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For happy children with a visual or visual-and-intellectual disability: Efficacy research to promote sensitive caregiving with the Barti-mat

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Abstract

Cycles of miscommunication often occur within the caregiver–child dyad when a child has a visual or visual-and-intellectual disability, influencing sensitive and responsive caregiver behaviour and child happiness. This study aims to examine the efficacy of using interactive technology, the Barti-mat, to promote sensitive and responsive caregiver behaviour, specifically mirroring behaviour, and increase the happiness of children with a visual or visual-and-intellectual disability. The secondary aim is to examine the social validity of the Barti-mat. A mixed-method approach was used, combining quantitative data from a multiple within-series single-case design and qualitative data comparing play-as-usual with play on the Barti-mat. Eleven caregiver–child dyads participated in a home-based study. No significant effects were found for Attunement nor for Valence. Significant improvements were found for Total Mirroring, Happiness, and Arousal. Overall, the caregivers enjoyed using the Bart-mat and were enthusiastic about the development of specialized play material for children with visual impairments. Results of the current study suggest that the Barti-mat can act as catalyst for caregiver mirroring behaviour and improve the happiness of a child with a visual or visual-and-intellectual disability. Caregivers were generally motivated to use and recommend the Barti-mat again. Minor product improvement recommendations were made. The

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Barti-mat is appropriate for a diverse group of caregivers and children with a visual or visual-and-intellectual disability and would be a good adjunct to preventive attachment-based interventions.

Keywords
Caregiver–child interaction, caregiver sensitivity, happiness, interactive technology, mirroring, multiple within-series single-case, visual impairment

Introduction

Miscommunication hinders the quality of social interactions between caregivers and children with visual or visual-and-intellectual disabilities (Sakkalou et al., 2021). Technology facilitates social interaction for people with disabilities (Bakkum et al., 2021; Dyzel et al., 2020). Improving sensitive and responsive caregiver behaviour is key in improving the caregiver–child relationship (Feniger-Schaal & Joels, 2018). But, can technology contribute to improving caregiver sensitive and responsive behaviour, and children's happiness? This study investigates the efficacy of interactive technology to promote sensitive and responsive caregiver behaviour, and whether this playful technology can increase happiness for young children with visual or visual-and-intellectual disabilities.

Sensitive and responsive behaviour contributes to a reciprocal relationship in which both caregiver and child feel understood and experience joy (Lee & MacWilliam, 2009). This type of caregiver behaviour is characterized by the caregiver's ability to notice, interpret, and appropriately respond to their child's cues (Kim et al., 2018; Sterkenburg & Vacaru, 2018). Stimulating the child to explore the environment and providing comfort and protection when the child is anxious or stressed is sensitive and responsive caregiving (Powell et al., 2014; Sterkenburg & Schuengel, 2011). Furthermore, a crucial part of sensitive and responsive behaviour is mirroring, which can be defined as the caregiver's attempts to understand the unique inner world of their child and reflect back their verbal, behavioural, and affective experience (Freeman, 2016; Lee & MacWilliam, 2009). For example, a father of a blind baby actively verbally mimics the laugh of his baby to let her know he is listening to her and encouraging her to carry on the interaction (Lee & MacWilliam, 2009). Most importantly, accurate caregiver mirroring functions as affect-regulative interaction and thereby teaches children to regulate their own emotions and behaviours (Freeman, 2016).

Caregivers of children with visual or visual-and-intellectual disabilities often exhibit lower levels of sensitive and responsive behaviour (Van den Broek et al., 2017) due to misinterpreted or missed communication cues (Loots et al., 2003). Loots et al. (2003) state that these children often appear passive due to lowered responsive and restricted repertoires of behaviour and emotions, as well as stereotypical behaviour. Over- or under-stimulation can also negatively influence children's behaviour and emotions (Janssen et al., 2002). In addition, caregivers of a child with disabilities experience higher levels of stress that can lead to lower levels of sensitive and responsive behaviour (Schuengel & Janssen, 2006).

The nature and structure of caregiver–child relationships of children with visual or visual-and-intellectual disabilities varies significantly from that of sighted children. Children with visual or visual-and-intellectual disabilities are more dependent on their caregivers, which can lead to a more directive and controlling caregiver interaction style (Sakkalou et al., 2021). As a result, relationship play opportunities in which a child takes the lead in exploring their environment are decreased, which in turn reduces chances of a caregiver accurately mirroring and responding sensitively (Sakkalou et al., 2021; Van den Broek et al., 2017).

Preventive attachment-based interventions attempt to teach caregivers how to pay attention and appropriately respond to their unique emotional cues (Mountain et al., 2017; Van den Broek et al., 2017). Interventions such as the Video-feedback Intervention to Promote Positive Parenting for children with Visual disabilities (VIPP-V) (Platje et al., 2018) and the Biofeedback System for persons with visual and severe intellectual disabilities (Frederiks et al., 2015, 2019), partly use technology to promote sensitive and responsive caregiver behaviour.

The use of interactive technologies to promote social bonding and interaction has increased, especially within the field of intellectual disability (Den Brok & Sterkenburg, 2015; Uğur Yavuz et al., 2021). This technology specifically focusses on improving the knowledge of sensitive caregiving (Sterkenburg & Vacaru, 2018; Van Wingerden et al., 2019), to promote various skills and contribute to more happiness for people with intellectual disabilities (Lancioni et al., 2012). However, up to now little research is conducted on the use of technology to improve the caregiver–child interaction and to increase the happiness of children with disabilities.

Therefore, the aim of this study is to examine whether interactive technology, the 'Barti-mat' – an interactive technology-based playmat, can promote sensitive and responsive caregiver behaviour (including mirroring) and increase happiness of children with visual or visual-and-intellectual disabilities. This intervention is one of the first interventions that utilizes technology to improve a caregiver's ability to react sensitively and responsively to their child's behaviour in a playful manner. It is therefore important to test the efficacy of this interactive playmat (Dekkers-Verbon et al., 2019).

The primary research questions are as follows: (1) Does the Barti-mat increase sensitive and responsive caregiver behaviours, including mirroring behaviour, compared to play-as-usual? (2) Do children with visual or visual-and-intellectual disabilities experience more happiness while playing on the Barti-mat compared to play-as-usual? A secondary research aim is to examine the acceptability of and satisfaction (social validity) with the use of the Barti-Mat.

Method

Study design

A multiple within-series single-case design, with randomized blocks of play-as-usual (phase A) and play on the Barti-mat (phase B) was used (e.g., ABAB-ABAB; ABBA-BABA, see Figure 1). The single-case design procedure produces within-subject replication and greater generalization of results, especially in small populations (Kratochwill & Levin, 2010). The study consisted of a total of eight phases, lasting 3 min each. The duration of 3 min per phase was set according to young children's short attention span. A 15-min break was given half way through the experiment. The intervention was conducted within 1 hr. The alternation sequences were randomized in four blocks of AB or BA prior to the intervention. Online randomization was conducted (www.random.org) by Author 2 prior to the study and was checked by Independent Researcher 1. Based on the chronological order of entry to the study, play sequences were assigned. In one dyad, one sequence was accidentally repeated twice.

A mixed-method approach was applied. The quantitative data of the primary variables included caregiver sensitive and responsive behaviour (including mirroring) and child happiness. Field observations (qualitative data) supported the quantitative data. To examine the desirability, practicability and subjective experience of using the Barti-mat by caregivers, social validity was examined using quantitative and qualitative data, which consisted of a questionnaire and open-ended questions. The study was approved by the Independent Review Board Nijmegen (20190604:21:09)

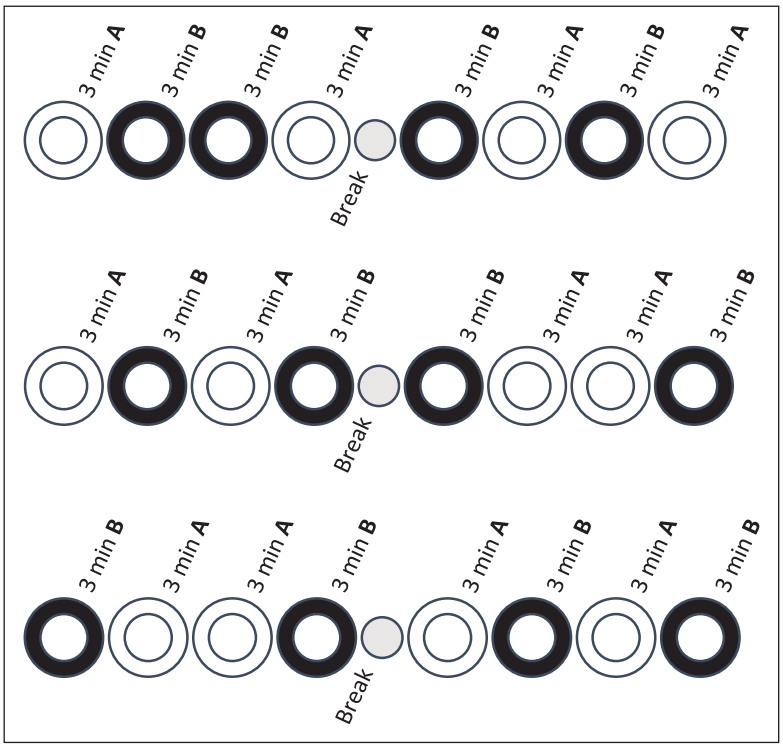

Figure 1. Example of the study design of three parent–child dyads.

and national Covid-19 pandemic guidelines were applied. In addition, this study was registered on the Open Science Framework (Dekkers-Verbon et al., 2019, https://osf.io/ct7ka).

Participants

A national recruitment was conducted via early intervention workers from two Dutch national organizations Bartiméus and Royal Vision providing support for persons with visual impairments. The inclusion criteria were: child's chronological age 6 months to 3 years or child's developmental age below 3 years and the child has a visual impairment confirmed by an ophthalmologist assessment report according to the World Health Organization norms (World Health Organization, 2007). As a result of the small target population, no exclusion criteria concerning language or other demographical characteristics were applied.

Fifteen caregiver–child dyads indicated that they wanted to participate. However, four of these dyads (of which two boys; children aged 7 months to 2 years and 4 months; blind or visually impaired) were unable to participate due to changed circumstances related to the COVID-19 pandemic. Due to the national lockdown from March to May 2020, three dyads participated in February/March and eight dyads participated in June/July 2020. All caregivers received verbal and written information about the study and the participants returned their informed consent forms. The biographical questionnaire was translated for one family.

Nine children had co-occurrent conditions such as genetic disorder, developmental delay, auditory impairment and/or epilepsy. One child was 4 years and 7 months with a developmental age of

about 4 months, which was determined using the Bayley Scales of Infant and Toddler Development combined with a parental diagnostic interview. Visual impairment ranged between moderately visually impaired to blind. Six children were girls and five were boys. Nine of the 11 videotaped caregivers were female and two were male (mean caregiver age was 35 years). Seven caregivers had a higher education degree. Ten caregivers were Dutch and one caregiver Asian. Table 1 presents an overview of the biographical information.

Intervention

The Barti-mat was developed in 2016 for children with Down Syndrome and their parents (Manojlovic et al., 2016). In 2019 it was further developed for young children up to 3 years of age, with visual or visual-and-intellectual disabilities. The collaborative process between experts and research teams utilized a multi-disciplinary user-centred approach to ensure that the interactive mat was user-friendly and functional for this target group (Dekkers-Verbon et al., 2019). The final product is a soft and lightweight fabric playmat of 120 × 120 cm that consists of various colourful, contrasting, textured blocks with built-in sensors to provide tactile, visual and auditory stimulation (see Figure 2). The built-in sensors are connected to a 3D printed sound box, which produces different sounds (e.g., animals or nature) when each block is touched. The volume of the sound box can be adjusted to accommodate both caregiver's and child's needs. The purpose of the Barti-mat is for young children to play together with their parents, where child-led play is key and the dyads connect through the mat with the help of sensitive and responsive parental behaviours including mirroring.

Procedure

The procedure comprised (1) identification and recruitment of caregiver–child dyads; (2) completion of informed consent, the biographical questionnaire and a social validity questionnaire; (3) a short introduction of the study and instructions on how to play with the Barti-mat, only mentioning that parent and child can play as usual (for a set amount of time) on the Barti-mat; (4) participation in the study; and (5) completion of the social validity questionnaire. One caregiver was unable to complete the social validity questionnaires, due to not being able to read in Dutch.

The study was home-based, and caregivers chose the most convenient day and time. To resemble the home-based early intervention sessions the children usually get, the absence of pets and siblings was encouraged. Due to the COVID-19 pandemic, for each questionnaire a total of seven caregivers preferred to answer the questions online (T0, $n=6$; T1, $n=2$) or telephonically (by Author 2) (T0, $n=1$; T1, $n=5$). All phases of the experiment were video recorded using two cameras, one of which filmed the caregiver–child interaction and the other focused on the child's upper body and face. Authors 1 and 2 monitored the cameras.

Measures

The biographical questionnaire included: gender, age, ethnicity, and highest level of the caregiver education; and chronological and developmental age, gender, degree of visual impairment and any other co-occurrent conditions of their child. The primary measures included Caregiver Sensitive and Responsive Behaviour; Mirroring Behaviour; Child Happiness; Observations; and Social Validity.

Table 1. Demographical information of participating caregiver–child dyads.

Dyad number	Caregiver gender and age (years)	Child gender and chronological age (years; months)	Child developmental age (years; months)	Child visual impairment	Child co-occurrent impairments			
					Genetic disorder	Developmental delay	Auditory impairment	Epilepsy
1	Female (35)	Boy (2;1)	0;9	Moderately visually impaired	No	Yes	No	Yes
2	Female (43)	Girl (2;9)	2;9	Blind, no light perception	Yes	Yes	No	No
3	Female (27)	Girl (2;3)	1;4	Severely impaired to blind	No	Yes	No	No
4	Male (39)	Boy (1;6)	0;5	Severely visually impaired	Yes	Yes	No	Yes
5	Male (37)	Boy (1;10)	1;0	Severely visually impaired	No	Yes	No	Yes
6	Female (37)	Girl (4;7)	0;4	Severely visually impaired	Yes	Yes	No	No
7	Female (25)	Boy (0;9)	0;9	Blind, with light perception	Yes	No	No	No
8	Female (34)	Boy (1;8)	1;8	Moderately visually impaired	No	No	No	No
9	Female (37)	Girl (2;11)	0;4	Severely visually impaired	Yes	Yes	Yes	Yes
10	Female (34)	Girl (2;10)	2;10	Blind, no light perception	No	No	No	No
11	Female (40)	Girl (2;9)	0;3	Severely impaired to blind	Yes	Yes	No	No

Figure 2. Barti-mat.

Quantitative measures

Caregiver sensitive and responsive behaviour. The Attune and Stimulate Mother-Infant checklist (A&S-MI; Doodeman et al., 2018; Vacaru et al., 2021) measures sensitive and responsive caregiver behaviour. This observational checklist assesses the degree of caregiver–child attunement. Author 2 randomly selected 27% of the data and subsequently, Author 1 and Independent Researcher 1 independently coded these films. The intra-class correlation coefficient (ICC) between the coders was .880 (child arousal), .974 (child valence), .923 (caregiver arousal), and .952 (caregiver valence) that are excellent (Hallgren, 2012). Independent Researcher 1 coded the rest of the data.

Mirroring behaviour. The frequency of caregiver mirroring behaviour was counted for each phase and added to form the variable of Total Mirroring (TM). Sub-categories focussing on Verbal Mirroring (VM), Affective Mirroring (AM), and Behavioural Mirroring (BM) were scored. Verbal Mirroring is the caregiver's mimicking of a child's sounds and words. Affective Mirroring entails the parent voicing the inner world of the child (expressing its' experiences and emotions). Behavioural Mirroring is the exact repetition of child's gross motor movements by a parent. Not included were caregiver mirroring behaviours that are not possible to perceive for blind children, such as facial expressions or minor gestures without touch. Author 2 and Independent Researcher 2 independently coded 27% of the randomly selected videos on the variables VM and AM. Any inconsistencies were discussed with Author 4. Author 2 coded the remaining films. With ICCs of respectively .981 and .751 the inter-rater reliability scores were excellent (Hallgren, 2012). For the BM variable 27% was randomly selected by Author 2 and double coded by Independent Researcher 1. The ICC was .548, which was fair (Hallgren, 2012). The ICC of the overall variable TM was .901, which is excellent (Hallgren, 2012).

Child happiness. Two observational checklists were used to measure each child's happiness. With the first checklist, the facial expression subscale of The Happiness Feature Score (Lancioni et al., 2002; Sterkenburg, 2020), the frequency and level of happiness (smile, laugh or laugh of high intensity) was measured. This scale was divided into time intervals of 30 s, giving us 6 scores per 3 min phase and therefore a total of 48 scores per child (of which 24 Barti-mat and 24 play as usual). Author 2 and Independent Researcher 1 independently coded 27% of the randomly selected films and the ICC was .840, which is excellent. Author 2 coded the remaining films.

It is difficult to fully understand the emotional experience of children with visual or visual-and-intellectual disabilities, thus a second checklist, the Arousal and Valence Scale, was used (Frederiks et al., 2019). This Likert-type scale checklist consists of two sub-scales: Arousal and Valence and is scored in time intervals of 30 s. The Arousal sub-scale measures the amount of experienced arousal of a child. 'Over- and under-arousal' entail low scores of 1 or 2 or high scores of 6. Optimal arousal scores are 3 up until 5. The Valence sub-scale measures whether the arousal is positive, negative, or neutral on a scale ranging from −6 to 6: −1 low negative arousal to −6 high negative arousal; 0 is neutral; 1 low positive arousal tot 6 high positive arousal. Authors 1 and 2 randomly selected and independently coded 27% of the data, the ICC for Arousal was .923 and Valence was .982, both are considered excellent. Author 2 coded the remaining films.

Qualitative measures

Observations. During the study, Authors 1 and 2 independently compiled and wrote observation reports. The observations focused on the dyad experience, as well as any relevant contextual factors. Thematic analysis was conducted to highlight general overlapping themes within the reports (Braun & Clarke, 2006).

Social validity. The expectations and experiences of the participating dyads were measured with a pre- (T0) and a post-intervention questionnaire (T1). Both questionnaires were based on the social validity scale used by Seys (1987) and Jonker et al. (2015). A member-check was done. T0 contained 16 questions, and T1 23 questions, and 1 open-ended question. The questionnaires comprised of a 5-point Likert-type scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Themes embedded in the questionnaires included the following: (1) desirability of the intervention (T0: five questions, T1: one question); (2) the intervention itself (T0: two, T1: three); (3) practicability of the intervention (T0: two, T1: one); (4) effectiveness of the intervention (T0: five, T1: four); (5) subjective evaluation of the caregiver (T0: one, T1: four); and (6) subjective evaluation of the child (T0: one, T1: three). In addition, T1 had five questions focused on product improvements and two on product recommendations. Caregiver remarks about the study or the Barti-mat were obtained in the open-ended question. An example of a question: 'I expect that regular use of the interactive playmat will be beneficial for me and my child on the long term'. Eight questions (T0: one, T1: seven) were posed in the form of a negation so to prevent social bias. These answer scores were reversed before processing them.

Statistical analysis

The inter-rater reliability of the different continuous variables was calculated using the intra-class correlation coefficient (ICC), using a two-way mixed, absolute agreement, single measures model (Hallgren, 2012; Koo & Li, 2016; Shrout & Fleiss, 1979). An exception is the A&S-MI ICC which is calculated on average scores instead of single measures. Improvements in caregiver sensitive and responsive behaviour were calculated using a difference score of the A&S-MI checklist results. Difference scores were significant if the difference between the control and intervention phase was > 0.57 (Sterkenburg & Schuengel, 2011). In combination with visual analysis, non-overlap of all pairs (NAP; Parker & Vannest, 2009) assessed any within subject change in caregiver mirroring behaviour and child happiness. NAP is an index of data non-overlap between phases in single-case research. The analyses were done using the NAP calculator on the Single Case Research website (http://www.singlecaseresearch.org/calculators/nap). Parker and Vannest (2009) provided tentative clinically relevant effect sizes, based on the NAP ranges: weak effects: 0–0.65; medium effects 0.66–0.92 and strong effects: 0.93–1.0. When the score was lower during the intervention phase

(A) than during the control phase (B), the NAP calculation was reversed in the online NAP calculator (Morley, 2015).

Using the Fisher combined probability test, an overall average effect size was meta-analytically calculated by combining the results of the 11 single cases. This method consists of the sum of the natural logarithms of the *p*-values of each dataset, multiplied by −2. The result is a chi-square deviation with twice the number of *p*-values as the degree of freedom. Individual cases for which *p*-values were $< .005$, were replaced with .01 to exclude the possibility that the significance of the whole Fisher test was solely based on that p-value. If the results occurred in a non-expected direction, a *p*-value of .5 was used (De Weerth & Van Geert, 2002; Glass et al., 1981).

Social validity was calculated using the mean, standard deviations, and mean differences and the Wilcoxon signed-rank tests were performed on themes one, five, and six. Data was analysed using IBM Statistical Package of Social Sciences (SPSS version 25).

Results

Quantitative data

Caregiver sensitive and responsive behaviour

Attune and stimulate mother-infant checklist. The difference scores of the A&S-MI checklist did not yield significant results (see Table 2).

Mirroring behaviour. Figure 3 presents a comparison of the subscale Affective Mirroring (AM) behaviour during the control versus the intervention phases. Caregiver 11 showed a significant improvement across all four phases. Considerable improvement of AM across three phases was observed (Caregivers 4, 6, and 8). Caregivers 2, 9, and 10 decreased on AM in at least one of the phases, however they varied in their AM behaviour during the other phases. Even though Caregiver 2 had a considerable decrease in AM during one phase, she did experience a slight increase during the other three phases. Caregiver 9 appeared to have had the most significant decrease in three phases and only remained unchanged in the other phase. Despite a considerable decrease in AM behaviour in Caregiver 10's behaviour, she did show improvement during the other two phases.

The NAP scores on Total, Affective, Behavioural and Verbal Mirroring are reported in Table 2. Total Mirroring (TM) results indicated one significant strong positive effect (Caregiver 4: NAP = 1; $p = .021$). Non-significant but medium positive effects on TM were found for Caregivers 5, 6, and 11. Finally, Caregivers 1, 2, 9, and 10 exhibited non-significant medium negative effects.

Four caregivers made significant improvements in AM (Caregiver 4: NAP = .969, $p = .030$; Caregiver 6: NAP = .938, $p = .043$; Caregiver 8: NAP = .938, $p = .043$; Caregiver 11: NAP = 1, $p = .021$). Caregivers 1 and 5 had non-significant medium positive effects and Caregivers 9 and 10 had non-significant medium negative effects in AM, which could be of clinical relevance.

No significant strong positive or negative effects for Behavioural Mirroring (BM) were found. Caregivers 3, 7, and 9 showed a non-significant medium positive effect size and Caregivers 1 and 11 showed a non-significant negative effect size. The former indicating an increase and the latter a decrease on BM. The Verbal Mirroring (VM) results did not yield significant strong positive effects. Caregiver 8 scored significantly lower on VM in the intervention phase (NAP = .937, $p = .043$). Caregiver 4 had a non-significant, medium positive effect and Caregivers 2 and 9 had a non-significant negative effect.

In general, the NAP results indicate that 4 of the 11 caregivers (4, 6, 8, and 11) experienced a significant improvement in some form of mirroring behaviour. Furthermore, 8 of the 11 caregivers exhibited (all caregivers but 2, 8, and 10) medium positive effects related to at least one of the

Table 2. Difference scores and the NAP between the two phases for sensitive and responsive behaviour and for mirroring of the caregiver.

Dyad number	Sensitive and responsive behaviour	Total mirroring			Affective mirroring			Behavioural mirroring			Verbal mirroring		
	Difference score[a]	NAP score (effect size[b])	90% CI	*p*	NAP score (effect size)	90% CI	*p*	NAP score (effect size)	90% CI	*p*	NAP score (effect size)	90% CI	*p*
1	−.09	.656 (− −)	[−.400, 1]	.471	.719 (++)	[−.275, 1]	.312	.656 (− −)	[−.400, 1]	.471	.625 (−)	[−.462, .962]	.564
2	.25	.750 (− −)	[−.212, 1]	.248	.500 (+)	[−.712, .712]	1	.563 (+)	[−.587, .837]	.773	.875 (− −)	[.038, 1]	.083
3	.27	.625 (+)	[−.462, .962]	.564	.719 (− −)	[−.275, 1]	.312	.813 (++)	[−.087, 1]	.149	.563 (−)	[−.587, .837]	.773
4	.10	1 (+++)	[.288, 1]	.021*	.969 (+++)	[.225, 1]	.030*	.500 (+)	[−.712, .712]	1	.750 (++)	[−.212, 1]	.248
5	−.25	.750 (++)	[−.212, 1]	.248	.844 (++)	[−.025, 1]	.112	.500 (+)	[−.712, .712]	1	.625 (−)	[−.462, .962]	.564
6	.09	.875 (++)	[.038, 1]	.083	.938 (+++)	[.163, 1]	.043*	.438 (−)	[−.837, .587]	.773	.438 (+)	[−.837, .587]	.773
7	.46	.625 (+)	[−.462, .962]	.564	.469 (−)	[−.775, .650]	.885	.750 (++)	[−.212, 1]	.248	.406 (+)	[−.900, .525]	.665
8	.25	.625 (+)	[−.462, .962]	.564	.938 (+++)	[.163, 1]	.043*	.594 (+)	[−.525, .900]	.665	.938 (− − −)	[.163, 1]	.043*
9	0	.688 (− −)	[−.337, 1]	.387	.781 (− −)	[−.150, 1]	.194	.750 (++)	[−.212, 1]	.248	.688 (− −)	[−.337, 1]	.387
10	−.03	.844 (− −)	[−.025 <> 1]	.112	.688 (− −)	[−.337, 1]	.387	.625 (+)	[−.462, .962]	.564	.625 (−)	[−.462, .962]	.564
11	.08	.875 (++)	[.038 <> 1]	.083	1 (+++)	[.288, 1]	.021*	.688 (− −)	[−.337, 1]	.387	.5 (+)	[−.462, .962]	1
Fisher	−	$\chi^2 = 34.44$, df = 22, $p < .05$ *			$\chi^2 = 41.78$, df = 22, $p < .01$ **			$\chi^2 = 15.76$, df = 22, $p < .9$			$\chi^2 = 12.72$, df = 22, $p < .95$		

NAP = non-overlap of all pairs; CI = confidence interval.

[a]Difference score of > .56 is significant. [b]Effect sizes: + weak positive (NAP 0–0.65); ++ medium positive (0.66–0.92); +++ strong positive (0.93–1); − weak negative (0–0.65); − − medium negative (0.66–0.92); − − − strong negative effect (0.93–1) (Parker & Vannest, 2009).

*$p < .05$. **$p < .01$.

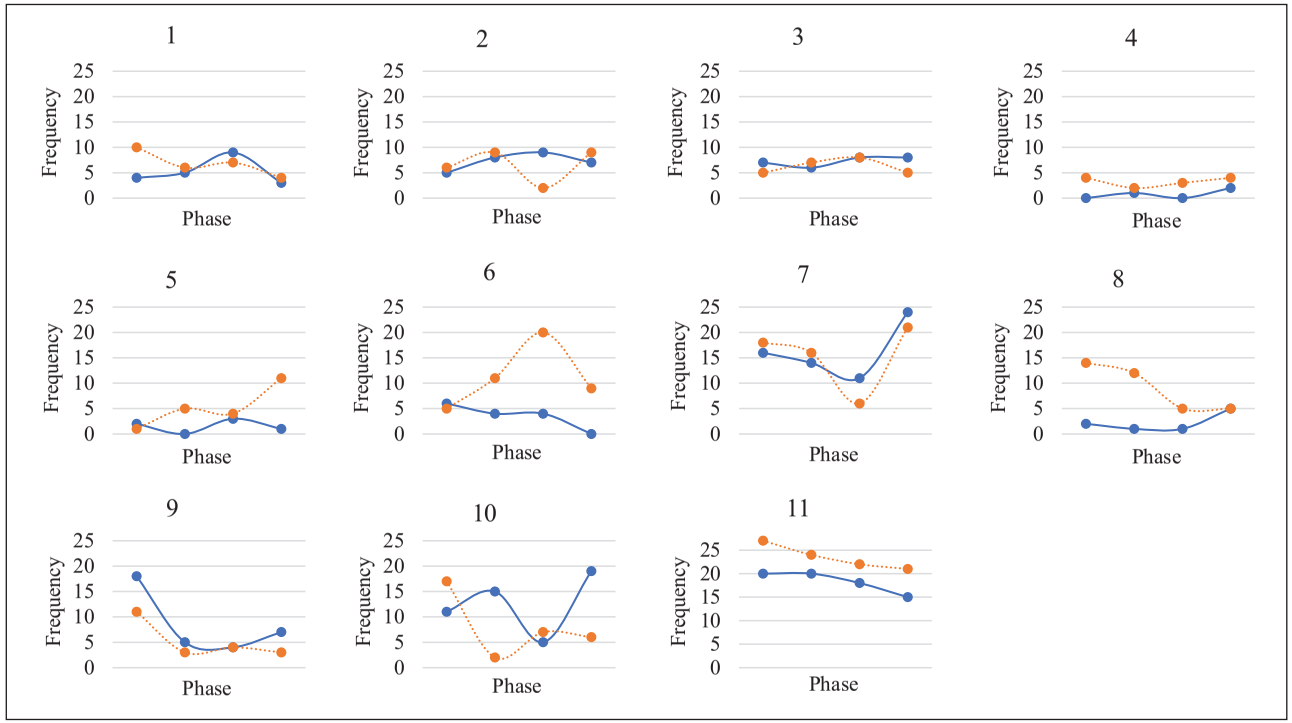

Figure 3. Affective mirroring (AM) graphs (numbers match Table 2) during play-as-usual (solid line) and Barti-mat (dotted line).

mirroring subcategories. Negative medium effects were observed in at least one of the mirroring behaviours in six caregivers (1, 2, 3, 9, 10, and 11). It was noted that Caregiver 8 exhibited significantly lower scores of VM, however she had significantly strong positive effects on AM.

The Fisher's combination of the *p*-values for the 11 caregivers indicated a significant improvement in TM ($\chi^2 = 34.44.$, $p < .05$) and AM during the intervention phase ($\chi^2 = 41.78$, $p < .01$). No significant differences between the intervention and control phases were found for BM and VM.

Child happiness

Happiness feature score. Table 3 shows the Happiness NAP scores. Child 3, 9, and 11 showed significant strong positive effects related to Happiness (all three children: NAP = 1, $p = .021$). On the other hand, Child 4 had strong significant negative effects (NAP = .969, $p = .030$). Child 7 exhibited non-significant medium positive effects and Child 5 and 10 non-significant medium negative effects. The Fisher's meta-analysis of the *p*-values for the 11 caregivers indicated a significant improvement in Happiness ($\chi^2 = 37.80$, $df = 22$, $p < .025$).

Arousal and valence. The valence of each child is depicted in Figure 4. Upon visual inspection, 5 of the 11 children (1, 5, 6, 9 and 11) exhibited more positive valence and less extreme fluctuations between positive and negative valence during the intervention phase. Six of the 11 children (2, 3, 4, 7, 8 and 10) showed more negative valence and greater fluctuations in valence. Even though three children (3, 7, and 8) had more negative valence and fluctuations during the intervention phase, it was noted that child three exhibited fewer extreme fluctuations and her positive valence was more consistent, whereas the other two children had higher levels of positive valence more consistently.

A summary of the Arousal, Valence and Positive Valence NAP results are reported in Table 3. Four of the 11 children had significant medium positive effects in their Arousal, indicating more optimal Arousal (Child 1: NAP = .751, $p = .003$; Child 4: NAP = .688, $p = .025$; Child 7: NAP = .756, $p = .002$; Child 11: NAP = .764, $p = .002$). Furthermore, a trend was found for Child 9 with a medium positive effect (NAP = .656, $p = .064$) and Child 10 with a medium negative effect (NAP = .660, $p = .060$).

The Valence results yielded significant medium positive and negative results. Two children displayed significant medium positive effects (Child 9: NAP = .881, $p < .001$; Child 11: NAP = .806, $p < .001$) and two children significant medium negative effects (Child 4: NAP = .887, $p < .001$; Child 10: NAP = .679, $p = .035$).

In summary, 4 of the 11 children had significant medium improvements in their Arousal. One child had clinically relevant positive and one child had clinically relevant medium negative effects on Arousal. Two children had significant positive medium effects and two children significant negative effects on Valence. One child improved on Arousal, as well as Valence.

The Fisher's combination indicated a significant improvement on Arousal ($\chi^2 = 51.42$, $df = 22$, $p < .01$) and no overall significant differences were found for Valence ($\chi^2 = 32.62$, $df = 22$, $p < .1$).

Qualitative data

Generally, caregivers were eager to play on the Barti-mat and three (4, 5, and 10) caregivers noted that their child needs additional time to get used to new toys. Five caregivers (1, 3, 7, 8, and 9) required additional reassurance about their ability to play. Two children (2 and 10) appeared disinterested in the Barti-mat. They had developmental ages of 2;9 years and 2;10 years and did not sleep well the night before. The moment of the visit influenced the play. For example, upon arrival two children (5 and 11) were still asleep. Even though additional time was given in which they could wake up, they were more fatigued throughout the session than other children. Fatigue and/or overstimulation was reported for 5 of the 11 children (1, 2, 3, 4, and 8). The play quality differed

Table 3. Summary of results of child variables.

Dyad number	Happiness			Arousal			Valence		
	NAP score (effect size[a])	90% CI	*p*	NAP score (effect size)	90% CI	*p*	NAP score (effect size)	90% CI	*p*
1	.594 (−)	[−.525, .900]	.665	.751 (++)	[.225, .779]	.003**	.648 (+)	[.018, .572]	.080
2	.594 (−)	[−.525, .900]	.665	.425 (+)	[−.428, .126]	.370	.646 (−)	[.015, .569]	.083
3	1 (+++)	[.288, 1]	.021*	.582 (+)	[−.114, .440]	.333	.409 (+)	[−.459, .095]	.279
4	.969 (− − −)	[.225, 1]	.030*	.688 (++)	[.100, .654]	.025*	.887 (− −)	[.497, 1]	<.001***
5	.750 (− −)	[−.212, 1]	.248	.428 (+)	[−.133, .421]	.392	.523 (+)	[−.324, .230]	.781
6	.594 (−)	[−.525, .900]	.665	.553 (−)	[−.171, .383]	.529	.555 (+)	[−.168, .386]	.516
7	.719 (++)	[−.275, 1]	.312	.756 (++)	[.235, .789]	.002**	.499 (+)	[−.279, .275]	.992
8	.688 (++)	[−.337, 1]	.387	.581 (+)	[−.116, .438]	.338	.528 (+)	[−.221, .333]	.742
9	1 (+++)	[.288, 1]	.021*	.656 (++)	[.035, .590]	.064	.881 (++)	[.485, 1]	<.001***
10	.813 (− −)	[−.087, 1]	.149	.660 (− −)	[.041, .601]	.060	.679 (− −)	[.079, .639]	.035*
11	1 (+++)	[.288, 1]	.021*	.764 (++)	[.251, .805]	.002**	.806 (++)	[.336, .890]	<.001***
Fisher	$\chi^2 = 37.80$, $df = 22$, $p < .025$*			$\chi^2 = 51.42$, $df = 22$, $p < .01$**			$\chi^2 = 32.62$, $df = 22$, $p < .1$		

NAP = non-overlap of all pairs; CI = confidence interval.

[a]Effect sizes: + weak positive (0–0.65); ++ medium positive (0.66–0.92); +++ strong positive (0.93–1); − weak negative (0–0.65); − − medium negative (0.66–0.92); − − − strong negative effect (0.93–1) (Parker & Vannest, 2009).

*$p < .05$; **$p < .01$; ***$p < .001$.

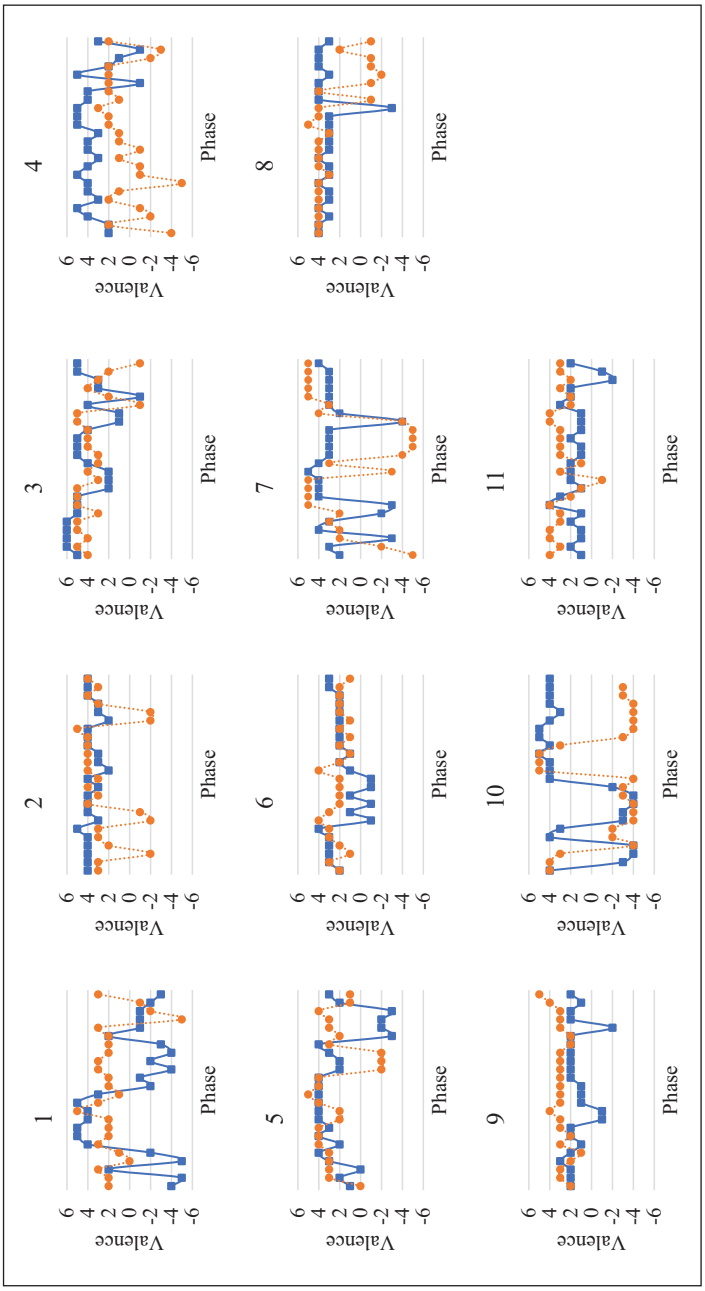

Figure 4. Valence graphs of all children (numbers match Table 3): play-as-usual (squares) and Barti-mat (dots).

Table 4. Social validity scale mean scores on the different themes.

Theme	T0: *M* (*SD*)	T1: *M* (*SD*)	Difference score
(1) Desirability	3.30 (.48)	4.00 (.67)	.70
(2) Intervention itself	3.78 (.51)	3.93 (.56)	.15
(3) Practicability	4.20 (.35)	3.70 (1.06)	−.50
(4) Effectiveness	3.56 (.46)	2.78 (.58)	−.78
(5) Caregiver subjective evaluation	3.60 (.52)	3.80 (.37)	.20
(6) Child subjective evaluation	4.00 (0)	3.03 (.71)	−.97
(7) Improvements		2.69 (.54)	
(8) Play again?		3.80 (.92)	
(9) Recommend?		4.00 (.94)	

from sensitive and supportive play (2, 5, 6, 8, and 11) to rough play (Caregiver 4) and one parent did not engage in relationship play (Caregiver 5).

Social validity

Expectations about the intervention desirability were on average 3.30 (see Table 4). The average experience related to desirability was 4.0, indicating an increase. Caregivers' experience of the intervention itself ($M=3.93$) were slightly higher than their expectations ($M=3.78$). The Barti-mat intervention was experienced as less practical than expected (T0: $M=4.20$; T1: $M=3.70$). Expectations related to the effectiveness ($M=3.56$) were positive, however their experience was less positive ($M=2.78$). Caregivers' subjective evaluation was more positive at T1 ($M=3.80$) than expected at T0 ($M=3.60$). This was confirmed by a significant change between the expectations and experiences of caregivers ($Z=-2.00$, $p=.046$). Subjective expectations of their child's enjoyment of the intervention were higher than what was experienced (T0: $M=4.00$; T1: $M=3.03$; Wilcoxon signed-rank test showed no significant difference). Seven caregivers indicated that they would use the Barti-mat again ($M=3.80$), two caregivers were neutral, and one was not interested. Furthermore, eight caregivers would recommend the Barti-mat to other caregivers with a child with a visual impairment ($M=4.00$), one caregiver was neutral, and one would not recommend it. The caregiver that was unable to complete the questionnaire, was interested in using the mat again. Improvements related to the volume and diversity of sounds were suggested ($M=2.69$).

Caregivers reported that they enjoyed participating in the study and were enthusiastic about the development of specialized play material for children with visual impairments. One mother described the value of the Barti-mat as: 'it makes it easier for parents to follow on the play of their child'. Some caregivers were uncertain about how to play with the Barti-mat. Most caregivers reported that their children enjoyed at least one aspect of the multi-sensory experience. Some children appeared to actively engage with the Barti-mat, whereas others felt pressured to perform or became passive. In general, children enjoyed the sequin and furlike fabric. Suggestions related to future development were: the length of sound should be adjusted, additional sound settings should be added, making the mat non-slip, a variation for wheelchair bound children should be developed and altering of the size of the mat and/or squares could add to the frequent use.

Discussion

This study investigated the efficacy and social validity of the Barti-mat – an interactive supportive technology, focussing on improving sensitive and responsive caregiving (including mirroring) and

the happiness of children with visual or visual-and-intellectual disabilities. The use of a multiple within-series single-case design, with randomized blocks is unique within this population group and allows for greater generalizability of the results (Kratochwill & Levin, 2010). To the best of the author's knowledge this is one of the first interventions that utilizes supportive technology to promote sensitive and responsive caregiver behaviour and improve the happiness children with visual or visual-and-intellectual disabilities. Furthermore, the Barti-mat is currently in the highest stage of technology readiness (i.e., 'actual system proven through successful mission operations'), which is rare for interactive technology within this field (Dyzel et al., 2020).

Caregivers experienced an improvement in at least one sub-category of their mirroring behaviour, while interacting with their children on the Barti-mat. Specifically, significant improvements were seen in caregivers, male and female, that were either more naturally inclined to or had challenges related to relationship play, despite any language barriers. More research with regards to diverse caregivers should however be performed.

These results are important findings for caregivers with children with visual or visual-and-intellectual disabilities, especially as mirroring behaviour is often difficult due to the relationship dynamics within the dyad (Sakkalou et al., 2021). Using the Barti-mat as a natural catalyst for improving mirroring behaviour which, as a sub-feature of sensitive and responsive behaviour, is critical as mirroring is thought to be the primary mechanism influencing the quality of the caregiver–child relationship (Feniger-Schaal & Joels, 2018).

The Barti-mat stimulates relationship play in a naturalistic setting, without needing extensive psycho-education about sensitive and responsive caregiver behaviour. The caregivers resonated with this approach as their subjective experience of the Barti-mat as well as the desirability thereof was positive, and they would generally recommend and use the Barti-mat again.

Children either being over- or under-stimulated often hinder quality caregiver–child interactions (Frederiks et al., 2019; Van den Broek et al., 2017). When children engaged in relationship play on the Barti-mat they experienced fewer extreme fluctuations in their emotions and their they were more optimally aroused. Moreover, four children experienced a direct increase in happiness. These results indicate that children are more optimally aroused and experience more positive emotions on the Barti-mat, which allows for greater quality interactions between a caregiver and a child with a visual or visual-and-intellectual disability (Van den Broek et al., 2017). Even though there appears to be an improvement in both arousal and valence for children with a developmental age below 3 years, it was noted that older children without developmental delays who were tired, were less happy and more over-aroused. As such, more research is needed concerning the efficacy of the Barti-mat in older children.

Children who were blind or with a visual impairment were included and no children were excluded due to any co-occurrent disorders, allowing for a diverse group. The results of both caregiver sensitive and responsive behaviour and the children's happiness has important implications for the implementation of the Barti-mat, especially within such a diverse group in which each child's strengths and weaknesses can influence the type of play that they can engage in (Van den Broek et al., 2017). The Barti-mat creates an environment in which a child can engage in quality relationship play in their own unique manner at their own pace.

The caregiver's experience of the practicality and the effectiveness of the intervention was slightly less positive after the intervention. However, this was often attributed to the child's developmental age, caregiver's anxiety related to relationship play, the child's ability to engage with a new toy in such a short period of time and finally, contrary to the results, the parents' perception was that their child's subjective experience was slightly poorer than expected. Thus, these aspects need to be taken into consideration when introducing the Bart-mat in practice. For example, a Bart-mat video-clip and/or interactive Barti-mat play guide can optimize expectations and

support the use. The parent can then determine the length of play matching also the developmental age of the child.

The results show that the Barti-mat could be a valuable adjunct to the 7-session VIPP-V interventions (Overbeek et al., 2015; Platje et al., 2018) and 10-session ABC intervention (Mohamed et al., 2021). Combining this intervention with a preventive attachment-based intervention such as the use of the Barti-mat, may allow caregivers to practice sensitive and responsive behaviour in an optimal environment where children are optimally aroused.

Specific limitations related to the research were identified. Even though the sample size was diverse and representative of the general target population and for every child there were eight phases, a small sample ($n = 11$) was used. To further study the efficacy of the Barti-mat, a replication of the study and bigger and more diverse sample is advisable. Even though measures were implemented to decrease any bias during the study, the telephonic interviews could have caused social desirable answers. Furthermore, during the national Covid-19 pandemic lockdown caregivers and children spent more time together, it is unclear how the results were impacted. Finally, in future the quality of the research can improve when independent researchers conduct the data collection.

Conclusion

This study indicated that the Barti-mat, as an adjunct preventive attachment-based intervention, has the potential to improve sensitive and responsive caregiver behaviour and the happiness of a child with a visual or visual-and-intellectual disability. The simplicity of the intervention appears to make it appropriate for a broader caregiver population and does not exclude anyone based on their level of education, language, or gender. Furthermore, this intervention is appropriate for children under the developmental age of 3 years and does not exclude any child based on co-occurrent conditions. It allows caregivers and children to engage in quality interactions, which can decrease cycles of miscommunication and improve their relationship.

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Author Contributions

P.D-V. was the main researcher. P.D-V. and V.D. collected data and conducted the data analysis. V.D. wrote the first draft; thereafter, P.D-V. and P.S.S. revised the text. Then, all the authors contributed to all the parts of the manuscript. P.S.S. coordinated the study.

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Ethical approval

This study was approved by the Independent Review Board Nijmegen (Date: Tuesday, 4 June 2019, 21:09 pm), registered with the Open Science Framework (Dekkers-Verbon & Sterkenburg, 2019, 14 October; https://osf.io/ct7ka)

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