Edited by
Mary Ellen Cavitt, Texas State University

Measurement of Infants' Behaviors with Electronic Music Toys

Carla H. Merkow
The University of Texas at Austin

Toys with electronic sounds and music are widely present in the everyday experience of infants in more economically developed countries (Bartel, 2001; Ilari, 2011; Young, Street & Davies, 2006; Young, 2009). From crib mobiles to interactive jumpers, activity tables, dancing animals, and toy instruments, music in pre-programmed formats can be heard from numerous and varied sources in infants' environments. Compared to previous generations, young children today hear music that differs not only in its content but also in its source of production, mode of transmission, and integration with other activities or social contexts (Young, 2009). In fact, Young (2009) argues that digital technologies allow the home, as opposed to community sites, to be the primary place for many families' music participation. Commercial music products for infants put recorded melodies literally within in a baby's reach, with the potential for repeated experiences with certain music. These products offer varying durations, textures, and timbres of music in a manipulatable "interactive" medium that often integrates sound with tactile, visual, and graphic stimuli. The prevalence of such products suggests an important area of research for many disciplines, including music education. How do these button-activated melodies impact early musical development? How can we measure infants' interaction with electronic music toys?

Investigations of young children's engagement with music technology exist mainly as a component of research with a broader focus (DeVries, 2007; Ilari, 2005; Ilari, Moura & Bourscheidt, 2011; Young, Street & Davies, 2006). Windows into the everyday music experiences of toddlers and preschoolers have highlighted children's experience with music mediated through television, video games, and other multimedia (Gillen & Young, 2007; Lamont, 2008). A time-sampling research study in the U.K. indicated that, for 3- to 4-year-olds, music was heard in some form during 80% of a child's day, that the majority of music episodes involved recorded music, and that the home was the primary place for music experiences (Lamont, 2008). Music participation with digital technologies in the home was equally salient in the case studies of 2.5-year-olds around the world; investigators concluded that electronic music toys and screen media "extended and supplemented the children's everyday domestic music experiences" (Gillen & Young, 2007, p. 92).

In terms of the musical experiences of infants specifically, researchers have relied on information from parent questionnaires and interviews. Their reports confirm that infants in many countries experience music through digital and multimedia formats (DeVries, 2007; Ilari,

et al., 2011; Young, et al., 2006). Positive perceptions of infants' electronic music toys emerge from parents' enthusiastic descriptions of the toys and their multiple functions (Merkow, 2012; Young, 2008). At the same time, some parents choose to avoid the noise of the toys, and others express concern that they may over-stimulate infants (Merkow, 2012). Research suggests that some parents use commercial music DVDs or toys as a temporary "babysitters" for their children (DeVries, 2007; Ilari et al, 2011) or that parents may view the products as substitutes for their own lack of musical ability (DeVries, 2007). Parents' decisions to purchase music resources may be motivated by pressures to adhere to societal expectations and buy products endorsed by "experts" (Ilari, et al., 2011; Young et al., 2006).

Among music educators, opinions on the value of electronic music toys in early childhood vary considerably (Campbell, 1998; Campbell & Lum, 2007; Kersten, 2006; Levin & Rosenquest, 2001; Marsh, 2002; Nardo, 2008; Young, 2007; Young, 2008). Kersten (2006) and Nardo (2008) offer recommendations on the use of music technology for preschoolers but do not address the age group of infants. For preschool teachers, Kersten encourages selection of digital instruments or toys that play tunes "of musical value" and are within children's singing range (2006, p. 18). The toy used in observations for this paper, the Munchkin Mozart MagicTM Cube, has been highly recommended for 2- to 6-year olds as a teaching tool for timbre recognition (Kersten, 2006, p. 28).

Susan Young, whose literature contributes to the field that reflects upon the presence and role of digital music products in early childhood (2007, 2008, 2009; Young et al., 2006), suggests that the multi-modal functions in digital toys match young children's multi-modal, imaginative nature of engagement. Young proposes that toys with digital technologies allow children to engage their attention flexibly and interact with the dynamic "mosaic of overlapping and non-linear information" typical of the digital world (2007, p. 325). For example, toys such as a toddler's play cell phone afford opportunities for self-initiation, autonomy, and control on the part of the child (Young, 2007, p. 341). Other authors agree with Young in that electronic toys enrich children's play, and that these devices appropriately reflect the present technology- and media-rich culture (Campbell, 1998; Campbell & Lum, 2007; Marsh, 2002). On the other hand, Levin and Rosenquest (2001) express concern regarding the appropriateness of electronic talking, sounding, and moving toys. They argue that products, such as the "Rock-n-Roll Ernie," limit children's creativity and detract from quality social and verbal interactions between children and adults. These strong opinions for or against the value of electronic music toys, however, generally lack supporting empirical evidence.

Measurement of Infants' Music Behaviors

To begin exploring infants' interaction with digital music products, I undertook a project to observe videos of infants playing with such a toy. The issue of measurement--what to measure and how--was important to address before pursuing further research. What behaviors can be observed during children's interactions with electronic music toys? What patterns emerge as salient or meaningful during infants' play?

Even though a measurement tool for infants' responses to electronic music toys did not previously exist, researchers have contributed documentation of children's music behaviors in other contexts. The musical behaviors of young children have been systematically observed since the Pillsbury Foundation project in the late 1930s (Moorhead & Pond, 1941). A school dedicated to researching the natural music making of children, ages 18 months to 8 years, set a precedent in providing varied musical materials and an unstructured environment to encourage spontaneous

musical activity. The directors of the school were perhaps the first in the United States to bring attention to children's musical development as an observable and important area of study (Moorhead & Pond, 1941).

Since that time, early childhood music educators have developed various systems to describe and classify early musical development (Bolton, 1997; GIML, 2011; Music Together, 2008; Lai, 2008; Valerio, Reynolds, Morgan & McNair, 2012). Edwin Gordon positions musical behaviors within a framework of stages called preparatory audiation. Gordon refers to the music learning of infants as "acculturation," which includes three stages of response: absorption, random response, and purposeful response (GIML, 2011). Music Together®, a music curriculum for infants through 4-year-olds, provides music teachers with an observation scale for children's tonal and rhythmic development (2008). In terms of music behaviors observable in infants, most recently, an observation tool to assess young children's music-related behaviors was developed by Valerio, Reynolds, Morgan, and McNair (2012). The instrument utilizes a parent questionnaire to collect information about the activities parents use with their children and what music-related behaviors are observable.

In general, systems for observing young children's musical behaviors are designed for wide-ranging use by practicing teachers or parents, not as specific protocols for research studies. The presence of electronic music products in most babies' homes introduces a prominent context for which to observe infants. The purpose of this study was to design a measurement tool that can be used to observe infant response to and interaction with electronic musical toys.

Method

Participants

For the purposes of this observational study, participants were obtained from home videos posted on YouTube, which are deemed to be in the public domain and usable for academic research purposes by the fair use provision. I began the process of collecting sample videos by querying a search with the terms "baby music toy." Among the search results, one particular electronic music toy commonly appeared, the Munchkin Mozart MagicTM Cube (abbreviated in this paper as the Cube or the toy). Because I could easily access numerous videos featuring an infant and the Cube, I decided to use this particular toy as the primary criterion for selection. By performing additional queries for "mozart magic cube" and "music cube," as well as following YouTube's suggested links, I collected 37 videos with infants and the Cube. Next, I chose to limit the developmental age of the sample by selecting only videos in which the infant was sitting by him or herself; thus, infants who were lying down or who walked with the toy were excluded. The length of the video (more than 30s and less than 4 min) and clarity of the recording were additional factors in selection. The final sample included 10 videos of infants (5 boys) posted on YouTube between September 11, 2007 and June 17, 2012. Two of the infants appeared in non-English speaking homes. The adult(s) recording the video, though unseen, were also included in the study, as their speech dialogue could be observed. In all cases, the infant was the only child who appeared, and he or she was seated on a soft floor in a living room or bedroom. The settings in which infants played presented few distractions from the toy; other objects were only present and within reach in two videos.

Materials and Procedure

I used SCRIBE software (Duke & Stammen, 2011) to code and analyze observations from the YouTube videos. A web browser extension allowed me to save YouTube videos and then open them for analysis in SCRIBE. I created a custom SCRIBE template to measure and code the video content. The markers included infant behaviors (gaze, vocalizations, dancing, and mouthing), toy behaviors (activation of the music on/off, change in melody) and adult behaviors (verbal directives, praise, narrative, and touching the toy). The targets of infants' looking fell into three mutually exclusive categories: toy, camera/person, or other. Glances under one second were not recorded. Vocalizations were measured for durations according to natural pauses; one vocalization could include a single syllable utterance or 10 seconds of continuous babbling. I defined "dancing" as infants' repetitive movement that lasted more than three seconds and involved physical rocking or waving arms. I performed seven or more passes with each video in order to observe overlapping or co-occurring variables. A trained independent observer also used the SCRIBE template to observe 20% of the sample videos. The overall reliability of observers for frequencies of behaviors (infant vocalizing, infant looking at toy/camera/other, music on) was 73%. In terms of duration, the difference in timed data of the two observers averaged 1.9 seconds, with a range of 0.2 to 6.3 seconds.

In addition to gathering quantitative data with SCRIBE, I took handwritten notes on anecdotal observations and I transcribed the parents' speech. Finally, I obtained a Munchkin Mozart MagicTM Cube so that I could see and handle it "in person" and understand how the toy functions.

The Munchkin Mozart Magic™ Cube

The toy is a brightly colored, plastic six-inch cube with soft rubber corners. A small switch turns the electronic functions on or off. Each of the six sides of the Cube has a square button with an image and the word label of a musical instrument (violin, harp, French horn, flute, and piano) or the orchestra. When a button is activated, music plays and a red light pulses from behind the instrument picture. The "main" orchestra button activates one of eight Mozart melodies. When the main button is pressed and music is playing, a user can press the button again to skip to the next tune of the series. By default, the main button sounds the fullest texture combination with every instrument side flashing light. The Cube's other five buttons allow alterations to the timbres and textures of the music. For example, the user may subtract the voices of four different instruments and hear "Twinkle, Twinkle" played only by the flute. In sum, Cube users have the opportunity to hear melodies in various combinations of countermelodies, accompaniments, and instrumentation. Once the toy is activated, it will continue to sound until the melody comes to an end (an average of 21 seconds). The eight Mozart melodies featured in the Cube are listed on the toy's packaging. I further documented the musical characteristics of key, tempo, and meter as rendered by the toy (see Table 1). All of the tunes are in a major key and the tempos range from moderate to fast, between 90 and 140 beats per minute.

Table 1

Characteristics of Melodies Played by Munchkin Mozart Magic™ Cube

Melody	Key	Tempo	Meter	Duration (s)
Non Piu Andrai	D Major	120	Duple	20
Country Dance No. 5	A Major	132	Duple	30
Come Sweet May	F Major	90	Compound duple	21
Twinkle	D Major	116	Duple	25
Magic Flute	A Major	95	Duple	21
March in D	B Major	126	Duple	15
Landler	C Major	140	Triple	21
Don Giovanni	C Major	130	Duple	19

Results

Infant behaviors are listed in Table 2 as individual subjects' data averages.

Table 2

Infants' Behaviors with Mozart Magic Cube.

	Sex	Video length	Looking at toy (%)	Looking at camera (%)	Looking at other (%)	Music on (%)	Music off (%)	Melodies played	Vocaliz-ations	Mouthing	Dancing
Emma	f	1:33	57	14	28	54	45	2	10	yes	
Leo	m	3:01	63	29	7	67	32	4	10		
Zane	m	2:06	73	19	6	64	35	1	2	yes	
Joe	m	0:43	63	36	0	75	20	1			yes
Martin	m	2:57	56	18	26	88	10	2	2		yes
Jack	m	2:09	78	9	12	51	49	1			
Serena	f	0:53	29	69	0	50	48	1			yes
Cammie	f	1:06	61	38	0	82	16	1	14		
Madison	f	3:23	74	13	11	48	42	3	5		yes
Lucy	f	1:02	83	3	0	60	40	2	4		
Average		1:53	64	25	9	64	34	1.8			

Looking times

Infants' looking times to three target areas (toy, camera, and other) were summed and calculated as percentages of the total duration of video. Infants spent the majority of time looking at the toy ($M = 63\%$). They directed their gaze to an adult or to the camera for the second greatest amount of time ($M = 24\%$), and to other areas in the environment for the least time ($M = 9\%$). Some infants (25%) did not look at anything besides the toy and the cameraperson in their environment.

Vocalizations

During the videos, a majority of infants (70%) made vocal sounds, including hums, sighs, grunts, babbles, and laughs. One child produced sustained periods of babbling, the longest of which lasted 16 seconds and happened while she looked at the toy and heard music. Another of the infants also babbled, saying "dada" and "gaga" while the music played and after it stopped. A

third infant laughed throughout her play with the Cube, while a baby boy squealed with laughter at one climatic point when looking at his parents.

Physical interaction with the Cube

All infants had at least some physical contact with the Cube, although the nature of this contact varied. In most of the videos, infants handled the toy by grasping and patting its surface. In two cases, infants picked up and held the toy off of the floor with two hands. The toy's shape allowed all of the infants to rotate it, either in their laps or on the floor, such that orientation of the instrument buttons changed. One infant was observed pointing at the flashing lights that flashed on her Cube. Two others used the toy as a balancing prop to pull themselves up to a kneeling or standing position. Two infants were observed briefly mouthing or chewing the toy.

Dancing

Twenty-five percent of the infants also showed repetitive rhythmic movement, coded as dancing, while interacting with the Munchkin Mozart MagicTM Cube. These four infants expressed different types of rhythmic movement, but each individual showed a consistent and characteristic motion throughout his or her video. Rhythmic movements included one or a combination of the following motions: arm waving, rocking forward and back in a sitting position, bouncing, and rocking in a crawling position. Periods of dancing lasted between less than a second and 14 seconds (M =3.6 s). Dancing movement coincided with four of the different melodies, in versions with single and multiple instrumental textures.

Toy Behaviors

To investigate the activity of the toy, I recorded the number and length of intervals in which music played during each infant's video and calculated the duration of music as a percentage of the total duration of the video. The Cube's music sounded for the majority of the time in the videos (M = 64%, SD = 13.9). On average, intervals during which music played (M = 15.2 seconds) were longer than intervals of no music (M = 9.6 seconds). I also recorded the rate at which music turned on. On average, the music was initiated, or started from silence, three times per minute (SD = 1.7). Since all surfaces of the Cube are sensitive to activation, I recorded the source of initiation every time music played. Activation resulted most often from contact with the infant's hand (56%). In other cases, infants used their thumbs in isolation to successfully press the button (12%). Unintentional contact between the toy and a baby's foot resulted in 16% of activations. The remaining initiations of music occurred when the toy brushed the floor (2%), when the baby mouthed the toy (2%), or when an adult touched it (2%). Ten percent of the activations were unobservable due to the perspective of the video camera.

Across the ten sample videos, I heard five of the eight possible melodies programmed in the Cube (the first five listed in Table 1). The melodies of the toy maintain their sequential order, although not every infant's video started on the first melody. Country Dance No. 5, the second tune, was played most frequently, while the fifth tune, Magic Flute, was heard in only one video. Infants listened on average to two different melodies during the course of each video.

Adult Behaviors

In this study, adult participation was considered an important element. First, parents' decisions and actions contributed to the data collection: They provided the Cube toy, decided to record their infant's play, and chose to publicly share the video. Additionally, many of the adults talked to the infant or the camera audience on their recordings.

Adult verbal participation during an infant's play with the Cube varied in frequency and content. Content data was not available for two videos in which parents spoke foreign languages. The number of spoken phrases ranged from no comments in one video to 28 comments during a two-minute video. The adults behind the camera assumed different levels of involvement. Some were quiet observers and responded only when the baby seemed to be looking at the camera for a response. Others acted as instructors, giving frequent directions, encouragement and praise. The majority of adult dialogue was infant-directed. Phrases spoken to infants included directives related to the toy, directives unrelated to the toy, praise, and other infant-directed talk. Comments directed to adults included narrative or asides about the infant and the toy. Examples of each adult comment category are listed in Table 3.

Table 3

Example of Adults' Comments During Videos

Infant-directed				Adult-Directed
Toy-related directives	Unrelated directives	Praise	Other ID talk	Narrative
"Can you push one of the buttons?"	"Can you show me the sign for drink?"	"Good job!"	"That's something, isn't it?"	"Uh.. that doesn't sound like the piano."
"Get it, Madison."		"Very nice, Leo."	"Are you sittin' and playin'?"	"There is Zane with his Mozart Music Cube that he adores."

Discussion

Development of a systematic observation tool

Through a systematic process of observing infants on video, I created a measurement system to record and assess their interactions with an electronic toy. Collecting data from a non-standardized source of home videos presented some limitations and challenges. First, the age of the infants in the sample is unknown. Though all of the babies had achieved the milestone of

sitting up, several months of age difference potentially exists between the youngest and oldest; within this age range substantial changes in perceptual, cognitive, social, and motor development can occur. The types of behaviors observed and results would likely be different if age was more homogenous in the sample.

Data from a reliability observer demonstrated overall high degree of agreement on observations. The greatest discrepancies in data resulted from an unclear definition of infant looking behavior; the reliability observer recorded any movement of the eyes as a change, whereas I (the primary researcher) disregarded the momentary glances. In the future, I would train an observer to count a looking occurrence only if it lasted for more than one second.

The variable of intention or motivation was not addressed in this study, yet is an important one to investigate. The sensitive buttons and particular cube design of this toy make it especially challenging to observe intentional actions. For example, when a baby's hand activates the button, the cause is often ambiguous: Was it because she was banging on it as she does on all surfaces, rotating the object, trying to touch the light, waving her arms to dance, or purposefully hitting the button? Furthermore, the child's motivation to interact with the toy is obscured by the toy's accidental activations, when music and lights play without choice or obvious cause. While it may be possible to investigate infants' intentional behavior with a different kind of electronic music toy, I imagine that sensitive buttons are quite common on these types of products. Easily activated buttons accommodate infants' level of physical strength or coordination and increases the likelihood that the sounds will function. Admittedly, determining whether infants' actions are intentional is a complicated task and requires an experienced observer. Nevertheless, an experimental procedure that positions the toy out of reach or offers a choice of toys may help highlight the infants' motivations and intentions.

General discussion

> "This is a multi-purpose [toy] – teether (slash) entertainer (slash) teaching tool!"
> - Mother's voice in video

The satisfaction with the Mozart Magic™ Cube that this mother expressed is a common theme in the sample of YouTube videos used in this study. What observations did parents make of their infants that motivated them to record and share the video publicly on the Internet? The process of reviewing a sample of videos provided insight onto adult perception of the Cube and interpretations of the child's behaviors. First, the access to numerous videos with the same toy is likely a result of the Cube's popularity, and the distinctiveness of its name. I found these videos in large part because parents chose the words "Mozart" or "music cube" in the description of their babies' videos. The video descriptions themselves reflect the relative importance of the toy and the experience it provides for the baby. For example, one video was titled "Singing with the Mozart Music Cube" (as opposed to simply "Singing"). Many of the videos appeared to be set up as opportunities to showcase the infants' play with the toy, since few other objects were within reach. The evident parental amusement with the Cube in this study mirrors the enthusiastic reviews of infants' electronic music toys, as documented from parent interviews (Merkow, 2012; Young et al., 2006).

Systematic observations in this study revealed that, as one mother mentioned, the Cube affords multiple kinds of interactions. The tactile, visual, and auditory features of the toy aroused different responses from the infants. Many of these behaviors correspond to other researchers' observations and categorizations of infant music behaviors (GIML, 2011; Music Together,

2008). For example, Emma and Lucy's vocalizations may be considered a "random response" in Gordon's acculturation phase, as their sounds were in response to, but unrelated to the music stimuli (GIML, 2011). Infant movement while interacting with the toy corresponds to documentation of rhythmic development in the Music Together® observation scale (2008). It is important to keep in mind, however, that existing assessments of music behaviors emerged from the traditional contexts of early childhood music classes or live parent-child musical interactions, not in semi-solitary play with a toy. It is interesting to consider how the music mediated through a toy may elicit similar and different responses than those described by Gordon and Music Together®.

The data collected on the toy's "behavior" when manipulated by an infant was especially informative. From casual viewing of videos, my previous perception was that the Cube changed melodies rapidly and played fragmented phrases in music. However, in this study, the music was turned on less frequently than I expected, an average of three times per minute. During videos that lasted around two minutes, infants heard an average of two different melodies. These data demonstrate that infants may prefer to hear complete renditions of melodies and that the melodies are likely to be repeated within a period of play. This makes sense considering the programming of this particular toy; only one of the six buttons causes the melody to change, while the others alter the musical texture. In this case, the toy offers some continuity of the musical material while altering the sound (timbre/texture) in response to touch.

The applications of the measurement tool designed for this study are numerous. Research regarding electronic music toys could address infants' interactions from different disciplines and perspectives. Experimental studies may investigate how the context of music activities, the mode of listening, or repeated experience with toys affects infants' discrimination of musical elements (i.e., timbre, melody, rhythm, pitch, etc.). The impressive movement that infants produce while playing with toys is also subject to research. A recent experiment demonstrated that 4- to 7-month-olds are less likely to demonstrate rhythmic movement in response to music when it is paired with a visual stimulus (Morgan, Killough, & Thompson, 2011). This question of sensory dominance is relevant to the multimodal nature of the Cube and other electronic music toys. Given the abundance of perceptual information – lights, sound, color, shape, and texture - what is most salient to infants? In addition to studying movement responses, infants' vocal responses when playing with electronic music toys are worth further exploration. More specifically, what are the effects of periods of sound and silence on infants' vocal production? Since early child music educators encourage adults to provide purposeful silences to elicit young children's musical responses (Valerio, Seaman, Yap, Santucci, & Tu, 2006), this variable may be important in the context of interactive music products. Finally, the role of social interaction in infants' learning with electronic toy is a potential avenue for research. The mediation of the toy between an adult and child is likely to influence attention and learning, and findings may be compared with the influence of adults in the context of screen media (Barr, 2008). Are infants' experiences with electronic music toys enhanced or hindered by social interaction? What behaviors do adults model when playing with their infants and these toys? Answers to research questions such as these have meaningful implications for parents, music teachers, and early childhood educators.

As researchers and educators, we benefit from a concept of early childhood music experiences that include the diverse ways in which very young children listen to, interact with, and create meaning from music. Digital technologies and electronic music toys are prevalent beginning in infancy, yet we know little about how sound- and light-making, interactive devices are integrated into children's learning and development. The measurement tool outlined in this

paper serves as a starting point for broadening our perspectives on the rich and complex musical environments of infants today.

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