Comparison of Tablet-Delivered and Instructor-Delivered Teaching on Receptive Identification in Children with Autism Spectrum Disorders

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Abstract

The purpose of our study was to compare the effectiveness of tablet- and instructor-delivered teaching (i.e., prompting and reinforcement) on the receptive identification of one-word concepts in children with autism spectrum disorders (ASD). To this end, we embedded a multielement design within a multiple probe design to compare the effectiveness of the two instructional modalities in seven participants. Two of seven participants showed generalization on all concepts in fewer instructional trials following instructor-delivered teaching whereas the remaining five participants had mixed results depending on the concept. In total, the participants showed more rapid generalization with the instructor for 14 of 19 concepts taught. Our results suggest that tablets should not systematically replace instructor-delivered prompting and reinforcement, but that they may be used to provide supplementary teaching to children with ASD.

Keywords: autism, tablet, generalization, teaching, technology, receptive identification

Comparison of Tablet-Delivered and Instructor-Delivered Teaching on Receptive Identification in Children with Autism Spectrum Disorders

In recent years, researchers and practitioners have been adopting the use of technology for teaching children with autism spectrum disorders (ASD; Alzrayer, Banda, & Koul, 2014; Kagohara et al., 2013; Knight, McKissick, & Saunders, 2013; Lorah, Parnell, Schaefer Whitby, & Hantula, 2015; Ploog, Scharf, Nelson, & Brooks, 2012; Ramdoss et al., 2011; Saade Chebli, Lanovaz, & Dufour, 2017; Sansosti, & Powell-Smith, 2008; Stephenson & Limbrick, 2015). Even though the literature abounds with examples validating the effectiveness of computer technology with this population, few studies have compared the effectiveness of technologically-delivered instruction with traditional teaching (i.e., one that is delivered by a human instructor). Because of the dearth of studies comparing the two modalities, not much is known about the effectiveness of computer-delivered instruction relative to traditional teaching. Despite the growing body of literature pertaining to the effectiveness of technologically-delivered prompts (e.g., Saade Chebli et al., 2017; Goldsmith & Leblanc, 2004), whether computer-integrated prompts are more effective than instructor-delivered prompts to teach children with ASD receptive language remains open to debate. Given their increased use in educational and clinical settings, comparing the effectiveness of tablet-delivered teaching (i.e., prompting and reinforcement) with that of a human instructor warrants our attention.

In a notable example, Moore and Calvert (2000) examined the effects of both modalities on the acquisition of vocabulary words in fourteen children diagnosed with ASD. Results of the study indicated that children had more favorable outcomes with the computer-delivered condition: They learned more words, were more attentive, and were more motivated during the computer-delivered instruction. While this study represents a strong illustration of the

importance of comparing the relative effectiveness of computer- and instructor-delivered teaching, the trainers only used flashcards or pictures during instruction. As such, it is unclear whether learning with technology led to generalization of the concepts to three-dimensional representations. Moreover, both the computer-delivered and instructor-delivered conditions involved the same instructor-delivered verbal prompts, which prevents conclusions from being drawn regarding the relative effectiveness of computer-delivered and instructor-delivered prompts.

In a more recent study, Allen et al. (2015) compared the effectiveness of instructor- and computer-delivered language instruction. The authors evaluated whether the children generalized the concepts taught on a computer program and on picture books to three-dimensional objects, but they only examined generalization to differently colored objects. Although Allen et al.'s study represents an improvement over Moore and Calvert's (2000) design, one cannot expect all objects taught on a computer program to only vary in color, highlighting the need to examine generalization on objects that vary on a broader range of characteristics. Most studies that examined the effectiveness of computer-delivered instruction alone (Bosseler & Massaro, 2003; Whalen et al., 2006) and in comparison with traditional teaching (Schery & O'Connor, 1997) share similar limitations (i.e., lack of, or limited, generalization probes). Much like Moore and Calvert's (2000) design, the same instructor-delivered prompt was used in both conditions, rendering the participant dependent on the instructor and hindering us from drawing a conclusion concerning the effectiveness of a computer-delivered prompt.

From an educational standpoint, examining responding to untaught exemplars is important because children with ASD often have difficulties with generalization to novel materials, contexts, and individuals (Carr & Kologinsky, 1983; Plaisted, 2001; Stokes & Baer,

1977). Another limitation often shared by studies is the lack of maintenance measures over time (Allen et al., 2015; Bernard-Opitz, Sriram, & Sapuan, 2001). Even when maintenance was evaluated in prior research, it was only monitored over a short period of time. For example, Moore and Calvert conducted probes only one week following the termination of computer instruction. In sum, monitoring both generalization and maintenance appears important as the lack of either would seriously limit the ecological validity of the teaching procedures.

One of the reasons tablet-delivered teaching holds promise as an instructional tool for children with ASD is attributed to the reduced labor requirements it entails as opposed to instructor-delivered teaching (Moore & Calvert, 2000). Based on this premise, instructors and teachers should be able to use tablet-delivered teaching to facilitate working with several students at the same time. In most studies dispensing computer-delivered instruction, some sort of instructor-mediated prompts and reinforcement was provided (Bernard-Opitz, Sriram, & Nakhoda-Sapuan, 2001; Bosseler & Massaro, 2003). The same holds for comparison studies: Both the Allen et al (2015) and Schery et al. (1997) relied on the instructor to deliver reinforcement and prompts to the students. The reliance on an instructor prevents us from concluding that the technological tool is effective by itself since this added level of support could be facilitating learning (Saade Chebli et al., 2017). While we do not think that including a human component to the computer-delivered instruction is inadequate, this level of involvement may be counterproductive in certain settings, such as when an educator is unavailable to provide one-to-one support. To address the previously noted limitations, the present study aims to extend the literature by (a) comparing the effectiveness of tablet-delivered to instructor-delivered teaching, (b) evaluating generalization of concepts taught to three-dimensional representations, (c)

assessing maintenance of correct responding up to a few months following the instruction, and (d) comparing non-responding across modalities.

Method

Participants and Settings

We recruited seven children diagnosed with ASD (based on the DSM-IV or DMS-V criteria; American Psychological Association, 2000, 2013) by an independent multidisciplinary team. Those children attended a French-instruction specialized school for children with ASD in Montréal, Canada, because they presented a low level of functioning or problem behaviors preventing their inclusion in integrated classroom settings. To participate in this study, the students had to: (a) already have a diagnosis of ASD, (b) currently be learning one-word concepts, and (c) be able to stay seated for at least 5 min. The school board and the researchers' university research ethics board approved our research project. Following approval, we presented the project to teachers of the school and asked them to refer students meeting our inclusion criteria. Based on teacher referrals, we then presented the project to the children's parents and obtained their written informed consent.

To characterize our sample, we scored the CARS-2 (Schopler et al., 2010) based on our school observations to provide an estimate of the severity of autistic symptomatology and we administered the Adaptive Behavior Assessment System – Second Edition (ABAS-II; Harrison & Oakland 2003) by interviewing parents to provide an estimate of adaptive functioning for each participant. Table 1 presents the characteristics of the participants and the concepts taught. Sam was 8 years old at the start of the study, had severe symptoms of ASD, and did not have a means of communication other than squeals and informal gestures. Similarly, Carine was 9 years old, had severe symptoms of ASD, and did not have a means of communication other than informal

gestures. Nancy was 5 years old, had mild to moderate symptoms of ASD, and used one-word statements to communicate such as “cookie”. Ian was 6 years old, had mild symptoms of ASD, and made one-word statements mainly in an echolalic form. Alex was 7 years old, had mild to moderate symptoms of ASD and displayed meaningful speech (three- to five-word sentences such as “Session is over?”), but he would often mix-up certain words. Adam was 8 years old, had severe symptoms of ASD, and sometimes used one-word statements with unclear pronunciation. Lastly, Antoine was 9 years old, had mild to moderate symptoms of ASD, and used one-word statements to communicate such as “sleep”.

<Insert Table 1 about here>

All participants had prior experience with tablets, which were often used to provide access to reinforcing activities (e.g., games, videos) in their classrooms. Due to their prior experiences, each participant could turn the tablet on and off, access some apps independently, and make selections on a touch screen. That said, most of the instruction in class was provided by an instructor instead of the tablets. Instruction was provided in French for all participants as it was the primary language of instruction in the school. All sessions were either conducted in a small conference room or in a private room within the school. Most of the time, only the participant and the first author were present during those sessions; a research assistant was only occasionally present to measure interobserver agreement (IOA). When she was present, she sat in front of the first author or on her left. In both tablet-delivered and instructor-delivered teaching, participants sat at a large table with the first author sitting next to them on their right.

Data Collection and Interobserver Agreement

To compare the effects of the tablet-delivered and the instructor-delivered teaching, we measured the children's responding during baseline, instruction, generalization, and maintenance

sessions. A correct response was defined as the child touching the image or object corresponding to the named concept within 3 s of the concept being named. An incorrect response was defined as touching an image or object other than the one associated with the named concept within 3 s, and finally the absence of a response was defined as the child not touching an image or object within 3 s. We calculated the percentage of correct responding by dividing the number of correct responses by the number of unprompted trials (i.e., always 5) and multiplying the quotient by 100. We calculated the percentage of non-responding by dividing the number of absence of responses by the number of unprompted trials (i.e., always 5) and multiplying the quotient by 100. The IOA was calculated by dividing the number of agreements by the number of agreements and disagreements and multiplying the result by 100, which resulted in mean IOAs of 99% or above for each participant.

Instructional Materials

We used an Android-based Samsung Galaxy Note 10.1 tablet with a 25.4-cm screen on which we installed an app designed to teach receptive identification of vocabulary words. The OpenSource Discrete Trial Instructor is an app developed by the research team, which uses discrete trials, integrated video reinforcement and prompting to teach one-word concepts. Our research team was composed of undergraduate and graduate students in the field of educational psychology as well as of a doctoral student in software engineering. The app is not available to the public at this time as it is mainly used as a research tool (see Saade Chebli et al., 2017). The details regarding the presentation of the instructional trials by the app are described in the procedures section below. Instructor-delivered teaching was similar to tablet-delivered teaching except that the instructor offered the instructions and prompts as opposed to the tablet.

Experimental Design and Procedures

Table 2 presents a summary of the teaching procedures. To compare the effectiveness of instructor-delivered and tablet-delivered teaching, we used a multielement design while staggering the introduction of subsequent pairs in a multiple probe design. We also integrated periodic generalization and maintenance probes to the research design. Each child participated in six to twelve sessions per day, three days per week (depending on their availability) for a period of 15 to 30 min. We selected six concepts to teach each child based on teacher and parental reports (see Table 1). The concepts taught were based on the child's lack of knowledge of those words, their availability on our app, and the children's reduced risk of exposure to them outside of the experimental setting. For instance, we taught Alex the "skirt" concept since he was a boy and was therefore less exposed to it on a daily basis. We taught each child three pairs of concepts (six concepts in total). Three concepts were taught with the tablet and three with the instructor. In addition to randomly assigning a concept to an instructional modality, we selected pairs of concepts composed of examples with similar levels of difficulty. For example, we taught Nancy the "horse" concept using the tablet and the "duck" concept with the human instructor. Both concepts are animals and included a similar level of variations in the exemplars presented.

<Insert Table 2 about here>

Prior to teaching a concept, we conducted baseline sessions to ensure that the participant did not already master it. The participant had to demonstrate correct responding on less than 80% of trials for at least three consecutive sessions spread on two different days. In accordance with the multiple probe design, we only started teaching the second pair of concepts when the child demonstrated a rate of correct responding of at least 80% on three consecutive generalization probes on at least one concept of the first pair of concepts. When only one concept from the concept pair was generalized, we conducted five additional teaching sessions of the second

concept not yet generalized before introducing the new pair of concepts. Since some participants showed generalization more rapidly for one concept of the previous pair, we introduced the new pair of concepts while pursuing teaching the previous concept on which the participant had not yet shown generalization. We stopped teaching a concept when the child showed correct responding of 80% or more on three consecutive generalization probes spread on at least two different days.

Sam, Nancy, Ian, Alex, and Adam ended their participation in the project when they showed generalization on all three pairs of concepts. As for Carine and Antoine, we terminated their participation earlier prior due to time restrictions (i.e., end of project). At the end of the instructional period, Antoine had shown generalization on two pairs of concepts and Carine had met the criterion for two concepts taught by the instructor and one with the tablet. Even though we asked the children's teachers and parents not teach the concepts targeted in our instruction during the course of the study, we had to introduce new pairs of concepts not originally tested for several participants as they showed mastery on some concepts prior to teaching.

Baseline. To evaluate a participant's pre-instruction knowledge of the concepts taught, we began by conducting baseline probes. For each concept, we conducted at least three baseline sessions for each child on at least two different days. Additionally, we also assessed pre-instruction knowledge of the four other concepts targeted for later teaching. Every session included five trials. For concepts taught on the tablet, three images (either colored photographs or colored drawings of the concept) were concurrently presented on the tablet screen with one image depicting the target concept and two others depicting distracters (images of associated categories not currently taught). An automated digital voice named the concept and the child was required to choose the image associated with the concept by manually selecting it on screen. The

app randomized the position of the correct responses and did not provide any reinforcement or feedback to the participant during baseline. If the child did not choose an image within 3 s of the instruction, the instructor told the participant to listen to the instruction and select an image while transitioning to the next trial (presenting a different example of the concept). If the child stood up from the chair, the investigator asked him to sit down within 3 s. If the child did not sit down following the vocal prompt, the instructor repeated the vocal instruction and pointed to the chair. If the child still did not sit down following the verbal and gestural prompt, the instructor manually guided him to the chair by placing his hand on his shoulder until he sat down. We followed similar procedures for concepts taught with the instructor: The first author presented the instructions and the images were presented on paper rather than on the tablet screen.

Teaching with the tablet. The instructional sessions were similar to the baseline sessions with the following exceptions. First, the app played a preferred video for 10 s contingent on correct responding. The reinforcer provided was a video because we wanted to evaluate the effectiveness of the tablet-delivered teaching with minimal adult interference. The instructor identified the preferred video prior to teaching using a modified paired-choice preference assessment and re-evaluated preference every 40 instructional sessions to maintain the child's motivation. It is also worth mentioning that we had demonstrated in a prior study that the preferred videos identified using a tablet functioned as reinforcers (see [removed for blind review] for detailed procedures). Second, when the participant provided an incorrect response, the correct image of the concept grew larger while the name of the concept was repeated simultaneously. The prompting procedure was implemented automatically by the app following incorrect responses (i.e., without input from the instructor). The procedure was repeated until the child responded correctly. Correct responding on prompted trials resulted in access to the video

reinforcement. We did not include prompted trials in our calculation of percentage of correct responding as they were almost always followed by correct responses, which would have skewed our results (because there were no prompted trials in baseline). As in baseline, we always presented five unprompted trials to remain consistent. During all instructional sessions, we did not provide social reinforcement; the only reinforcement offered contingently on correct responding was the preferred video playing on the app.

Teaching with the instructor. Instructor-delivered teaching was similar to tablet-delivered teaching with some exceptions. To reinforce correct responding, we presented four of seven participants (Sam, Carine, Ian, and Adam) with their preferred video displayed on the tablet for 10 s following a correct response. Alternatively, we presented three of seven participants (Nancy, Alex, and Antoine) with their preferred food choice also contingent on correct responding. Our initial plan was to deliver edible reinforcers to all participants as they require less time to deliver and may be more potent than video-based reinforcers (i.e., primary vs. secondary reinforcer). However, the teachers reported that Sam had several food allergies, Ian had diabetes, and that Adam and Carine displayed a high level of rigidity with food, which prevented our use of edible reinforcers. Thus, we used video-based reinforcers for these participants, which allowed us to examine differential effects across both types of reinforcement.

As for the prompting procedure, the instructor pointed the correct image while simultaneously repeating the name of the concept following an incorrect response.We did not provide any social reinforcement during instruction; the only reinforcer was either the preferred video or the edible. To minimize potential carry-over effects, we set the maximal number of teaching sessions per day at ten per concept. This restriction was applied to both the instructor-delivered and tablet-delivered teachings.

Generalization. To evaluate generalization to new exemplars, we assessed the child's knowledge of five different untaught exemplars of the target concept. Those exemplars differed from the ones used during instruction. For example, if we taught the “dog” concept with a German Shepherd, a Pug, a Beagle, a Pit Bull and a Poodle, we evaluated generalization with a Chow Chow, a Boxer, a Siberian Husky, a Rottweiler and a Chihuahua. Alternatively, if we taught the “red” concept using a red table, chair, purse, cup and shirt, we evaluated generalization using a red hat, shorts, car, pen and frame. We conducted the generalization probes prior to instruction and then periodically following each series of five instructional sessions of the taught exemplars. We used both three-dimensional representations (e.g., figurines, toys, objects) and untaught images of the target concept. Generalization probes for tablet- and instructor-delivered teaching were similar to baseline probes except that they were always conducted by the instructor. During trials, we placed three items (the target concept and two other distracter items) on a table facing the child. The instructor named the target concept and the child had to select the item representing the concept. We did not offer any reinforcement or prompts during these trials because the aim of our study was to examine whether the children would respond correctly on untaught exemplars. For each concept, we conducted five generalization trials, every trial presenting a different exemplar of the concept.

When a child responded correctly on 80% of target trials during the session, one more session was conducted thereafter and a third final one the next day in order to obtain three data points spread on at least two different days. As for the untaught concepts, we also conducted generalization probes when the child first began participating in the study and following 20 baseline and instructional sessions of the target concept to ensure that the child had not learned the untaught concept in another context prior to the start of instruction. Due to mail delivery

delays, we originally assessed Nancy's generalization to the "drums" concept using images only, but later integrated the object in her maintenance probes.

Between each trial, we presented simple instructions that the child already performed correctly prior to their inclusion in the study (e.g., giving a high five). The purpose of these instructions was to maintain responding during generalization trials as no reinforcement was provided for correct responding. Correct responding on these instructions was followed by edible or social reinforcement (e.g., great job, well done!) or both on a continuous reinforcement schedule (i.e., fixed ratio of 1). We did not collect data on responding on mastered instructions as our purpose was to measure generalization.

Maintenance probes. After having met the generalization criterion for a concept, we conducted maintenance probes every two weeks for up to three months for some concepts (depending on availability). The maintenance probes were identical to baseline, except that they occurred following teaching.

Results

Figure 1 shows the number of instructional trials required for each participant to display generalization following tablet-delivered and instructor-delivered teaching whereas Table 3 presents non-responding. Results show two patterns: First, two of seven participants (Sam and Carine) consistently showed generalization within fewer instructional trials on the concepts taught by the instructor. Second, five of seven participants (Nancy, Ian, Alex Adam and Antoine) had mixed results: The effectiveness of the instructional modality varied depending on the concept being taught. Interestingly, the two children who learned all their concepts more rapidly with the instructor had access to the same reinforcer across conditions (i.e., video-based only)

whereas the three children who received edibles during instructor-delivered teaching showed mixed results across modalities

<Insert Figure 1 about here>

<Insert Table 3 about here>

Among the participants learning more rapidly from the instructor-delivered teaching (see Figures 2 and 3), Figure 2 indicates that Sam required fewer instructional sessions to generalize the three concepts taught with the instructor compared to the concepts taught with the tablet. As for his maintenance probes, his rate of correct responding was slightly higher for concepts taught with the instructor compared to those taught with the tablet. Additionally, Sam displayed lower levels of non-responding with the instructor. As for Carine, Figure 3 shows a more rapid learning rate while receiving instructor-delivered teaching. Concerning the second pair of concepts, she showed generalization on the concept taught with the instructor, but never reached generalization criterion for the second concept taught with the tablet. Carine also showed better maintenance on the concepts taught and had less non-responding with the instructor.

<Insert Figures 2 and 3 about here>

As for the remaining five participants (Nancy, Ian, Alex, Adam, and Antoine; see Figures 4 to 8), the effectiveness of the instructional modality in terms of the number of trials required to show generalization varied across concepts. Figure 4 indicates that Nancy met the generalization criterion within fewer sessions following instructor-delivered teaching on two of three concept pairs, while showing generalization more rapidly on the first concept taught with the tablet. Furthermore, Nancy showed better maintenance on concepts taught with the instructor, but displayed a lower level of non-responding with the tablet. Figure 5 indicates that Ian displayed more rapid generalization on the first two concepts taught with the instructor compared to the

concepts taught with the tablet. He did however display more rapid generalization of the third concept taught with the tablet compared to the one taught with the instructor. Ian also showed better maintenance and displayed lower levels of non-responding during instructor-delivered teaching.

<Insert Figures 4 and 5 about here>

Similarly to Ian, Figure 6 reveals that Alex displayed more rapid generalization following instructor-delivered teaching with the first two pairs of concepts. Nevertheless, his results differed for the third pair of concepts because he reached the generalization criterion more rapidly with tablet-delivered teaching. It is also worth mentioning that Alex had similar levels of correct responding on maintenance trials for both modalities. He also displayed lower levels of non-responding with the instructor. Figure 7 indicates that Adam was also able to generalize the first two concepts taught with the instructor following fewer sessions. That said, Adam showed generalization more rapidly the concepts taught with the tablet. Adam also showed similar levels of maintenance with the two modalities while displaying higher levels of non-responding with the tablet. Lastly, Figure 8 shows that Antoine displayed more rapid generalization following instructor-delivered teaching with the first concept while displaying more rapid generalization of the second concept taught with the tablet. Antoine also showed better maintenance of concepts taught with the instructor and displayed lower levels of non-responding during instructor-delivered teaching.

<Insert Figures 6, 7, and 8 about here>

Discussion

In sum, our results indicate two participants always showed more rapid generalization during instructor-delivered teaching whereas the results of the remaining participants varied

across concepts. For the latter group of participants, nine of fourteen concepts were generalized more rapidly following instructor-delivered prompting and reinforcement and the remaining five concepts more rapidly following tablet-delivered instruction. During maintenance, five participants showed better maintenance of the concepts learned with the instructor and the results were the same across modalities for two participants. Moreover, six of seven participants displayed lower levels of non-responding during instructor-delivered teaching whereas only one participant showed less non-responding with the tablet.

Overall, our results support the use of tablet-delivered prompting and reinforcement as a supplement to traditional instruction. Children still showed generalization on nearly all concepts taught using tablets (18 of 19). As such, tablets represent an interesting option, particularly in contexts where limited financial and human resources preclude the delivery of individualized instruction. The reason why some children required fewer instructional trials with the instructor may be related to non-responding. Nearly all children engaged in less non-responding with the instructor than with the tablet, which is inconsistent with the results of the study conducted by Moore and Calvert (2000). Our results suggest that being more engaged with the instructional material may lead to be better outcomes, but more research is needed on this topic. The use of two types of reinforcers for some participants may also explain some differential results.

Our study contributes to the research literature on the use of technology to teach children with ASD. In addition to comparing instructor- and tablet-delivered prompting and reinforcement, we evaluated whether the participants showed generalization and maintenance of the concepts taught using both modalities over several weeks. Examining generalization to three-dimensional objects as well as maintenance over an extended period of time is important because it may decrease the need for further instruction. By including a video reinforcement component

and an integrated prompt in the app to promote learner independence, we decreased instructor involvement, potentially allowing the implementation of the procedures with multiple students simultaneously. Our results therefore extend previous studies comparing the two modalities in children with ASD (Allen et al., 2015; Moore & Calvert, 2000).

Limitations and Future Research

Our results are limited insofar as the difficulty of the concepts taught with the two modalities could have inadvertently differed, which is why we chose to teach three concepts to each participant with both modalities. Similarly, difficulty levels could have differed across participants (for instance, prepositions are usually harder to master than colors). Furthermore, some participants responded arbitrarily during the instruction as the reinforcement was available for an equal duration of time following both prompted and unprompted correct responses. To address this issue, we recommend that researchers differentially reinforce correct responding following prompts in the future. To encourage independent responding, a participant could receive a smaller magnitude of reinforcement (e.g., 3 s rather than 10 s of video) following a prompted response as opposed to an independent correct response. Presenting some participants with a food reinforcement while presenting others with a video reinforcement in the teacher-delivered instruction could have added some level of variability between the participants. We suggest that future researchers use one type of reinforcement with all the participants. Finally, our small sample size precluded inferential statistical analyses regarding the contribution of individual characteristics to the modalities' effectiveness (e.g., scores on the ABAS-II, CARS-II, age).

In the future, studies should replicate our study with a larger number of participants and examine whether variables such as IQ, non-responding, and the severity of autistic symptoms moderate the association between tablet-delivered instruction and generalization. Similarly, researchers should consider examining the effects of preference on the predictive effectiveness of each modality. For example, children may participate in concurrent-chain arrangements to assess the relative preference for tablet- and instructor-delivered prompting prior to comparing both modalities (see Hanley, Piazza, Fisher, Contrucci, & Maglieri, 1997). Future studies could also replicate the study with other types of instructors such as parents or paraprofessionals. Moreover, examining whether the participants respond to the digital voice in the same manner as a human may also be the topic of research in the future.

Because of the mixed results obtained and the complexity of the topic studied, we cannot conclude that one prompting or reinforcement modality is always more effective than the other. Individuals with ASD have unique learning profiles, which is why we believe that some learners might benefit more from instructors while others might benefit more from tablets. Based on this premise, we recommend that practitioners assess the effectiveness of each procedure using single-case designs (as was done in this study) before assigning a learner to a teaching modality. That said, the topic examined in the present study remains a burgeoning field and much work still needs to be done in that area. We suggest that researchers replicate our study while examining different assessments that could render the identification of the most effective modality more efficient.

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Table 1

Characteristics and Concepts Taught for Each Participant

Participant	Age	Gender	CARS-2 *T* score	ABAS-II GAC	Concepts Taught	
					Tablet	Instructor
Sam	8	Male	49	65	Dog Shoes A	Cat Gloves D
Carine	9	Female	56	55	Red Blue	Yellow Green
Nancy	5	Female	44	40	Blue Horse Drums	Green Duck Guitar
Ian	6	Male	38	77	Red Blue Dog	Yellow Green Cat
Alex	7	Male	41	77	Horse Skirt Drums	Duck Socks Saxophone
Adam	8	Male	50	Not available	E Shoes Drums	D Gloves Guitar
Antoine	9	Male	47	52	Cow Inside	Horse On

Note. CARS-2: Childhood Autism Rating Scale, ABAS-II: Adaptive Behaviour Assessment System - II (Second Edition), GAC: General Adaptive Composite.

Table 2

Procedures for Tablet-Delivered and Instructor-Delivered Teaching

	Tablet			Instructor		
	Stimulus presentation	Prompt procedure	Reinforcement for target concepts	Stimulus presentation	Prompt procedure	Reinforcement for target concepts
Baseline	Three images presented on screen, one representing the target concept and two representing distractors.	None.	None.	Three images presented on paper, one representing the target concept and two representing distractors.	None.	None.
Teaching	Three images presented on screen, one representing the target concept and two representing distractors.	Correct image of the concept grew larger.	Preferred video played for 10 s.	Three images presented on paper, one representing the target concept and two representing distractors.	The instructor pointed the correct image of the concept.	The instructor showed the preferred video for 10 s or delivered an edible reinforcer
Generalization	The instructor presented a mix of five real objects and untaught images of the target concept.	None.	None.	The instructor presented a mix of five real objects and untaught images of the target concept.	None.	None.
Maintenance	Same as baseline and generalization probes.	None.	None.	Same as baseline and generalization probes.	None.	None.

Table 3

Percentage of Non-Responding for Each Participant

Participant	Non-Responding (%)	
	Tablet	Instructor
Sam	21	7
Carine	31	8
Nancy	3	24
Ian	11	4
Alex	27	1
Adam	6	0
Antoine	10	1

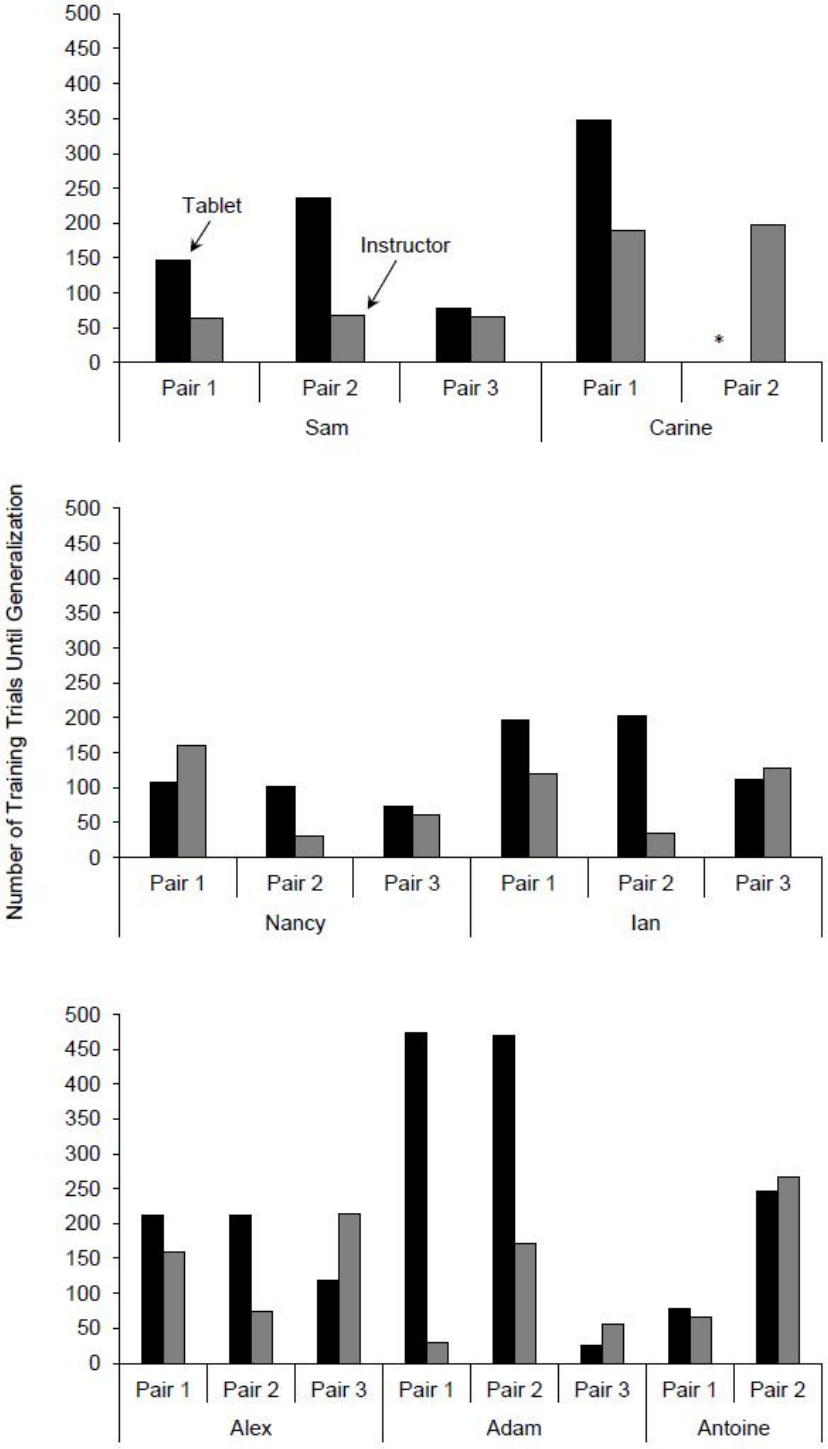

Figure 1. Number of training trials until each participant showed generalization on each pair of concepts taught. The asterisk identifies a concept on which the participant never showed generalization.

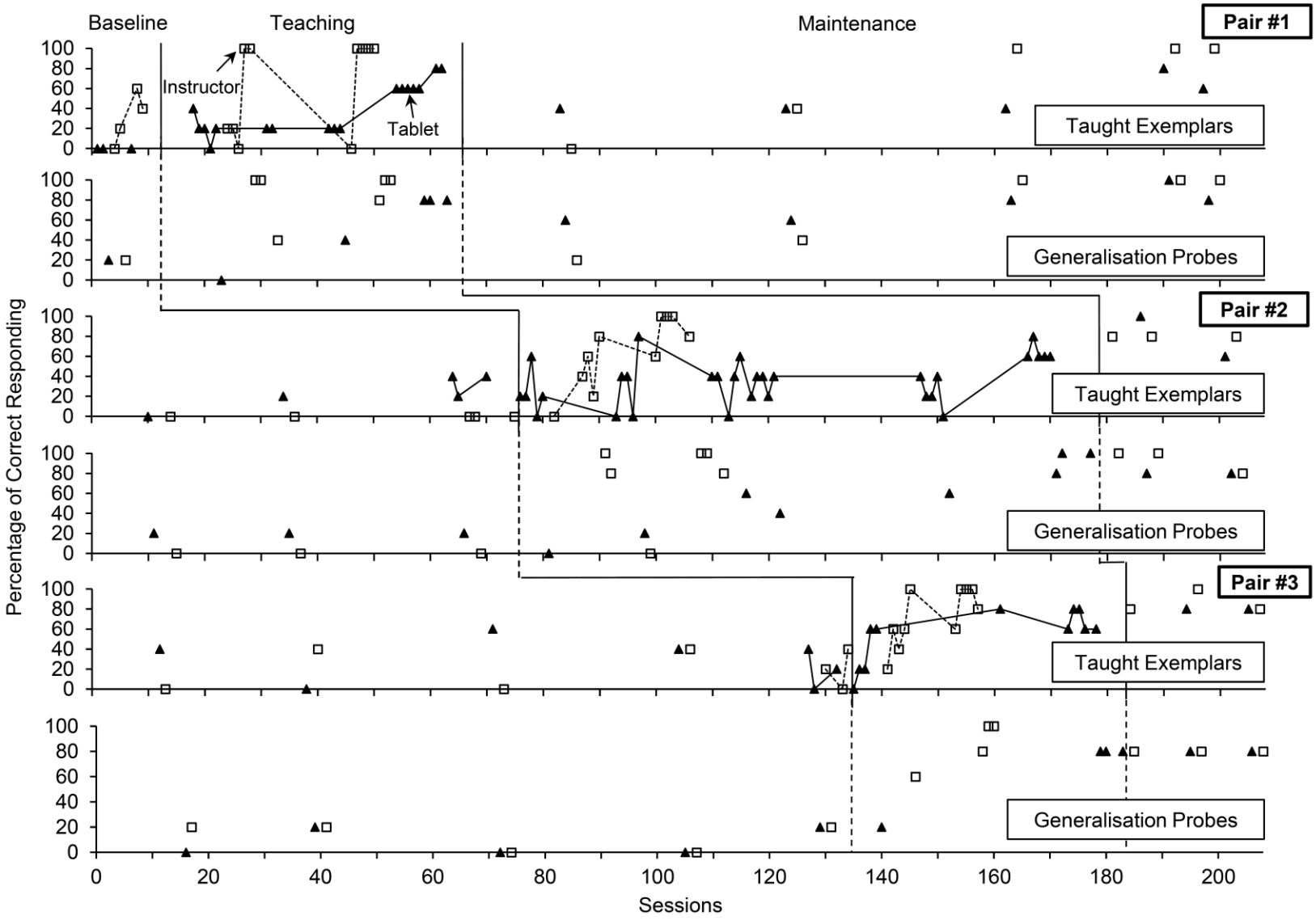

Figure 2. Sam's percentage of correct responding on taught exemplars and generalization probes for each pair of concepts.

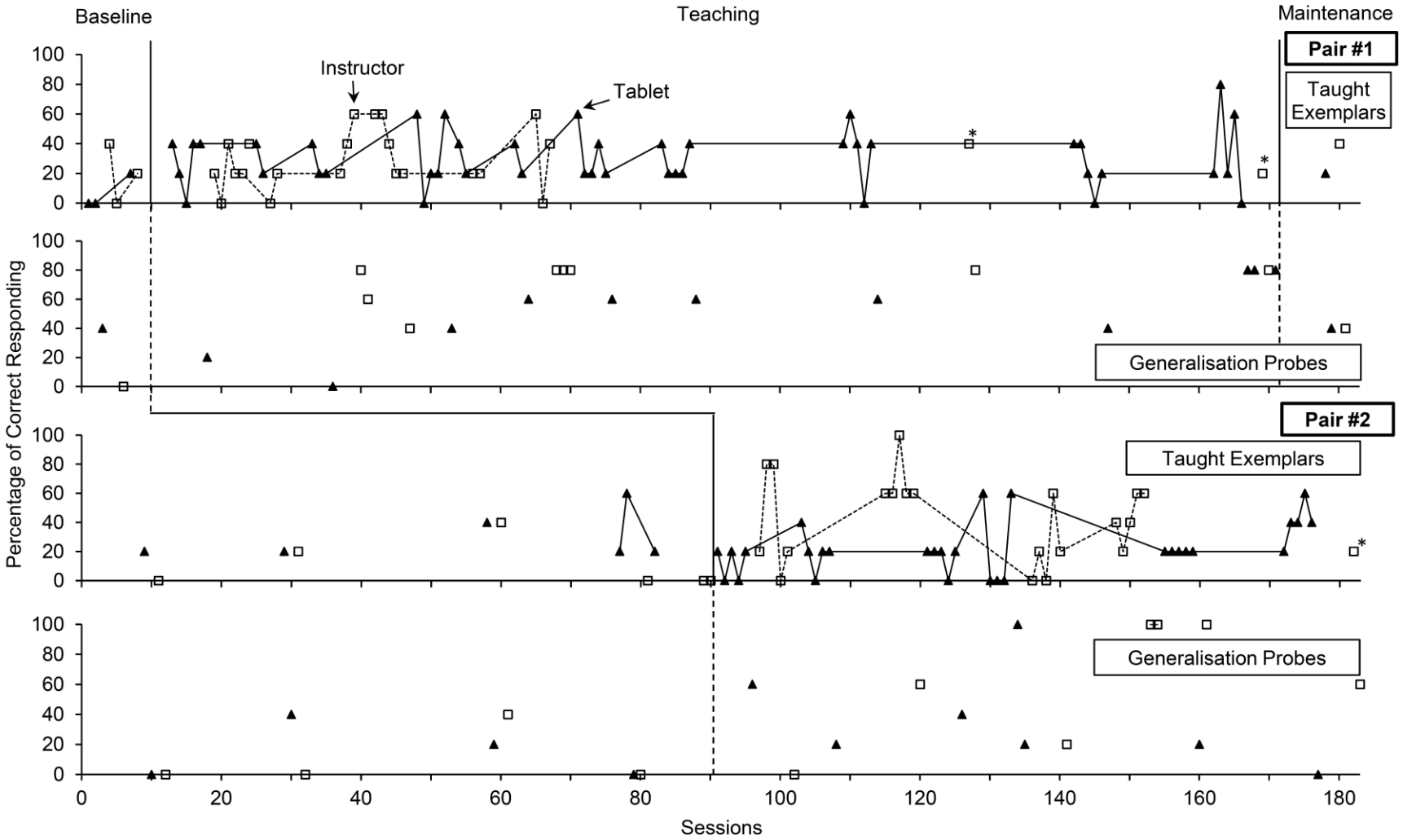

Figure 3. Carine's percentage of correct responding on taught exemplars and generalization probes for each pair of concepts. Asterisks identify maintenance probes conducted during teaching.

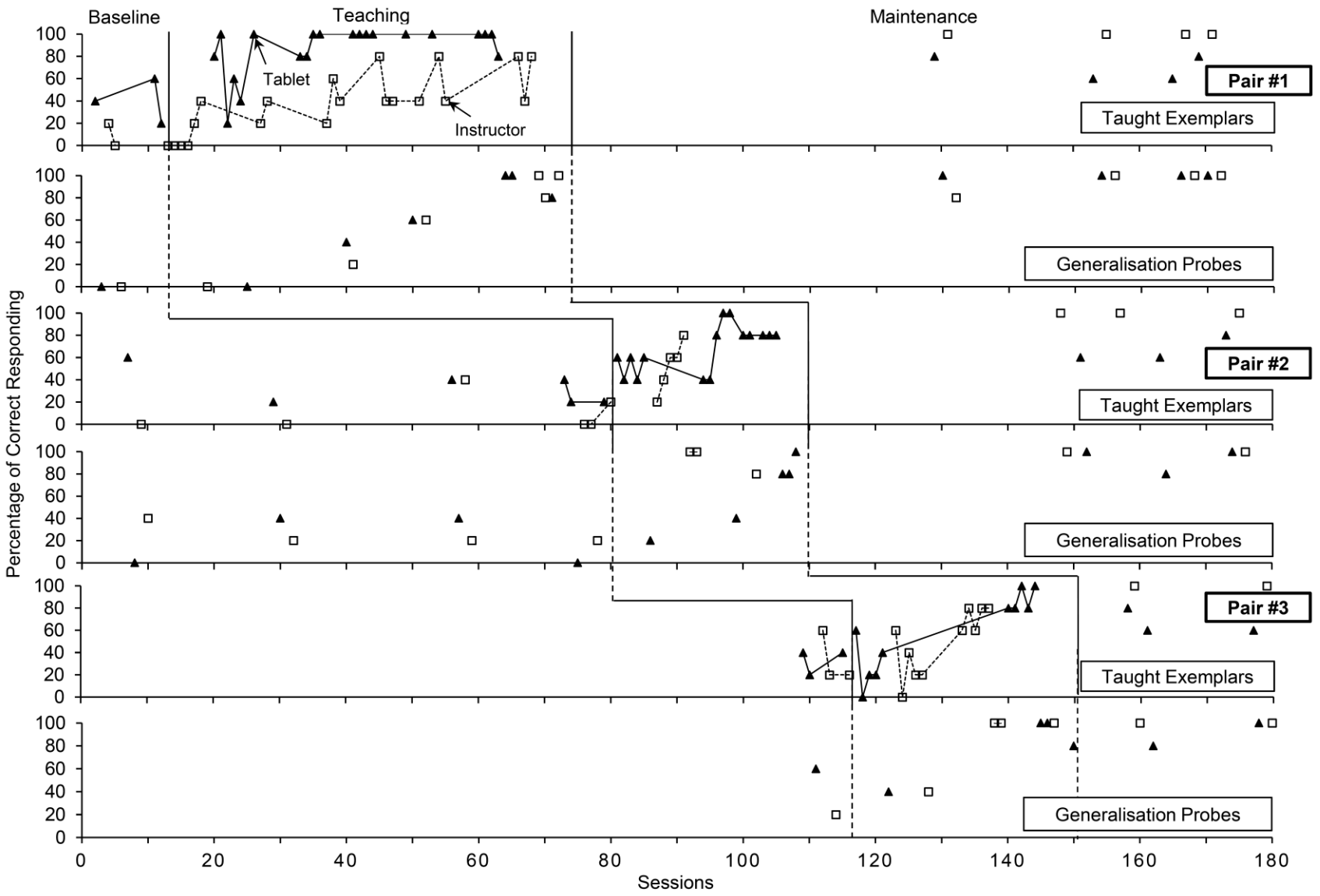

Figure 4. Nancy's percentage of correct responding on taught exemplars and generalization probes for each pair of concepts.

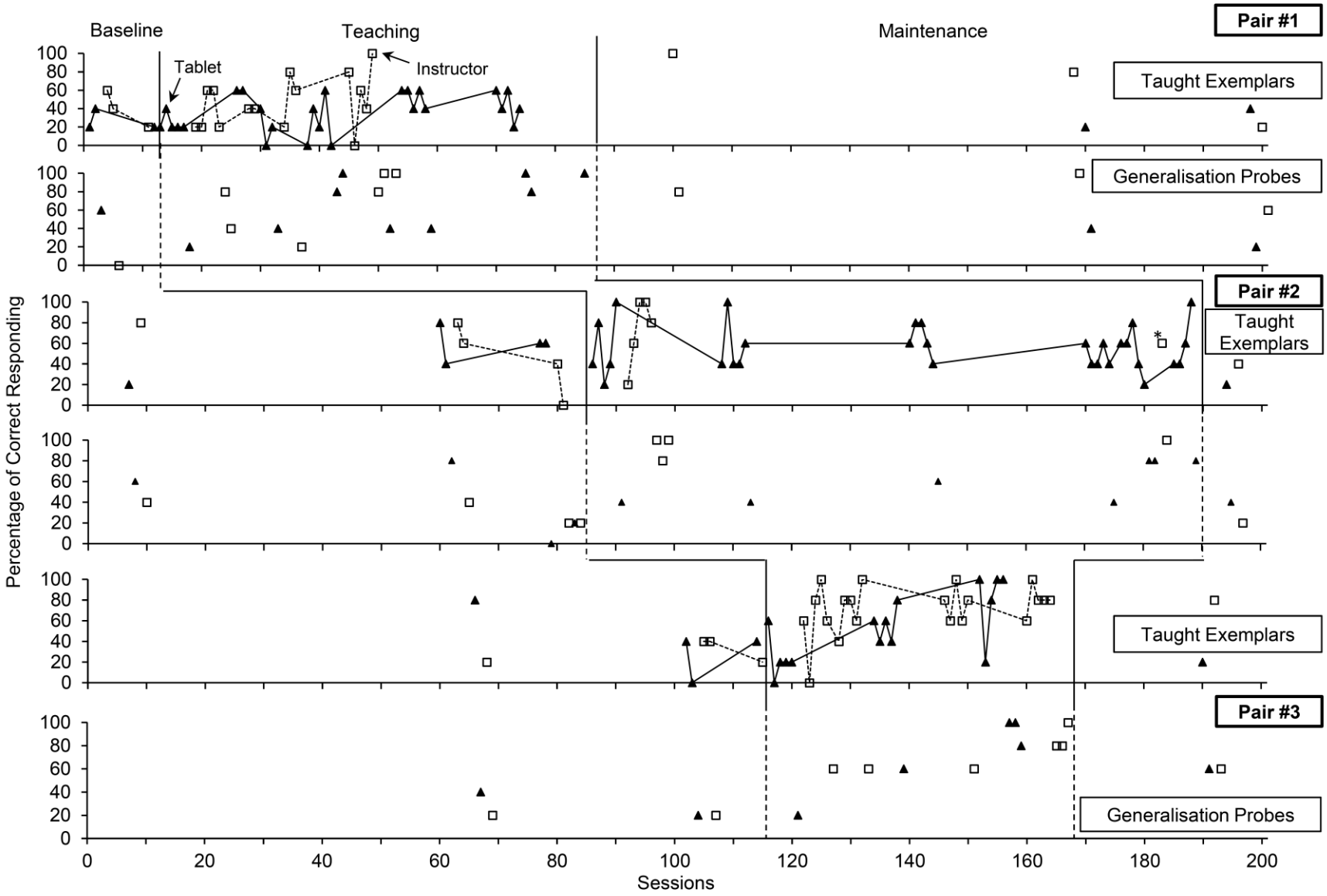

Figure 5. Ian's percentage of correct responding on taught exemplars and generalization probes for each pair of concepts.

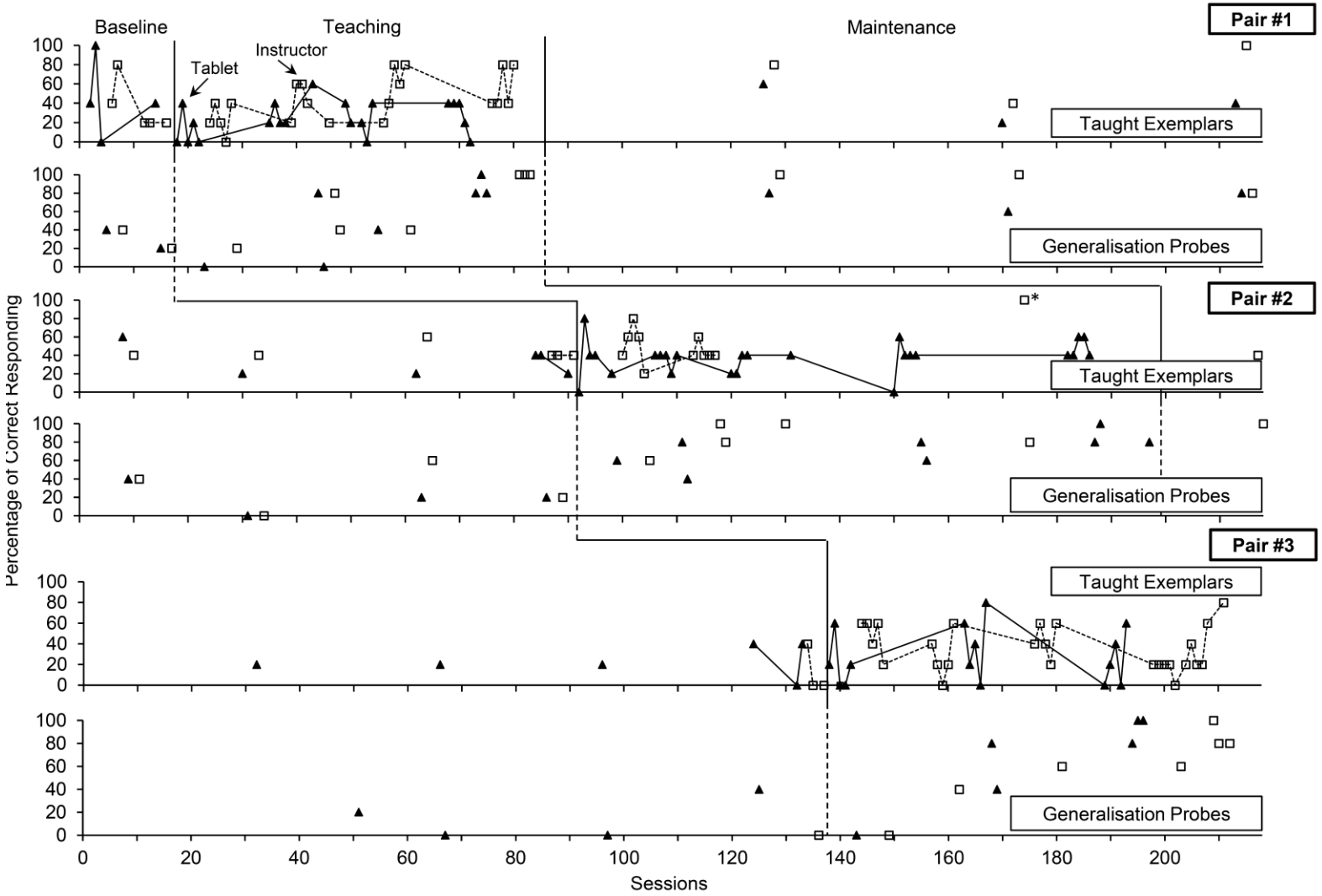

Figure 6. Alex's percentage of correct responding on taught exemplars and generalization probes for each pair of concepts. Asterisks identify maintenance probes conducted during teaching.

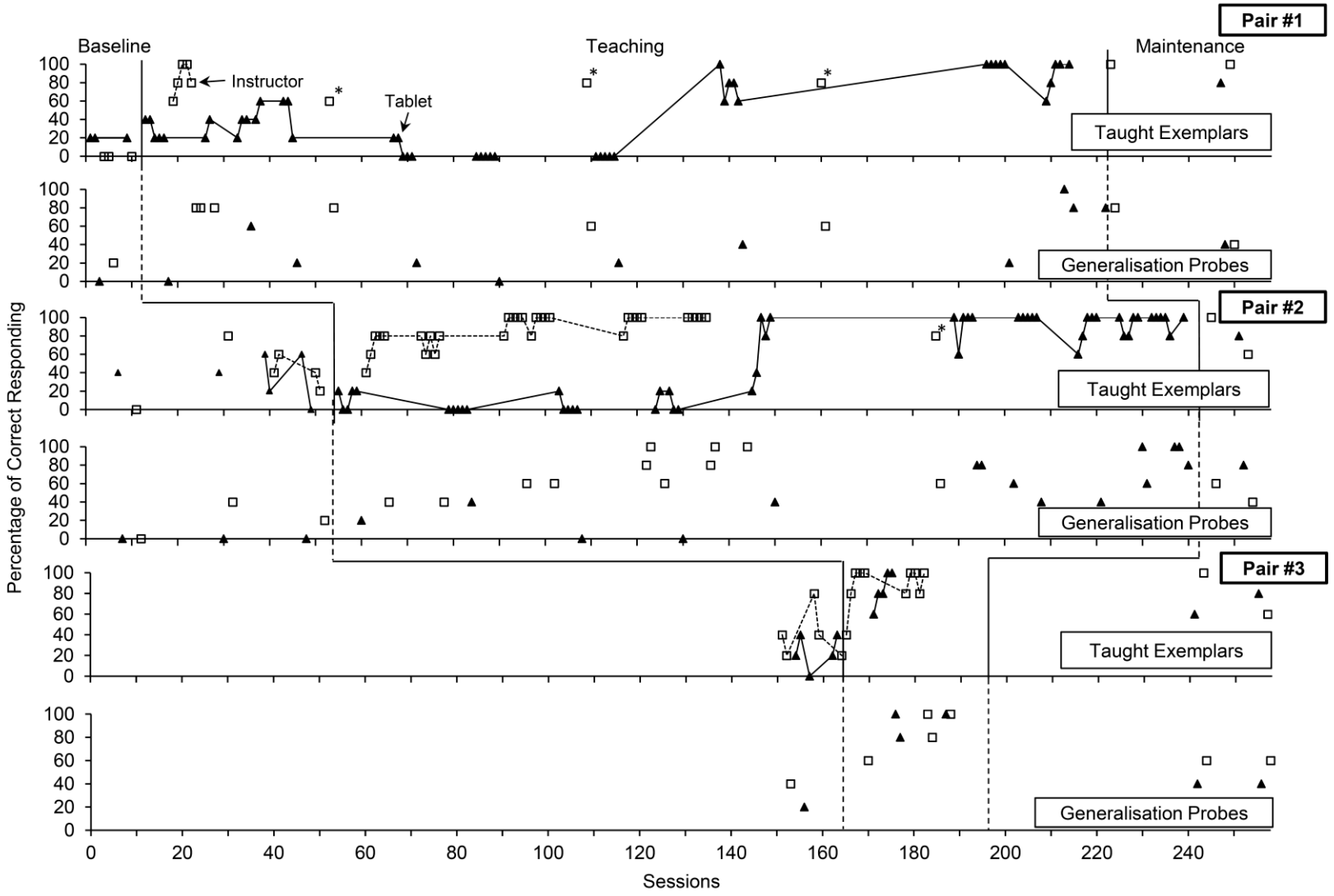

Figure 7. Adam's percentage of correct responding on taught exemplars and generalization probes for each pair of concepts. Asterisks identify maintenance probes conducted during teaching.

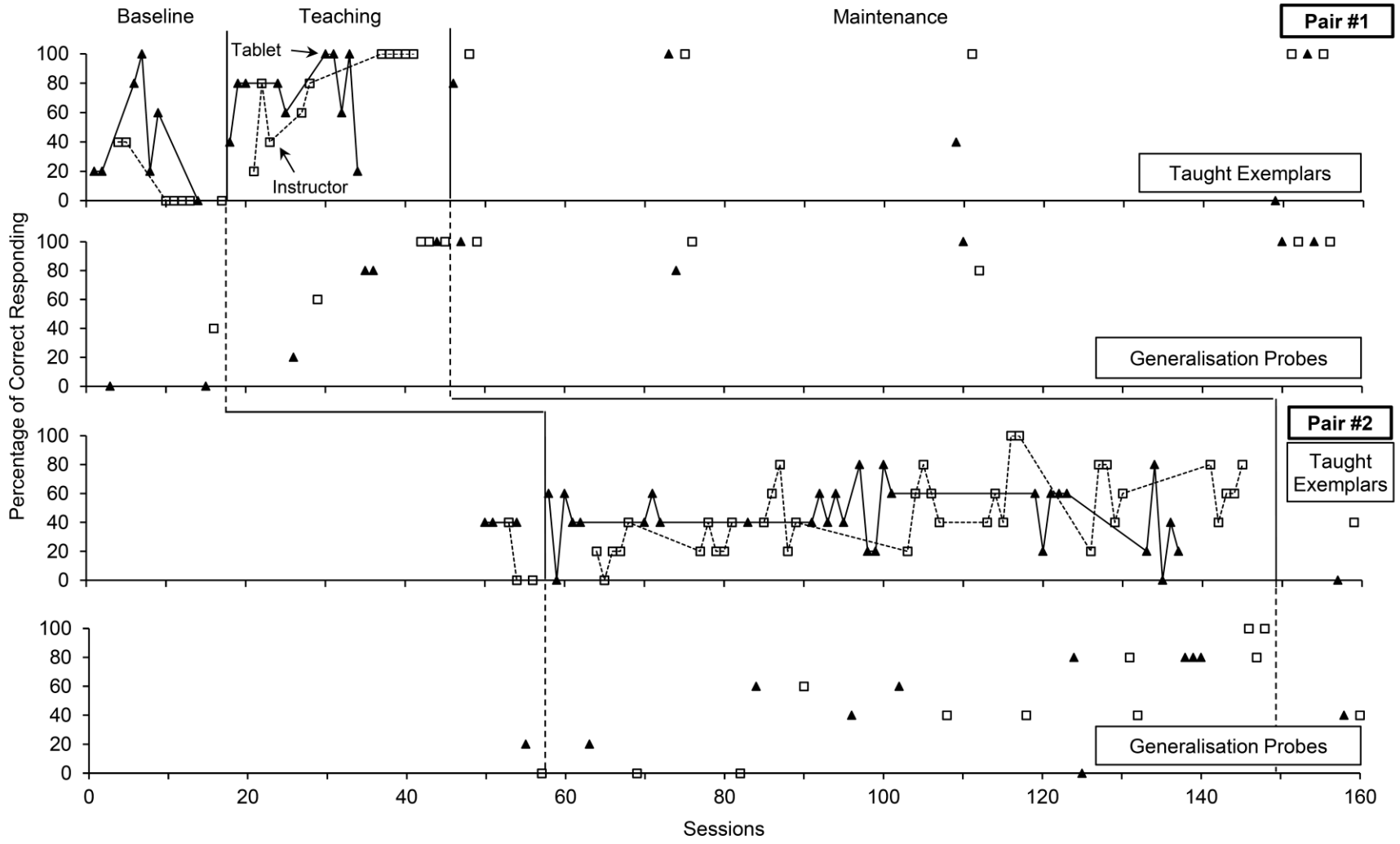

Figure 8. Antoine's percentage of correct responding on taught exemplars and generalization probes for each pair of concepts.