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Commentary

Wearable Technology: The Future in Sensory Processing Disorder Intervention

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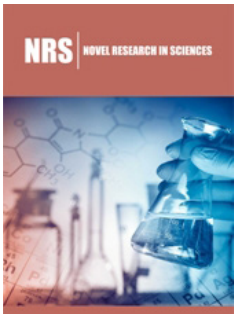

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Introduction

The use of wearable technology appears to be becoming more prevalent and relevant as additional advanced tools are being produced. Labis et al. (2015) defined wearable technology as an innovative trend comprised of mobile computers and sensors that users can interact with while being worn as part of clothing. People are now able to monitor their physical and physiological activity levels as a result of these wearable microcomputer systems. For example, users of the Apple Watch™ can use visual and tactile prompts from the Breathe Application to synchronize their breath with these sensory cues. Also, the Fitbit™, a microcomputer system worn on the wrist, can assist wearers of the product in monitoring their ambulation and mobility. These wearable devices have the potential to promote movement, general health, and increased participation in functional everyday activities. Wearable technology can also be incorporated in education, particularly with adults and students who have special needs. Wearable technology as an innovative trend appears to receive increased focus in its potential to be applied in various educational settings, particularly special education. Pepe C et al. [1] described the use of the Fitbit™ as a means to encourage students in an adaptive physical education program to track their ambulatory activity.

These wearable devices worn on the wrist can measure steps and track the distance travelled during the day. The authors added that students at their special education program can use the Myo Gesture Control Armband™ instead of a computer mouse. This device can be worn in the upper extremities so that users can control a computer using the armband by using gross motor movements instead of fine motor skills.

The purpose of this report is to show how several wearable devices (BB8 Robot- Force Band™ combination, Muse Headband™, and Apple Watch™) can be used by adults and children who have difficulty processing sensory information. By using these wearable technologies, people can learn adaptive ways to regulate external and internal sensory stimuli. Ultimately, the objective in using these devices that involve receiving sensory stimuli from the environment is for students to exhibit an adaptive response. This report also emphasizes the benefits of interdisciplinary collaboration in the special education classroom, particularly between rehabilitation professionals and educators. The intended audience for the conferences are rehabilitation science professionals and educators who are interested in using technology-based interventions for students who have issues with processing sensory stimuli.

Background

One salient characteristic of wearable technology is that these devices can emit or detect sensory stimuli. Environmental stimuli can be detected by the following seven human senses: visual, auditory, olfactory (smell), gustatory (taste), tactile (touch), proprioceptive (knowing the position of one's joints in space), and vestibular (balance). Thus, wearable technology can have the potential to assist adults and students with special needs in sensory integration activities. According to Lane SJ et al. [2], sensory integration is a theory that explains the ability to produce an adaptive response after receiving and processing sensations from the body and the environment. For example, as students listen to a lecture, they are surrounded by noise, visual distractions, various odors, and the tactile sensation of their clothes. These numerous stimuli may "overload" the nervous system so that students may not be able to focus on tasks. However, if sensory integration is present, students can tune out extraneous stimuli so that they can produce an adaptive response to the environment, or in this case, pay attention to the teacher.

Many children and adults are able to internally regulate these sensory stimuli so they are able to generally function in the classroom. However, there are some students with sensory processing disorders who may not be able to process and modulate the simultaneous sensory that they receive from their external environments and within their own bodies. Vaughn P [3] stated that, "Sensory Processing Disorders (SPD) is a condition in which a person has difficulty organizing and integrating sensory information for use" (p. 1176). The author added that people with SPD find difficulty adapting to sensory stimuli and consequently, these individuals face challenges in performing functional tasks. In this report, the problem presented is that a significant number of students, both children and adults, exhibit SPD, a condition that can hinder their learning and optimal participation in classroom activities. For example, some children who may exhibit tactile defensiveness may complain that they were "pushed," when in fact they were only "lightly" touched by a classmate. On the other hand, students who seek tactile input may indiscriminately touch objects and their peers. These examples of sensory processing issues can interfere with students' ability to elicit an adaptive response in the classroom as they may find difficulty in attending to important classroom tasks.

Rehabilitation science professionals like occupational and physical therapists often use sensory integration techniques to address students' sensory processing issues. Often, these professionals might use devices or equipment that will provide visual, auditory, tactile, proprioceptive, or vestibular stimuli for children to learn to internally regulate these sensations. For example, if children with SPD are aversive to touch, the therapist might use a brush to desensitize them to tactile stimuli. In another case, students may sit on an indoor swing for them to tolerate various vestibular challenges that can help them develop their sitting or standing balance. Therapists can select from their repertoire of sensory integration intervention tools in order for children with SPD to become sensitized to certain sensory information and ultimately develop a functional attention span for classroom activities.

Wearable technology has the potential to promote sensory integration in the classrooms of students with SPD. However, educators must be judicious in selecting devices that can increase opportunities for these children to acquire adaptive skills in regulating sensory stimuli. One way these teachers can assist in choosing wearable technology in the classroom is by consulting with rehabilitation science professionals and educational technologists before purchasing technology-based devices.

Possible Solutions

The researcher also vigorously proposes the use of the following wearable technology devices for sensory integration for students with special needs in the classroom:

A. Combined use of BB8™ (robot) and Force Band™ (wearable technology worn on the wrist that promotes the use of proprioception))

B. Muse Headband™ (device worn on forehead that provides auditory cues)

C. Apple Watch™ (Breathe application that emanates vibrotactile cues)

The BB8™ robot and Force Band™ can be used in combination for the acquisition of sensorimotor and cognitive skills. The Force Band™ can be worn around the wrist to control the BB8™. The wearer can move the arm in various directions and planes to move the robot from a distance.

In its website, Muse [4] mentioned that its headband product, worn on the forehead can be used to monitor the wearer's brain wave activity. The company then explained that the device uses the brain wave information to impart feedback (auditory cues) of soothing sounds that can calm the user. In this way, people appear to self- regulate their internal environment prior to engaging in an activity that requires attention and concentration. Additionally, users may be able to learn how to modulate various stimuli form the environment in order to produce a more adaptive response or behavior. According to Muse, this device-designed for adults-is recommended to be used by people 16 years and older. Muse also mentioned that they plan to create a Muse device designed for children in the future. The Apple Watch™, through its Breathe app, can provide wearers visual and tactile cues to be more aware of their breathing and consequently, promote relaxation and decreased stress. The device user can sync the breath to the visual patterns on the watch screen and the vibration on the wrist. Visual and tactile cues can be utilized to voluntarily regulate the breath and therefore, provide opportunities for relaxation and healthy habits.

Existing theories, found predominantly in educational settings, support the use of the BB8™, Force Band™, Muse Headband™, and Apple Watch™ in learning. Ormond JE [5]stated that sensory cueing can provide signals to people on how to behave. Gredler ME [6] explained that motor skills learning involves first learning, and then practicing and refining movement. These theoretical explanations can be used as the foundation in applying various wearable technological devices in learning and education. The activities that use these wearable technology devices involve a lot of sensory input and cues. For example, the use of the BB8™-Force Band™ combination gives the wearer visual (the moving BB8™ robot), auditory (voiced instructions from the phone- based app and Force Band), and proprioceptive/ kinesthetic cues (movement of upper extremity joints). The Muse Headband™ provides auditory cues to provide feedback for the wearer to relax. The Apple Watch™, through its Breathe app, can provide wearers visual and tactile cues to be more aware of their breathing and consequently promote relaxation and decreased stress. These wearable technological tools can provide a varied “sensory diet” (a selection or repertoire of sensory-based tools and activities) in a classroom that can provide students enjoyable opportunities for sensorimotor skill acquisition.

Theoretical processes from the rehabilitative sciences can also be used to provide the rationale for the use of wearable technology in the school setting. Activity analysis is a fundamental process in occupational therapy that involves the extensive examination of a task to explore the uses of activity in interventions and uses for learning (e.g. sensory, motor, and cognitive). Crepeau EB et al. [7] mentioned that, “Activity analysis addresses the typical demands of an activity, the range of skills involved in its performance, and the various cultural meanings that might be ascribed to it” (p. 239). These authors’ activity analysis format included the following categories: description, objects used in the task, space demands, social demands, sequence (including timing and patterns), required skills (observable actions/performance skills), required body structures and functions, safety hazards, adaptability to promote participation, and grading (modification of activity according to a person’s skill level). Activity analysis is used to examine and explore the uses of the selected wearable technology in providing sensory integration activities in the curricula. Although activity analysis is mainly used in occupational therapy, this process reflects some aspects of a lesson plan. For example, the description may contain objectives of the lesson an educator wants to impart. Also, the required materials can be seen in both activity analyses and in lesson plans. A salient difference is that activity analysis contains Required Body Structures and Functions, a section that is more therapy- and medical- based.

Each of the three wearable technological devices used as interventions for SPD are subjected to activity analysis as seen in the tables below: As seen in Table 1, the use of BB8™-Force Band™ may require a larger space than the use of the other wearable technologies. For instance, the users wearing the Force Band must have adequate space to move their upper extremities in order to control the robot. The BB8™ itself must have enough space to move around. As seen in Table 2, the Muse Headband™ can be a useful preparatory activity before users attend to tasks that require intensive concentration. Besides relaxation, this device can be used for self-regulation so that users know if they are in a more relaxed or active state. By using this tool, students may increase their self-awareness while engaging in healthful breathing and meditation techniques. In Table 3, the Breathe app in Apple Watch™ can be seen as a simpler version of Muse in that the duration of the breathing activity is shorter (one minute). A student who may not be able to sit still during a Muse Headband™ breathing exercise for three minutes can use this application first. As students are able to attend to task for more than one minute, they can then progress to using the Muse Headband™.

The uses of these wearable technology devices can be beneficial additions to students’ repertoire of sensory-based activities in the classroom as the tools involve the use of auditory, visual, proprioceptive/ kinesthetic, and tactile cues for sensorimotor learning. Additionally, these are interesting and attractive ways for children to learn movement, engage in self-regulation tasks, and simply have fun. Also, by using wearable technology, sensorimotor lessons and tasks that were previously more complicated and time-consuming, can be more conveniently implemented. The use of wearable technology as part of SPD intervention can presents some disadvantages, too. Wearable technology devices can be costly, especially for schools with much more limited funding. The Apple Watch™ and Muse Headband™ cost several hundred dollars each. Skeptics may also view these tools as novelties. Students may use these devices enthusiastically only in the beginning. Additionally, some people may experience difficulty setting up the devices to work.

Table 1: Activity analysis for BB8™-force Band™.

1. Description	The students will perform sensory-based tasks using the Force Band to control the BB8™ robot
2. Materials	BB8™ (robot), Force Band™(wrist wearable technology), and the corresponding smartphone apps
3. Space Demands	Ideally, the activity with these devices should be performed in a spacious environment without too many obstacles that can hinder the free movement of the BB8™ robot
4. Social Demands	The students, teacher, and paraprofessionals will be involved in this sensory-based activity that reflects play and leisure time.
5. Sequence, Timing, and Patterns	Ample time (around one hour) can be given to organize the activity. The materials need to be gathered and the students assembled in a room with ample space. Students can take turns using the devices.
6. Required Skills	The students and staff will have to organize the materials needed. The students will need to follow the directions needed for the safe implementation of the activity. The students need to initiate, continue, and terminate the activity. They need to attend to task and move their arms adequately in order to control the robot.
7. Required Body Structures and Functions	The skills that can be developed using this activity include the following: Eye-upper extremity coordination, muscular movement (shoulder flexion abduction, horizontal abduction and adduction), trunk and head control, praxis, arousal, attention, topographical orientation, visual-spatial relations, body schema, left-right discrimination.
8. Safety Hazards	The robot contains a detachable head part that can possibly be achoking hazard. The students participating in the activity must be supervised by teachers and other staff members.

9 Adaptability to Promote Participation	Depending on the students' musculoskeletal conditions and activity tolerance, students can either perform the tasks seated or standing. To make the activity easier, students can sit down while performing the task
10. Grading	To make the activity more challenging for some students, they can stand up while performing the task. The Force Band can also be worn on the non-dominant hand.

Table 2: Activity analysis for muse headband™.

1. Description	Students16 years and above can perform regulated breathing task for relaxation and self-regulation using the Muse Headband. Adults can use this device independently.
2. Materials	Muse Headband™, headphones, and Muse App™ (in smartphone)
3. Space Demands	The activity can take place in the classroom.
4. Social Demands	The teachers and staff will supervise the students' (16 years and above) use of the devices. Adults can independently use this device.
5. Sequence, Timing, and Patterns	After the teachers have set up the use of the devices, students will follow the guided instructions. The students may start performing the meditation activity for three minutes and gradually increase the duration in succeeding sessions. After the activity is done, the teachers and staff will interpret the activity results displayed on the smartphones and convey the results to the students. Data will include the percentage of time the users have emanated "calm," "neutral," or "active" brain waves.
6. Required Skills	The students will have to have functional trunk control strength to sit upright, attending to the auditory-based instructions, motor- planning their breathing to the Muse Headband™ auditory cues.
7. Required Body Structures and Functions	The skills that can be developed using this activity include the following: Attention, praxis, respiratory (synching breathing with auditory cues), sensory modulation
8. Safety Hazards	Although the Muse Headband™ complies to product standards and regulations of the United States, supervision of the use of the device is highly recommended as the headband may not fully fit smaller head sizes.
9. Adaptability to Promote Participation	The activity may be done one-to-one if the student has difficulty understanding the instructions. The teacher can guide students in understanding auditory app instructions first.
10. Grading	The duration of the meditation session can be increased as students increase their skill in sitting still and attending to task.

Table 3: Activity analysis for apple watch.

1. Description	Students will perform regulated breathing task for relaxation and self-regulation using the Apple Watch with its Breathe app.
2. Materials	Apple Watch™ with its Breathe app.
3. Space Demands	The activity can take place in the classroom.
4. Social Demands	The teachers and staff will supervise the students use of the devices.
5. Sequence, Timing, and Patterns	The staff members will provide guided instructions on how to perform the breathing activity. The students may start performing the meditation activity for one minute. They will synchronize their breaths with the visual (imagen in watch interface) and the vibrotactile cues (buzzer) from the Apple Watch™. They can perform the activity intermittently throughout the day as a self- regulation and relaxation task.
6. Required Skills	The students will have to have functional trunk control strength to sit upright, attend to task, and motor-plan their breaths to the Apple Watch™ visual and vibrotactile cues.
7. Required Body Structures and Functions	The skills that can be developed using this activity include the following: Attention, praxis, respiratory (synching breathing with auditory cues), sensory modulation
8. Safety Hazards	Although the Muse Headband™ complies to product standards and regulations of the United States, supervision of the use of the device is highly recommended
9. Adaptability to Promote Participation	The activity may be supervised one-to-one if the students has difficulty synchronizing them breathes to the visual and tactile cues.
10. Grading	The students may independently perform the activity throughout the day in preparation for educational tasks that require concentration and attention.

Conclusion

Sensory Processing Disorders (SPD), conditions in which people are not able to optimally regulate incoming sensory information, can hinder students' participation with functional activities in the classroom. Emerging wearable technology devices can potentially be used in SPD interventions by promoting sensory learning of students. These devices such as the BB8 Robot™-Force Band™ combination, Muse Headband™, and Apple Watch™ can be applied in the sensory integration of students with SPD in order for these children to produce an adaptive response in education-based learning environment. Additionally, these devices, through their generation of tactile, visual, auditory, and proprioceptive cues, might assist users in regulating and modulating sensory stimuli received from the environment.

In order for wearable technology to be effectively applied in sensory-based learning, educators and rehabilitation science professionals like occupational and physical therapists need to collaborate in creating learning opportunities that incorporate the use of wearable technology in order for students to achieve sensory integration. Teachers and therapists can combine their analytical techniques such as lesson plans and activity analysis to examine how wearable devices can be applied in the classroom to assist students in developing sensory skills. As more technology-based research is undertaken, the repertoire of wearable devices will most definitely expand in number and scope. Moreover, interdisciplinary collaboration will only help to solidify wearable technology's niche in the education of students with special needs and sensory integration intervention.

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