Keepon

A Playful Robot for Research, Therapy, and Entertainment

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Keepon interaction w/ normally developing children

- **0–1-year-olds:** Interaction was dominated by tactile exploration using the hands and/or mouth. The children did not pay much attention to the attentive expressions of the robot, but they exhibited positive responses (such as laughing or bobbing their bodies) to its emotive expressions.
- **1–2-year-olds:** The children demonstrated not only tactile exploration but also awareness of the robot's attentive state, sometimes following its attention. Some mimicked its emotive expressions by rocking and bobbing their own bodies.
- **2+-year-olds:** These children first carefully observed the robot's behavior and how caregivers interacted with it. Soon they initiated social exploration by showing it toys, soothing it (by stroking its head), or verbally interacting with it (such as asking questions).

Preschoolers

- Study with 27 normally developing 3-4 year olds over multiple weeks

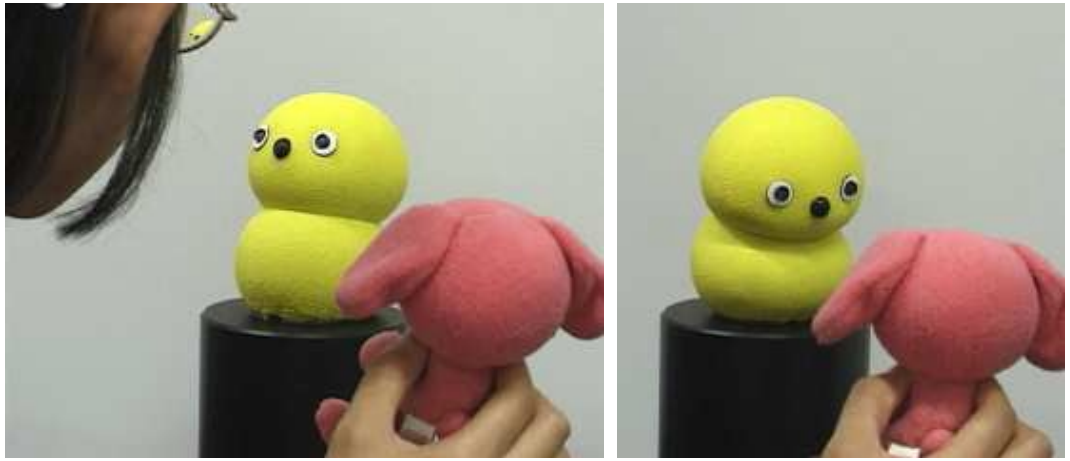
- **Violent vs. protective behavior:** In S3, a boy TM (hereafter TM/m) beat Keepon several times, and a girl SR (hereafter SR/f) stopped him, “No! No!” In S9, when NR/m hit Keepon’s head several times, HN/f stopped him by saying, “It hurts! It hurts!” In S13, FS/m and TA/m strongly hit Keepon’s head a couple of times, as if demonstrating their braveness to each other. YT/f and IR/f, observing this, approached Keepon and checked if it had been injured, then YT/f said to Keepon and IR/f, “Boys are all alike. They all hit Keepon,” stroking its head gently.

- **Demonstrative behavior:** In S6, KT/f played with Keepon in the outdoor playground; a boy in the 4-year-old class approached Keepon and said to KT/f (referring to Keepon), “This is a camera. This is a machine,” but KT/f insisted, “No, these are Keepon’s eyes!”
- In S8, pointing to an insect cage, SR/f guided Keepon’s attention to it. During reading time in S11, NK/f and TM/m approached and showed their picture books to Keepon.
- In S17, YT/f taught Keepon some words—showing it the cap, she said, “say, *Bo-shi*,” then switched to Keepon’s knitted cap and said, “This is a knit *Bo-shi*, that you wear in winter” (to which Keepon could only respond by bobbing).
- In S25, NK/f gave a toy sled to Keepon. Keepon showed a preference to another toy NK/f was holding. After some negotiation, NK/f brought over another sled and persuaded Keepon, “Now you have the same thing as me.”

- **Self-conscious behavior:** In S22, after all the children practiced a song with the teachers, several of them ran to Keepon and asked one by one, “Was it good?”, to which Keepon responded by nodding and bobbing to give praise. In S24, NZ/m sang a song quietly for a while; when he noticed Keepon beside him, he became surprised and ashamed.

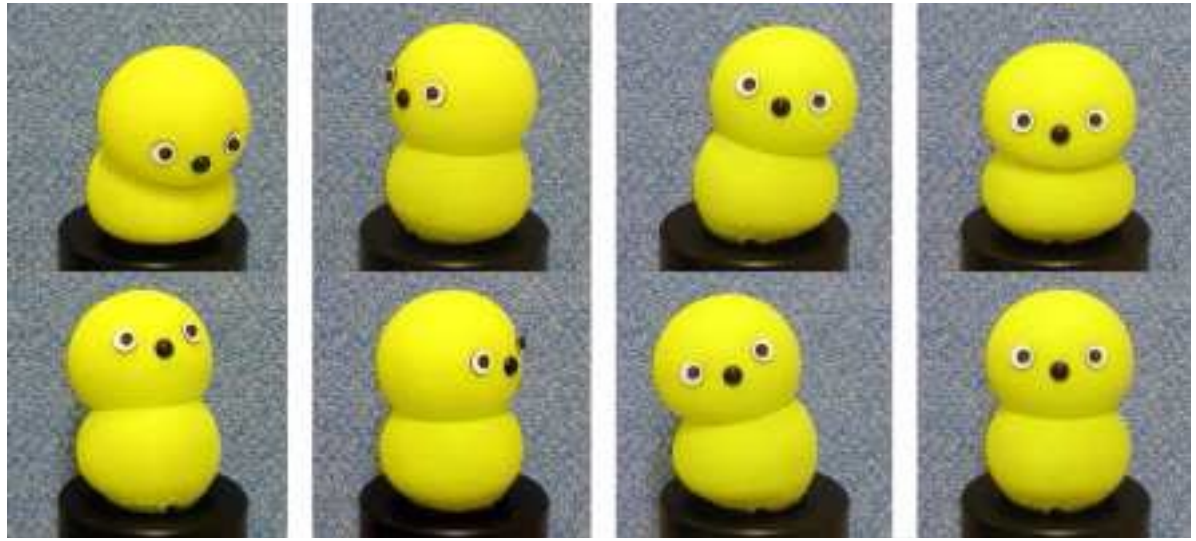
Longitudinal autism study

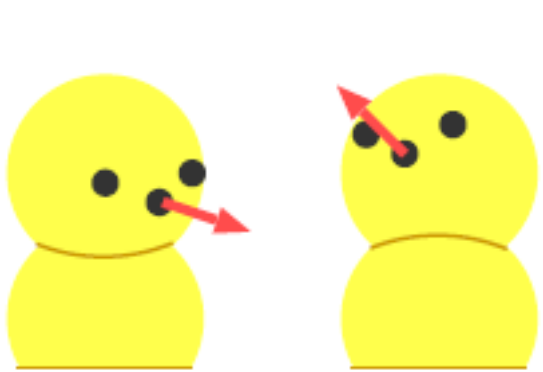
- 1.5 year study, >500 child interaction sessions
- 2-4 year old children w/ autism, Down's symdrome, Asperger's and similar conditions
- teleoperated Keepon robot



Most common challenges associated with Autism

- **Social interaction**: Difficulty in understanding others‘ intention and emotion, and in sharing interests and activities with others; difficulty in forming social, cooperative relationships.
- **Communication**: Difficulty in verbal and non-verbal communication, especially of everyday pragmatic use; delay or lack of language development; stereotyped and repetitive speech.
- **Imagination**: Stereotyped and restricted pattern of interest and behavior; adherence to specific things and aimless routines; difficulty in coping with novel situations (e.g., unknown places or activities).





Attentive action

Emotive action





Participant M (15 sessions, 3 months)

- M showed strong interest from Session 1 (hereafter S1), but did not get close to *Keepon*. Through S1 to S7, M avoided being looked straight at by Keepon (i.e., aversion to eye-contact); however M often looked into *Keepon*'s prfiole.

Participant M (15 sessions, 3 months)

- In S5, after observing another child R put a paper cylinder on *Keepon*'s head, M dragged the nurse's arm, asking her to do the same thing to *Keepon*. When the nurse completed the task, M looked satisfied and left from *Keepon*. Through S5 to S10, the distance to *Keepon* gradually got shorter (to 40.50cm).

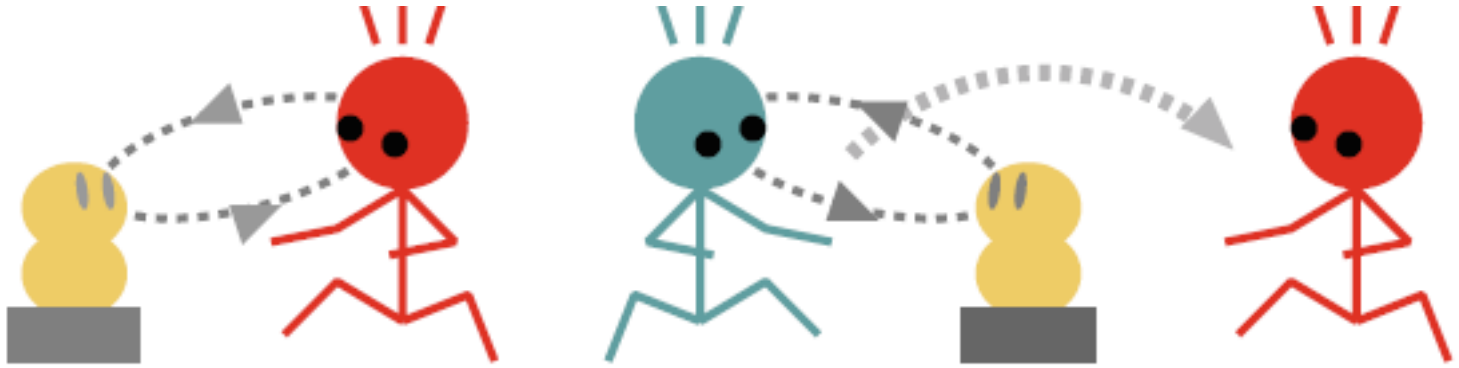


Fig. 9 Emergence of dyadic interactions: exploratory actions directed to Keepon (*left*) and interpersonally triggered/copied actions (*right*)

Participant M (15 sessions, 3 months)

- In S11,M touched the head of *Keepon* with a xylophone stick, then M directly touched with her hand as if M had examined the texture and smell of *Keepon*.

- After this first touch, M started social interactions including eye-contact and vocalization (S12.), putting a cap on *Keepon*, asking her mother to do the same (S13.), and hugging and kissing *Keepon* (S14).

Participant N (39 sessions, 18 months)

- In S1, N gazed at *Keepon* for a long time. After observing another child W played with *Keepon* using a toy, N was encouraged to play with *Keepon* using the same toy, but N did not show interest in doing that.

- Through S2 to S14, N did not pay attention to *Keepon*, even when she was next to it. However, N often glanced at *Keepon*, when she noticed its sound, such as “Pong pong pong”.

Participant N (39 sessions, 18 months)

- In S15, after observing another child R put a cap on *Keepon*'s head, N touched *Keepon* with her finger.
- In S16 (after 3-month break from S15), N came close to *Keepon* and looked into its movement. In the snack time, N came to *Keepon* and poked its nose, to which *Keepon* responded by bobbing, and N showed surprise and smile. The mothers and nurses burst into laughter. During this play, N often made referential looks with smile to her mother and the nurse.

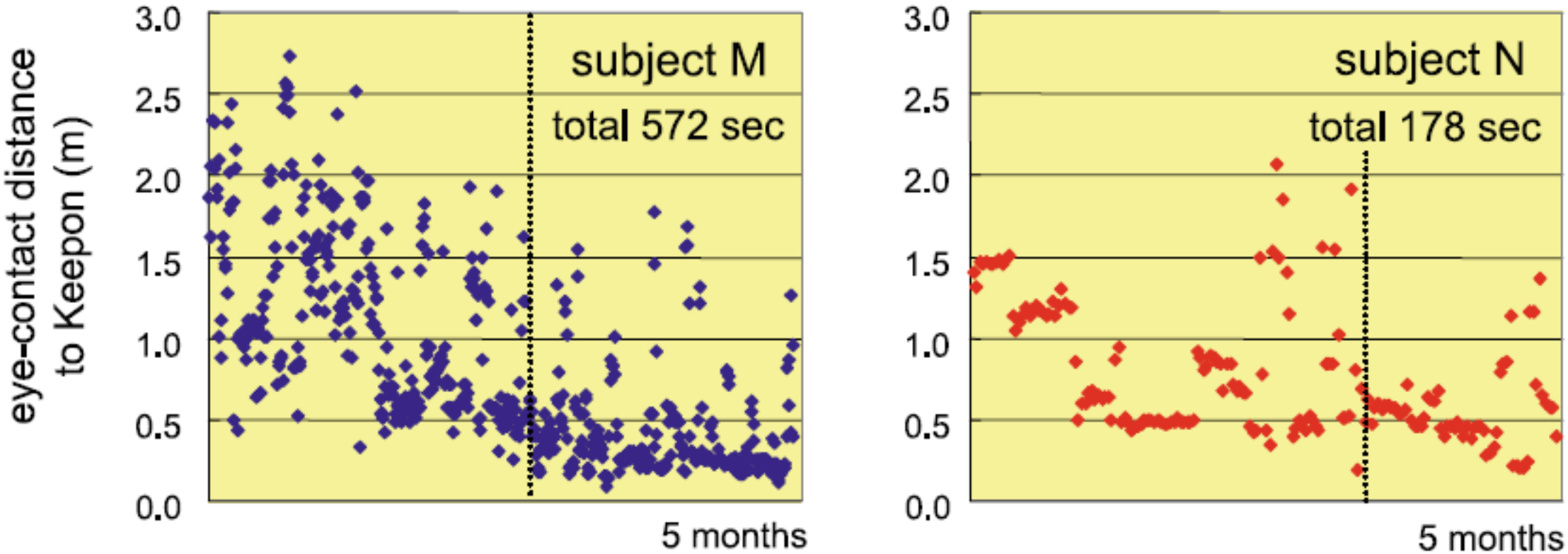
Participant N (39 sessions, 18 months)

- From S17, N often sat in front of *Keepon* with her mother; sometimes she touched *Keepon* to derive some response. From S20, N started exploring *Keepon*'s ability by walking around it to see if it could follow her.

Participant N (39 sessions, 18 months)

- In the snack time of S33, N came to *Keepon* and started imitation play, when N performed one movement (bobbing, rocking, or bowing), soon *Keepon* mimicked; then N did another, and *Keepon* did the same. Through S33 to S39, N often played this “imitation game” with *Keepon*, during which she often made referential looks to her mother and the nurse.

Fig. 10 Emergence of triadic interactions: the child discovers “wonder” in Keepon (*left*) and then looks at the partner to share this “wonder” (*right*)



Dotted line represents first touch.

Conclusions (from paper)

- even autistic children possess the motivation for sharing and exchanging mental states with others, and that the challenge for therapists and parents is to elicit this motivation.

- Although it is widely believed that this motivation is impaired in autism, we have observed in a number of cases that autistic children established social relationships with the simple robot, which was carefully designed to express its mental states comprehensibly.

Conclusions (from paper)

- While we have presented three cases that are representative of the successful elicitation of social behavior from children with autism, it should be noted that these results are not to be considered “generalizable.” Rather, they are meant to illustrate the potential for an appropriately designed robot to evoke rare but positive responses.

- The robot thus serves as a tool *during* the therapeutic sessions by enabling therapists to conduct a novel form of mediated interaction with the children as well as *after* the sessions by providing a recorded body of data that can be used by parents, therapists, and researchers in studying autism and in evaluating or tailoring individual children’s therapeutic treatments.

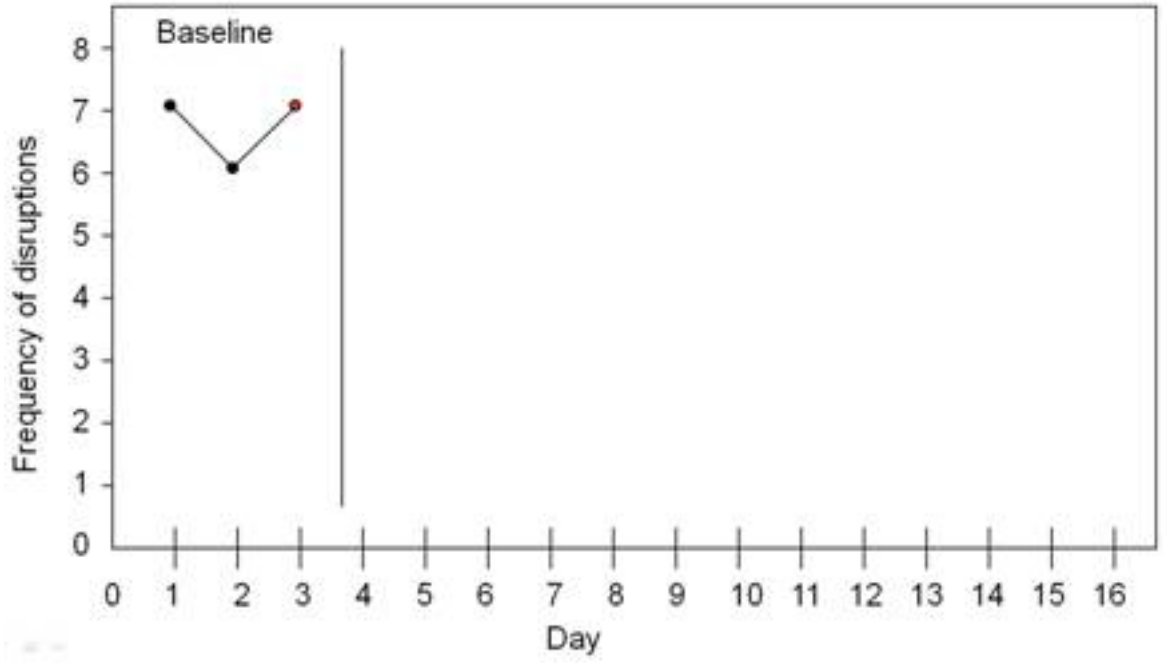
Although a lot of work went into this study, and it provides an interesting perspective, none of these findings are acceptable by clinical standards.

Single Subject Study Design

- useful when the researcher is attempting to change the behavior of an individual or a small group of individuals
- the participant serves as both the control and treatment group
- only one variable is changed at a time
- Single subject research designs are “weak” when it comes to external validity

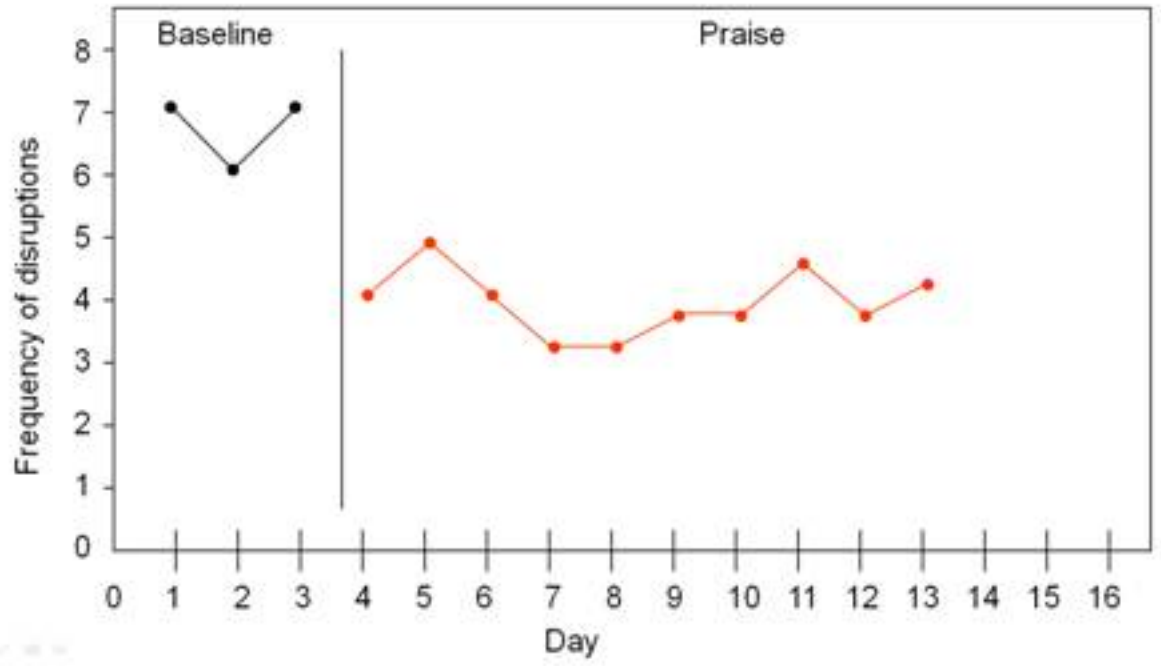
Example – Effect of Praise

- investigate the effect of praise on reducing disruptive behavior over many days.
- First, establish a baseline of how frequently the disruptions occurred (measure how many disruptions occurred each day for several days)

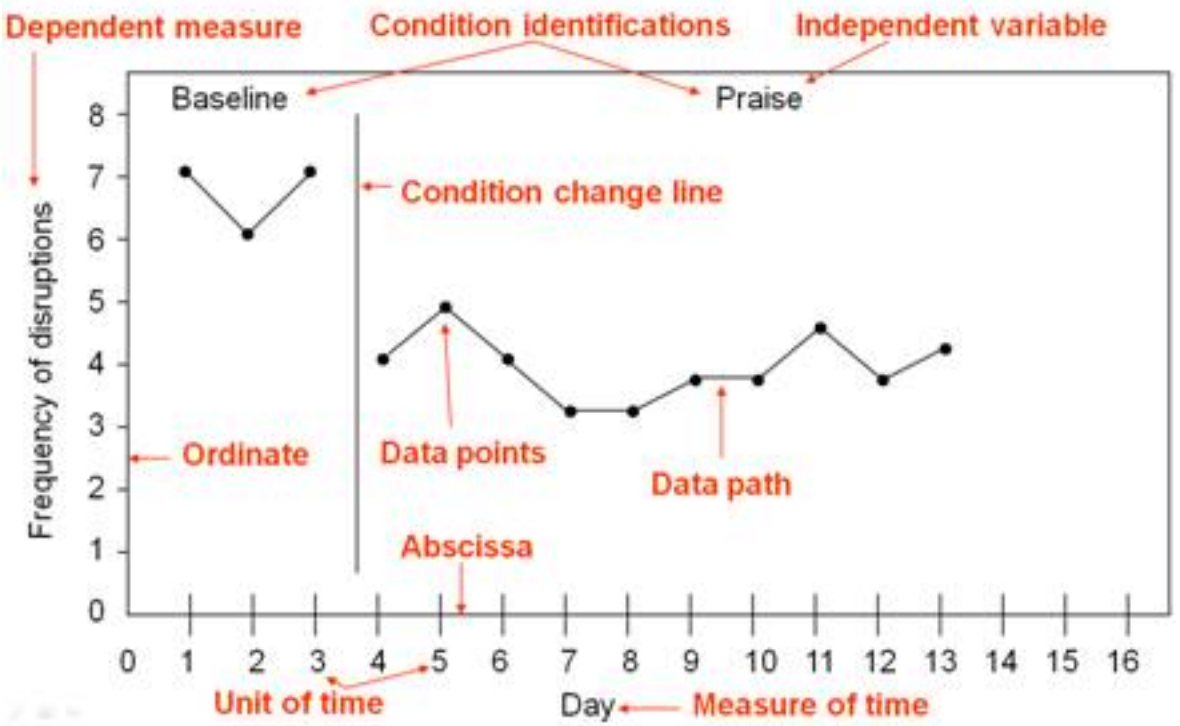


Example – Effect of Praise

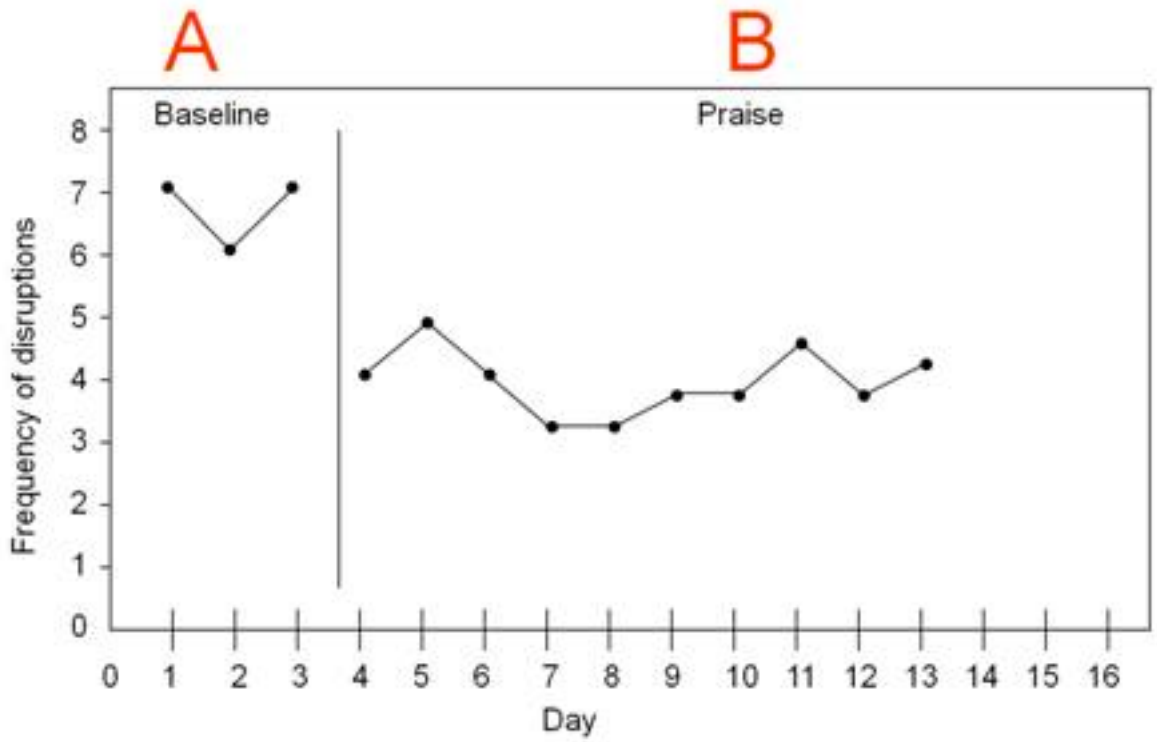
- baseline of behavior has been established once a consistent pattern emerges with at least three data points
- intervention can begin -- researcher continues to plot the frequency of behavior while implementing the intervention of praise.



Graph Labels

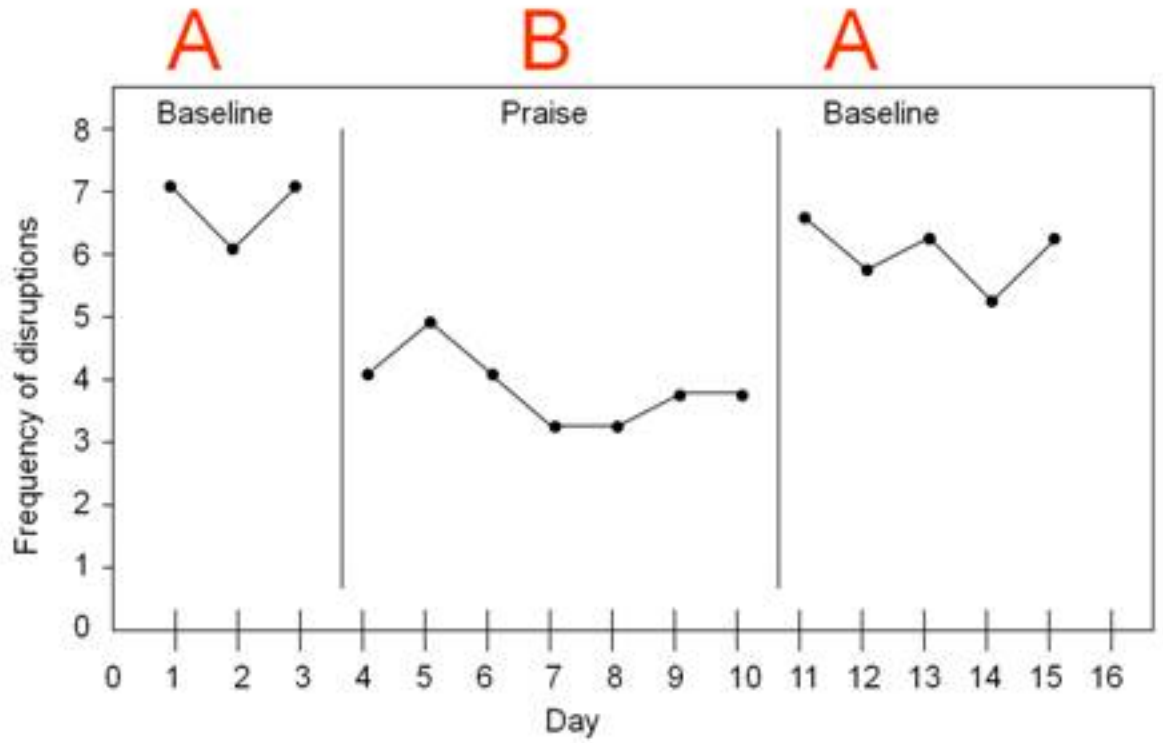


A-B Design


A
B
Baseline
Praise
Frequency of disruptions
0
1
2
3
4
5
6
7
8
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Day

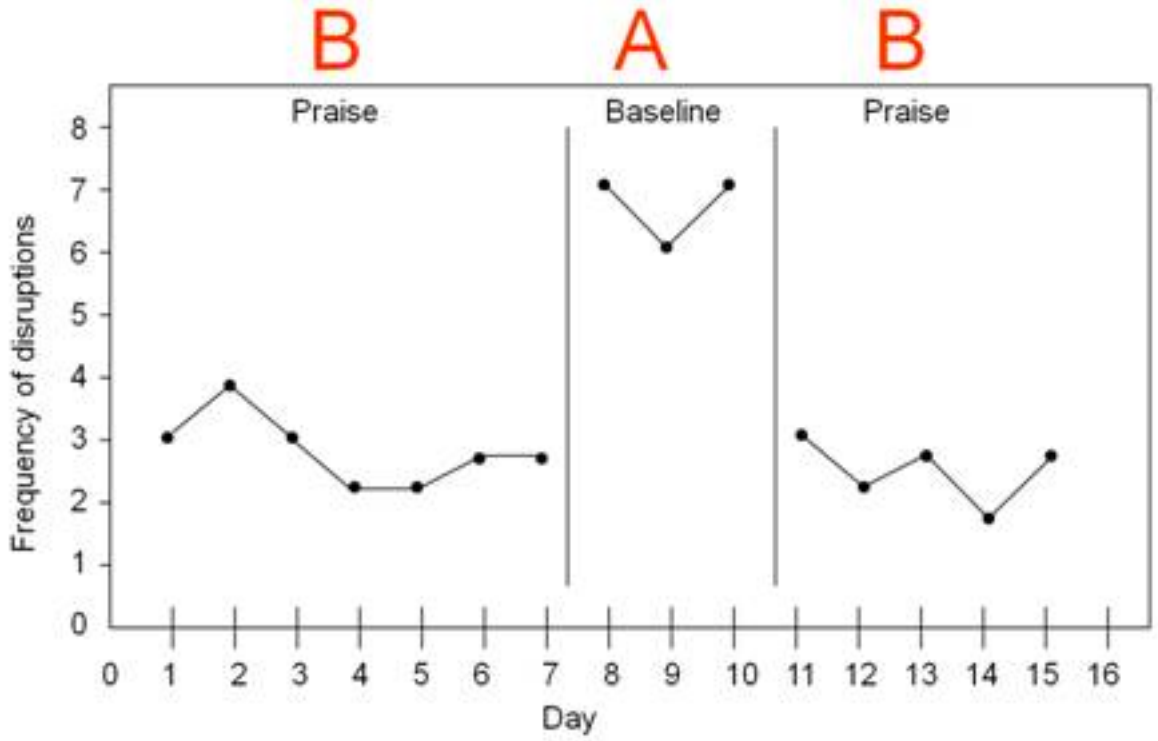
A-B-A Design

- involves discontinuing the intervention and returning to a nontreatment condition.



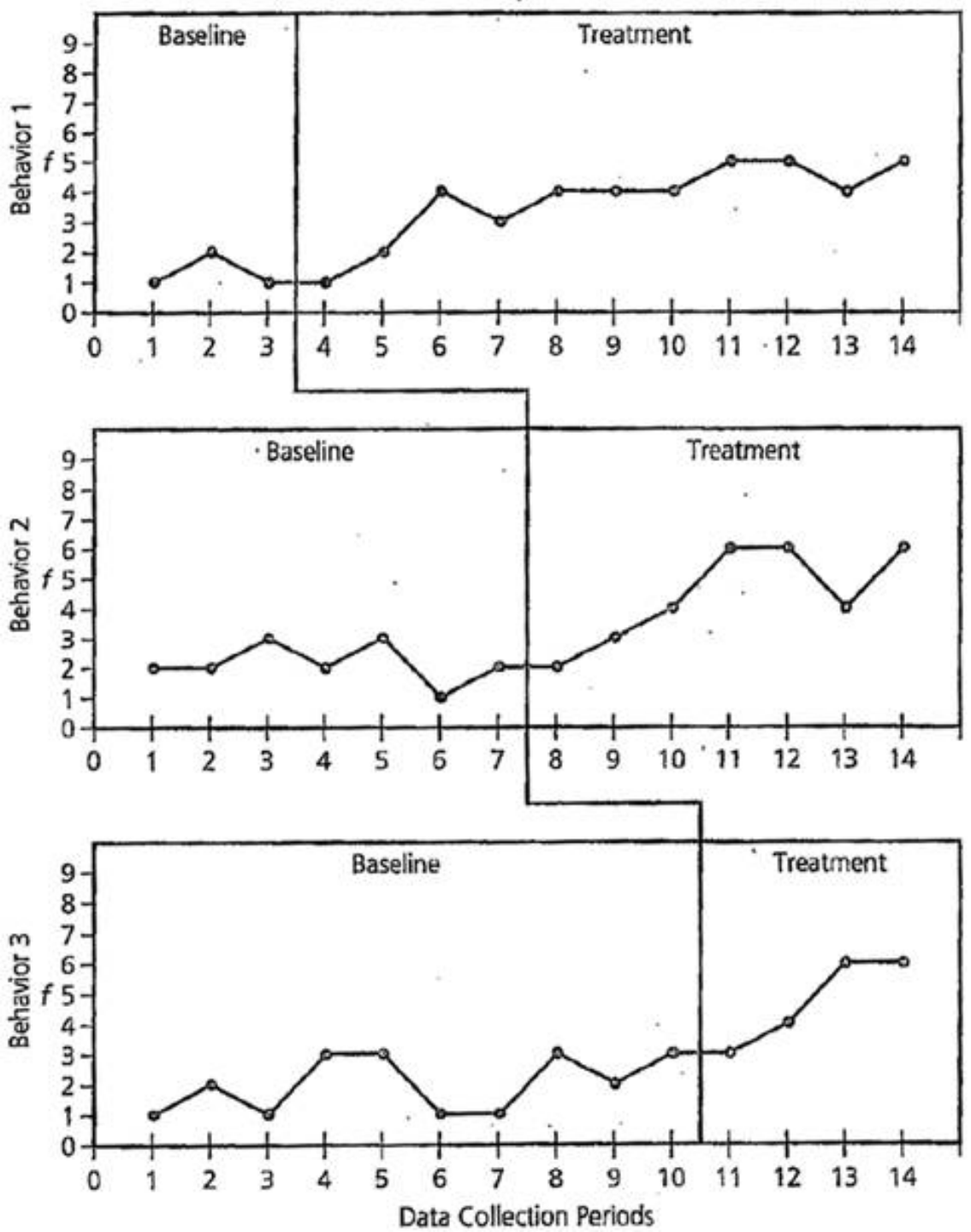
B-A-B Design

- Used when an individual's behavior is so severe that the researcher cannot wait to establish a baseline and must begin with an intervention.



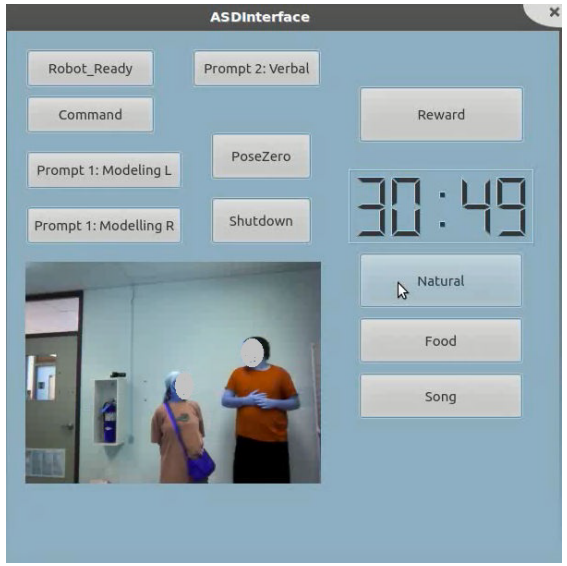
Multiple Baseline Design

- Used to address several issues for one student or a single issue for several students.
- Intervention introduced at different times to show more clearly that effects can more likely be credited to the intervention itself as opposed to other variables



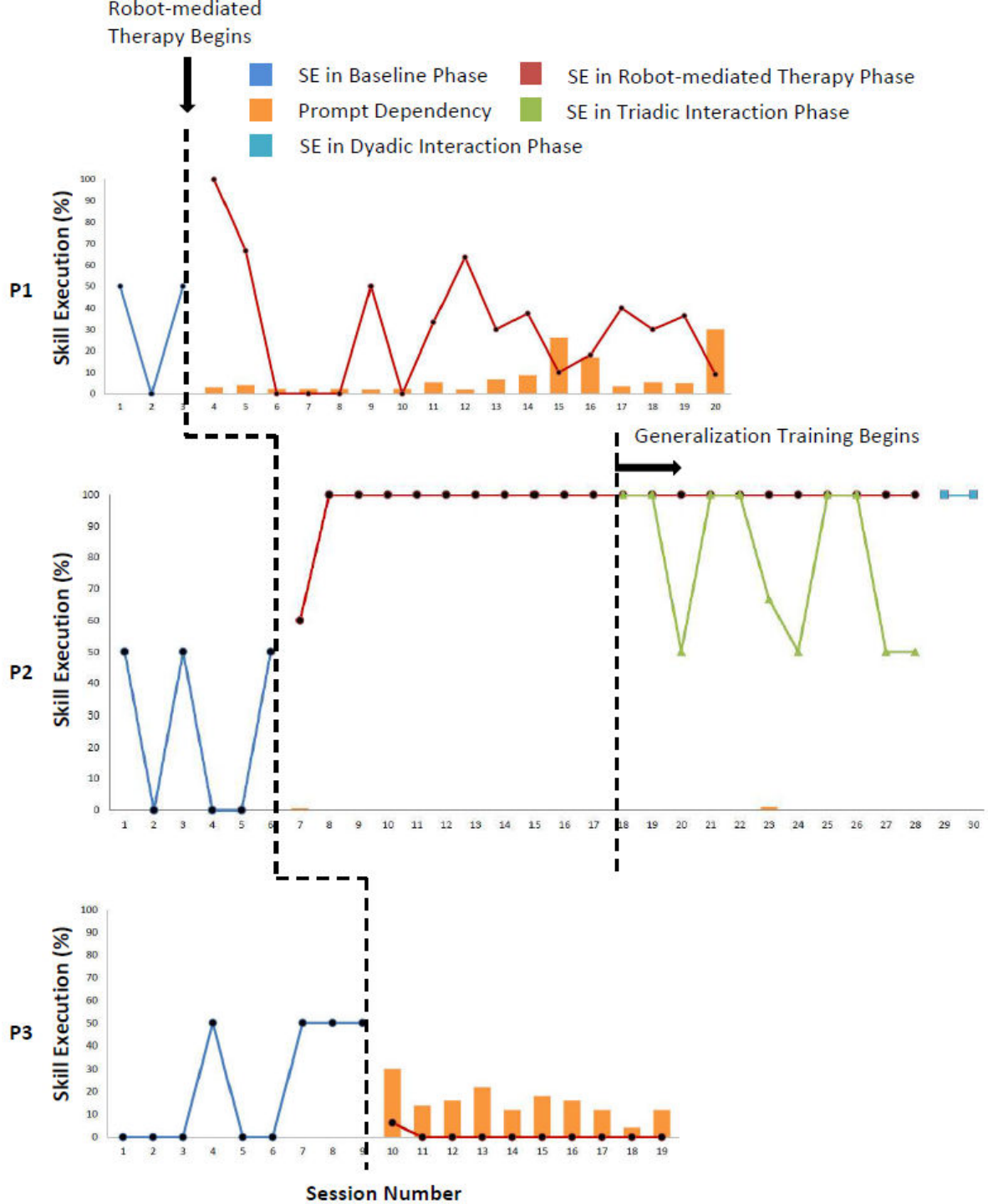
Measuring the Efficacy of Robots in Autism Therapy: How Informative are Standard HRI Metrics? [Begum et al 2015]

- Single-subject design experiment in a clinical setting with 3 individuals with severe autism
- One of the *very* few robotics studies which shows transfer of a skill learned with assistance of a robot to human-human interaction


ASDInterface
Robot_Ready
Prompt 2: Verbal
Command
Reward
PoseZero
Prompt 1: Modeling L
30:49
Shutdown
Prompt 1: Modelling R
Natural
Food
Song

Metrics

Efficacy Metrics: skill execution and prompt dependency
HRI Metrics: Gaze, Communication, Affect


Robot-mediated
Therapy Begins
SE in Baseline Phase
SE in Robot-mediated Therapy Phase
Prompt Dependency
SE in Triadic Interaction Phase
SE in Dyadic Interaction Phase
P1
P2
P3
Skill Execution (%)
Generalization Training Begins
Session Number

Findings

- HRI metrics predict ‘