The Use of Music, Motor Movement, and Visual Stimuli to Create Long Term Memories in Individuals with ASD by Using a New Intervention Termed Visual Motor Learning (VML)

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Abstract

This paper seeks to test the efficacy of a new behavioral intervention termed visual motor learning (VML) by using a case study. Does targeted musical and auditory information that elicits an emotional response coupled with specific motor movements, aid in the acquisition of long-term memory of replacement behaviors in people with ASD by lowering incidents of aggression and tantrum behavior? Behavior analysts spend much time teaching replacement behaviors to people with ASD and learning disabilities, many times in which replacement behaviors are unable to be encoded in an individual’s memory for retrieval when it is needed due to a variety of issues. VML seeks to aid in the acquisition of long-term memory (LTM) of replacement behaviors by updating video modeling (VM) and adding content that fosters an emotional response in combination with a motor learning activity. It is hypothesized that the emotional response combined with motor learning activates the limbic system and more specifically helps stimulate the creation of spatial and autobiographical memory. By combining an emotional response with a congruent motor movement such as the preferred replacement behavior, VML may be specifically targeted to an individual. Video watching is an activity in many people’s repertoires especially individuals with ASD, so the intervention is ideally designed to be an enjoyable and preferred activity. The main areas of focus are long-term memory (LTM), emotional memory, music memory, motor memory, and standard behavioral modalities such as verbal prompts, preference assessments, and replacement behaviors. The experiment conducted here was a single subject reversal ABAB design across the behaviors of aggression and tantrums with a parent/caregiver centered model. Based on the results of the study, it seems that there is evidence that VML as a behavioral intervention can help with encoding and retrieval of LTM, which is likely to be important for behavioral change in individuals with ASD.

Keywords: [Long-Term Memory, Emotional Memory, Music Memory, Autobiographical Memory, Motor Memory, Limbic System, Video Modeling, Replacement Behaviors]

Introduction

Chapter 1, This research study was designed to create a new intervention termed Visual Motor Learning (VML) to help individuals with ASD or learning disabilities to access their Long-Term Memory (LTM) more efficiently. It differs from Video Modeling (VM) and Video Self Modeling (VSM) in that it uses an individual's preferences in the form of characters, imagery, and music to evoke an emotional response that aids in activating the limbic system where emotions are processed in the brain and in turn, aids in the encoding and retrieval of LTM. The information that is embedded in the video is then paired with verbal prompts either spoken or written and motor movements which are acted out in the video that are actually the replacement behaviors used during a typical differential reinforcement intervention. To test the efficacy of this hypothesis we must answer the question, can targeted musical and auditory information that elicits an emotional response and is coupled with specific motor movement, aid in the acquisition of long-term memory of replacement behaviors in people with ASD thereby creating motor memories that can lower aggression and tantrum behavior?

The areas of focus in this research are the mechanisms of the encoding and retrieval of LTM, emotional memory, music and how it relates to memory, motor memories and typical behavioral modalities that are embedded in the video that promote behavior change. Long-term memory is distinct from short-term memory (STM) where STM also known as working memory is more conscious and has more limited storage than LTM (Desaunay, Briant, Bowler, Ring, Gérardin, Baleyte, Guénolé, Eustache, Parienti, & Guillery-Girard, 2020). It is also evidenced in the literature that LTM is encoded without an individual attending to the information (Hutmacher, & Kuhbandner, 2020). In other words, it occurs without an individual being consciously aware that it is happening, LTM entails encoding, retrieval, and storage of information and has been known to be ubiquitously connected to an emotional response either in the encoding phase or the retrieval phases and does not seem to be connected to storage problems in LTM (Desaunay, Briant, Bowler, Ring, Gérardin, Baleyte, Guénolé, Eustache, Parienti, & Guillery-Girard, 2020; Maras, Gaigg, & Bowler, 2012). The existence of emotions at the point of forming LTM or in the retrieval phase prompted study in this area and it was found that LTM has more connectivity in the brain when there is emotional content available (Solomon, Iosif, Krug, Nordahl, Adler, Mirandola, & Ghetti, 2019).

Music memory is a concept that refers to the triggering of memories usually autobiographical memories that were encoded because they were associated with a particular piece of music (Aube, Peretz, & Armony, 2013). Aube et al, (2013) also state that autobiographical memories are memories that are personal to an individual and these types of memories are precisely the types that are difficult for individuals with ASD to retrieve from long-term memory. In music theory there are combinations of notes that are distinct and are known to evoke emotional responses such as the tritone which is known as the “devil’s interval” and was banned from the catholic church in antiquity because of its association to negative behaviors. Many of these note combinations are present in all types of music and may trigger memories even without hearing a whole piece of music.

Motor memories are the memories that become habits over time and through repetition such as is common with athletes practicing certain physical movements to better their performance. This is also the case as it concerns unwanted habits such as the physical act of smoking cigarettes where the simple act of putting ones hand up to one’s mouth is a habit in and of itself. According to Koriat, & Pearlman-Avnion, (2003) the physical act of moving one’s body spatially activates the motor cortex and encodes memories through the motor cortex.

The behavioral modalities incorporated in this study that pertains to visual motor learning (VML) are verbal prompts, preference assessments, and replacement behaviors. All of these concepts are embedded in the novel intervention of VML and are discussed in relation to the individual's ability to encode and retrieve LTM and specifically the replacement behaviors that are picked that serve the individual according to the social significance of the behavior.

All of these concepts are related to the acquisition of LTM and although these concepts apply to all learners, it is specifically designed for individuals diagnosed with ASD or learning disabilities because the lack of interconnectivity with proficient brain functioning especially in the pre-frontal cortex signifies that another conduit for memory absorption may be needed (Fauzan & Amran, 2015). Invoking emotions, processed in the limbic system (which is located in the mid brain area) should aid in the acquisition of autobiographical memories. Coupling of these emotional memories with motor movements that activate the motor cortex can make these memories even more palpable than memories that form conventionally via visual representation (Koriat, & Pearlman-Avnion, 2003). VML seeks to pair key words or phrases (referred to as verbal prompts) with motor movements that are congruent with replacement behaviors targeted for reinforcement with visual and auditory emotional content. This content is derived from preference assessments and refers to the characters or imagery and or musical content that helps foster an emotional engagement with the material. This is how LTM is hypothesized to be accessed, thus circumventing the pre-frontal cortex and directly reaching the hippocampus, and simultaneously utilizing the motor cortex (Stephan, Heckel, Song, & Cohen, 2015).

The experimental study undertaken in this paper was a single subject ABAB reversal design across behaviors where the behaviors being tracked were aggression, property destruction and tantrums. The participant was a high functioning 5-year old boy named Ben diagnosed with Autism Spectrum Disorder (ASD) with severe aggression and tantrums. VML was selected as an intervention because Ben already had imitative skills and video watching was in his repertoire as a preferred activity. The intervention showed promising results where Ben's behaviors had altering effects with the onset and reversal of treatment from stable baseline measures.

This study is socially significant for two reasons. First, VML has the potential to be an effective intervention that behavior analysts can use remotely and garner more support from parents and caregivers because they are directly involved with administering the intervention. Second, VML has the potential to make the lives better for individuals who have issues accessing their LTM in conventional ways which in turn can help them to learn new behaviors more readily which can raise their self-esteem (Lee, S. Y., Lo, Y., & Lo, Y., 2017).

Chapter 2 Literature Review

Long Term Memory

The acquisition of long-term memory (LTM) is not generally something we give a lot of direct awareness to understanding. When something is important, we either consciously or unconsciously find a connection or a reason to remember it. We may even find that memory is triggered by our senses such as a certain smell or a familiar sound. People with learning disabilities such as ASD often have a hard time remembering things that should be important for them (Maras, Gaigg, & Bowler, 2012). The encoding of information into long-term memory for recall later has many opportunities for such an acquisition which will be discussed further.

There is an assumption commonly made that people do not encode memories into longterm memory unless the information is attended to (Hutmacher, & Kuhbandner, 2020). In other words, information that is in the background was thought to not be remembered by an individual for recall later. What Hutmacher et al (2020) found in their experiment is that humans store detailed copies of sensory stimulations in long term memory independent of attentional focus. They also found that humans have the ability to encode thousands of visual stimuli into long-term memory after only seeing them for a few seconds. This implies that LTM may have an unlimited storage capacity. The question then becomes are problems with LTM for people with ASD in the encoding and retrieval stage, a storage problem, or both?

A meta-analysis by Desaunay, Briant, Bowler, Ring, Gérardin, Baleyte, Guénolé, Eustache, Parienti, & Guillery-Girard, (2020) discuss this concept and concluded that LTM has an unlimited storage capacity and can be divided into two subcategories explicit and implicit. Explicit, or declarative memory, refers to verbalizable information, accessible to awareness and contrasts with implicit and procedural memory which are both dedicated to actions and processes that take place without conscious awareness. It is acknowledged that children with ASD tend to have phenomenal rote memory and are able to remember things from years before (Desaunay et al, 2020). This implies that the hippocampus although still functioning, may not be functioning correctly as it is known to process spatial awareness which aids in accessing LTM. Also, memories concerning general knowledge is very good, but memories of personally experienced events seem to be diminished in ASD such as episodic memory. Episodic memory consists of specific memories of personally experienced events, situated in the temporal and spatial contexts of their acquisition and enables the retrieval of associations between items as well as being associated with autonoetic conscious awareness which is recollection that is associated with remembering (Desaunay et al, 2020).

There is generally a distinction made between two types of memory such as short-term memory (STM) and long-term memory (LTM). Desaunay et al, (2020) defines STM as the storage of a limited capacity and encompasses working memory which emphasizes the manipulation of information during cognitive tasks. LTM on the other hand, as well as encompassing an unlimited storage capacity can be divided into two subcategories explicit and implicit. Explicit, or declarative memory, refers to verbalizable information, accessible to awareness and contrasts with implicit and procedural memory which are both dedicated to actions and processes that take place without conscious awareness for the processing of relational information, individuals with autism can employ such processes effectively (Desaunay et al, 2020). This account leads us to suppose that memory difficulties with associative information are more related to organization at both rather than at the encoding stage (Desaunay et al, 2020). The acquisition of LTM with regards to individuals with ASD seems to have its roots in the encoding and retrieval stages as opposed to the ability to store information. What is different in terms of brain functioning in individuals with ASD and specifically the areas of the brain that are responsible for cognitive processes and memory retention?

An area of exploration into this question can be realized by looking at brain wave patterns in individuals with ASD as compared with TD individuals. An article by Fauzan & Amran, (2015) discusses this relationship by using a Quantitative Electroencephalogram (QEEG) to record brainwave patterns in these two groups. It is interesting to note that this technique was designed to diagnose individuals with ASD where the researchers realized an 88% success rate in their diagnoses, but this discussion will focus more on the areas of the brain that are effected and the types of brainwaves that are witnessed and their implications.

The mere fact that Fauzan & Amran, (2015) had an 88% success rate in diagnosing ASD shows that there are obvious connectivity problems in different lobes of individuals with ASD when compared to TD individuals. A disruption in overall brain functioning is defined as hyper connectivity and the excessive presence of slow delta wave patterns at the frontal lobe and the excessive presence of beta waves may relate to hypo brain connectivity. More connectivity issues that were found were low alpha wave patterns at the sensory motor regions, an excess of alpha wave patterns in the left hemisphere and an excess in theta wave patterns in the right frontal region. These findings are consistent with issues concerning attention, anxiety, and social behaviors in individuals with ASD (Fauzan & Amran, 2015). Brain wave patterns in the TD group were overwhelmingly consistent and dispersed evenly throughout the brain with a small degree of variability. The researchers also noted excessive levels of alpha wave patterns in the left hemisphere as well as the temporal regions which is linked to impairment in verbal memory as well as language and communication impairments in the ASD group. What is interesting about this is that the presence of alpha waves implies that mirror neurons are present. Mirror neurons represent the capacity of the brain to mimic what is happening around it such as the spontaneous yawn when someone yawns right in front of an individual. The ASD group had higher rates of theta wave patterns especially in the right hemisphere and it should be noted that normal theta wave patterns are associated with higher levels of learning and memory and is also related to suggestibility which is a facet of VML (Fauzan & Amran, 2015). Learning and memory is intricately related to the limbic system such as the amygdala and hippocampus which is where emotions are processed and will be shown, plays an extremely important role in the acquisition of LTM.

Emotion and Memory

Emotions are indeed connected to memory and have been shown to be the mechanism that forges an event into a long-term memory. Maras, Gaigg, & Bowler, (2012) explain that there is ample evidence that emotionally arousing events are better remembered and more resistant to forgetting than neutral events. The researchers stated an assumption that people with ASD do not benefit from emotions related to their memory as well as typically developed individuals (TD). What they found in their experiment was that although people with ASD have less detail in their recall, there is effectively no difference in their ability to recall events that are coupled with an emotional event as compared to TD individuals.

To show the efficacy of this concept, Solomon, Iosif, Krug, Nordahl, Adler, Mirandola, & Ghetti, (2019) conducted an experiment to show that emotional laden events are more meaningful and subsequently remembered in more detail than emotionally neutral events. The experiment compared 8 high functioning adults diagnosed with ASD to 16 TD adults where each group was asked to watch a video or view a still picture that contained an event that either had emotional content or was emotionally neutral. Solomon et al (2019) found that both groups had a higher rate of memory when the event contained emotional content. It should be noted that this study was not replicated, but a subsequent study also didn’t find any differences between the groups.

So, there is evidence that emotions play a pivotal role in encoding LTM, but do emotions play any role in the retrieval of memories? A study by Buchanan, (2007) suggests that emotions are involved in this process as he states that “The emotion experienced while retrieving a memory effects the ability to recall the memory." It was alluded to earlier that the amygdala and hippocampus play an important role in the retrieval of memories and Buchanan (2007) adds that the prefrontal cortex also plays a vital role in memory retrieval possibly because there is a reexperience of the emotion at the time of encoding when retrieving the emotion. According to Buchanan (2007), memory retrieval is the reactivation or reconstruction of stored internal representations and as such, as this information receives attention it is more likely to be available for retrieval.

It is understood that exposure to a reminder of an emotional event elicits brain activity similar to the experience of the original event which shows the extent to which the brain uses emotion in connection with memory. The emotional content is related to reinforcement in behavioral terms because an individual may return to a location in their memory that may have been rewarded with reinforcement in the past. Buchanan (2007) also sites evidence in his article that emotional memory is evident in the retrieval of auditory, visual, and olfactory senses even in the absence of sensory stimulation and that "Similarly, the specific sensory cortices that are active in mental imagery are the same as those active during the actual experience of a stimulus." (Kosslyn, Ganis, & Thompson, 2001).

Music and Memory

There shouldn't be any surprise that music is also related to memory. Why is it that individuals can remember words to songs they haven't heard in a long time and why are melodies coupled with the things people want to remember for recall later paired together so often? This is because music has the ability to engage core brain structures such as the amygdala and ventral striatum where emotions are associated with note combinations or songs that individuals remember, especially when the song reminds someone of exciting autobiographical memories such as a first kiss (Aube, Peretz, & Armony, 2013). Autobiographical memories are memories that are specific to an individual's life and it is precisely these autobiographical memories that people with ASD have a hard time either encoding or retrieving from long-term memory (Belfi, Karlan, &Tranel, 2016). What is interesting is that Belfi et al, (2016) found that there are mechanisms in the brain specifically in the amygdala that process sounds, music, and vocalizations which in turn convey emotion and there is evidence that this is recognized across cultures as cited by Belfi et al, (2016).

Belfi, Karlan, & Tranel, (2016), in their own study sought to compare music evoked memories to autobiographical memories (MEAMS) evoked by famous faces. Participants in this experiment were able to choose music randomly that had been in the top 20 songs from 19502013 which increased the likelihood that all participants would have had contact with these songs and the pictures consisted of famous people that they would have seen throughout their lives. The outcome of their experiment showed that MEAMS had more detail and were more vivid than memories evoked with famous faces. Pictures and music were paired in this study because they are both external sensory cues which can evoke involuntary autobiographical memories.

There is evidence that music and emotions are coupled together and aid in encoding autobiographical memories. There is even evidence that an individual’s mood also affects the kind of information that is likely to be remembered. Stalinski, & Schellenberg, (2013) expand on this by citing that information learned while in a positive or negative mood is more likely to be recalled while in a positive or a negative mood, respectively (Bower, 1981; Bower, Monteiro, & Gilligan, 1978). So, the mood that an individual is in when a memory was encoded into LTM is related to the mood they are in while retrieving that emotional memory. This has many implications that are related to the VML intervention and will be discussed further later on.

Another interesting facet cited by Stalinski et al, (2013) is termed the exposure effect which simply states that just being exposed to something many times causes an individual to like it more when it reencountered. This is obvious as repetition helps in encoding things into LTM, but it is also related to music. The more one hears a particular piece of music assuming they do not have a visceral response to it, the more that individual will begin to like the music and the more an individual actually likes a piece of music, the deeper the processing is during encoding and the more readily the material is for recall later. Once again, this has implications that are congruent with the VML intervention because simple repetition of stimuli can enhance memory especially when there is a positive emotional response associated with it.

Motor Memory

As stated earlier, rerouting the encoding of long-term memory (LTM) away from the prefrontal cortex and through the motor cortex can help an individual who is lacking in this ability to still access information from their LTM. Issues with LTM acquisition can either be in the encoding phase or the retrieval phase. An article by Eigsti, Rosset, Col Cozzari, da Fonseca, & Deruelle, (2015) suggests that bodily experiences play a key role in representations such as when things are recalled from memory to serve as action goals. Eigsti et al, (2015) cite literature that states that motor and sensory processes require mental representations and go on to say that emotions and memories are coupled with motor movement such as moving towards someone you love to hug them or a smile forming on your face when you feel happy.

Incidentally, they also suggest that the motor activity can also create the emotion such as forming a smile on your face can cause you to feel happy. Eigsti et al, (2015) conducted a study where they compared those with ASD and a TD group. The experiment consisted of having each group take an open or approach stance or a closed and avoidance stance while deciphering symbols and words. An fMRI was used to see which areas of the brain are active and results showed that sensory cues are co-activated and bound together with mental representations. This is important because it shows that emotions and memories are intricately connected to motor movements. Another question that arises is can motor movements aid in the encoding of LTM? The answer is a resounding yes because according to Eigsti et al, (2015), research on a variety of physical postures suggests that they can impact emotion because mental representations retain the spatial, physical, and kinesthetic properties of the events they represent as cited in their literature review. In other words, motor movements have the ability to aid in memory acquisition in form and function.

More evidence that supports the acquisition of LTM from motor movement is from Koriat, & Pearlman-Avnion, (2003) where they propose that task performance changes the very basis of memory organization. The physical act of moving ones body spatially activates the motor cortex and there is evidence that even the intention to perform the described acts in the future can improve memory performance termed prospective memory because it is the encoding of motor movements that contributes to the enactment effect (Koriat, & Pearlman-Avnion, 2003). The encoding of memory due to motor movements should not be underestimated because there is evidence that memory for self -performed tasks (SPT) have been found to be superior to memory for verbal tasks (VT) where systematic differences were found in the variables that affect performance to the extent that some authors have raised the possibility that the laws applying to memory for actions differ from those governing memory for VT (Koriat, & Pearlman-Avnion, 2003). This is understood because brain imaging shows that motor areas in the brain are functioning during recollection of enacted actions and encoding and retrieval following enactment were associated with activation in several left-hemisphere regions, such as the parietal cortex and the motor cortex (Koriat, & Pearlman-Avnion, 2003). The encoding under these circumstances seems to be largely automatic as compared to memory encoding for VT which implies that SPT can be encoded without attention or intention, and their encoding is equally efficient under shallow and deep levels of processing ((Koriat, & Pearlman-Avnion, 2003). This makes the prospect of using VML more useful even as background instruction as the motor cortex can be activated without direct cognitive control.

VML is an intervention that utilizes visual and auditory prompts with emotional awareness grouped with motor movements such as behavioral replacement behaviors to invoke encoding of LTM. The question now is do auditory stimuli work with the motor cortex to encode these memories? According to Stephan, Heckel, Song, & Cohen, (2015) exposure to specific auditory sequences could lead to crossmodal induction of motor memories. To look at this phenomenon, Stephan et al, (2015) had participants in their study memorize a melody and have it paired with finger movements. Half of the participants paired a melody with congruent movements and the other half paired the melody with incongruent movements. An example of congruent movements are movements from left to right being associated with tones of ascending pitch and vice versa for incongruent movements among other types of movements. The VML intervention is intended to be a workaround for people with an impaired prefrontal cortex. Stephan et al (2015) cite that “the idea of inducing plastic neuronal changes in the motor system by way of other sensory modalities is intriguing and could be viewed as a ‘‘backdoor’’ to the motor system in cases where physical motor training is difficult”. There is still much to be explored on this topic of auditory-motor system interactions, but they might contribute to the development of new strategies using sound as a neuro-modulatory tool for motor rehabilitation or other dysfunctions involving auditory-motor neuronal networks according to Stephan et al, (2015).

Motor movements and even the thought of motor movements in the future have an effect on memory, so there shouldn’t be any surprise to the fact that physical exercise has an effect on memory retention. According to Roig, Skriver, Lundbye-Jensen, Kiens, & Nielsen, (2012) regular physical activity has a positive impact on cognition and brain function. Results from this study suggest that intense physical exertion either right before, but especially right after a motor skill acquisition practice session is enough for better LTM retention. The reason for this is postulated that increased concentration of neurochemicals such as epinephrine and brain derived neurotrophic factor (BDNF) during exercise facilitates memory consolidation and learning by optimizing the allocation of mental resources that aids in cognitive processes such as the encoding of motor memories (Roig, et al, 2012). For this reason, VML which seeks to teach replacement behaviors, requires that the individual practice these physical behaviors daily to aid in the retention of these behaviors through the motor cortex.

Behavioral Modalities

The video motor learning (VML) intervention is designed to be paired with known behavioral principles such as using prompts, replacement behaviors, preference assessments, and repetition. Although VML differs in some ways from video modeling (VM) and video selfmodeling (VSM), it does share some commonalities. A study by Nikopoulos, (2007) looked at the efficacy of VM and identified 9 key areas that make this modality very useful and desirable for people with ASD. Some of the areas discussed consist of visual stimuli being easier understood that verbal stimuli, the act of watching an Ipad or television is already in the individual's repertoire, it doesn't require a transition to a new activity, and it's cost effective. The experiment that was conducted by Nikopoulos (2007) showed that an increase in a participant's play skills was achieved and in a very short time. The experiment used TD peers modeling specific behavior such as inviting someone to play and after the participant viewed the video they were brought to another room and the scenario was played out. A key limitation to this study was that it was not conducted in the natural environment and although it was said to generalize to different settings, the classrooms were in the same building with not much difference to them which affects external validity, but it should also be acknowledged that the experiment was not seeking to achieve generalization.

VM and VSM have been used for some time in behavioral psychology as it has been shown to be a good modality for individuals diagnosed with ASD (Nikopoulos, 2007). According to Lee, Lo, & Lo, (2017), it is stated that functional play helped children make sense of the world and it promotes critical cognitive development. VML uses many behavioral concepts in the video format to affect LTM therefore, it is important that behavioral principles such as prompts, reinforcement, and preference assessments be utilized. Lee, Lo & Lo (2017) also state that there is evidence that using VSM in combination with other interventions such as prompting or reinforcement with children and youth with ASD has been applied effectively to increase social and communication skills. Preference assessments are crucial in the field of applied behavior analysis (ABA) because determining a reinforcer that an individual will work for is simply one of the most important ways to motivate an individual to do something. Richman, Barnard-Brak, Abby, & Grubb, (2016) agree that finding the proper motivating reinforcers are crucial to developing empirically supported interventions especially for challenging behaviors.

Chapter 3 Methodology

Introductory Paragraph:

There is ample evidence in the literature that emotions are connected to LTM and that music can enhance this effect (Solomon et al, 2019; Belfi et al, 2016). There is also evidence that the visual representation of memory that occurs in the brain interacts with the body through the motor cortex and that this relationship can be accessed either through the body such as putting a smile on one's face to feel happy or though the brain such as feeling happy which causes the facial muscles to contract and form a smile (Nikopoulos, 2007). The gap in the literature exists because the experiments that show the connection between the concepts of music, emotion, verbal prompts, and motor movement are stand-alone revelations. Combining these concepts into a single modality that attempts to unify the body's LTM conduit through the motor cortex is what the VML intervention seeks to achieve. As the literature shows, people with ASD generally suffer from a low functioning prefrontal cortex as well as an overwhelmingly diminished brain wave pattern (Fauzan & Amran, 2015). This in turn creates a difficult time for behavior analysts in teaching replacement behaviors with differential reinforcement because individuals do not have a connection to the behavior to be learned as it relates to their own personal narrative and how that connects to their autobiographical memories in the encoding and retrieval phase of memory acquisition. The purpose of this study is to create a new intervention called VisualMotor Learning (VML) which synthesizes the concepts described above and packages them into one cohesive intervention which can be used as a parent centered or caregiver centered model where the method creates a permanent product which can be administered by stakeholders.

Research Question

Can targeted visual stimuli, musical and auditory information that elicits an emotional response and is coupled with specific motor movement, aid in the acquisition of long-term memory of replacement behaviors in people with ASD by lowering incidents of aggression and tantrum behavior?

The independent variables are the music and visual stimuli in the video which also contain emotional content. The emotional content is derived from preference assessments where individuals chose the characters, themes, and music that they respond to. The dependent variable is the acquisition of LTM and specifically associated with remembering what the replacement behavior is opposed to aggression and tantrum behavior and to what capacity it is utilized such as across settings or individuals.

Target Population

The participant was a five-year old boy named Ben who was of Hispanic and Native American origin and was diagnosed with ASD at the age of two years old with the Modified Checklist for Autism in Toddlers (M-CHAT-RTM) screening tool by his pediatrician. A pseudonym is being used to protect the identity of the participant. Ben had a history of target behaviors such as aggression, property destruction, and tantrums and the behaviors under scrutiny for this study were also aggression, property destruction, and tantrums. Ben was selected for this study because he already possessed imitation skills as evidenced by his singing of songs he heard on his tablet and the words he would say which were based on videos of his favorite characters such as Thomas the Train and Cars the movie where he generally had free access to these videos throughout his day. Ben had the necessary prerequisite skills and watching videos independently was in his repertoire. Ben was a client at a behavioral company where he and his mother had the benefit of a behavioral consultant and three behavioral tutors up to 6 days per week for 6 months and then saw that drop to just 2 tutors and 3 sessions per week for another 6 months. The VML intervention is designed to be parent and caregiver centered, so as COVID 19 occurred, it became apparent that Ben would not be able to receive in person behavioral services that he and his family were accustomed to and needed. This made the ethical decision of administering VML during this time forthcoming. Ben and his mother were not offered an incentive to participate in this research as the work in administering the intervention and data collection were already a part of the contractual agreement for behavioral services.

Procedure:

Video Targeting Aggression, Property Destruction, and Tantrums

The video used in this study targeted aggression, property destruction and tantrum behavior and consisted of Ben watching a video specifically designed with his preferences, multiple times per day. Aggression towards others and property destruction were counted together for ease of data collection for the parent. The video consisted of a song that paired the SD, the word “no” with the words “maybe later”. It should be made clear that this intervention was designed specifically for Ben and that the pairing of these two terms were equated with the activities he was accustomed to such as asking for snacks, using his tablet, and going outside to play. The intervention consisted of Ben being introduced to the video to see if he liked it. This was determined by Ben's mother and the criteria was Ben choosing to watch the video independently after its initial introduction. After Ben showed that he liked the video he was allowed to watch it up to 10 times before any demands were placed on him. This was the teaching method, and it correlates to emotional responses that activate the limbic system and the pathway toward autobiographical memories. Watching the video 10 times was chosen because Ben's mother suggested that when he liked a particular video, he usually watched it about 10 times right away. The intervention took place in Ben's natural environment as it was intended to be. He would invariably ask for something tangible or an activity and his mother would say the words "no" "maybe later" and she would reiterate by saying Ben's name and saying maybe you can have that later. Ben's mother would then record any aggression or property destruction, or tantrums with the data sheets provided. Aggression and property destruction were grouped together and defined as any amount of pushing, hitting, or kicking another individual or throwing an object in his hand or knocking objects over from their natural positions in the room. Only these instances that occurred within 2 minutes of hearing "no maybe later" were recorded in the data. This is because during baseline measurement, Ben's aggression or tantrums started within seconds of hearing the word "no", and up to 2 minutes after the SD. This way, any SD's that occurred after 2 minutes were not associated with Ben's response to the word "no". Tantrums were defined as throwing himself to the floor or on the bed or couch, crying or screaming for up to 5 minutes or more and this behavior needed to begin within 2 minutes of hearing "no", "maybe later" as well. Any of these behaviors that occurred after 2-minutes of hearing "no", "maybe later" were not recorded as frequency data on the data sheets.

Setting: The setting of the intervention took place in Ben's suburban home. Ben lived with his mother, grandparents, and infant sister. It should also be noted that Ben had many cousins ranging in age from 3 ½ to 7 years of age who would be present many days throughout the week.

The interventions could take place in any room in his house such as the living room, kitchen, bedroom, or outside play area.

Instruments: Data sheets were provided for Ben’s mother that consisted of date and frequency count of the behaviors which were aggression and tantrums. Ben’s mother was asked to record a frequency count of instances of aggression after being told “no” for baseline and “no” “maybe later” during the treatment phase. Data was collected after each phase and a new data sheet was delivered to Ben’s mother to avoid any confusion with respect to the individual phases. The video was provided to Ben’s tablet and his mother’s phone via an unlisted YouTube video where only they had access to the video and a WIFI connection was needed for access.

Time: The study was conducted from March 15, 2020 to May 6, 2020.

Research Method: The experimental design used was an ABAB single subject reversal design across behaviors. This design was chosen because it would be very clear if the video intervention actually caused Ben’s behaviors to change and Ben’s mother was onboard with the reversal because she wanted to know if the quality of videos had an effect on her son’s behavior as Ben watched a lot of video content according to her. The intervention consisted of recording a baseline A level of Ben’s behavior when he was told “no” by his mother when he requested a reinforcer which resulted in either neutral behavior denoted as a 0 on the data sheet, aggression towards her, other children present, property destruction, or tantrums which could last between 5 and 30 minutes. For ease of data recording for Ben’s mother, aggression and property destruction were grouped together. Baseline was recorded by Ben’s mother on data sheets provided by the behavioral consultant overseeing Ben’s case and consisted of no video watching and when Ben asked for a reinforcer at an inappropriate time, he would hear the word “no”. An inappropriate time was defined as asking for snacks right before a meal or instead of a meal, asking to use the Ipad for longer than an agreed upon time, or asking to go outside to play when there was no apparent adult supervision available. Ben was shown the video by his mother which consisted of a song that sang the words “no means maybe later” and a video which consisted of his favorite characters from the Disney movie Cars derived from preference assessments and a list of movie preferences provided by Ben’s mother. This treatment phase B started by Ben watching the video a total of 10 times before he had contact with a situation where he was to hear the word “no” when he asked for a reinforcer. This was the teaching method. The number 10 was chosen because Ben’s mother indicated that when he showed interest in a video, he usually watched it around 10 times right away. The video consisted of Ben hearing the words “no” and “maybe later” paired together and seeing images that he enjoyed. Next, Ben’s mother was asked to keep making the video available at least 2 times per day and even just listening to the song in the car was acceptable. During this 2-week period as Ben would ask for a reinforcer, his mother would say “no” “maybe later” and recorded his responses on the data sheets that were provided. After 2 weeks of the intervention, the treatment phase was reversed back to A. During this third phase, Ben’s mother was instructed to start saying “no” again without the words “maybe later” and Ben no longer had access to the video. If Ben tried to access the video, it would say no longer available. This phase lasted only 5 days because it was evident that Ben’s behavior had returned to levels reminiscent of baseline levels and his mother wanted to return to the treatment phase. The next phase B began with Ben having access to the video and in the same day, his mother using the words “no” and “maybe later”. Data was recorded by Ben’s mother and retrieved by the behavioral consultant for analysis.

IOA: IOA wasn’t applicable because it was a completely parent centered intervention. It was explained to Ben’s mother what the definitions of aggression were towards herself or others such as hitting, kicking, pushing, or biting. Property destruction consisted of throwing the item that was in Ben’s hand or picking up any item and throwing it or pushing something off a table or shelf. Tantrums were defined as falling to the ground while crying or screaming for 5 minutes or longer. Ben's mother was instructed to look at her watch to determine the length of the tantrum. It is acknowledged that the parent centered approach to recording data has its limitations in this study.

Treatment fidelity: The video was uploaded as an unlisted YouTube video therefore all views were readily tracked via the analytics provided on the platform. No one else had access to the video, so all views corresponded to Ben and his family. Weekly check-ins were also instituted with Ben's mother to ascertain the level of compliance with the protocol.

Analysis: Phase A baseline data for the video intervention was conducted from March 15, 2020 to March 31, 2020 with a frequency of 11 instances of aggression and 4 instances of tantrum behavior without watching the video. See Figure 1 for a representation of the data sheet. This data represents the information that was retrieved by the behavioral consultant. The treatment phase B began on April 1, 2020 to April 15, 2020 where Ben watched the video a total of 25 times during this time period while his mother paired the word "no" with the words "maybe later". Ben's frequency of aggression during this phase were 6 instances and tantrums were 3 instances. After 2 weeks of the intervention, the reversal phase A was instituted by Ben's mother. This phase was slated to last the same duration of the other phases, but it only lasted 5 days from April 16, 2020 to April 21, 2020 because the results showed a reversal to baseline levels where there were 5 instances of aggression and 2 instances of tantrums. This prompted Ben's mother to revert back to the treatment phase as to not lose any gains from treatment. The last treatment phase A was conducted from April 22, 2020 to May 6, 2020 where levels of aggression dropped to only 1 instance and tantrums also dropped to only 1 instance. See Figures 2 and 3 for graphs of aggression and tantrum behaviors. Days with no aggression or tantrums were marked with a 0. It is unclear if on the days with no target behaviors if Ben had contact with being denied access to his reinforcers. There were some days however, where Ben's mother indicated that she did not challenge him by saying "no" and there were some days that she only recorded one instance and did not record others. For the purpose of this experiment, the severity of the behavior was the prime issue opposed to the quantity of occurrences.

Behaviors	A	B	A	B
Aggression	11	6	5	1
Tantrums	4	3	2	1

Figure 1 depicts the frequency data recorded for all phases of the single subject design across behaviors for this study.

Internal validity is addressed in this study by the methodology of the single subject ABAB reversal design across behaviors which adds to the reliability of this study. Aggression and tantrums were the two behaviors being tracked and both of these behaviors were altered by the onset of treatment and the cessation of treatment. Figure 1 shows how the target behaviors decreased during treatment phase B and then increased again during phase A to levels reminiscent of baseline levels and then decreased abruptly during the final treatment phase B. External validity was addressed in this study by the fact that it was conducted in the participant's natural setting and administered by Ben's mother. Ben was never in a situation where he had to respond differently due to an experimental situation such as a change in setting or people. This adds to the generalizability of the VML technique to other individuals with similar challenges and prerequisite skills. The only confounding variables were possibly the approach by Ben's mother which was controlled as much as possible by frequent check ins by the behavioral consultant. According to Ben's mother, she kept to the protocol and expressed that she was happy that the experiment as it caused her to change her own wording to Ben which was a socially significant situation that resulted from the study.

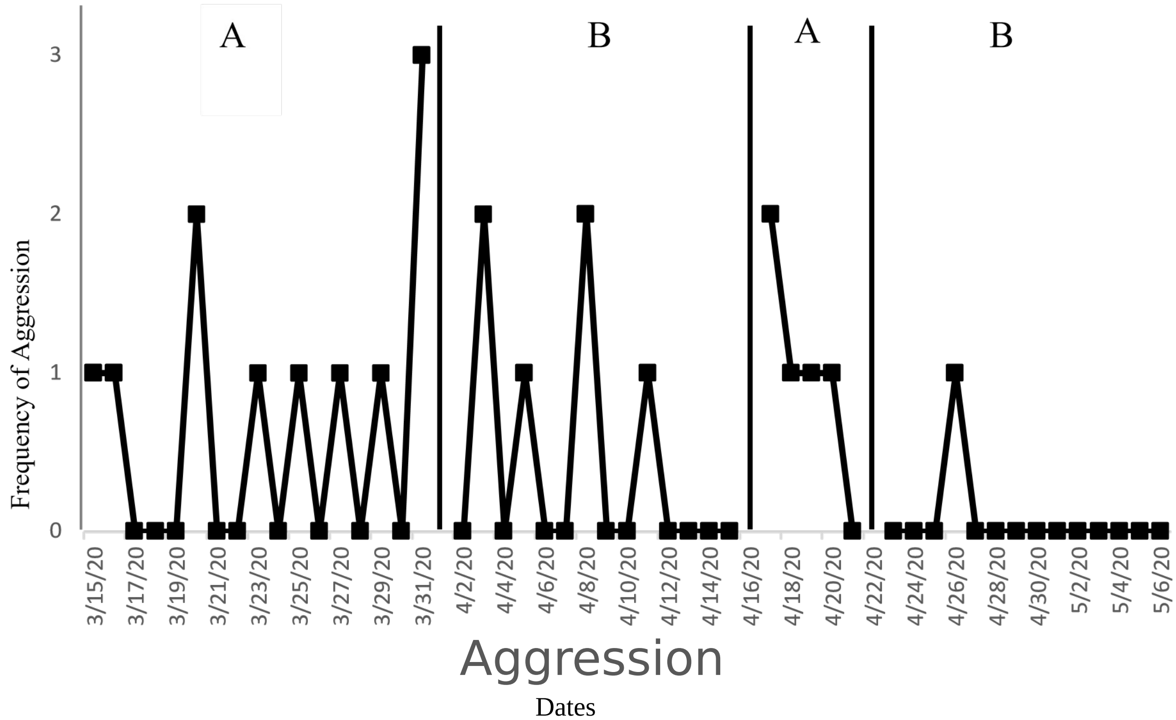

Figure 2 is the graphed data for Ben's aggressive behavior during the 4 phases of the experiment.

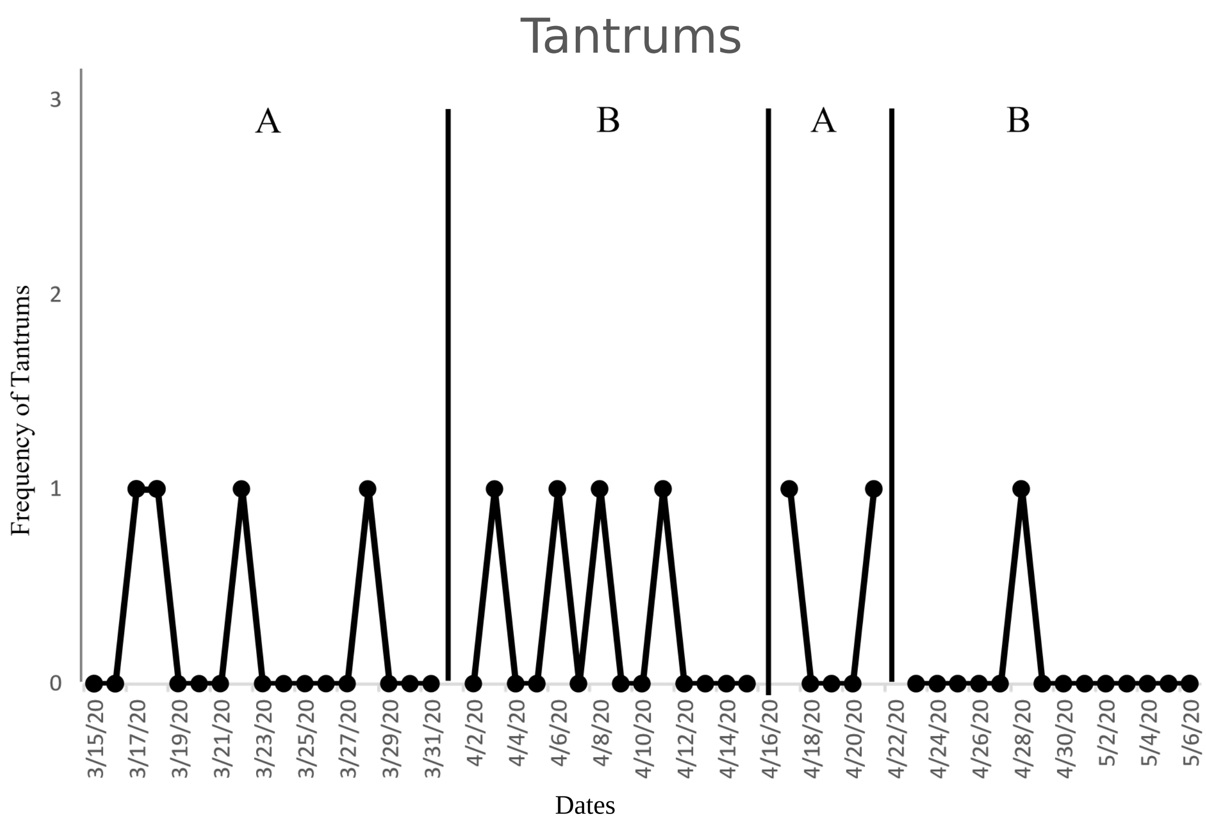

Figure 3 is the graphed data for Ben's tantrum behavior during the 4 phases of the experiment.

Chapter 4 Results

Chapter 4, Based on the literature reviewed for this study, it was expected that the experimental video would decrease the target behavior because there is evidence that video modeling does in fact model replacement behaviors and given the right reinforcement, has revealed an effective form of treatment (Lee, Lo & Lo, 2017). Ben's behavior did in fact decline during the treatment phase of the study and also resurfaced when the video instruction faded coupled with hearing the word "no". Ben's aggression and tantrum behaviors showed a clear decrease from 11 instances of aggression and 4 tantrums down to 1 instance of aggression and 1 tantrum during the final treatment phase. It was also expected that Ben would generally enjoy the video because of the emotion that would be evoked based on his preference for the characters in the movie attached to the video. This is not to say that any video that simply contained preferred characters would be enjoyable for Ben. The combination of the characters, the song itself, and the simplicity of the words were surmised to create an effective treatment. The study by Solomon et al, (2019) showed evidence that detailed memory is inherent when an individual is exposed to information with emotional content.

Ben's motor movements connected to his target behavior such as aggression, property destruction, and tantrums were being maintained by positive social attention as evidenced by the FBA. The new replacement behavior being taught to Ben was to simply put his Ipad down instead of holding on to it, or to redirect to another activity in place of his requested reinforcer. Changing Ben's motor movements such as his habitual aggressive and over-emotional behavior helped him to remember what was expected of him because the memories were being channeled through his motor cortex through his limbic system and emotional state (Buchanan, 2007; Maras, Gaigg, & Bowler, 2012).

It was also expected that Ben would remember what the expected behavior was to be when he was told "no" "maybe later" based on the auditory stimulus of the song itself and the verbal prompts embedded in the song. According to Ben's mother, he liked the song because she would hear him singing along with it as well as shaking his head up and down when it was playing. This is in alignment with Stalinski, and Schellenberg, (2013) because the emotional state an individual is in during the encoding phase is congruent with the emotional state one is in during the retrieval stage. For this reason, it was expected that Ben would have a positive emotional response when he was told “no” “maybe later” by his mother because he was in a positive emotional state while encoding the information while watching the video.

It was clear from the literature and specifically from Aube et al. (2013) that autobiographical memories are the kind of memories that are not readily encoded for individuals with ASD. The positive emotional state from seeing the characters that Ben enjoyed coupled with hearing the replacement behavior was intended to be an autobiographical memory where he would have an attachment to the new behavior because of the emotional content and the positive consequence of getting what he desired later instead of not all.

Since the VML intervention is a permanent product and designed to be enjoyed by the individual it was expected that the video would be viewed many times after the study as maintenance. The analytics of the views on YouTube’s platform showed that Ben viewed the video a total of 62 times which is well over double the times he was required to watch with views still being logged 9 months after instruction.

Conclusion

Chapter 5, The purpose of this study was to connect the encoding and acquisition of LTM to a myriad of its component parts such as emotion, music, and motor movement to circumvent the pre-fontal cortex thereby helping an individual with minimal functioning in that region to use their motor cortex in its place. Based on the results of the study, it seems that there is evidence that VML as a behavioral intervention can help with encoding and retrieval of LTM. The visual representation of the video is derived from preference assessments and aid in invoking an emotional response because it is what the individual wants to be watching. The music that is used is congruent with the visualizations or at the very least, it is derived from a genre that the individual already enjoys. The motor movements correspond to the replacement behaviors being taught and the video itself is the teaching instruction that also becomes a permanent product to be used throughout the length of the instruction and beyond.

The VML intervention is versatile where it can be a stand-alone intervention used in a parent/caregiver model where it is the only behavioral instruction being used at any given time or it can function in conjunction with other behavioral modalities such as differential reinforcement and antecedent interventions administered by behavior analysts. As of the writing of this paper, there is a global pandemic with a corona virus which has forced individuals to use virtual means for meetings and has curtailed face to face visits for some time. The VML intervention is uniquely suitable to work under these conditions or any conditions where face to face visits are not readily available.

There is anecdotal evidence that VML can help individuals gain intrinsic motivation to learn their replacement behaviors. As evidenced earlier, LTM is accessed when there is sufficient scaffolding of information such as emotional content, music that is either preferred or emotional in nature, and motor movements that are congruent with the task to be remembered and this is what adds to the encoding of autobiographical memories. It is precisely these autobiographical memories that are congruent with intrinsic motivation because they help to define individuals lives and are also a part of their personality. An individual’s personality trait consisting of intrinsic motivation to learn and to find ways for successful habilitation are what VML is seeking to tap into. This concept can be a focus of future study in using VML to aid in socially significant behavior change that truly benefits an individual's sense of who they are and what they are capable of doing in their lives.

There were some limitations to this study such as the parent centered model itself. Although there were frequent communications and education before the start of the experiment, it is unknown to what extent the behaviors being tracked were in fact recorded correctly. Another limitation to this study was there was no control for pairing the words "no" and "maybe later" without the video. It is possible that the pairing of these words would have had an impact without the video explaining this connection. It is apparent however, that the video softens the blow so to speak for the instruction. In other words, it was easier for Ben's mother to incorporate the change in her terminology because Ben was happy while learning the pairing and it took some of the instruction off of her and put it in the hands of the video where Ben may not have seen that connection. Future research can benefit from requiring more motor movement practice before and after the visual instruction as well as multiple trials with and without the video instructional piece.

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