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REVIEW ARTICLE

Just-in-Time Supports in Augmentative and Alternative Communication

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Abstract Individuals with developmental disabilities such as autism, physical disabilities, and intellectual disabilities frequently are candidates for augmentative and alternative communication (AAC) systems as well as visual supports. The purpose of this paper is to apply the business construct of just-in-time (JIT) to the field of AAC with particular reference to new possibilities for JIT support arising from the advent of the mobile technology revolution. In addition to a review of the history of JIT within AAC, a taxonomy of JIT supports is proposed. Potential benefits of JIT supports are postulated based on conceptual underpinnings related to working memory demands, situated cognition, and teachable moments. Implications of JIT supports are drawn for both the learner and the communication partners' competencies. Finally, several directions for future research are posited.

Keywords Augmentative and alternative communication · Autism · Developmental disabilities · Just-in-time · Intervention · Mobile technologies · Visual supports

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Just-in-Time (JIT) refers to a Japanese business strategy that strives to increase efficiency via improvements to the inventory chain by relying on signals ("Kanban") that inform the production line when to create a succeeding part (e.g., Cheng and Podolsky 1996). It was introduced in the 1970s within the Toyota manufacturing plants by Taichi Ohno in order to meet consumer demands with minimal delays in a cost-effective manner (Goddard 1986). Since its successful introduction in the business world, the just-in-time construct has been adopted and adapted across a variety of fields. For example, the field of medicine has introduced JIT as it pertains to knowledge management in order to best assist practioners with information demands in practice (Davenport and Glaser 2002). The concept is also being applied in continuing medical education. For example, clinicians are presented with a video of a particular procedure just prior to having to apply the same procedure in patient care (Wang et al. 2015). Along these lines, a JIT approach, combined with peer instruction, was used in a medical residency program to teach core curriculum content (Schuller et al. 2015). Specifically, students were given web-based questions prior to each session, and their responses were then used to tailor the content of the session to the students' needs. Related to the treatment of addiction, Muench et al. (2013) studied the use of mobile devices to deliver JIT text messages to support users therapeutically in real-time. The JIT construct has also been applied to education. For example, under the acronym JITT (Just-in-time teaching), Novak (2011) advocates for providing post-secondary students with pre-class questions (socalled warm-ups) that instill in the students the need to know, cooperative learning during classtime, and timely feedback. In speech-language pathology, the JIT construct is beginning to get traction as well. Brooks et al. (2015) found that children with specific language impairment make use of phonological information in word production if that information is provided in a JIT manner.

The purpose of this paper is to discuss the JIT construct as it pertains to the field of augmentative and alternative communication (AAC). AAC systems and interventions supplement or replace natural speech and/or handwriting via unaided approaches such as manual signs and/or aided approaches (e.g., graphic symbols, speech-generating devices) (American Speech-Language-Hearing 2005; Beukelman and Mirenda 2013). The notion of providing support when it is needed is not new to the field. For instance, AAC clinicians frequently rely on prompt hierarchies such as least-to-most prompting (Demchak 1990; Ducker and Moonen 1986; Durand 1993; Light et al. 1999). By their very nature, prompt hierarchies dictate that the next level of prompt should be provided only as needed; that is, in the least-to-most hierarchy, for example, a more intrusive prompt is only delivered if the learner does not respond or responds incorrectly to the current prompt.

This, however, is not what we would consider a JIT approach. This paper is more concerned with supports that are typically (traditionally) not provided as needed, but are now possible to provide in a JIT manner. The concept of JIT is not entirely new to the AAC field due to the notion of "situation-specific vocabulary" provided by Global Positioning Systems (GPS). While situation-specific vocabulary via GPS is relevant to a comprehensive discussion of JIT in AAC, this paper is largely focused on new possibilities arising from recent advances made with mobile technologies. The advent of mobile technologies has caused a shift from the use of dedicated devices (e.g.,

Dynavox™[1]) to general consumer level devices (e.g., iPad,®[2] iPhone,® [2]) with AAC-specific applications (e.g., Proloqu2Go™[3]) (McNaughton and Light 2013; Shane et al. 2012). This shift has improved the portability and acceptability of AAC supports while decreasing cost. Mobile technologies have been found effective in teaching communication skills to children with autism and other developmental disabilities (Alzrayer et al. 2014; Kagohara et al. 2013). Mobile technologies also bring about additional benefits not possible with dedicated devices, including but not limited to synchrony across devices (Shane et al. 2012).

The JIT construct in the AAC field began when Shane (2007), intrigued by the notion of potentially more efficient information exchange, applied the JIT axiom to information exchanges that involve persons with little or no functional speech using assistive technology. As part of his role in the Rehabilitation Engineering Research Center (RERC) on Communication Enhancement (2007–2013), Shane designed and produced two applications that enabled a JIT message broadcast between a mentor (e.g., parent, instructor) and a learner using an iPad. The JIT concept was at the core of these applications. The symbolTalk[4] application enables rapid creation, retrieval and transmission of messages in the form of visual supports that are delivered from one iPad to another. The second application, M-STARR[4] (Multi-Sensory Transmission of Alerts, Reminders, and Rewards), permits the transmission of first - then displays (with embedded timers and countdown displays) or multi-step activity schedules. In both applications, the supports are transmitted over a Wi Fi network. Shane (2007) proposed that the JIT concept has the potential to bolster assistive communication technology in several ways, including (a) delivery of prompts, reminders, rewards, encouragement, memory aids and error correction from a distance; (b) the potential to improve independence across settings; (c) potential of far more efficient storage, retrieval, and delivery compared to low-tech materials; and (d) affordance of multiple formats of delivery that can be tailored to an individual's processing strengths.

At approximately the same time, researchers and developers advocated for the benefits of context-sensitive or situation-specific display of vocabulary on AAC devices with the help of GPS (e.g., Patel and Radhakrishnan 2007). For example, when a learner enters a restaurant (location), the display might change to symbols related to the menu of the restaurant based on the anticipated need to place an order (goal) (e.g., Kim et al. 2009). Researchers and developers continue to refine these technologies (e.g., Demmans Epp et al. 2011; Kim et al. 2009). Additionally, developers have proposed methods other than GPS to provide access to context-sensitive vocabulary, including the use of automated speech recognition of the communcation partner's speech (Wisenburn and Higginbotham 2008) and algorithms to retrieve vocabulary from internet accessible corpora (Demmans Epp et al. 2012). These applications have the

[1] The Dynavox is a registered trademarks of Dynavox Inc., Pittsburgh, PA 15203, U.S.A.
[2] The Apple Watch, the iPad and the iPhone are registered trademarks of Apple Inc., Cupertino, CA 95014, U.S.A.
[3] Proloquo2go is a registered trademark of AssistiveWare B.V., Amsterdam, The Netherlands.
[4] M-STARR and symbolTalk were both licensed to SpecialNeedsWare, New York, New York, U.S.A. Principles of Symboltalk and specifically the ability to send direct static or dynamic scene cues from one device to another are scheduled to be incorporated in the next release of Autismate 365 and Teachmate 365 scheduled for January 2016.

potential to provide JIT access to situation-specific vocabulary, which may minimize the need by the learner for searching and navigating vocabulary on an interface.

Shane et al. (2012) offered an organizational framework for describing traditional and emerging AAC technology, and emphasized how mobile technologies can now support the implementation of a visual approach to everyday communication and language instruction that was previously not possible. In doing so, they argued that this technology "increases the ability of mentors and learners alike to quickly access scene cues 'just in time' to take full advantage of each communication opportunity" (p. 1231) and enables the capturing of "images for on-the-spot creation of materials" (p. 1231). Scene cues are visual images that portray relevant concepts and their relationships in context via pictorial forms, photos, or video (Shane 2006) (e.g., a scene cue may illustrate the directive "make the boy climb the ladder").

Light et al. (2012) presented a paper at the American Speech-Language-Hearing Association Convention, investigating the effects of JIT technology in three connected studies. Dr. Light was part of the RERC that introduced the JIT concept to the AAC field under that name. In Study 1 involving 6 adults without AAC experience, two traditional non-JIT visual scene display (VSD) platforms (i.e., SD Pro Software, InterAACT software on vmax) were compared to a JIT technology (i.e., PlayTalk™[5]) in terms of programming time. The JIT technology took considerably less programming time than the non-JIT platforms. The results implied that clincians might engage in more programming for new vocabulary if they had access to JIT technology. In Study 2, the researchers compared a JIT techology (JIT PlayTalk) to a non-JIT technology (SD Pro Software) in terms of communicative turns and quantity of vocabulary of three preschoolers with developmental delay and little or no functional speech. Identical VSDs with the same hotspots were programmed into both systems, except that the JIT technology allowed for on-the-spot creation of additional hotspots during the play routines in which the technologies were introduced. Using an alternating treatments design, the children were found to take more turns and had access to more vocabulary during the sessions with JIT technology. Although the researchers were concerned that the children might lose interest during the JIT programming phase of the interaction, it was found that they remained engaged at high levels. In Study 3, the researchers replicated Study 2 but with a focus on longer-term effects in five children with developmental delays due to a range of diagnoses. The children showed greater improvements in both turn taking and range of vocabulary with the JIT PlayTalk compared to the traditional software (SD Pro), and maintained these gains in home, school, and day care settings.

Drager et al. (2014) presented a paper at the Biennial Conference of the International Society for Augmentative and Alternative Communication on the effectiveness of an aided intervention using technology that enabled JIT programming with adolescents who have severe disabilities. Specifically, they studied how an intervention using aided AAC with JIT programming impacted turn taking and the number of different semantic concepts communicated during shared activities. Participants included nine adolescents between the ages of 8 and 20, all with little or no functional speech, and varied diagnoses (seizure disorders, Autism Spectrum Disorders (ASD), cerebral palsy). The intervention utilized PlayTalk, a Windows-based software which permitted the

[5] PlayTalk is a registered trademark of InvoTek, Alma, Arkansas, U.S.A.

following JIT components: quick and easy import of photos as VSDs; quick and easy programming of hotspots and vocabulary; drawing function to add text, photos, or pictures; and a simple menu understood by children. As a result of the JIT intervention, participants showed improvements in turn-taking and diversity of semantic concepts.

In discussing recent innovation related to AAC for children with autism, Schlosser et al. (2014) introduced both SymbolTalk and MSTARR as recent innovations that permit the provision of JIT supports for children with ASD. Additionally, they posited several research questions that will be discussed under the section "Directions for future research." Next, we propose a taxonomy of JIT supports.

Taxonomy of JIT Supports

Taxonomies are classification systems or organizational frameworks. In the fields of education and communication sciences and disorders, Bloom's taxonomy of objectives is perhaps the most widely known and relied upon taxonomy (Bloom et al. 1956). In AAC, a taxonomy for describing symbols had been proposed in the 1990s (Fuller et al. 1992). Here, we propose a taxonomy of JIT supports in an attempt to help readers understand the varied nature of these supports and to provide a framework for organizing and integrating future discussions and future research and development efforts. JIT supports can be classified in terms of (a) intended purpose, (b) modalities, (c) source, and (d) delivery method.

Intended Purposes of JITs

JITs may serve several *intended purposes*, including prompts, reminders, rewards, and encouragement (Shane 2007). JITs may serve as prompts if they are aimed to bring about some form of action by the recipient. For example, a dynamic scene cue (i.e., a full motion video-clip illustrating a scene) that is sent to a learner's iPad may function as a prompt for carrying out a directive illustrated by the scene cue. A graphic symbol supplied in a JIT manner may serve as a prompt for the child to comment on an unfolding event. JITs may serve as a reminder as well. For example, a student who neglects to check her visual schedule and, as a result, appears confused may be supplied with a visual representation of the completed activity along with the next activity, serving as a memory aide. Likewise, a child may be given a visual timer as a reminder of how long a favorite activity will continue before it ends. In a recently completed field study involving an adolescent with autism, a reminder was also used in a JIT manner (Shane et al. 2010). Here, the teenager typically neglected to turn on the light or close the door before using the bathroom. Reminders in the form of scene cues were provided in the exact moment when each of these actions should occur, every time the learner used the bathroom. Over time, these repeated reminders helped to establish a new routine that included turning on the light and closing the door.

A JIT may also function as a reward for an attained behavioral or academic accomplishment. For example, upon successful completion of a daily living activity in a work experience program, an adolescent learner may be supplied with a visual representation indicating that he can now listen to his favorite songs. Alternatively, the

learner may be given a generalized reward symbol, indicating that he has earned a reward which he may now request. Of course, rewards should always occur in a JIT manner so that the reinforcement is temporally associated with a desired behavior. In terms of enouragement, a communication partner could be sending a thumbs up symbol when witnessing a successful conversation by the student using AAC with a non-disabled peer.

JITs could also function to help an individual to start, maintain, or part from a conversation, what might be called "Conversation JITs." Individuals with developmental disabilities are often experienced by communication partners as passive communicators who find it diffcult to initiate a conversation (Basil 1992). Here, a partner could send a visual representation that the child could use as an ice-breaker, and the partner could model its use for the learner. Along these lines, JITs could also be handy to help repair communication breakdowns (Sigafoos et al. 2004) that the learner is unable to repair without the additional support.

A JIT approach may serve additional purposes, including vocabulary selection, vocabulary instruction, vocabulary organization, and generalization. In terms of vocabulary selection and instruction, conceivably, a JIT approach could be used to introduce new vocabulary when a teachable moment arises. For example, a student engages in an activity in which a particular concept would be helpful to communicate, but the student has either not learned the meaning of this graphic representation or the student's system does not include this vocabulary. Particularly in inclusive settings, children who use AAC are often expected to participate yet lack the vocabulary needed to do so, which creates often insurmountable barriers to participation and independence (Schlosser et al. 2000) – often due to a lack of preparation and pre-planning. Here, the communication partner could supply the graphic representation in the moment, model via augmented input (i.e., pointing to the symbol while saying its meaning), and scaffold its use to the student. To take this a step further, if the planning had neglected to include multiple vocabulary and phrases, the instructional aide may be able to prepare a small topic-specific display on the fly. To be feasible, this may require a little bit of advance notice given by the teacher, who might share an overview of a multi-phase activity at the beginning of class, allowing the aide to quickly select appropriate vocabulary in an early phase for vocabulary needed later in the lesson.

Shane et al. (2010; 2014) offered an example where it was possible to quickly adapt an existing topic-specific display. Specifically, when a learner unexpectedly demonstrated a great deal of amusement while blowing very large bubbles, her "bubbles" topic display could be quickly altered to include the concepts "big" and "little." The learner's high degree of motivation to use these concepts resulted in an unexpected teaching opportunity and a richer interaction. In this case a JIT approach allowed mentors to follow the learner's lead and cater to her individual interests in a way that would not likely have been possible using a non-JIT approach. Another example of JIT support for the intended purpose of vocabulary selection and instruction involves the quick and easy import of photos as Visual Scene Displays and the quick and easy programming of hotspots (Drager et al. 2014).

A JIT approach might also assist with encouraging generalization from one setting to another. Even if training initially occurred in the therapy room, which is inconsistent with the "train in the natural environment" approach (Schlosser and Lee 2000), the JIT approach might assist the learner to transfer skills to the natural environment. In a

recent field study involving an adolescent girl with autism, animated graphic symbols representing various language concepts were organized within folders on one learner's Apple iPad (Shane et al. 2010, 2014). The learner received regular speech therapy, during which time selected concepts were taught and mapped to their corresponding graphic symbols. Then, each time one of these target concepts occurred outside of the therapy environment, the appropriate graphic symbol could be easily accessed and presented using a JIT approach. This helped to ensure that opportunities for review and generalization did not go to waste, even if the opportunity was not anticipated and prepared for in advance. Examples of concepts taught in this manner include "open," "push," "in," "on," "pour," and many others.

A JIT approach may also be used to clarify vocabulary organization for a learner who seemingly cannot remember how to navigate to a particular symbol whose meaning he had previously acquired. The learner would need to "signal" to the mentor that he can't remember a concept, and the mentor would need to infer from the context and/or prior history interacting with the learner what that concept might be. Then, instead of simply sending the likely symbol in question, a mentor could send the exact navigation path so that the learner might learn and remember this path for the next time. These, what might be called "navigation JITs," could be represented visually (text: FOOD→SANDWICH→REUBEN, or graphic) and/or auditorily via voice. This bring us to modalities.

Modalities of JITs

JIT supports can be supplied in multiple *modalities* (see also Shane 2007) for which Shane et al. (2014) offered alternative terminology. In the *auditory modality* (socalled "Earcons"), JITs may be in the form of spoken language (Shane et al. 2014) or non-linguistic environmental sounds (e.g., Harmon et al. 2014). These may be either pre-recorded or created at the time of delivery. In the *visual modality* (socalled "Eyecons"), JITs may be in the form of static or animated graphic symbols (e.g., line drawings), traditional orthography, photos, static scene cues, dynamic scene cues, video (for video modeling), and flashing screens or indicators. These supports may be readily retrieved if included in a learner's system or they may be created on the spot. In the *vibrotactile* modality (socalled "Vibrons"), JITs may be in the form of a pulsating mobile technology as provided by the newly released Apple Watch®[2] (https://www.apple.com/watch/), a wearable technology that vibrates on the wrist when a new text message arrives. Obviously, JITs may also contain combinations of more than one modality. For example, a JIT could consist of a static scene cue along with recorded speech, combining visual and auditory modalities. The selection of modalities for JIT purposes bears implications for assessment and feature matching. For example, in an inclusive setting, where students with disabilities often work with non-disabled peers in cooperative learning activities, it may be important to be discreet. Here, using the Apple Watch might be a good fit since its haptic cue for informing the arrival of a new JIT is unobtrusive. Also, in an inclusive setting, visual JITs should not be accompanied by auditory stimuli in order to be as inconspicuous as possible. In general, the selection of modalities should also take into account the processing strength of the specific individual.

Sources of JITs

Another aspect that helps conceptualize JITs in AAC relates to the *source* of the JIT; that is, who or what is evoking a JIT. JITs may be self-initiated by the learner. These *self-initiated JITs* are called up when the learner becomes aware of a need for more support. For example, a learner who is still acquiring the meaning of symbols on a display may touch an unknown symbol to activate the speech output to remind her what the symbol stands for. Another learner who is experiencing difficulty interpreting the meaning of a static symbol for a verb may call up an animated version of the same symbol. Yet another learner may have difficulty with interpreting a static scene cue and call up its dynamic counterpart.

As discussed earlier when reviewing the history of JITs in AAC, *automated JITs* are supplied by a device or app at the time when needed without additional human assistance. These JITs may be preprogrammed to appear at a certain time (similar to an alarm clock) or they may be environmentally-guided by a GPS with the capacity to detect a location (e.g., kitchen). The Autismate™[6] application, for example, changes its home display depending on the location, showing kitchen-related vocabulary when in the kitchen and play-related vocabulary when on the playground. Alternatively, a learner with intellectual disabilities may enter the bathroom and as he approaches the sink, a video will appear that demonstrates how to wash his hands. Currently, GPS systems are not capable of detecting a location (sink) within a location (bathroom). As discussed earlier, automated JITs may also be generated by analyzing the speech of the partner (Wisenburn and Higginbotham 2008) or by using algorithms for searching internet corpora (Demmans Epp et al. 2012). Finally, *mentor-generated JITs* are supplied by a family member, peer, or paid support personnel such as teachers, teacher aides, or speech-language pathologists. The on-the-spot creation of a hotspot on a visual scene display (Drager et al. 2014) is an example of a mentor-generated JIT.

Methods for Delivering JITs

The *methods for delivering* the JIT supports is another way to add to our understanding and differentiation of JITs in AAC. Mentor-generated supports, for example, can be supplied *face-to-face*. An instructional aide, for instance, might provide a dynamic scene cue to a student with autism to help the student understand a particular directive. Mentor-generated JITs may also be delivered to the learner via *wireless transmission*. Both symbolTalk and M-STARR afford this type of transmission from the mentor's mobile platform to the learner's platform. With automated JITs, the delivery method may be viewed as *pre-programmed*; when the GPS recognizes a new setting, the home display on the learner's device might change accordingly. *Tele-practice* represents another method through which mentor-generated JITs may be communicated. Allen et al. (2015) describe a case-study in which a 13-year old boy with autism who resides out of state received scene cues via a tele-practice platform from Boston Children's Hospital. Finally, with self-initiated JITs, the delivery method is *direct* since the learner generates the JITs on his or her display.

[6] Autismate is a registered trademark of SpecialNeedsWare, New York, NewYork, U.S.A.

The proposed taxonomy allows the classification of JITs along the four dimensions (intended purpose, modalities, sources, and methods). For example, the on-the-spot creation of hotspots could be classified as a mentor-generated auditory-visual JIT that is created face-to-face for the intended purpose of vocabulary selection and instruction. Likewise, a scene cue that arrives on the learner's iPad is classified as a mentor-generated visual JIT that is transmitted wireless for the purpose of aiding comprehension of directives.

Conceptual Underpinnings for the Benefits of JIT Supports

Working Memory Demands

Several authors have theorized about the additional demands on working memory placed for individuals using an aided AAC system (Light and Lindsay 1991; Thistle and Wilkinson 2013; Wilkinson and Henning 2009). According to Baddeley (2007), working memory involves the ability to store and manipulate information actively during the pursuit of a goal-directed process. Assuming a dynamic display, the learner must keep the target concept in mind while simultaneously (a) remembering the page on which a particular symbol is located, (b) remembering the best navigation path to get to the target page, (c) remembering the location of the target symbol on the target page, and (d) inhibiting any responses due to arising distractions (Thistle and Wilkinson 2013). If a learner is building a sentence involving multiple symbols, this process has to be repeated until the sentence is complete. Thistle and Wilkinson (2013) described several strategies to bypass working memory challenges exhibited by users of aided AAC systems, including improved display organization (plus learner involvement in that process), scaffolding by the partner, and use of a message window to track progress toward phrase completion. The JIT construct is proposed as yet another strategy that might minimize working memory demands placed on users of aided AAC systems. For example, a learner who appears to have difficulty remembering the navigation path to a familiar target symbol could be sent the target symbol by a mentor, compensating for the memory lapse and ensuring the continuity of an ongoing conversation. Alternatively, the mentor could remind the learner of the path by sending a visual that illustrates the path (i.e., sequence of symbols to be activated) which then can be imitated by the learner. Here, the JIT would function akin to a memory aide. Potentially, a JIT approach might also be useful when introducing new vocabulary/symbols within a particular context. Initially, this might involve the sending of a new symbol without burdening the learner with the specific location of the symbol – focusing only on symbol understanding.

Situated Cognition and Situated Action

One benefit of JITs is the "timing" of the support - support is not made available in advance, nor is it made available when it is no longer needed; rather, it is made available exactly when it is needed. In addition to timing, however, there is at least one other factor that is evoked through the provision of support when it is needed. This factor is perhaps best elucidated by the construct of *situated cognition* as it pertains to learning in general

(e.g., Brown et al. 1989) and situated action as it speaks to language learning (Barsalou 1999). JIT support is not provided in a vacuum, but likely occurs during an activity that is being carried out. As such, JIT is by its very nature situation-specific. According to Barsalou (1999), language comprehension becomes possible through situated action: "On encountering language, associating its elements with perceived referents in the accompanying situations is often central to the basic goals that comprehenders seek to achieve" (p. 63). If that is so, JIT supports can further clarify the relations between objects, graphic symbols and other visual supports, events, and agents within a particular situation. Brown and colleagues (1989) note that in face-to-face conversations, the communication partners can interpret indexical expressions such as "here" and "now" because they can access the indexed features of the situation. When providing scene cues in a JIT manner, for example, the scene cue becomes comprehensible in the presence of speech in conjunction with the respective figurines on the tabletop.

Teachable Moments

A concept closely related to situated action and situated cognition, the pedagogical construct of "teachable moments," may serve as another conceptual underpinning of JIT supports. According to Hyun and Marshall (2003), the foundations of teachable moments trace back to Rousseau (1948), the Swiss pedagogue Pestalozzi (1898), and the German pedagogue Fröbel (1909). According to Fröbel it is the role of the adult to observe a child's natural development and provide activities that will allow the child to learn what he or she is ready to learn when they are ready to learn. Along these lines, Ayres (1989) defined teachable moments as opportunities that may emerge when students are excited, engaged, and primed to learn. Accordingly, it is exactly within these teachable moments when the provision of JIT supports may enhance the likelihood that learning occurs. An analysis of narrative reflections of both novice and seasoned teachers led Hyun and Marshall (2003) to the conclusion that "teachable moments arise when teachers observe, recognize and interpret the spontaneously occurring interests of diverse learners" (p. 113). So clearly, while student-centered at the core, a teachable moment demands an active role by the teacher, which brings us to the implications of JIT for communication partners and students.

Implications Of JIT For Communication Partners and Learners

Communication Partners

To capitalize on some of the opportunities that a JIT approach affords, communication partners need to be able to read pertinent "signals." But what does it mean to read pertinent "signals" related to communication and interaction? Here, the work of Hyun and Marshall (2003) on teachable moments might be informative. Specifically, they refer to three steps that teachers of early childhood students must take in order to take advantage of teachable moments: observe, recognize, and interpret. The first step entails careful observation of children in interaction. Only with careful observations will communication partners recognize the unique essence of the situation and allows them to interpret (make sense of) the moment from the child's point of view.

Relative to JIT implementation involving scene cues, the steps may unfold as follows: when observing an instructional aide providing a spoken directive to a child with autism and watching the child's response, the teacher recognizes a failure to carry out the directive along with nonverbal behaviors such as a facial expression of confusion. The teacher interprets that this situation is indicative of a lack of comprehension of the spoken directive, and then decides to supply a visual scene cue as a JIT. A JIT approach requires of partners to be proficient at second-person perspective taking and to be in the moment or practice mindfulness. Mindfulness has been defined as an awareness that arises through intentionally attending in an open, accepting, and discerning way to whatever is arising in the present moment (Shapiro and Carlson 2009).

Upon realizing an opportunity exists, partners also need to be able to retrieve or, if necessary, create AAC supports and visual supports "on-the-fly." For example, they may need to have the competence to retrieve a graphic symbol using the voice recognition feature of an application, and then sent it via text message or the wireless network. If an appropriate visual support is not available, they may need to quickly arrange and assemble objects, and then capture photographs of the objects on the spot.

Hyun and Marshall (2003) also point out that teachable moments do not just arise from nothingness. Rather, there is purposefulness behind teachable moments in that the teacher sets a teaching goal, and watches for an opportunity in which to accomplish the goal. Related to AAC, a communication partner would need to understand that vocabulary selection, vocabulary instruction, and vocabulary organization training are potential goals that can be implemented in a JIT manner, and then to identify opportunities for implementation.

A frequently observed phenomenon in inclusive classrooms is that teaching assistants are hovering over a child with disabilities to whom they are assigned (Giangreco et al. 1997; Hemmingsson et al. 2003). In a well-meaning attempt to provide support, assistants inadvertantly separate students with disabilities from their peers, removing any possibility for the student to function independently, and unnecessarily stigmatize these students. With a JIT approach, assistants may alter their proximity to the student, knowing that they can still support the student from a distance when needed, but otherwise leave the student to develop his or her independence or rely on the interdependence provided in cooperative learning groups from non-disabled peers.

Learners

With a JIT approach, learners need to accept and adapt to the support provided automatically (e.g., through situation-specific vocabulary driven by GPS) or generated by a mentor (face-to-face or wireless) as it arrives in the moment of an activity. Typically, non-JIT supports are provided face-to-face. So, a JIT approach using wireless transmission or telepractice would be different. Also, learners in some settings might be used to certain times for learning or teaching. With JIT, learning may occur at any time. This may present a significant departure from current practices and may require some adaptive skills as well as new operational competencies and demands. The Apple Watch, for example, is a wearable technology with a relatively small screen. Not only do learners need to tolerate wearing the watch, but they also need to be able to perceive images on a small screen. Finally, to receive visuals such as photos via text message, they need to interpret the haptic cue as a prompt to raise their arm and to look at the

watch, and lower their arm after having viewed the image. The viewing of videos requires an additional step – the tapping of the image – in order to activate the video. The same additional step may be needed when receiving a video on an iPad. These additional steps necessitated by JIT likely impose some costs of communicative competence upfront, but gradually with every additional message received these additional demands should be handled in a more automatic manner.

When receiving JITs via wireless transmission, learners need to be able to connect the JIT with their ongoing activity, and upon "reading" the JIT, shift their attention back to the activity at hand. The same self-directed attention shift, however, is required when the JIT is supplied in a face-to-face manner.

JIT may work best when the partner can understand the "signal" that a JIT is needed. Hence, learners need to be able to provide some sort of signal; for example, they may look to the partner for help, point to a symbol for requesting assistance, point to a symbol that conveys the learner does not have the needed vocabulary, or employ pre-linguistic behaviors to communicate a need.

Directions for Future Research

The application of the JIT construct to AAC offers several directions for future research. Some of these directions are focused on the behaviors and attitudes of communication partners and others are directed at the behaviors of individuals with developmental disabilities.

Communication Partners

Traditionally, vocabulary selection, vocabulary instruction, vocabulary organization, and even symbol selection are implemented upfront as time-limited activities when a communication system is being established for a given individual with periodic updates at later times (e.g., Beukelman and Mirenda 2013). Although the philosophy that assessment is ongoing aims to instill otherwise, we suspect that in practice these activities remain largely in these distinct upfront preparations rather than ongoing. Likewise, visual supports are typically prepared ahead of time even though they come into use only as needed (Quill 1997). As a result, in many ways these upfront preparations and tools that are developed once allow for little flexibility to accommodate emerging or unforseen needs.

A JIT approach allows for more flexibility and timeliness because every activity offers the potential to select new vocabulary, teach new vocabulary, refresh retention of learned vocabulary, teach navigation to previously unused or forgotten vocabulary, and to select symbols and other visual representations of vocabulary. Similarly, a JIT approach allows for and demands the creation of visual supports on-the-spot, which affords the ability to adapt to emerging and unforseen situations. This raises questions as to whether communication partners can adjust attitudinally and also competence-wise to such changes. For example, a teachable moment can only be capitalized upon if clinicians and educators can produce the JIT sufficiently fast. Whether they can requires further investigation. Researchers at The Pennsylvania State University have completed two studies investigating programming time offline versus mobile technology that

allows for VSDs, and clinician's ability to implement JIT (J. Light, personal communication, August 6, 2015). Likely, clinicians and other communication partners will require training so that they are in a better position to observe, recognize, and interpret situations that may lend themselves to JIT implementation, and develop the skills to retrieve, produce/program, and deliver the JIT supports. Future research activity should be directed to evaluate the effectiveness of such communication partner interventions.

Future research might explore whether JIT implementation will permit teachers and instructional aides to provide more visual supports throughout the day, and to provide visual supports for unforeseen circumstances. Because some technologies allow easy access (e.g., via voice recognition) to visual supports, does a JIT approach encourage parents to use more visual supports at home? Likewise, does a JIT approach compared to an non-JIT approach allow teachers and instructional aids to introduce more new vocabulary, solidify existing vocabulary, to better teach navigation to vocabulary, and select more symbols? These are all questions worth asking and answering.

The effects of JIT implementation on the behavior of instructional aides also warrants attention. Specifically, will JIT implementation permit aides to hover less over the students to which they are assigned? Changes in proximity and JIT supports may, in turn, affect peer interaction, peer attitudes, and independence by learners.

The proposed taxonomy offered several examples of intended purposes of JITs. That being said, it is likely accurate that the field has yet to fully grasp all possible ways that JITs could be utilized in both clinical and natural environments. Descriptive studies asking teachers, clinicians, and parents to keep diaries on situations in which they implemented a JIT, or situations where they wished they could have provided a JIT but could not due to a barrier (e.g., did not have the technology), are going to be informative toward developing a full understanding of the JIT potential and its limitations.

Learners

A JIT approach may require different kinds of operational competencies and demands that warrant empirical scrutiny. Researchers at The Pennsylvania State University have completed a study examining the developmental demands placed on very young children when using a JIT approach (J. Light, personal communication, August 6, 2015). Some of these competencies are dictated by the mobile technologies being used. The Apple Watch, for example, is a wearable technology with a relatively small screen. For learners with autism it remains to be studied whether they can learn the operational skills needed to operate an Apple Watch. Our research group is currently investigating whether children with autism are able to meet these competencies and demands for using the Apple Watch. Moreover, we are investigating whether children with autism can carry out directives when provided with visual scene cues in a JIT manner (after they have failed to do so when receiving the directives in the spoken modality) – a replication of a non-JIT study in which spoken cues were compared with two augmented modalities (i.e., dynamic scene cues and static scues) (Schlosser et al. 2013). In that study, visual scene cues were found more effective than spoken cues alone.

As discussed above, JITs may be supplied in a variety of single modalities or combination of modalities. Another line of future research could examine, for example, in what situation it is beneficial to receive JIT support in a combined auditory-visual modality versus a single modality (visual only or auditory only).

Related to automated JITs, it is unclear to what extent learners can take advantage of situation-specific vocabulary. On the one hand, it is conceivable that they would welcome this type of support as it reduces their need to navigate to the appropriate page. On the other hand, they may be surprised by these changes that were not initiated by them, at least initially, and perceive this to be a lack of control related to their communication system.

Given its potential, future research should determine whether a JIT approach to providing activity-specific vocabulary will allow students to participate more actively and independently in classroom activities (Schlosser et al. 2000). Similar research could be conducted with adolescents transitioning to adulthood in work and community settings. Finally, in presenting the taxonomy of JIT supports, we have discussed several intended purposes that JIT may serve. Future research should carry out studies on the effectiveness for each of these intended purposes.

Directions for Future Development

State of the art technology and especially ubiquitous mobile devices make the JIT concept an innovative and fresh way to think about AAC. The JIT framework described in this paper offers several practical ways in which a JIT can be applied. We believe our suggestions are just the beginning of a long list of ways in which the subtle intrusion offered by a well placed JIT will lead to clearer communication, greater independence, and better understanding of social situations. No doubt, future JIT supports will evolve as an outgrowth of emerging technologies. We predict that wearable technologies will play a critical role in allowing for clearer transmission, easier detection, enhanced viewing and improved listening of innovative and productive JITs. Future development efforts will be pushed forward as more communication partner practice with a JIT mindset and demand technology that is intuitive and quick to apply to keep pace with daily life.

Summary and Conclusions

In this paper we aimed to apply the construct of JIT to the field of AAC with particular reference to new support possibilities arising from the advent of the mobile technology revolution. Following a brief review of the history of JIT within AAC, we proposed a taxonomy of JIT supports that includes the intended JIT purpose, the modality or modality combinations, the source, and the method of delivery. The taxonomy is aimed to facilitate future scientific communication and clinical discourse related to JIT as well as with organizing current and future development and research activities relative to JIT. A review of conceptual underpinnings related to working memory demands and situated cognition resulted in several hypothesized benefits of JIT supports relative to non-JIT supports. These potential benefits, however, need to be tempered by some of the new demands that JIT places on communication partners and learners alike. Finally, several directions for future research and future development are posited. JIT has been brought to the forefront once again (after the initial focus on GPS guided situation-specific vocabulary) due to technological advances made with mobile technologies.

Clinical practice changes are warranted so that JIT can be meaningfully exploited. Undoubtedly, JIT is a promising construct. Although the few studies available thus far have not completed peer-review and some may require replications with a larger N, initial findings regarding JIT are all positive. Hence, future research efforts on JIT are critical in order to catch up with these technology-driven innovations. In turn, as more communication partners begin to practice with a JIT mindset, development efforts will be catapulted forward to make a JIT approach more intuitive and feasible.

Conflict of Interest The authors report no conflicts of interests.

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