the concrete ways in which users interact with a robot system in a first contact situation. This qualitative approach allows us to uncover (1) how a user's perception and categorization of a robot system emerges step by step during and from the interaction with the system and (2) to focus thereby on the user's attempts to establish contingent interaction with the system as a central basis for his/her perception of the system. Our initial case analyses suggest that users might not only (or primarily) consider the robot's physical appearance as grounds for their perception of a system [2, 3], but rather (or importantly) orient to systematic features of their interactional responsive conduct [6, 7]. To uncover those relevant interactional features is a central challenge for HRI.

In what follows, we will present some preliminary, explorative analysis from a study in which users of different age groups were invited to play with the toy robot Pleo. We will focus on two cases from this corpus – infants 3 to 8 years of age – and address the following questions: How do users perceive a robot system? How might their perception and categorization change over time while interacting with the system? How is this related to forms of contingent interaction they are able to undertake with the system? – Analysis will provide some first insights into the ways in which a qualitative-interactional approach is able to shed light on the question of perception and categorization of robot systems and provide the basis for further, systematic analysis of the entire data set.

2 BACKGROUND AND MOTIVATION

Over the last years, research in HRI has begun to explore people's attitudes towards and perceptions of robot systems: which kinds of applications and tasks they might be useful for [1], the attribution of competences on the basis of their physical appearance [2, 3], the relationship between the robot's physical appearance and its behaviour, or the effect of its human-like-ness [8]. On a methodological level, these studies have generally investigated the users' categorizations using questionnaires and/or interviews. However, Kahn et al. [4] suggest – analysing infant-robot-interaction – that participants' reasoning about

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[3] Similar differences in people 'talking about their actions' and 'doing' them have often been observed for adults and have lead in the Social Sciences to empirical methods that qualitatively reconstruct the participants' interactional practices [5].

robots and their behavioural interaction with them differ: On the one hand, infants' explicit evaluation of the robotic dog AIBO and a stuffed dog are similar with regard to animacy, biological properties, social rapport, mental states and moral standing. But their behaviour towards these objects shows e.g. that they engaged more often in exploratory behaviour and attempts of reciprocity with the robot and anxiously flinched away from it after it initiated an action. A follow-up study [9] comparing their conception of AIBO vs. a real life Sheppard dog showed that infants classified it as being more like a robot than a real dog and at the same time treated AIBO in ways that were dog-like. Based on this, the authors suggest that "a new technological genre" might be developing that challenges traditional ontological categories, e.g. between animate and inanimate.

Observations like these call for more detailed exploration of the concrete ways in which participants – both adults and infants – perceive and categorize robot systems. While questionnaires/interviews and coding of videotaped HRI (of measures such as physical distance, contact or body position) are able to reveal a *general attitude* towards these systems, but they won't be able to take into account the *interactional practices* which participants use to explore the system, whether/how their behaviour and their perception might change over time and which features of the robot's conduct they might treat as relevant for their categorizations.

This is where our study starts: We aim at exploring how the users' perception is instantiated within and through the interaction with the robot system, how their categorizations are shaped and re-shaped over time and which features of the systems conduct they orient to.

3 METHODOLOGY: CONVERSATION ANALYSIS AND CATEGORIZATION

In order to investigate the ways in which users perceive a robot in situ, i.e. in and through the interaction with the system, we use the basic concepts and methodological tools from Ethnomethodological Conversation Analysis (EM/CA) [5]. CA constitutes an ethnographic approach that aims at investigating the procedures and methods by which social interaction is organized. Its core, is to investigate the sequential relationship between the different co-participants' actions, the precise timing of events and how they are related to each other. In doing this, it is able – on a structural level – to show that and how some participant's multimodal action makes another set of actions contingently relevant (and provides a basis for detecting missing actions) and to reveal recurring interactional patterns that participants use to solve their concrete, practical problems in and through the interaction.

In this line, Conversation Analysis has suggested an interactional approach to "categorization", which is interested in reconstructing the practices and resources which participants use to refer to persons, objects etc [10]. An analytical apparatus has been developed – the Membership Categorization Device (MCD) – which consists of a set of categories and rules for their applications. Important to us is its idea of 'category-bound activities', i.e. the "kinds of activities or actions or forms of conduct taken by the common-sense or vernacular culture to be specially characteristic of a category's members" [10: 470]. A typical example for such category-bound activities is the often cited "the baby cried – the mommy picked it up" [11], in which the activity of 'crying' is tied to the category 'baby' in the MCD 'stages of life' and which introduces a scene, in which "the mommy" is understandable as the mommy of that baby. For our investigation of the users' perception of a robot system this is relevant on two levels: (i) through their own pro-active actions (first turn) and (ii) through their reactions upon the robot's actions (second turn) users attribute certain properties to the robot which define it as a token of a type X.

CA's way of proceeding is strictly empirical and qualitative. Analysis begins with a single case analysis in order to reveal – from the data themselves – the relevant analytical issues and categories. In doing this, it attempts to reconstruct the member's perspective – as opposed to applying an analyst's external interpretations or coding schemes to the data. At this stage, it consists of manual analysis, i.e. repeated inspection of video-taped data, transcribing the interaction and by this to uncover the precise timing and relationship of the events of all interaction partners. Its goal is to uncover the structural organization of the event and how one action makes another action contingently relevant next [5, 12, 13]. In a second step (which is beyond the scope of this paper), on the basis of a larger data corpus, it brings together a set of single cases analysis in order to reveal generalizable issues and patterns. A recent and methodologically highly interesting question is whether and, if so, how to best link results from CA to quantitative approaches [14, 15].

4 ROBOT SYSTEM: PLEO

As we wanted to explore how users of different age groups perceive, explore and interact with a given robot system, we chose to use a robotic pet that would be suitable both for infants and adults alike [17, 18]. We needed a system that is able to show 'social behaviour', to engage in sequences of action with the user and to be usable by the participants without prior knowledge or explanations. Also, we wanted it to be easily available and at a reasonable price, so that we would not need to worry having children experiment and play with it. Given these criteria, we choose for our study the robotic baby dinosaur Pleo[4] developed by Ugobe.

Pleo is about 19 cm tall and 50 cm wide, and disposes of sensors for sight, touch, sound and tilt/shake underneath a painted rubber skin. It has got loud speakers, infrared sensors/transmitters and 14 motors that allow for extensive body movement (Fig. 1).

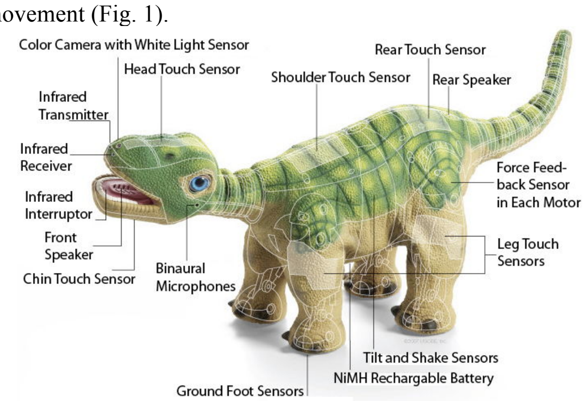


Figure 1. Pleo with its sensors

[4] For further details see `http:///www.pleoworld.org`.

The system disposes of a set of pre-defined actions displaying various emotions and attentional awareness (e.g. swaying its tail, hooting) and, at the same time, is able to learn over time depending on the input it receives from the interaction with the user. In its original state, Pleo behaves like a one week old dinosaur, and – from the interaction with the user – develops to display more and more actions over time. Further capabilities and features can be added to the system via a programming interface.

The Pleo robots used in our study featured the original software and had been intensively 'played' with for about 5 hours each, so that they were able to display (at least) the following behaviours: reacting upon caresses, walking, falling asleep and being waked up, 'eating' a green plastic leave (which is part of the Pleo package) and displaying playful behaviour with it.

5 USER STUDY

In order to investigate the ways in which users would interact with a robot system in a 'first contact situation', we have undertaken a field experiment videotaping pairs of users who freely played and interacted with Pleo (10-12/2008). We choose to investigate pairs of users ('dyades') as this would require the participants to talk to each other, to make their actions accountable for the co-participant and to display their interpretations of the co-participant's actions. This way, their 'practical reasoning' would be available for analysis and reconstruction by the researcher.

The corpus comprises of three different subgroups: (I) Children (3 to 8 years), (II) Teenagers (16 to 18 years) and (III) Adults (21 to 59 years) who all had some general interest in robots, but had no previous experience in interacting with them. For the study, each pair of users was lead to a room where a Pleo was waiting, which was then switched on by the experiment leader. Users did not receive any information about what the system was able to do or any guidance on how to interact with it. They were only instructed as to freely explore and play with the robot as long (or short) as they would like to, yet handle it with care.

	(I) Kids	(II) Teenagers	(III) Adults
Age (years)	3 to 8	16 to 18	21 to 59
Sessions	8	3	2
Duration/Min.	12'52''	23'44''	48'51''
Duration/Max.	42'26''	33'32''	54'20''
Duration/Avg.	28'05''	28'55''	51'53''

Figure 2. Corpus

For the exploratory case analysis presented in this paper, we consider two cases from group (I): a pair of two male siblings (aged 4 and 6 years) and a single girl (aged 3 years). [5] For group (I), the infants' parents or care-takers were generally present in the room being invited to take a seat next to the 'playzone', have a snack and observe their offspring playing (Fig. 3). During the first minute of the session, the experiment leader sat close by the children on the floor as to intervene if some damage to the robot would have been foreseeable, and then retreated to control the video cameras.

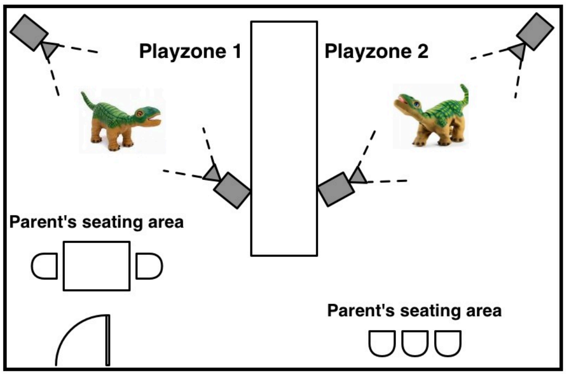


Figure 3. Set up: Infants playing with toy robot Pleo

6 CATEGORY-BOUND ACTIVITIES: STAGES OF INTERACTING WITH PLEO

In a first analytical move, we will be interested in the ways in which a user's perception and categorization of a robot emerges step by step during the interaction with the system. We will undertake a detailed case analysis in order to reconstruct the subsequent stages of the infant's conduct and her interaction with Pleo. Analysis will unveil the 'category-bound activities' that the infant exhibits, her methods of approaching the system and subsequent interpretations and re-interpretations of the new object during the course of the interaction.

Stage 1 (00:00 to 00:15): First intuitive approach – Handling an inanimate object. When the child – we call her Bea (3 years old, for details see section 4 and footnote 5) – enters the playzone, the experimenter lifts Pleo and switches it on. At this first moment of getting in contact with the robot, Bea touches Pleo at its head/mouth, i.e. that part of the robot that is closest to her and that she could reach instantly (Fig. 4a). The experimenter then offers her Pleo's leaf, which she takes but immediately puts to the side and, instead, clutches the robot's neck – making a fist and holding it tightly – and pulls it up (Fig. 4b). Thus, the infant's first, intuitive approach during the first 15 seconds exhibits no hesitation or fear, and the way in which she grabs it (i.e. rawly clutching) categorizes Pleo as some kind of inanimate object.

Figure 4. (a) Bea touches Pleo at its head while the experimenter switches it on; (b) Bea clutches Pleo's neck and lifts it up.

[5] Originally, the girl was expected to participate with her brother, but at the play session he was averted at short notice. As this part of the data collection took place during a science festival at Bielefeld University (`http://www.geniale-bielefeld.de`), we decided to not decline the girl's participation, but rather decided to include it as a special case in our study. In fact, during the session, the girl does not play with Pleo on her own, but – from early on – involves the experiment leader as co-participant.

Stage 2 (00:15 to 01:20): Socialization into appropriate treatment of Pleo – Experiencing Pleo as an animate object. When Bea clutches Pleo at its neck and lifts it up, the experimenter intervenes (in her responsibility to ensure the robot's safety): "not so strong- it might feel hurt" ("nicht so doll- dem tut das sonst weh"), and puts Pleo back on its feet. From this, a tryadic situation emerges, during which the infant is shown that her handling of the robot might not be appropriate and is offered alternative ways of treating Pleo: (1) Padding gently, and (2) feeding Pleo with the leave. During this second stage (which takes about 65 seconds) the child begins to experience Pleo as an animate object that has its own way of acting and might potentially be threatening.

We will show this in detail at the basis of an interactional fragment[6], in which the experimenter (E) suggests 'gently padding Pleo' as an appropriate conduct towards the robot. After rejecting Bea's (B) grabbing-round-the-neck (l. 01-03), the experimenter instructs Bea "you need to be ve::ry gentle" (04) while beginning to pad Pleo's back. The child immediately copies this conduct (l. 04, 21.10).

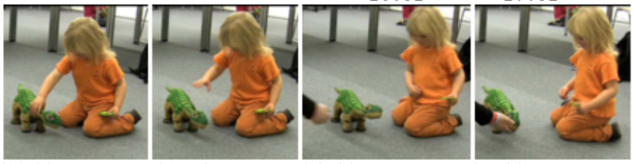
Fragment 1 (S005, 00:18 – 00:28)

```
01 B: grabs P's neck |...
   E:                |ah- nicht so ↑DOLL; (.) dem tut
                      ah- not so   ↑STRONG;   it might

02 E: das doch |↑WEH;   |
      feel      hurt
               |pads P |
   B:                   |lifts P's front legs |

03 E: |puts P on its feet          |
      |nicht dass du dem WEH tust; |
       not   that you would hurt it

04 E: |mußt du |ga::nz VORsichtig *sein; |
       you need to be ve::ry careful;
      |pads P's back                     |
   B:          |pads P's back ...................|
                                   *21.10
```

15.56 15.84 21.20

But soon – after the experimenter herself stops to do so – Bea again clutches Pleo's (P) neck (l. 05). Immediately after this, the robot turns its head slightly towards the girl and then produces a growling sound (l. 05: "gr:::", 24.20), which makes Bea abruptly retract her hand (24.72). Pleo then upgrades its sound as if crying "A::RRR" looking to the other side and then back towards Bea. Once it arrives again at Bea's she shrieks ("AH") and backs off an instance from the robot (26.32, 27.32). At this stage, Bea displays her understanding of Pleo as animate, i.e. as an object that reacts upon her actions – here: that exhibits its dislike of a certain kind of treatment (clutching the neck) which the experimenter previously has rejected as inappropriate.

```
05 B: |grabs P's neck |     |shrieks, retracts hand|
   P:        |head to C |gr::|::;
                            *24.20          *24.72

06 P: ↑AR:::::::::             |
      head to E, head to C |
   B:                          |.hh=AH!
   B:                          |retracts hand |moves back
   E:                                         |pads P
                                    *26.32     *27.32
```



24.20 24.72 26.32 27.32

The experimenter reacts upon the child's withdrawing by again padding Pleo (27.32) which Bea observes. However, once Pleo again turns its head towards her (38.12), she instantly backs off even further (38.92, 39.88).

38.12 38.92 39.88

Thus, not only does the robot appear animated to Bea producing its own motions, but also is the concrete interactional timing of this behaviour relevant: following onto what has been considered by the experimenter as being 'inappropriate' conduct, the robot seems to react to this by facing the source of this conduct and producing a growling sound – as if to immediately display its dislike of this conduct by itself. Immediately, the infant displays a new quality of conduct towards the system: by retracting her hand, shrieking and backing off in two subsequent moves, she displays her new interpretation of Pleo as an animated object that is potentially threatening.

One methodological note is on order here: Our analysis takes into account the participants' observable and hearable conduct, i.e. it reconstructs their conduct at the *interactional surface*. This said, we do not make any claims as to whether Pleo – internally – indeed reacts upon the infant's way of clutching its neck or whether its actions simply occur by chance at that moment in time. Instead, important for the analysis presented here[7] are the participant's interpretations of this conduct in the context in which it occurs.

Stage 3 (01:20 to 06:20): Exploring and Experimenting Pleo – Developing interactional patterns. In a next stage of approaching, Bea gradually moves from being an observer (of both Pleo and Pleo in interaction with the experimenter) to becoming an actor. After about 1 minute and 20 seconds in the interation, she begins to explore herself the suggested ways of

[6] The fragment is rendered using the following transcription conventions: The participants' talk is transcribed as it occurs, i.e. including pauses, hesitations, etc. [16]. Utterances are generally noted in lower case; upper case is used to mark stressed syllables (e.g. not so STRONG) and interpunctuation is used to signal specific prosodic features (e.g. in ↑STRONG; the prosodic contour starts with a high onset and falls at the end). The participants' visual conduct is annotated as short glosses, written in italics and generally accompanied by a frame grab of the video. The sequential relationship between events is rendered by their positioning on a virtual timeline.

[7] In general, to link this kind of surface level analysis with logging data showing the system's internal states are a relevant methodological issue. See e.g. the suggestions in [17].

treating Pleo (padding, feeding – see the example in section 7) and to uncover new forms of behaviour (walking, making Pleo fall asleep and wake it up).

This change in Bea's participation status and role in the interaction transpires in her physical position in the room: Contrary to her previously backing off the robot, she physically re-approaches step by step (01:26.28; 03:52.88; 04:28.56). Interestingly, the experimenter – who is setting opposite Bea on the floor (the black person in the video stills) – shadows this conduct and thereby shows her analysis of the emergent interaction: After Bea's first steps of approaching the robot, she begins to physically move backwards and leave the infant to the (originally intended) dyadic situation with Pleo.

01:26.28 03:52.88 04:28.56

This gradual diminishing of the physical distance between herself and the robot goes in pair with a change in her interactional conduct: While, at the beginning, she had been shrieking and withdrew her hand once Pleo's head approached, this reaction disappears step by step. In and through her interaction with Pleo, she uncovers its conduct as being – in part – systematic and begins to develop re-occurring interactional patterns with the system. For instance, when Pleo holds the leave in its mouth for a certain time, it begins to quickly shake its head and grumble. Over several instances, we can observe Bea beginning to treat this as a request to take the leave off its mouth. This way, Pleo becomes an animated object that is able to engage in systematic sequences of actions with her and that is, in this sense, predictable and looses its initial threatening character.

Stage 4 (06:20 to 12:52): Interacting with Pleo in different worlds – A polyfunctional object. After these subsequent stages of discovering and experiencing Pleo, Bea begins to treat the robot as a polyfunctional object with which she can interact in different worlds, real and symbolic ones. Depending on the concrete ways in which she momentarily defines and redefines the situation, Pleo is endowed with different qualities and properties. In addition to continuing her repertoire of the previously developed activities, Bea involves Pleo in a range of different activities, which people – in general – do with babies, puppets, or their pets. She explicitly categorizes Pleo as "baby", makes it sit on her laps while padding it carefully (11.09.24), picks the robot up and walks away with it from the playzone to show it to her mother (12.12.36, "show mumy" and "baby go with me") or bids farewell to it when she finally leaves (12.39.44, "bye, robot").

11.09.24 12.12.36 12.39.44

In sum, this reconstruction of the different stages the infant's conduct and her interaction with Pleo shows how her perception and categorisation emerge and change step by step within and from the interaction. The robot subsequently is considered as (1) an inanimate object, (2) an animate object that is potentially threatening, (3) an animate object that is able to engage with her in re-occurring interactional patterns, and finally becomes (4) a polyfunctional object with which she can interact in different (real and symbolic) worlds.

Presented here as case analysis of one particular user, similar methods of approaching an unknown robot system and its subsequent practical interpretations and re-interpretations during the course of the interaction can be observed with other (both infant and adult) users. To undertake a series of such case-studies focusing on the *interactional practices of categorization* and their development over time, will enable us to get a better understanding of the users' perception of robot systems *in situ*, how these emerge over time, and which features of their interactional conduct might be relevant.

7 EXPERIMENTING SEQUENTIAL ORGANIZATION: FEEDING PLEO

In the course of the previous case analysis detailed inspection of the video-taped data has brought to light that little sequential phenomena of the robot's timely conduct in relation to the infant's actions play an important role in the process of the infant's categorization and re-interpretation: e.g. the robot's head turning and growling which follow directly the infant clutching its neck and thus *appear* to the child as a consequential reaction to her own action (see esp. stage 2). In what follows, we will take a closer look at how users – in their interaction with the robot – are oriented to such sequential relationships and experiment with establishing contingent 'sequences of action' with the robot.

We will explore this issue by analysing two instances taken from different user groups in which the users attempt to feed Pleo. In fact, 'feeding Pleo' is an ordered sequence of actions which involves the following three consecutive steps: (1) Pleo opens its mouth; (2) User places the green leave in the robot's mouth; (3) Pleo closes its mouth. As a rule, the robot is programmed to open its mouth once it detects – with its camera located at the tip of its nose – the leave's green colour. However, in our experiment the users do not receive this information, and thus are faced with the practical problem of (i) either finding by themselves a systematic way of making Pleo open its mouth or (ii) use those occasional moments for inserting the leave when Pleo randomly opens its mouth by itself.

Case 1: Experimenting and the role of a translating mediator. When Bea, the 3 year old girl from our previous case analysis, attempts to feed Pleo for the first time (cf. section 6, stage 3), she encounters some difficulties and needs several attempts to achieve this. In doing this, she experiments with the contingencies that the system's conduct offers.

(I) While Pleo's mouth is open, Bea firstly approaches the leave to about 5 cm and waits (01.26.36). However, after two seconds, Pleo shuts its mouth (01.28.12) and her first attempt fails.

Fragment 2 (S005, 01:24 – 01:42):

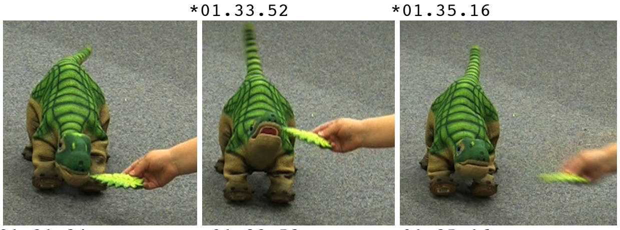
```
01 E: probier DU doch mal; (2.0)|vielleicht *nimmt er's
      you try it                 perhaps it might take
   P: mouth open
   B:                           |present-leave-1
                                                 *01.26.36

02 E: ja; |
      it
   P:     |mouth shut |
   B:                 |
          *01.28.12
```

01.26.36 01.28.12

Structurally speaking, the infant treats a certain conduct exhibited by the robot (open mouth) as a first move in a potential 'feeding sequence' which she responds to by offering the leave at distance. This move would make contingently relevant next some reaction by Pleo either indicating that it would like to accept the leave or directly grasping it. Closing its mouth, thus does not meet the relevancies established and closes this attempt of a 'feeding sequence'. It appears that the robot performs a set of actions which could be treated as moves in a potential 'feeding sequence', but – in fact – appear to be part of its own set of action scripts.

(II) Bea then undertakes a second attempt and experiments with another strategy. While Pleo's mouth is closed, she approaches the leave and tries to insert it (01.31.24). Pleo appears to respond to this first turn by a relevant next action: opening its mouth. However, at the same time, the robot lifts and turns its head (i.e. withdraws), which hinders Bea to insert the leave (l. 03, 01.33.52). When Pleo again closes its mouth, she retracts the leave and comments it with a puzzled "↑HM;" (l.03, 01:35.16).

```
02 E: ja; |
      it
   P:     |mouth shut |              |mouth open
   B:                 |present-leave-2 |
                         *01.31.24

03 P:                  |mouth shut |
   B: insert-leave-1   |           |retract-leave
   B:                              |↑HM;
                     *01.33.52      *01.35.16
```

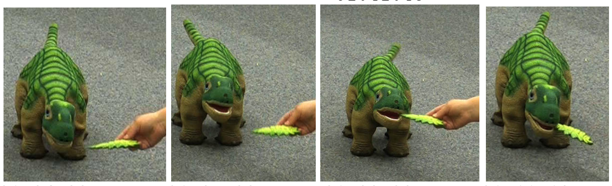


01.31.24 01.33.52 01.35.16

In this second instance, the robot appears, on the one hand, to engage in a response to Bea's first turn, but then, on the other hand, again continues to follow its own set of action scripts. The girl thus attempts to arrange with the structures and logic of action provided by the system and tries to find within these a slot that allows her to perform the action that she aims at. This means: Instead of being able to initiate a collaborative sequence of actions in coordination with the robot, Bea organizes her own actions with regard to the contingency exhibited by the system.

(III) Bea then undertakes a third attempt: She holds the leave at about 2 cm off Pleo's head (01.36.88), Pleo then opens it's mouth (01.37.92), she moves the leave nearer to the mouth (01.38.92) and the experimenter comments "NOW insert the leaf". Bea finally introduces the leaf, the experimenter acknowledges "alright", Pleo closes its mouth and when Bea retracts her hand, she sees Pleo remaining with the leave in its mouth (01.41.48), which she comments with a happy exclamation "HE!".

```
04 B: hier; (.) HM; |              |approach leave |
      here;     HM;
   P:               |mouth open |
               *01.36.88     *01.37.92         *01.38.92

05 E: und JETZT mußt du's dem REINtun;|          |genau;
      and NOW you have to insert it               alright
   B:                                 |insert-leave-2

06 P: mouth shut |head down |
   B:                       |↑↑HE! |
   E:                              |laughs
                         *01.41.48
```



01.36.88 01.37.92 01.38.92 01.41.48

It is only in this third attempt, in which the experimenter becomes involved as a collaborator, that the infant manages to engage in a successful 'sequence of actions' with the robot. Interestingly, the experimenter operates on a structural level helping the infant to do the appropriate next action at the right moment in time: she observes both the robot's and the infant's actions and helps to 'translate' the robot's actions in terms of which next actions they make relevant from the user. Thus, the experimenter links between the infant's and the robot's actions and thereby enables these two participants to engage in a coherent and collaborative 'sequence of actions'.

Case 2: Observation and reasoning. In another user group, two brothers – we call them Tim and Jon (4 and 8 years old) – try as well to engage in a 'feeding sequence' with Pleo. When they approach Pleo, which is standing in the middle of the playzone and next to its leave, the 4 year old boy Tim immediately grabs the leave and attempts to feed the robot, but fails (similar patterns occur as in Case 1 above, (I) and (II)). Then his older brother Jon grabs the leaf and gives it a try. The robot's mouth is shut when Jon moves the leaf towards it. He presents the leave for about one second holding it horizontally (00.51.64). As no change in Pleo's conduct occurs, he repairs his action by turning the leave into a vertical position (00.52.64). Again, no change in Pleo's conduct occurs and after another second, Jon brings the vertical leave even closer to Pleo's face (00.53.16). About 0.5 seconds later, Pleo opens its mouth and Jon introduces the leave (00.54.32), Pleo closes its mouth and the leave remains inside (00.54.32).

Fragment 3 (S003, 00.48.00 – 01.00.00):

```
01 P: mouth closed                               ..
   P: hackling                   |
   J:            |present-leaf-1 |present-leaf-2
                  *00.51.64       *00.52.64

02 A: ich muß das |vor die KA|mera halten; |
      i have to hold it INFRONT of the camera
   A: ..          |pr-leaf-3 |
   J:                                      |insert-leaf
   P: ..                     |mouth open   |
                  *00.53.16

03 P: |mouth shut |
   J:             |turns to M    |
   M: |du mußt das daVOR halten; |
       you need to hold it inFRONT;
        *00.54.32

04 J: ja; ich weiß wo die KAmera ist; (.) darum hab ich
      yes; i know where the cam is        thatÄs why i

05 J: das BLATT auch erst daVOR gehalten;
      did hold the leave inFRONT of it;
```

00.51.64

00.52.64

00.53.16

00.54.32

00.55.60

Jon's success in engaging in a 'feeding sequence' with Pleo results from a basically different approach than that shown by Bea in Case 1: He reaches his goal by observation and reasoning. Jon step by step changes small aspects of his way of presenting the leave (horizontal vs. vertical orientation; distance). In fact, after his second attempt, Jon also begins to explicitly comment his actions: "I need to hold it in front of the camera" and "I know where the camera is (.) that's why I have positioned the leaf right in FRONT of it". In comparison to Bea's attempt of feeding Pleo, Jon (who is considerably older than Bea) not only displays a more technical view on the system, but also he also assumes the approach to evaluate and test the robot's capabilities: Which possibilities does the system offer that allow me to successfully interact with it?

In more general terms, the comparative analysis of these two cases of 'feeding Pleo' reveal to which extent and how users – in their interaction with the robot – are oriented to the sequential relationship between actions and experiment with establishing contingent 'sequences of action' with the robot. In order to understand how it comes that users conceive of robots in a certain way, categorize and re-categorize the systems during the course of the interaction, we need to get down for analysis to the level of sequential organisation. Also, we have been able to detect different ways of the users proceeding when attempting to understand the system's conduct and to collaborate with it. In these two cases they are, surely, linked to the infants' different age (3 years vs. 8 years) and it will be relevant whether we can detect – on the basis of the entire corpus – different user strategies depending on their age.

8 SUMMARY & DISCUSSION

Starting point for our investigation has been the aim to investigate how users perceive a given robot system and which features might be relevant for this. Differently from the methods used in existing studies – questionnaires/interviews and coding rendering either abstract categories or single features of individual behaviour towards a robot – in this paper, we have suggested a different methodological approach: to use the concepts and methodological tools from qualitative Ethnomethodological Conversation Analysis (EM/CA), in particular the ideas of 'category-bound activities' and sequential organization. Using a corpus of video-taped data from a study in which a set of dyadic user groups freely interacted with the robotic dinosaur Pleo, we wanted to know how a user's perception and categorization of a robot system emerges step by step during and from the interaction with the system and which interactional features might be relevant for this. We have presented some preliminary, explorative analysis on the basis of two cases, which allowed us to present the methodology and the kind of findings it is able to generate.

Comparing our results to existing studies, we can begin to discuss further the question raised by Kahn et al [4] whether – for infants – robotic pets seem to blur foundational ontological categories, such as animate vs. inanimate, and to which extend a "hybrid object" and/or a "new technological genre" might emerge. Our analysis reveals – using the example of a 3 year old girl – how a user's perception and categorisation of a robot emerges and changes step by step within and from the interaction. The robot was subsequently considered as (1) an inanimate object, (2) an animate object that is potentially threatening, (3) an animate object that is able to engage with her in re-occurring interactional patterns, and finally becomes (4) a polyfunctional object with which she can interact in different (real and symbolic) worlds. While a single case analysis cannot claim to derive any generalizable conclusion, we are able, however, to uncover those emergent categories. It will be matter of further analysis on the basis of the entire corpus whether the categories derived here might be relevant for other infants as well.

At the same time, our detailed inspection of the video data has brought to light that small sequential phenomena of the robot's timely conduct in relation to the infant's actions play an important role for the infant's categorization and re-interpretation. In a second step, then, we have investigated how users attempt to establish coordinated 'sequences of action' with the robot and have been able to reveal different strategies: (1) Experimenting and organizing their own actions with regard to the contingency exhibited by the system; (2) Making use of a 'mediator' who observes both the robot's and the infant's actions and helps to 'translate' the robot's actions in terms of which next actions they make relevant from the user; (3) Observation and technical reasoning. Also here, further analysis is required on the basis of the corpus to investigate both the users' strategies and the features they are reacting to.

When turning the single case analyses presented here into a corpus study, we will need to take into consideration further issues: We will need (1) to differentiate between the age groups of our participants – infants, teenagers, adults – and (2) include, for the infants, the different cognitive abilities and ways of conceiving the world between 3 and 8 years of age and how these might be linked to their ways of interacting with the robot. (3) As it transpires from the third fragment, in which two infants play together with the robot, it will be interesting to uncover in which ways this 'collaborative' component impedes on the interaction. In doing this, we might not primarily learn about human-robot-interaction, but about the ways in which siblings interact with each other. (4) If we want to derive guidelines for the design of human-robot-interaction from such a corpus study, we will also need to link the qualitative analyses with quantitative approaches. While EM/CA is able to reveal in a very fine-grained manner features and patterns of the interactional conduct and micro-coordination, we will need to take this further by providing information about the precise timing of events, about the frequency with which certain patterns occur and the probability of some 'interactional paths' rather than others. For this, systematic annotation of the features uncovered in the qualitative analysis will be required using timeline-based annotation tools. On these grounds, we will be able to undertake computational investigation of the corpus (e.g. with MATLAB), in which timestamps and annotation values need to be parsed and algorithms developed for testing the hypotheses generated in the qualitative analysis [15].

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