Activity Schedules, Computer Technology, and Teaching Children With Autism Spectrum Disorders

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A review of selected literature suggests that integrating multimedia computer supports with activity schedules can be an effective way to teach students to manage their work, play, and skill-building activities independently. Activity schedules originally were a means of promoting independent execution of previously learned responses by using pictures and words in notebooks or lists to cue a student's performance of a sequence of activities. As activity schedules subsequently became more technologically elaborate, they also evolved as a means of expanding existing repertoires. Preliminary studies illustrate how activity schedules delivered on the computer may engender new learning via the videos, sounds, dialogue, images, and words employed as instructional stimuli. For the researcher, the blend of computer and notebook activity schedules provides a framework for studies on teaching play, socialization, and communication. For the practitioner, use of activity schedules addresses pressing needs to teach generative and functional skills.

Many special educators are familiar with the class of remedial techniques known generically as "visual supports." One currently popular form of visual support is broadly referred to as the "activity schedule" (Downing & Peckham-Hardin, 2000; Hodgdon, 1995; McClannahan & Krantz, 1999; Quill, 2000; Savner & Myles, 2000). A common format for activity schedules is a notebook that makes use of pictures, symbols, or text to cue an individual to perform specific sequences of activities; their use can yield functional skills that may not be readily achieved through instructional methods that are more adult directed and less naturalistic (Krantz, 2000; McClannahan & Krantz, 1997). In this respect, activity schedules are potent supplements to, and perhaps in some cases even replacements for, discrete-trial teaching. When activity schedules are combined with other instructional supports—in particular, when they are enhanced with computer supports made possible by multimedia software—their potential with respect to both research and instructional applications significantly increases.

There is a natural goodness of fit between activity schedules and computers, because the latter can pair static visual support with additional instructional stimuli such as audio and video recordings. Indeed, the potential for computerized use of video is vast, as suggested by a growing interest in the use of video modeling as a stand-alone intervention (e.g., Buggey, 1999, 2005; Neumann, 2004) as well as promising research on the topic (e.g., Charlop & Milstein, 1989; Charlop-Christy, Le, & Freeman, 2000; Gepner, Deruelle, & Grynfeltt, 2001; Hagiwara & Myles, 1999; Hepting & Goldstein, 1996; Schreibman, Whalen, & Stahmer, 2000; Sherer et al., 2001; Taylor, Levin, & Jasper, 1999; and see Cuvo & Klatt, 1992; Kern-Dunlap et al., 1992).

This paper first discusses selected research on activity schedules and on technology and instructional methods believed to interface with schedules. Next, preliminary work is described that involves computer schedules enhanced with sound and video to deliver educational programs to children with autism spectrum disorders. Finally, areas for further study are discussed as well as pros and cons of computer activity schedules.

Research With Notebook Activity Schedules

Most research regarding activity schedules has focused on their use as functional cues for skills that are within students' repertoires but that they rarely exhibit without another person prompting them to do so. Used this way, activity schedules are an environmental modification analogous to the adhesive-backed note or "to do" lists that many of us keep in prominent places to help us manage our time. Notebook activity schedules have been used to promote independent task initiation and completion and reduce undesirable behavior around transitions (Schmit, Alper, Raschke, & Ryndak, 2000) across numerous activities and in a variety of settings.

Activity schedules may, however, be used in another way: Once students have learned to use schedules independently to complete numerous activities in sequence, the possibility exists that they may be taught new skills within the context of schedule following (Downing & Peckham-Hardin, 2000; McClannahan & Krantz, 1999). MacDuff, Krantz, and McClannahan (1993) used most-to-least prompting in the form of graduated manual guidance to teach four boys with autism, ages 9 to 14, to follow pictorial activity schedules in a group home. The four participants learned to follow notebook schedules that contained photos of six activities (handwriting worksheets, Lincoln Logs®, Colorforms®, snack, puzzle, and TV) that were always presented in the same order. Once the students had mastered the initial schedule—that is, once they could independently perform an extended sequence of activities without supervision or prompting—the authors conducted two tests. The first test was resequencing: Would the students follow their schedules even though the order of the photos in their notebooks changed? The second test was for generalization: Would the students follow schedules with photos depicting six different activities that were familiar to them but that had not been included in the initial schedule (Lego® blocks, Pipeworks®, and different worksheets, puzzles, and snacks)? The answer to both questions was "yes." Rather than learn fixed six-item sequences (or chains), the test results suggested that it was the photos themselves that functioned as cues for the students' schedule following. They "read" the pictures.

In a related study that underscores both the generalizable use and multiple functions of activity schedules, Krantz, MacDuff, and McClannahan (1993) taught three sets of parents to use notebook activity schedules with their children with autism in their own homes. The intervention increased the children's engagement and social initiations and decreased disruptive behavior.

Enhancing social skills is a crucial focus and significant challenge in educational programming for students with autism (e.g., Koegel, 2000; Krantz, 2000; Rogers, 2000; Taylor, 2001). Play and social skill instruction often employs creative methods, such as teaching students with autism to use textual and auditory scripts to initiate interactions, and these methods meld nicely with notebook activity schedules (e.g., Krantz & McClannahan, 1993, 1998). For instance, Krantz and McClannahan (1998), taught 4- and 5-year-old children with autism to solicit social attention from adults. A page in the child's notebook combined a photo with text—either *Watch me* or *Look*—words they could already read. When the page was encountered, a child read the script (e.g., "Watch me"), obtained the materials for the activity (e.g., painting), went to the adult, repeated the script, and performed the activity. In response, the adult praised the child and provided language models. Some of the photos had scripts and some did not, and the former were gradually removed during script fading. Afterward, the children (a) initiated both scripted and unscripted comments, even after the scripts were faded and (b) initiated comments when the activities and conversation partners differed. According to the authors, "the script-fading procedure enabled children with autism to converse with adults, to benefit from adults' language models, and to engage in language practice that contributes to fluency" (p. 191).

Students who do not read may still learn to initiate social interaction from scripts presented as vocal models. For instance, Stevenson, Krantz, and McClannahan (2000) used audio cards to record scripts for four boys with autism, aged 10 to 15 years. When their schedule cued an interaction, the participants learned to remove the card from their notebook, pass it through a Language Master™ to play the script, then repeat the recorded remark to an individual they had approached.

Related Interventions That Promote Independence and Efficient Instruction

Ongoing work on self-management and choice-making procedures relates to research and practice using activity schedules. In general, self-management procedures attempt to teach the students themselves to select reinforcers, monitor performance, evaluate performance, and deliver reinforcers. Children with and without disabilities have even been taught to assess whether their performance is correct or not, and to recruit teacher praise when it is (Connell, Carta, & Baer, 1993; Stokes, Fowler, & Baer, 1978). All of these skills may be taught explicitly during instruction on activity schedules. Predating much of the work on activity schedules, research demonstrated that visually based self-management methods are useful for promoting many skills, from teaching children to play when they are unsupervised (Stahmer & Schreibman, 1992) to helping them independently get dressed or make a lunch (Pierce & Schreibman, 1994).

In practice, the use of activity schedules and self-management methods involve teaching children to make choices (McClannahan & Krantz, 1999). Teaching children to choose among activities themselves or among reinforcers available for completing a series of scheduled activities may both facilitate learning and curtail problem behaviors (Mason, McGee, Farmer-Dougan, & Risley, 1989). The visual media used in schedules may themselves contribute to facilitating learning and reducing undesirable behavior because they are not ephemeral in nature, as are spoken or signed cues (see Vaughn & Horner, 1995). Incorporating a choice-making component when teaching children to follow activity schedules is supported by the fact that methods are being developed that make ongoing assessments of activity preferences practical (DeLeon et al., 2001; DeLeon &

Iwata, 1996; Fisher & Mazur, 1997; Hagopian, Rush, Lewin, & Long, 2001).

Video modeling is another means of providing visual support. Video models can, in effect, bring many target settings to the learner and thereby avoid the time, expense, or logistical challenge of bringing the student to each setting. Video models are capable of providing controlled and consistent demonstrations to the learner of what to do, when to do it, and what to say about it. Video scripting could prompt seeking information, asking for a demonstration, telling about something, soliciting attention, and so on. Such responses may, in turn, appear during the student's discrete-trial, small-group, and free-play activities. What is more, children often enjoy watching them.

Video modeling usually entails students watching analogue videotapes on a television monitor that show models—or in some cases, the students themselves—completing criterion-level performances of targeted skills. While children with autism are notoriously poor observational learners (i.e., they typically do not imitate well [Siegel, 1996]), they have nonetheless learned many skills from video modeling interventions, including purchasing (Haring, Kennedy, Adams, & Pitts-Conway, 1987), communication (Charlop & Milstein, 1989; Taylor et al., 1999; Wert & Neisworth, 2003), and play skills (D'Ateno, Mangiapanello, & Taylor, 2003). Video models have been used to teach self-help skills (Bainbridge & Myles, 1999; Hagiwara & Myles, 1999) and to reduce disruptive behavior (Schreibman et al., 2000). According to Charlop-Christy et al. (2000), video modeling was more efficient than live modeling at teaching five children with autism to make social, language, or self-help responses in a biweekly after-school behavioral instruction program. Promising research that has used live modeling to teach, for instance, use of gestures when communicating (Buffington, Krantz, McClannahan, & Poulson, 1998) or display of appropriate affective behavior (Gena, Krantz, McClannahan, & Poulson, 1996) may also be conducted efficiently with video interventions. Sherer et al. (2001) found both self- and other-video modeling effectively taught conversation skills; Hepting and Goldstein (1996) used video self-modeling to teach language skills to preschoolers with developmental disabilities; and Buggey (2005), in a series of studies with five children between the ages of 5 and 11 years, used video self-modeling to improve language or social skills or to reduce tantrums or aggression in a private school setting.

Taylor et al. (1999) demonstrated the efficacy of video modeling when they used it to increase the play-related statements made by two boys with autism toward their siblings. One boy viewed videos of his sibling and an adult making scripted comments during play. After the boy viewed the videos, his play comments with his sibling increased. Another boy viewed videos showing his sibling and an adult playing and commenting, and he practiced the play routines using the same play materials shown in the video. As a result, his comments increased while he played with his sibling, and with different play activities. While some of his comments echoed what was said in the video, other comments were novel and appropriate to the play situation.

The possibilities for research and immediate application of video modeling, whether the medium is analogue or digital video, have promise for addressing the special difficulties that arise in teaching social and communication skills to students with autism. Intriguing possibilities include interventions with brief video depictions of future events and the behaviors appropriate to those events. For example, such "priming" interventions might enable children to make transitions easier (Schreibman et al., 2000), increase their interactions with peers (Zanolli, Daggett, & Adams, 1996), or improve their self-help skills (Hagiwara & Myles, 1999). Viewing brief video models might also assist in teaching students how to vary the way they play (Lalli, Zanolli, & Wohn, 1994; Miller & Neuringer, 2000) in creative and imaginative ways (Stahmer, 1995; Stahmer & Schreibman, 1992), which, in turn, could facilitate the student's social and communicative interactions.

The value of video as an instructional tool suggests its use is central to enhancing the content of computer teaching. Videos of complex events, used instead of or in concert with still photos, may facilitate learning (e.g., Gepner et al., 2001). There is some use of video in educational software (e.g., Compu-Thera, 2001; Discrete Trial Trainer, 2001; Mechling & Langone, 2000), but despite research suggesting that it may be an effective intervention for teaching children with autism (Charlop & Milstein, 1989; Charlop-Christy et al., 2000; Dauphin, Kinney, & Stromer, 2004; Kimball, Kinney, Taylor, & Stromer, 2004; Kinney, Vedora, & Stromer, 2003; Schreibman et al., 2000; Sherer et al., 2001), the commercial use of video modeling is nearly nonexistent. Fortunately, today's technology permits one to produce and edit video rather easily (e.g., Rubin, 2002). In addition, using video in teaching programs could become a matter of routine for educators using basic authoring tools like PowerPoint® or HyperStudio® (e.g., Lieberth & Martin, 1995). As illustrated next, teachers may write computer programs that help students participate more actively and naturally in the learning process.

Research With Computer Activity Schedules

Computer activity schedules derive from research on using computers to teach academic and communication skills (e.g., Stromer, Mackay, & Remington, 1996; Stromer, Mackay, & Stoddard, 1992) and using multimedia authoring software to supplement a child's educational plan with compelling instructional content (Stromer & Kimball, 2004; Stromer & Oross, 2000). Integrating computer supports with activity schedules is meritorious, in part, because students often find spending time on the computer reinforcing. Indeed, our observations generally have been consistent with those of Romanczyk, Weiner, Lockshin, and Ekdahl (1999), who reported that children with autism preferred instruction presented by a computer to that presented by a teacher. In addition, children with autism may learn more rapidly when tasks are presented by a computer rather than by a teacher, as Heimann, Nelson, Tjus, and Gillberg (1995) and Moore and Calvert (2000) found with children performing receptive language tasks. As described by Thorp (2001), access to computer activities can be used contingently to increase social and communication skills—that is, computer activities can be reinforcing.

Acquisition of Computer Schedule Following

For the work described below, methods described in McClannahan and Krantz (1999) were adapted to teach the computer schedules. In each instance, teaching began with activities for which students receptively identified and expressively labeled the objects, photos, and actions involved, and of which they demonstrated functional use. Stimulus events for the computer schedules were arranged in PowerPoint® because the software is relatively easy to use, has ample multimedia capabilities, and has a growing presence in the classroom. In addition, materials are available that instruct teachers in general education how to use such authoring tools (e.g., Caughlin, 2002); these materials are becoming available for special educators (e.g., Kimball, Kinney, Taylor, & Stromer, 2003; Rehfeldt, Kinney, Root, & Stromer, 2004).

Kalaigian, Kinney, Taylor, Stromer, and Spinnato (2002) taught Emma—a 6-year-old with autism in a private day school—to follow computer schedules in her classroom. For instance, Figure 1 shows that the activities in one of Emma's three-item computer schedules included independent play (listening to a book on tape), sociodramatic play (engaging in dialogue with puppets), and play bids (asking a peer to play ring around the rosy). The schedule began with a general recorded instruction, "Time for your activity schedule." Emma then clicked a "page-turner" button on the screen and one of three activity pictures appeared along with its label (e.g., a teacher's recording saying, "Book on tape"). Clicking on the activity picture produced an elaborated script (e.g., "I like to listen to books being read"), followed by a video clip of the activity. The closing frames of each video, as they appeared to Emma, are shown on the left side of Figure 1; the page-turner button is in the bottom right corner. After watching the video, Emma clicked another page-turner and a cue-to-play slide appeared: In an effort to promote generalization, this photo differed from the first and showed the materials in another context. When the cue-to-play appeared, Emma left the computer and performed the pictured activity. A computer "clock" timed the 2 minutes Emma had to play the activity. When the clock timed out, a recording said, "Emma, time to clean up." After completing the activity and putting it away, Emma returned to the computer and clicked to the next activity. After the last activity, a photo of a special, end-of-schedule activity appeared.

Competence in schedule following was defined as independently performing at least 80% of the steps necessary to complete a schedule. Given graduated guidance, Emma readily learned to advance the slides in her computer program, view videos of play routines, attend to scripted dialogue, get necessary materials, play with the materials, and state the scripts related to the play activity. She also succeeded on several resequencing probes, suggesting that events associated with the schedule—rather than a particular sequence of activities—controlled her off-computer responding. In addition, Emma passed every generalization test given to her: Her play and social skills generalized to notebook schedules with pictures (Figure 2, left); and, because she was an emerging reader, Emma also learned to use notebooks containing just textual messages (Figure 2, left).

Teaching Play and Commenting Skills

Tim was a 3-year-old with autism who, once having acquired schedule following, participated in a study examining whether computer schedules with video scripts could teach play and commenting routines in the home (Dauphin et al., 2004). Tim's new schedules presented photos and video models illustrating a toy with which to play, how to play with it, and what to say about it. The methods, which resembled those in studies of sociodramatic play (Goldstein & Cisar, 1992; Thorp, Stahmer, & Schreibman, 1995), focused on teaching generative skills by incorporating features of studies of matrix training (e.g., Karlan et al., 1982; McCuller & Salzberg, 1984; Remington, Watson, & Light, 1990). As will become clearer below, matrix training is a method of planning the presentation of instructional examples so that components of responses that are explicitly taught recombine to yield new untaught response forms (a result known as "recombinative generalization"). Such procedures have been shown to be effective and efficient ways of executing live modeling interventions that aim to teach play, communicative, and social skills (Goldstein & Mousetis, 1989).

For example, Figure 3 shows how a matrix was used to organize Tim's training and testing (Dauphin et al., 2004). Each cell in the matrix represents a video clip of a child (age 8) who modeled a play routine involving things to say and do. The actions and comments are noted on the left of the matrix, the characters' names and play materials along the top. Dauphin et al. directly taught performances in the three cells with borders (along the diagonal) and then tested the six other permutations of comments, actions, and play materials. Prior research on such matrix-training procedures suggests that the six new performances might occur after training just the three combinations (e.g., Remington et al., 1990).

At the computer, Tim first viewed a video model of the activity. When the video ended and the cue-to-play photo appeared, Tim learned to leave the computer, select the materials pictured, and imitate the routine. If needed, just during training, his teacher corrected mistakes by providing live modeling and graduated guidance. After learning the three routines targeted for training (e.g., saying "Girl is waking up" with corresponding actions; Figure 3), Tim was tested. Would Tim

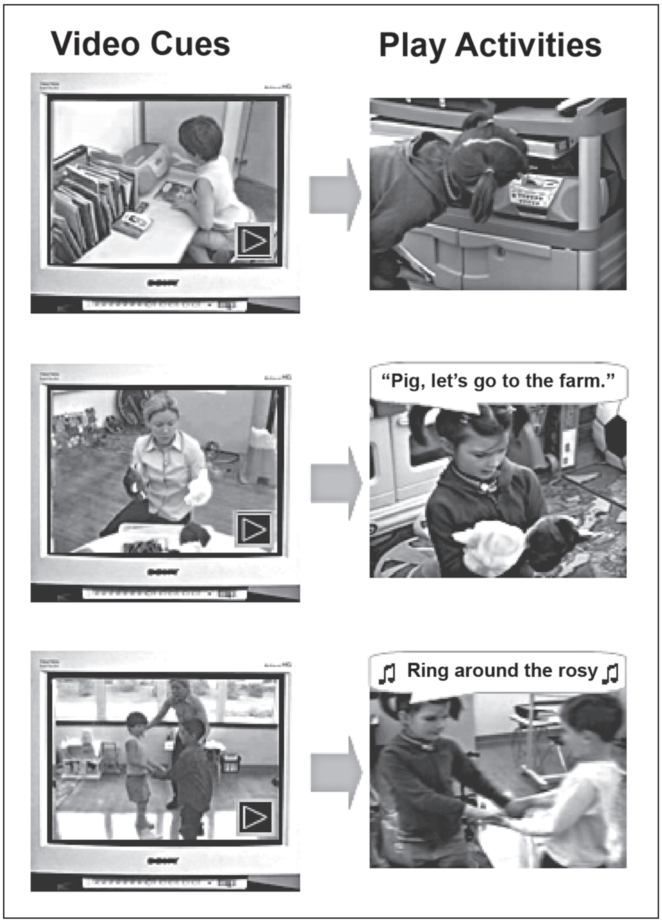

FIGURE 1. Emma's computer activity schedule, involving video cues for (a) listening to a book on tape, (b) playing with puppets, and (c) playing ring around the rosy. The photos in the right-hand column show Emma engaged in the scheduled activities.

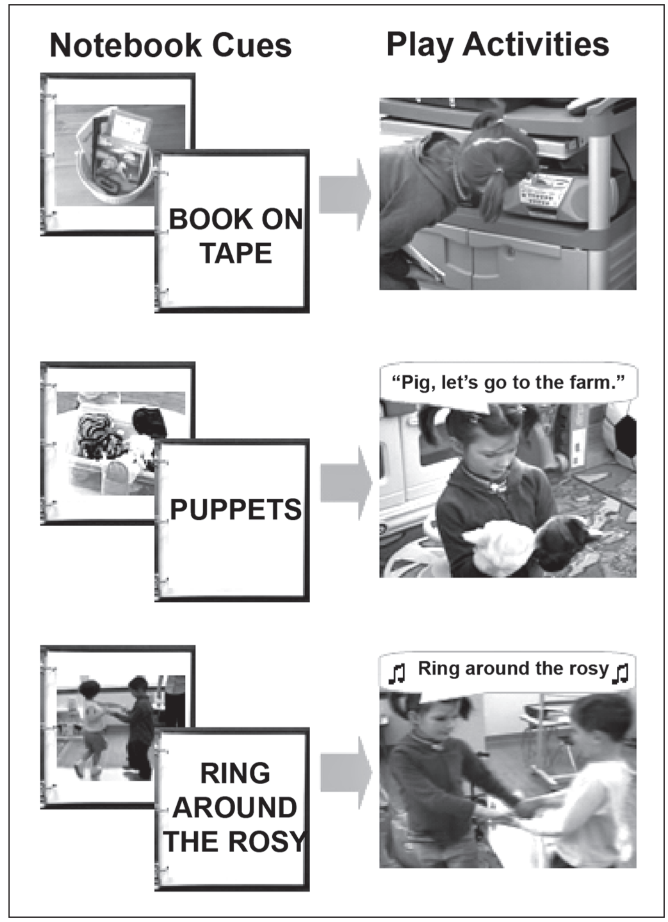

FIGURE 2. Two alternate versions of Emma's notebook activity schedule, with either pictures or textual cues for (a) listening to a book on tape, (b) playing with puppets, and (c) playing ring around the rosy. The photos in the right-hand column show Emma engaged in the scheduled activities.

now be able to perform the six untrained activities in a matrix when only photos appeared in his computer and notebook schedules (e.g., saying "Girl is eating breakfast" or "Dad is waking up," with corresponding actions)? By the end of the study, the results confirmed that he could.

As Wolery (2000) put it: "We need methods for teaching young children with autism to engage in varied, sustained, and generative play with toys and peers" (p. 380). A recommended teaching package to address this need includes (a) computer activity schedules that capture and hold the attention of the learner, (b) video modeling from which a child may learn observationally, and (c) matrix training to optimize the occurrence of generalized learning outcomes relative to invested time and effort.

Teaching Academic Skills

Academic skills like reading, spelling, and math might be taught as embedded tasks within computer activity schedules. For example, Kinney and Stromer (2001) used a computer with a program custom-made in PowerPoint® to teach Ana, a 7-year-old with autism who received home-based instruction, to follow several four-item schedules with printed words rather than the pictures she had learned initially. These results replicate Lalli, Casey, Goh, and Merlino (1994) showing a transfer of control of activity schedule following from pictures to words as a function of reading instruction.

After Ana had learned to follow written schedules, Kinney et al. (2003) taught her to write her own play schedules. A spelling program written in PowerPoint® employed matrix training in an attempt to engender generalized spelling outcomes (see Mueller, Olmi, & Saunders, 2000). Specifically, Ana viewed videos of her teacher writing target words from lists of play routines. After copying each of five target words correctly, Ana's reinforcer was access to a 15-second video of a play routine depicting the meaning of each word (e.g., *block*, *clock*, *lock*, *rock*, and *sock*). Ana rapidly learned to spell three, five-word sets to picture and to dictation cues. Ana also learned to use her spelling skills to write schedules, whereby she reproduced a series of play routines based on what she had viewed and heard in the videos. Significantly, teaching a subset of the word families (i.e., *-ock*, *-ore*, *-op*, *-ell*, *-est*, and *-ook*) led to generalized spelling of untrained words and generalized imitation of novel video displays. The results showed how generalized spelling (via matrix training) may derive from video models embedded in computer activity schedules that also encourage symbolic play. As a practical outcome, Ana's proficiency in learning generative spelling skills helped her acquire grade-level literacy skills commensurate with her general education placement.

Money and number skills may also be taught as tasks embedded in computer activity schedules—again using programs written in PowerPoint® (Vedora, Bergstrom, Kinney, & Stromer, 2001). For example, after Ned, a child with autism (age 4), became proficient with a basic computer schedule, he learned to count out subsets of one, two, and three objects as he followed his schedules. His schedules were used in home programming teaching and resembled the scripting methods described earlier (Krantz & McClannahan, 1998). After Ned clicked the activity picture, he watched a video showing his home-based teacher telling another adult to "Watch me count ___ [one, two, or three]." Then the teacher in the video counted out the subset and said, "I counted ___." Afterward, Ned's computer showed a cue-to-play slide with text that he read. From choices of photographs next to the computer, he selected the one identical to the cue-to-play image displayed on the computer screen, and took it with him to the materials. He gathered the materials, went to his mother, and said, "Watch me count ___." When Ned finished (corrections, if needed, were made by a "live" supervising teacher), he said, "I counted ___." Ned's mother praised his counting and said other things appropriate to the activity. Ned then played with the materials, put them away, and returned to the computer to do the next activity. The activities were changed from time to time to give him practice counting a variety of objects. Ned readily learned the routines for counting one, two, and three sets. He subsequently learned to count quantities of four, five, and six objects with the same procedures.

Play Materials

Saying and Doing — Teach/Test Matrix	"Girl" (Dollhouse 1)	"Mom" (Dollhouse 2)	"Dad" (Dollhouse 3)
"is waking up"	**Teach**	Test	Test
"is eating breakfast"	Test	**Teach**	Test
"is brushing teeth"	Test	**Test**	**Teach**

FIGURE 3. A matrix display of a set of interrelated sociodramatic play activities. Teaching involved photos and videos embedded in computer schedules (e.g., "Girl is waking up" and "Mom is eating breakfast"), the latter illustrating what to say and do with the play materials. Testing was accomplished with computer and notebook photos (e.g., "Girl is eating breakfast" and "Mom is waking up").

Discussion

Learning About Multiple Cues

As a practical matter for educators, it is possible that activity schedules can be used to encourage learning about multiple cues, something students with autism often have difficulty doing (e.g., Schreibman, 1997, 2000). As illustrated in exploratory work (Dauphin et al., 2004; Kalaigian et al., 2002; Kinney et al., 2003; Vedora et al., 2001), activity schedules can expose the learner to a range of static and dynamic stimuli: Typically, before leaving the computer to do any given activity, learners encountered two different photos, two auditory cues (i.e., an activity label and an expanded label phrase), and a video clip related to the activity.

As a question for further research, use of such complex stimuli raises the possibility that only some of the cues, or some component of them—not all of them—may exercise stimulus control over behavior. On the other hand, perhaps exposing the student to a range of cues can foster learning about categories or classes of stimuli that are not formally alike. Such outcomes can be tested and the results used to guide teaching (Stromer et al., 1996). For example, we are finding that schedule following is undisturbed by tests that rearrange sequences of photos and movies, or that present the sounds, photos, and movies individually. Students readily perform naming and matching tasks when they are embedded in an activity routine—tasks that ensure attending to at least some of the stimuli. Thus, assessment of the students' schedule following with components and permutations of the activity content suggests that they comprehend the relations among stimuli and are capable of attending to the stimuli even though the procedures often do not require it.

Another question for future research is whether a student's actively naming the stimuli associated with an activity might increase attention to these stimuli and thereby facilitate learning functional verbal skills (see Gutowski & Stromer, 2003). Self-produced names may function as transportable, self-instructional cues capable of mediating generalization (Stokes & Baer, 1977). Indeed, the script interventions used in Dauphin et al. (2004) and Krantz and McClannahan (1993, 1998) required multiple cue responding and perhaps verbal mediation. If these children had not learned to respond to multiple cues and mediate them over time and distance, it is unlikely that they would have looked at a photo and read its script, then engaged in significant intervening behavior (i.e., leaving the photo, obtaining the appropriate materials, and approaching the communicative partner), and only then demonstrated the cued response.

Shifting Control to Simpler Stimuli

Emma, Tim, Ana, and Ned learned to use both computer activity schedules and notebook schedules. From a teaching perspective we believe it is important to use both computer and notebook formats as components of a single, integrated package. This approach weds the unique capabilities of computers (e.g., the simultaneous integration of vocal and video cues) and the practicality and portability of notebooks and lists. Just as students benefit from learning to learn from a variety of formats—teacher paced and child initiated, individualized and group delivered, modeled live and on video—so they could profit from learning to use activity schedules presented on paper and on the computer. With respect to using video, there arises a two-part question ripe for research: What are the minimum critical skills and teaching steps necessary for a learner to (a) achieve generative observational learning via video (and maybe live) models, and (b) shift the stimulus control exercised by videos to photos and/or text? When the latter is achieved, photos and text can be accessed in notebooks or lists by the learner and used in a variety of settings.

In addition to shifting from high-tech and stationary to low-tech and portable formats, it is desirable to shift stimulus control from relatively more cues to the fewest cues needed to occasion an activity or sequence of activities. For example, if one of the scheduled activities is to “make lunch” (Pierce & Schreibman, 1994) and the student has learned to do so by using a 10-step, task-analyzed program, then the programming goal might be to reduce the number of steps to perhaps a single cue. In the end, the student may prepare a lunch to a single photo icon, the printed words *make lunch*, or the verbal instruction “Make lunch.” In fact, such a shift in stimulus control may be readily achieved: Several of Pierce and Schreibman’s students were able to continue doing their self-help activities, even during a “no-book” probe.

For other students and other tasks, of course, a gradual reduction in program steps may be required. To illustrate, a boy with autism (aged 6 years) had a history with computer (and notebook) activity schedules in his home-based services. He reliably followed four-item schedules cued by photos (e.g., cookie puzzle, putting numerals in order, reading words on flash cards, and sorting numerals) that culminated with something especially fun—watching a video with his parent. We wondered whether he would follow such four-item schedules if we merely told him what four activities to do and in what order, while showing him the respective photos one-by-one in a vertical list. While the list of photos stayed on the computer screen we observed his performance off-computer. As expected, he did not follow the overviewed schedule as it was listed. He did, however, perform all four of the activities. He began with the activity at the top of the list, and then, out of order, performed each of the remaining activities once before asking to watch a video. Thus, except for doing the activities out of order, his engagement with the materials was sustained and perfectly appropriate. The intervention resembles those used in studies of priming (e.g., Schreibman et al., 2000; Zanolli et al., 1996) and Social Stories™ (e.g., Hagiwara & Myles, 1999), except, perhaps, the provision of a list or menu of activities to be accomplished. Can we program further shifts of control of behaviors like play and social initiations from single-photo activity schedules to lists—by far the most common format observed in classrooms? Can we effect shifts eventually to the materials and communicative partners available in a setting? Such possibilities are worth investigating because of the greater levels of independence they represent.

“Pros” and “Cons” of Computer Activity Schedules

A concern often encountered has to do with the issue of independence—a commonly appreciated function of activity schedules (e.g., Green, 2001; Kimball et al., 2004; McClannahan & Krantz, 1997). Doesn’t it work against independence to require a child always to return to a computer? Is dependence merely shifted from adult to machine? Certainly, the lack of portability of computers could be seen as a mark against them, but this is one reason we have endeavored in all of our work to transfer stimulus control, once acquired, as quickly as possible from computer to notebook, thereby retaining the degree of independence associated with the less expensive and more portable “low-tech” medium. A point to be stressed is that the additional auditory and visual stimuli that can be introduced via computers are not just “bells and whistles.” Embedding instructional media within computer schedules enabled children to embed the practice of new skills within the natural context, be it social or academic, of those skills. Their repertoires were therefore expanded with negligible direct cuing or reinforcement from their teachers. This process contrasts significantly with more typical instruction, whereby skills taught under one set of adult-controlled conditions (e.g., discrete trials) are supposed to occur under qualitatively different kinds of conditions. Once learning to make a certain type of response while following a multimedia schedule (e.g., Tim’s commenting; Dauphin et al., 2004), a student may (a) maintain the response when the same activities are depicted in notebooks and also (b) generalize the response to novel notebook cues never before encountered.

Teachers, parents, and clinicians may find the prospects of using PowerPoint® to create computer activity schedules intimidating. Also, finding the time needed to become familiar with the software functions may necessitate “robbing” time from other projects. However, such concerns may fade as educators become comfortable using PowerPoint® in their teaching. In addition, the efficiency of instruction, as discussed above, could provide very good returns on an investment in time and effort to learn to create computer activity schedules. Another way in which this is true, not previously mentioned, is that once a program has been developed to teach a general type of skill, it serves as a template that may be used repeatedly for new units of material, or new students, simply by cutting and pasting new audio and visual content.

Finding multiple uses for a computer teaching program could contribute to its cost-effectiveness; this is especially so considering the time needed if an educator were to incorporate video models—arguably, a major potential advantage of using the computer in teaching. Comparing video to live models, Charlop-Christy et al. (2000) offered a number of potential "pros" for using computer-mediated models. Video models, they say, can be precise and unambiguous: The camera can reduce confusion by focusing on the critical stimuli to which a child must attend. Attention to critical stimuli may also be enhanced because the medium of presentation is either intrinsically reinforcing (all the more so when combined with a computer) or less challenging for the child in terms of the social demands (e.g., eye contact) that accompany live teaching.

Some "cons" have been mentioned more or less explicitly in the foregoing narrative, including the following: (a) the lack of portability relative to notebooks, (b) the lack of commercially available programs that capitalize on video modeling, and (c) the initial time needed to gather digital content and become acquainted with software. Other considerations in the minus column are that computers are much more expensive and fragile than notebooks, they may not be readily available (by virtue of either physical presence or scheduling conflicts for shared machines), and they may be so reinforcing to a child that he or she has difficulty leaving the computer upon completing a session (not a problem in the present study probably because the series of scheduled activities was always followed by another powerful "off-computer" reinforcer).

As implied earlier, one area of possible difficulty is generalization, not from computer to notebook, but from behavior on-schedule (regardless of computer or notebook) to behavior off-schedule. Bryan and Gast's (2000) study is instructive because some of their results were perhaps not desirable. The four students with autism (aged 7 to 8 years) showed high rates of general on-task behavior during baseline. However, they spent little time with the literacy materials made available. Later, after the students had a scheduling history of doing the literacy activities, the authors conducted probes without the notebooks. During the no-book probes, the students again spent little time doing the literacy activities. Whether more encouraging results would occur with different students or different materials (e.g., preferred play materials) is worth exploring. Perhaps the nature of a learner's history with activity schedules or the type and degree of off-schedule support (e.g., differential praise) influences the probability that the desired behavior change will be demonstrated off-schedule. In the current study, a child showed appropriate activity engagement using a list after a history with notebook schedules.

The present discussion begins to provide a framework within which to address many further questions. Apart from the obvious point that a child with autism must be able to imitate to benefit from modeling, we cannot at this point offer a formal algorithm, for instance, that determines what type of learner to teach what type of skills with what configuration of multimedia or basic schedule supports. How can we maximize the production of generative behavior as informed by studies of observational learning, matrix training, and stimulus classes (e.g., Stromer, 2000; Stromer et al., 1992; Stromer et al., 1996; Stromer & Oross, 2000)? What, if any, are the optimal activity schedule history and the necessary features of the instructional environment to promote choice making and engagement when a child is not using a schedule? In the absence of further research, we cannot be certain that instruction embedded within computer activity schedules promotes acquisition of skills more quickly than conventional instruction. However, the vocal commentary and generative outcomes evinced by Tim (Dauphin et al., 2004) and the combinations of academic and play skills simultaneously demonstrated by Ana (Kinney et al., 2003) offer compelling reasons to move forward with the research.

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AUTHORS' NOTES

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