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New Techniques in Interventions for Children with Autism Spectrum

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Abstract

Verbal instructions (VI) and *In vivo* modeling are two commonly used instructional methods in the interventions for individuals with autism. The use of visual supports (VS) and particularly the use of static pictures (SP) and video modeling (VM) have also shown very encouraging results. Yet, there has not been any study to directly assess the effectiveness of each method. Thus, the present study was designed to assess the effectiveness of these four instructional methods across a number of different tasks. Nine children diagnosed with autism participated and experimental control was accomplished using a single-group repeated measures design. The impact of each method on children's performance was determined through comparisons of the mean percentages of the completed steps in each task. Results showed that VM was the only instructional method which was more effective than VI. Possible reasons for the superiority of VM are provided and implications for future research are identified.

Keywords: Autism; Verbal instructions; *In vivo* modeling; Static pictures; Video modeling

Introduction

Autism is a lifelong neurodevelopmental disorder, which prevalence has shown a steady increase in the past four decades [1-3]. It has lifetime consequences with a range of impacts on the health, economic wellbeing, social integration and quality of life of individuals with the disorder and also on their families, healthcare professionals, teachers and potentially the rest of the society. Recent estimates have shown that families of children with autism, and in essence the entire healthcare system, face significant economic burden worldwide [4,5]. As a result of these compelling impacts, there have been consistent reports in the literature identifying the critical need for further research that aims to expand and improve the currently available interventions in an effort to address the individualized needs of this population [6-8].

Since 1981, applied behavior analysis (ABA) has been regarded as the treatment of choice for individuals with autism [9]. All these years, a vast range of instructional tactics incorporating the principles of ABA have been developed, such as those known as visual supports (VS), which have shown very encouraging results in the treatment of individuals with autism [10-12]. This is because people with this condition have been reported to process visual information easier than auditory information [13-15]. *In vivo* modeling, static pictures (SP) and video modeling constitute the predominant VS methods for teaching individuals with autism complex or multiplex skills and task sequences.

In vivo modeling involves the child observing a person model engaging in a targeted behavior live, and then imitating the behavior of the model [16]. *In vivo* modeling has been used to teach *play skills* [17]; *social skills* [18,19]; or *contextually appropriate affective behavior* [20,21]. Static pictures visually depict the steps of the chained task analysis or the final product of the targeted task [22,23]. They have been used to enhance, for example, *daily living skills* [24]; *community skills* [25,26]; *food preparation skills* [27,28]; or *vocational skills* [29].

Video modeling involves an individual watching a videotaped demonstration and then imitating the behavior of the model [30,31], while the model can be a peer, a sibling, an adult, or even oneself [32,33]. The list of video modeling achievements is growing fast and includes, for example, teaching of *functional living skills* [34-37]; *conversational skills* [16,38-40]; *social language (expressive) skills* [41-43]; *academic skills* [44,45]; *perspective taking* [46,47]; *socially relevant behaviors and*

play skills [48-64]; *iPod use* [65]; *generalized imitation skills* [66]; or *transitional behaviors* [67].

A few studies have been conducted to compare the effectiveness of in vivo modeling, SP and VM instructional methods. For example, Charlop-Christy et al. [16] compared the effectiveness of VM versus in vivo modeling for teaching developmental skills to children with autism. They found that VM was more effective as it led to faster acquisitions of the targeted behaviors and promoted the generalization of behavior changes. Alberto et al. [25] and Cihak et al. [26] compared the effectiveness and efficiency of SP versus VM on the acquisition and maintenance of community skills to students with moderate mental retardation. Both studies indicated that the strategies were effective in teaching the targeted skills and no functional differences between them were identified. In addition Mechling and Gustafson [22] indicated that VM was more efficacious than SP in teaching cooking skills in children with moderate intellectual disabilities. In 2010, Van Laarhoven et al. [23] compared the effectiveness and efficiency of picture prompts versus VM in teaching daily living skills to adolescents with autism. They indicated that although both methods were effective in teaching the targeted skills, VM appeared more effective and efficient across all dependent measures. In a recent study, Cihak [68] compared the effectiveness of SP activity schedules and VM-based activity schedules for children with autism during transitional situations. Results indicated that both visual supports could improve independent transitions. However, VM-based activity schedules appeared slightly more effective in terms of the number of participants who completed more independent transitions across both activity schedules.

In all of the above studies, participants were exposed to a series of training sessions using mainly the methods under investigation. Currently, however, there has not been any study to directly compare the effectiveness of *in vivo* modeling, SP, and VM not as an intervention

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method, but in a form of assessment. That is, how would children with autism respond to instructions which are delivered to them only once using any of these three different methods? Such an assessment may help educators and researchers in their efforts to design more effective interventions to meet the individual needs of this specific population and the needs of their families/caregivers. This is because studies that examine what instructional tactic work best under certain conditions are also needed. Accordingly, the main purpose of this study was to assess how children with autism perform in simple motor function (MF), social interaction (SI) and functional (F) tasks when instructed by *in vivo* modeling, SP or VM.

Method

Participants

Nine students (8 males and 1 female), ages 8-14 years and 3 months, who were attending a special school for children with developmental disorders, participated in the study. However, one of them (Aiden; please see below) did not manage to complete all required tasks and therefore his data were excluded from the results. Formal written parental consents were obtained for all participants. All participants had received a diagnosis of autism by outside agencies according to DSM-IV-TR [69] criteria for autism. Participants were selected for the study based on the following criteria: a) visual ability to watch a picture sequence, a live or a videotaped model; b) ability to spend at least 2 min in front of the TV or computer; c) no tendency to produce any harmful or distressful behavior when watching TV or computer for more than 2 min; d) ability to understand the command "Watch and do the same"; e) physical ability to perform specific gross and fine motor tasks; and f) limited experience in *in vivo* modeling and VS as teaching methods. The Vineland Adaptive Behaviors Scale [VABS-II; 70] was administered for the adaptive behavior rating of the participants. The P-scales, produced by the British Qualifications and Curriculum Authority [71], were also administered to assess the participants' performance in the speaking, listening, information and communication technology (ICT) and personal social and health education (PSHE) subjects. Table 1 lists participant respective characteristics.

Gary (all names are pseudonyms) was a 12 years and 4 months old boy. Gary's development was normal until the age of 18 months when he stopped talking. George was an 8 year old boy with a good sense of humor and the ability to understand the classroom routines. He had difficulties in speech, language and communication. Peter was 14 years old who had also been diagnosed with Attention Deficit Hyperactivity Page 2 of 9

Disorder. He presented impairments in social interaction, use of language, and imaginative play. His behavior could be unpredictable and occasionally aggressive or assaultive towards others and himself. Roddy was a 13 year old boy who had severe receptive and expressive language delay. This had a significant impact upon his ability to interact with his peers. Stuart was an 8 years and 9 months old boy who had severely limited social communication and interaction skills. He also presented increasingly restricted and repetitive behaviors and interests. Ted was a 12 year old boy who had difficulties in both receptive and expressive language, social communication and play skills. William was 12 years and 4 months old who presented severe learning difficulties, delayed speech and language development as well as difficulties with social communication, play, independence and self-help skills. Alice was a 14 years and 3 months old girl. She was a very active, presenting severe difficulty in confirming to expectations that she had to stay still and attend to adult directed activities, even for a short period. Finally, Aiden was a 10 years and 8 months old boy with severe learning difficulties. He had also obtained a diagnosis of Tuberous Sclerosis, epilepsy and mild left hemiparesis, which affected his ability to use his left arm (Table 1).

Setting

A typical room of the school was used throughout, which mainly contained a portable bookcase, a box with some toys and books in it and a TV set which was out of order. For the purposes of this study, a table and two child-sized chairs were placed in the corner. A 15.6 inch laptop had been placed on the table for video viewing. During the assessment sessions, the curtains were closed to prevent any external distractions.

Stimulus materials

One board game, a book, a plastic ball and 11 everyday objects (i.e., 2 tables, a basket, 3 chairs, a plastic box, a portable mirror, a coat, a hair brush and a towel) were used across all conditions. However, since the manipulation of the plastic ball required the use of both hands, it was replaced with a tennis ball for the participant with the arm dysfunction (Aiden) in the respective tasks. All participants were familiar with these objects and therefore no additional instructions were required on how to operate them appropriately.

Videotape

Nine video clips were mainly created for each of the tasks. The videos were recorded with a Panasonic SDR-S70 mini DV camcorder and edited on the laptop computer using the Windows Media Player

	Gary	George	William	Stuart	Roddy	Alice	Ted	Peter	Aiden
Age	12.4	8	12.4	8.9	13	14.3	12	14	10.8
VABS-II [*]									
Communication	80	55	67	123	78	16	85	34	22
Daily living Skills	52	49	59	75	57	64	87	40	39
Socialization	24	55	43	63	32	39	45	26	23
Motor Skills	78	67	64	78	61	56	67	64	61
QCA P-scales [™]									
Speaking	P6	P7	P6	1B	P6	P6	2A	P6	P4
Listening	P6	P7	P7	1B	P6	P6	2B	P6	P4
PSHE and Citizenship	P6	P7	P7	P7	P7	P7	P7	P6	P5
ICT	P7	P7	P7	P7	P7	P7	3	P6	P6

'Scoring: 20 to 70=low, 71-85=moderate low, 86-114=adequate, 115 to 129=moderate high, 130-160=high

"P-scales: Describe the progress of pupils with special educational needs who are working towards level 1 of the national curriculum. P-scales are consisted of 8 scales P1 is the lowest and P8 is the highest. Pupils working above level P8 will be working within the national curriculum levels (Levels: 1 to 6, Sub-levels: c, b, a)

Table 1: Participants characteristics.

software program. The duration of the videos ranged from 12 to 28 s and featured either one or two unfamiliar adults performing the tasks. It was anticipated that using adult models rather than peer models would not affect the performance of the participants since children with autism may learn equally well from both adults and peers as models [46,53]. However, additional videos were created for Aiden wherein the tennis ball had to be depicted instead of the plastic ball.

Static pictures

One photo album was created for each task category (3 albums in total), similar to those created for a pictorial activity schedule [72,73]. The tasks of each category were broken into smaller steps following specific suggestions from the literature [74] and were depicted in a sequence of colored digital static pictures, one per page, in the size of 20 cm by 15 cm each. The pictures were snapshots taken from the videos (approximately one every 3-4 s) using the Panasonic HD Writer AE 2.0 software program. These pictures were then printed, laminated and displayed horizontally in the order of task occurrence.

Response measurements and data collection

Data were collected for the performance of each participant in nine tasks assigned to three distinct categories: a) Motor function (MF), b) Social interaction (SI) and c) Functional (F) (Table 2). As long as the focus of the present study was on assessing the performance of the participants when were given only one instruction by any of the methods under investigation, these tasks should be as much naïve even arbitrary as possible. Final selection and formulation of the tasks were based on the assertion of the school staff that participants had the required physical abilities to complete them successfully (Table 2).

Each of these tasks was broken into smaller steps following specific suggestions and examples in the literature for conducting a task analysis [74]. When a step occurred exactly in the way it was intended within 5secs after the initial instruction or completion of the previous step in the sequence and in the absence of any further instruction or assistance, then this performance was recorded as *independent*. Whenever a further verbal instruction was provided to a participant for performing a step in the sequence, which was not meant to, then it was measured as a *verbal prompt* (VP). A *physical prompt* (PP) included any gestural cue in addition to verbal prompts which enabled the participant to initiate, continue or complete the task. Finally, whenever verbal and/or physical prompts could not facilitate the successful performance of any step in the sequence, then direct *physical assistance* (PA) was provided and the researcher physically guided the child to complete the respective step.

Experimental design

A single group, repeated measures design [75] was used to assess

the effectiveness of *in vivo* modeling, SP and VM against each other and against the verbal instructions (VI; baseline). Data in all conditions were collected in the experimental setting.

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During all sessions, the tasks were delivered randomly and no specific consequences for behavior or additional instructions were established by the experimenter [76,77]. Three to four sessions were conducted each day, depending on each child's daily routine, each lasting approximately 5 min between each session there was about 2-4 min break when the child was free to engage in any activity he/she would like to within the room. Thus, the total time spent in any given day was approximately a maximum of 30 min.

Procedure

Each child was taken from his/her classroom and was brought to the experimental room accompanied by a staff member who remained there as an observer. Then, he/she was guided to sit in a chair next to the table. All tasks, irrespectively of the method to be implemented, began from the child sitting in that chair.

Verbal instructions (VI; baseline)

During this condition, instructions for completing each task were delivered verbally for two main reasons: a) this way of delivering instructions constitutes the usual practice for typically developing children, and b) the use of any other method (i.e., live demonstration, pictures or videos) would be considered as redundant, if the participants consistently performed all tasks after having been instructed with this rather effortless method. Thus, each participant was given the VI of the selected task. The instructions were repeated twice when a participant did not respond after 5 s. If a participant still did not respond, VP, PP and PA were applied in a sequence, until the steps in the task were completed. That is, if a participant's incorrect response or no response occurred within 5 s after the VI was given, then a VP was given to complete the first step of the task. If an incorrect response or no response was also occurred within further 5 s, then PP followed. If there was still an incorrect response or no response within the next 5 Sec, then PA followed. The same sequential process applied for the remaining steps in the task.

In vivo modeling

Each participant was initially given the verbal instruction "[name] *Watch me*". Then, the researcher demonstrated the selected task. Whenever appropriate, VP and PP were given (e.g. please watch there), if he/she was not paying attention to the demonstration. Once the researcher had finished the demonstration, he said: "*now do the same as I did*". If a participant did not respond or responded incorrectly within 5 s, VP, PP and PA were applied in sequence until the steps in the task were completed.

Task Category		Instructions					
	MF1	Take the ball from the floor, walk towards the basket and put the ball in the basket.					
MF	MF2	Take the ball from the basket and place it in the plate on the floor					
	MF3	Walk towards the basket, take the ball and place it on the floor.					
	SI1	Hold that person's hand, sit on the floor and play together with the ball.					
SI	SI2	Get the book, take that person by his hand and sit on the floor to read it together.					
	SI3	Take that person by his hand, sit on the floor and play together with that game.					
	FI	Walk towards the hanger, take the coat and put on the coat.					
F	F2	Walk towards the mirror, take the hair brush, sit on the floor in front of the mirror and brush hair.					
	F3	Walks towards the box, wash hand(s) and dry hand(s).					

MF=Motor Function; SI=Social Interaction; F=Functional

Table 2: Selected tasks.

Static pictures (SP)

Here, each participant was shown the selected task using the photo album. The researcher sat next to him/her and turned the photo album's pages. Verbal and physical prompts were provided when a participant did not pay attention to the photos presentation. The presentation was repeated twice when a participant failed to watch at least half of the respective pictures in the photo album. After the presentation, the researcher asked each participant: "*now do the same, just as in the pictures*". Again, if a participant did not respond or responded incorrectly within 5 s, VP, PP and PA were applied in sequence until the steps in the task were completed.

Video modeling (VM)

Each participant was requested to watch the selected task in a video display. Combinations of verbal and physical prompts were applied to ensure that each participant indeed watched the video. The video was repeated twice when a participant did not watch at least half of it. Afterwards, the researcher asked him/her: "*now do the same, just as in the video*". As it was the case in the previous procedures, if a child did not respond or responded incorrectly within 5 s, VP, PP and PA were applied in sequence as appropriate until the steps in the task were completed.

Each participant was assessed across all tasks in the VI condition and across one task in each of the three categories (i.e., MF, SI, and F) in the remaining conditions (i.e., *in vivo*, SP and VM) in order to control for potential practice effects across methods. Pre-defined counterbalancing was used to control for order effects in essence that learning did not occur on occasions where the same instructions were given, but delivered using a different method [64]. For example, one participant may have experienced the following order of assessments: F2, F3, SI3, SI1, F1, MF2 MF1, SI2, MF3 (all VI) and SI3 (SP), F2 (VM), SI1 (VM), F1 (*in vivo*), MF3 (VM), MF1 (SP), MF2 (*in vivo*), F3 (SP), and SI2 (*in vivo*).

Data Analysis

The impact of each instructional method on participants' performance was determined primarily through comparisons of the mean percentages of the steps completed either independently or after the provision of an additional prompt (i.e., VP or PP) [23,25]. Steps which required the provision of physical assistance (PA) from the researcher were scored as non-completed. Specifically, the score in each task was calculated by dividing the number of steps completed independently and after VP, PP and PA by the total number of the steps in the tasks and multiplying by 100. Each of the MF1, MF2, SI1, SI2 tasks was broken into 5 steps. Consequently, each step was counted for 20% of the overall task calculation. The remaining tasks were broken into 4 steps; hence, each step was counted for 25% of the overall task calculation. In each task across all conditions, the percentages of the steps completed after VP and PP were added and were presented as 'prompts'. Then, the percentages of these prompts were added to the percentages of the steps completed independently and were presented combined as 'steps completed'. The reason for this was to get an overall idea about the effectiveness of each condition on the completion of each task, either independently or independently with the addition of some prompts.

Reliability

Interobserver agreement, which typically involves the comparison of the data collected from two or more observers who record their data independently, was measured to evaluate the quality of the obtained data [78]. This was assessed on 30% of all observations and at least one reliability session was obtained for each child during all conditions. The second observer was blind to the experimental conditions as well as to the objectives of the study. The percentage of the inter-observer agreement was calculated by dividing the numbers of agreements by the number of agreements plus disagreements and multiplying the results by 100. Average inter-observer agreement was 99% ranging from 98% to 100%.

Data for procedural integrity were collected by the second observer [79]. These measurements included the following: a) checking if the participants completed the required number of tasks; b) checking if the tasks were completed as stated in the research protocol; c) checking if the instructions for the tasks were given as stated in the research protocol; d) checking if the correct materials were used; and e) checking that the prompting/assistance was delivered as intended. Procedural integrity was calculated by dividing the correct measures by the total number of assessed variables and multiplying by 100. Procedural integrity agreement was 98% (range, 96-100%). Procedural errors included: a) during the MF3 task and under the VI condition, Peter did not walk to the basket, but crawled, b) during the MF3 task and under the VI condition, Alice did not place the ball on the floor, but gave it to the researcher, c) during the SI1 task and under the VI condition, Alice did not sit on the floor, but kicked the ball to the other person.

Results

The overall percentages of steps completed by all participants between VI and in vivo modeling, SP and VM conditions (Table 3). Collectively, participants completed 76% of the steps either independently or with the provision of additional verbal or physical prompts when in vivo modeling was used. Their performance was marginally better (78%) when assessed in exactly the same tasks but instructed verbally. Similarly, in SP condition, participants completed 75% of the steps, very close to 76% achieved in VI for the same tasks. In the VM condition, however, participants completed 83% of the steps as opposed to a percentage of 76% in the VI condition when assessed in the same tasks. Normality in the data could not be assumed and since two sets of scores that come from the same participants were compared, the Wilcoxon Signed Ranks Test was employed. It showed that the use of in vivo modeling (Z=-0.526, p=0.599), static pictures (Z=-0.245, p=0.807) and video modeling (Z=-0.691, p=0.489) did not elicit a statistically significant change in the performance of the participants.

In more details, Table 4 presents the percentages of steps completed in the *in vivo* modeling, SP and VM conditions for each participant (Table 4). Each comparison with VI concerns the performance data of each participant when assessed in exactly the same tasks. George's and Ted's performance was equal across the three conditions, since all steps (100%) in their tasks were completed successfully. A quite similar performance was demonstrated by Roddy in terms that all steps were

	Independent	Prompted	Median	р
In vivo modeling	52%	24%	25	
Verbal instruction (VI)	58%	20%	33	0.599
Static pictures	45%	30%	30	
VI	55%	21%	32	0.807
Video modeling	53%	30%	38	
VI	53%	23%	31	0.489

Table 3: Comparison of percentages of steps completed by all participants between verbal instructions, *in vivo* modeling, static pictures and video modeling conditions.

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	In vivo modeling		Static F	Pictures	Video modeling		
	Independent	Prompted	Independent	Prompted	Independent	Prompted	
Gary	0	73 (0-100)	0	67 (0-75)	20 (0-60)	67 (40-100)	
VI	37 (0-60)	23 (0-25)	15 (0-25)	29 (0-50)	0	33 (0-60)	
George	100		80 (40-100)	20 (0-60)	100		
VI	87 (60-100)	13 (0-40)	100		93 (80-100)	7 (0-20)	
William	25 (0-75)	8 (0-25)	22 (25-40)	37 (0-60)	8 (0-25)	29 (0-40)	
VI	20 (0-60)	50 (0-60)	8 (0-25)	33 (0-100)	13 (0-25)	41 (0-50)	
Stuart	50 (0-100)	17 (0-25)	27 (0-80)	45 (20-50)	54 (0-87.5)	39 (0-80)	
VI	66 (0-100)	7 (0-20)	33 (0-100)	31 (0-50)	66 (0-100)	7 (0-20)	
Roddy	100		75 (25-100)	25 (0-50)	80 (40-100)	13 (0-40)	
VI	87 (63-100)	13 (0-38)	100		93 (80-100)	7 (0-20)	
Alice	25 (0-75)	54 (0-100)	33 (0-80)	37 (0-50)	48 (20-100)	52 (0-80)	
VI	33 (0-100)	54 (0-75)	33 (0-100)	60 (0-50)	33 (0-100)	60 (0-100)	
Ted	100		100		100		
VI	100		100		100		
Peter	17 (0-50)	36 (0-50)	20 (0-60)	13 (0-40)	17 (0-25)	38 (0-37.5)	
VI	33 (0-100)	0	55 (25-100)	15 (0-25)	23 (0-55)	29 (0-37.5)	

Table 4: Comparison of percentages of steps completed during all conditions for each participant.



Figure 1: Comparison of percentages of steps completed by all participants between verbal instructions, *in vivo* modeling, static pictures and video modeling conditions in motor function, social interaction and functional tasks.

completed successfully in the *in vivo* modeling and SP conditions and nearly all of them in the VM condition (93%). For Gary, Alice and Peter their higher percentages of steps completed successfully were achieved in the VM (87%, 100%, 54%) and the lower in the SP conditions (67%, 70%, 33%), respectively. Stuart's best performance was also demonstrated in the VM condition (93%), however, the lowest percentages were achieved in the *in vivo* modeling condition with 67% of steps completed successfully. William's performance was different, since the higher percentages of steps completed successfully were achieved in the SP (58%) and the lower in the *in vivo* modeling (33%) conditions, respectively. It is worth mentioning that one participant (Aiden), was not able to be assessed across all conditions as required due to his extensive non-compliant behavior and acute epileptic symptoms. Hence, his performance data were not included in the final results.

Finally, the comparison of percentages of steps completed by all participants under the VI, *in vivo* modeling, SP and VM conditions across the MF, SI and F tasks (Figure 1). In MF tasks, participants completed more steps when instructions were given by static pictures, whilst fewer steps were completed when instructed by *in vivo* modeling

(82%). In SI tasks, VM was the condition in which participants performed the higher percentage of steps completed successfully (71%), as opposed to *in vivo* modeling condition in which the lower percentage (45%) was achieved. Finally, in the F tasks, VM and SP were the conditions in which participants performed the higher (87%) and the lower (75%) percentages of steps completed, respectively.

Discussion

Collectively and despite individual differences, results showed that VM was the only instructional method which was more effective than VI; it was also more effective than both *in vivo* modeling and SP. On the other hand, *in vivo* modeling and SP procedures appeared equally effective with VI. However, SP was the most effective method for the participants to complete the MF tasks, whilst VM remained as the most effective method in the SI and F tasks.

These results concur with previous research in that VM may be a superior instructional method in the treatment of individuals with autism in comparison to VI [80], *in vivo* modeling [16] and SP [23,68]. Also, results validate previous studies which have suggested VM as an effective technique in enhancing the social and functional skills of individuals with autism [34,48,49,81,82]. In the current study, VI appeared equally effective with *in vivo* modeling and SP, which was a surprising finding since it has been well reported that individuals with autism usually face difficulties when instructed verbally [15,83]. A possible explanation might be that the predominant instructional method in the current school was the use of VI alongside some picture applications (e.g. drawing) and instances of *in vivo* modeling (nonsystematic live demonstrations).

Nevertheless, the most substantial finding of this study, even statistically insignificant, was the superiority of VM considering that participants had no previous experience in VM conditions at their school. Hence, this finding becomes clinically significant [84] and important for the design of structured programs for children with autism. Since videos provide a permanent product, one video recording of an adult's or peer's actions could undoubtedly reduce the cost of live models employed in such programs [85].

Video modeling has been suggested as a method that enhances individuals' with autism motivation, providing a change from the usual work environment [16]. Therefore, it might intrinsically facilitate the participants to pay attention when watching videos and hence to respond better when they were required to perform the videotaped tasks or behaviors. Another possible explanation might be that VM may compensate for children's stimulus over selectivity. Individuals with autism may focus and respond to only one or to a limited number of cues in their environment [16,34,86]. Therefore, when participants were instructed by VI or *in vivo* modeling they might focus to an irrelevant cue, (e.g., the instructor's watch) instead of focusing to relevant cues, such as the actual target behavior. When using VM, participants' over selectivity may be compensated by zooming with the camera in only the relevant cues, something which allows them to follow the model's relevant behaviors more easily [87].

A factor that should be taken into careful consideration when assessing different instructional methods is the participants' individual characteristics. Undoubtedly, participants had different experiences, past reinforcement history and preferences. Therefore, they had various responses across the instructional methods, the selected tasks and the stimulus materials, which affected their performance [23,26]. For example, four participants (i.e., Gary, Alice, Stuart and Peter) achieved a better performance when VM was used, one (i.e., William) performed better during the SP condition, one (i.e., Roddy) in both in vivo modeling and SP conditions and two (i.e., George and Ted) performed equally well in all conditions. Any effort to identify individual characteristics in the behavioral repertoire of these participants, however, was rather unsuccessful and therefore, any clear suggestion is unlikely to be made. Indeed, individuals with autism show a remarkable variability in the expression and severity of their symptoms as well as in their performance in the IQ, language, communication and social domains [88] and hence, further research in this area is certainly needed.

The findings of the present study contribute to previous research in several ways. For example, this stands as the first report to directly compare the effectiveness of VI, SP, *in vivo* and VM; however, not as intervention methods. Instead, an effort was made to assess the differential effects that each instructional method had on the performance of children with autism across a number of tasks when the instruction was delivered to them just once. Such an assessment was facilitated by the careful selection of the tasks, which were as much naïve as possible. Further, this study attempted to offer a feasible, practical and sensitive (cf. use of measurement scales) approach to assessing an important aspect of the instructional methods used in teaching children with autism. However, the overall outcomes and interpretations of this study may have been affected by several limitations. First, the sample size was relatively small and therefore no categorization according to the participants' characteristics could be achieved. Similarly, a second limitation was that the study was conducted with participants who had no previous school experience in VM conditions and limited *in vivo* modeling and SP conditions. It may well be that our population of children with autism is not representative of other children who receive special education services. Thus, future studies should involve not only a larger sample, but also children who have gained experience in a wider range of teaching methods across a number of different tasks. Certainly, evaluations over longer periods of time are also required to determine the full impact of each instructional method.

Future research should also investigate which combinations of instructional methods best improve the participants' performance according to their individual characteristics in various types of tasks and across different contexts [89]. That is, although initial evidence has shown that the combination of videos with photos can be more effective than videos alone when applied in interventions aiming to teach individuals with disabilities [22], the performance of children may be altered in the presence of different antecedent stimuli. As opposed to the current study, such research would examine these methods as interventions in which the use of single-case experimental methodology (e.g. alternating treatments design) would be appropriate. Furthermore, in the present study, the initial instruction (i.e., 'now do the same as...') should remain similar across the four conditions. However, it may be possible that children perform differently in the context of free play or physical education, when there are balls available, when other children are playing and shooting baskets, and maybe in the presence of the simple instruction "Go play". Further, verbal instructions, in vivo modeling, static pictures, and video modeling might all be part of an instructional hierarchy for a child [90,91]. Certainly, these possibilities create avenues for further research.

Nevertheless, results from this study showed that visual supports constitute, potentially, the most effective instructional methods for children with autism. Undoubtedly, by taking advantage of the tendency of these children to better follow visual instructions, a more extensive use of visual supports and particularly of videotapes could become an advantageous addition in the educational curriculum of individuals with autism. This possibility may be further accelerated by recent advances in video and computer technology such as virtual environments [92-95].

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Declaration of Interest

The authors report no conflicts of interest.

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