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Research Article

Effects of presentation style and musical elements on the sequential working memory of individuals with and without Autism Spectrum Disorder

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ABSTRACT

Background: While information can be encoded and decoded via various channels, there is a lack of basic research investigating how presentation styles and musical elements might impact working memory of individuals with Autism Spectrum Disorder (ASD) as well as those who are neuro-typical (NT).
Objective: The purpose of this study was to examine the impact of presentation style (live versus recorded) and musical elements (melody versus rhythm) on the working memory of individuals with and without ASD.
Method: Participants ($n = 29$ individuals with ASD and $n = 30$ NT university students) listened to four separate sequences of seven randomized monosyllabic words. Sequences were delivered in live and recorded presentation styles with melodic or rhythmic musical elements. To assess working memory, the participants' tasks were to sequentially recall the information within each condition.
Results: Participants demonstrated significantly more accurate recall during the live versus the recorded conditions. There was no significant recall difference between the melodic and rhythmic musical elements. NT participants demonstrated more accurate recall than those with ASD.
Conclusions: The findings point to the possibility that information paired with music delivered in live presentation will increase the likelihood of recall and subsequent learning. Implications for clinical practice, limitations of the study, and suggestions for future research are provided.

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Introduction

As individuals with ASD may present with deficits in visual and auditory processing (Ouimet, Foster, Tryfon, & Hyde, 2012), this neurodiverse response may serve as a rationale for diminished working memory recall in individuals with Autism Spectrum Disorder (ASD). In an attempt to improve recall, cognitive processing, and subsequent learning, care providers often pair visual supports with verbal directions in order to communicate with and teach individuals with ASD (NAC, 2009, 2015). While information can be encoded and decoded via various sensory channels (i.e., auditory, visual, tactile and proprioceptive), there is a lack of basic research investigating how presentation styles (live or recorded instruction) and specific musical elements (melody or rhythm) can impact immediate memory recall in individuals with ASD, as well as for those who are neuro-typical. Moreover, Hanson-Abromeit (2015) concluded that additional information concerning operational definitions and the articulation of the therapeutic function of music in a systematic manner would benefit the music therapy profession. She specifically asserted that clinicians and researchers should carefully consider the use of timbre, rhythm, tempo, pitch, melody, dynamics, lyrics, form, harmony and style when considering how to utilize music in a therapeutic context. It is therefore important to continue investigations concerning the therapeutic function of these specific musical elements. The purpose of this study was to examine the impact of presentation style (live versus recorded) and musical elements (melody versus rhythm) on the working memory of individuals with and without ASD.

Literature review

In conjunction with other cortical areas such as the prefrontal cortex, the temporal lobe is involved in memory, hearing, understanding language, organization, and sequencing. It remains paramount for clinicians, teachers, caregivers and care receivers to

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understand how these cortical areas activate in individuals with ASD. Researchers have noted that individuals with ASD present with neurodiverse cognitive processing (Bauman & Kemper, 2005; DiCicco-Bloom et al., 2006). Additionally, researchers have specifically studied the working memory of individuals with ASD (Geurts, Verté, Oosterlaan, Roeyers, & Sergeant, 2004; Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006), which may be related to an apparent under-connectivity between the prefrontal and occipital lobes (Grandin & Panek, 2013). Moreover, during a sentence comprehension task, the degree in synchronization of activation between the various participating cortical areas was consistently lower for individuals with ASD than the control participants (Just, Cherkassky, Keller, & Minshew, 2004).

In his theory of working memory, Baddeley (1992) concluded that separate processing units are employed for different input modalities. However, when isolated, researchers have demonstrated varied results in visuospatial working memory (VSWM) tasks in individuals with ASD. Williams, Goldstein, and Minshew (2006) concluded that VSWM was impaired in children with ASD whereas de Jonge, Kemner, Naber, and Van Engeland (2009) asserted that children with ASD made less mistakes but their performances were not better when compared to neuro-typical participants during a VSWM task. Due to these discrepancies, there is a need for further research on the visuospatial working memory of individuals with ASD and how this system could be improved.

Related to VSWM, sequential working memory is the ability to immediately recall information either as presented or in reverse order. Poirier, Martin, Gaigg, and Bowler (2011) studied verbal short-term memory recall in individuals with ASD using three experiments. In experiment one, the participants engaged in forward and backward digit recall. The researchers utilized a standard immediate item (word) serial recall task in experiment two and tested short-term order memory with an order recognition test in experiment three. The researchers concluded that children with ASD demonstrated poorer performance in all three short-term memory recall experiments.

Working memory is required in order to attain new skills. Influenced by Social Learning Theory (Bandura, 1977) and Dual Coding Theory (Paivio, 1991), video modeling and video-self modeling have been utilized to foster development of and improvement in social, communication, motor and academic/cognitive skills of individuals with ASD. Moreover, many learning environments are offering web-based and video instruction. Researchers have investigated the effects of video and video-self modeling regarding a myriad of dependent variables for individuals with ASD (Bellini & Akullian, 2007). In their meta-analysis, Bellini and Akullian (2007) used the percentage of non-overlapping data points, which provides a measure of intervention effectiveness and is a method for systematically synthesizing single-subject research studies. They concluded that eight studies targeted functional skills and yielded the highest intervention effects, followed by social-communication functioning (15 studies) and behavioral functioning (three studies). Researchers studying the benefits of video modeling have also investigated "self" compared to "other" as the model (Sherer et al., 2001), video modeling compared to in vivo modeling (Charlop-Christy, Le, & Freedman, 2000), and video modeling to teach perspective taking (Charlop-Christy & Daneshvar, 2003). In regard to social-communication, functional skills and behavioral functioning, researchers seem to be in agreement that both live and video modeling are efficacious approaches that should be utilized when working with individuals with ASD (NAC, 2009, 2015). However, there is a lack of research supporting the use of in vivo versus recorded modeling to improve the working memory of individuals with ASD. With screen time being used for educational purposes, there is a need to investigate if presentation style (live versus recorded) will have differing effects on the sequential working memory of individuals with and without ASD.

Perhaps due to the increased use of technology to enhance learning, there appears to be a societal shift towards the utilization of video instruction for education. In their study with NT participants, Kizilcec, Papadopoulos, and Sritanyaratana (2014) utilized video modeling to assess academic achievement. They concluded that study participants spent about 41% of time looking at the face of the instructor and switched between the face and slide every 3.7 s. The researchers surmised that including the face in video instruction is encouraged based on learners' positive affective responses. Evmenova, Graff, and Behrmann (2015) examined the effects of adapted videos for improving factual comprehension of non-fiction clips by four high school students with significant Intellectual Disabilities. Students performed better with adapted and interactive video clips. Furthermore, social validity interviews revealed that all students enjoyed the adapted and interactive videos and found them beneficial.

It may be postulated that a multi-sensory experience that stimulates a myriad of cortical areas may elicit improvement in the working memory of individuals with ASD. Stegemöller (2014) concluded that music promotes neural plasticity in three key ways: (a) by promoting dopamine production (vital in the brains ability to make new neural connections), (b) promoting the "Hebbian Theory" which is defined as an increase in synaptic efficacy arising from the presynaptic cells repeated and persistent stimulation of the postsynaptic cell (neural cells that fire together, wire together) and (c) by providing a clear, structured signal. Researchers and clinicians have also used songs and melodies as memory devices to aid in the encoding and decoding of semantic information (Claussen & Thaut, 1997; Gfeller, 1983; Jellison, 1976). Specific to individuals with ASD, music was utilized to ascertain social skills (Brownell, 2002; Kern, Wolery, & Aldridge, 2007; Pasiali, 2004; Schwartzberg & Silverman, 2013) and increase both short-term and long-term memory recall (Schwartzberg & Silverman, 2012).

Previous researchers have recurrently concluded that more accurate working memory is demonstrated during primacy (i.e., the first information presented) and recency (i.e., the most recent information presented) serial positions (Jellison, 1976; Miller, 1956; Schwartzberg & Silverman, 2012; Silverman & Schwartzberg, 2014a, 2014b; Ward, 2002). Therefore, targeted information to be learned should be positioned in positions of primacy and recency to increase the potential for recall and subsequent learning.

Although musical elements and presentation styles may impact working memory and subsequent learning, no researcher has investigated the effects of musical elements presented in live and recorded formats on the sequential working memory of individuals with ASD. These data would be important in order to determine if musical elements (melody or rhythm) have differing effects on the sequential working memory of individuals with and without ASD and how to best present the information to be recalled and subsequently learned. Therefore, the purpose of this study was to examine the impact of presentation style and musical elements on the sequential working memory of individuals with and without ASD. Specific research questions included:

(1) Will presentation style (live versus recorded) have differing effects on the sequential working memory of individuals with and without ASD?
(2) Will musical elements (melody or rhythm) have differing effects on the sequential working memory of individuals with and without ASD?
(3) Will there be a difference in sequential working memory between individuals with and without ASD?