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Potential of a digital parenting app to support parents of toddlers: Relations between the intensity of app use, language-related parental self-efficacy and the home literacy environment

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Abstract

The home literacy environment (HLE) has a considerable influence on children's language development. How parents perceive their own parenting abilities (e.g., how well they encourage their children's language development) is particularly important when it comes to guiding their children appropriately through different stages of development. This self-perception, referred to as parental self-efficacy (PSE), is an important aspect of the home learning environment that has been shown to be a significant predictor of beneficial parenting practices and ultimately successful child development. However, families exhibit differences in how they encourage their children's language development and need support to feel confident in their parenting abilities. Furthermore, the family environment is becoming increasingly digitalised. Thus, there is great potential for the HLE to be enhanced via digital family support. The present study empirically tests relations between the intensity of use of a family support app, language-related PSE and HLE based on data from 184 German families with toddlers. Results of mediation analyses showed that the intensity of app use was positively related to increases in

language-related PSE, which again was positively associated with an increased frequency of language-stimulating activities in the HLE. There was no direct association between the intensity of app use and language-stimulating activities. The findings illustrate that parenting apps offer a promising approach to strengthening PSE. The results also reflect more broadly the relevance of language-related PSE for the HLE of families with toddlers.

KEYWORDS
digital family support, home literacy environment, parental self-efficacy, parenting app

Key insights

What is the main issue that the paper addresses?

The main issue of the paper is the potential of a digital parenting app to increase parental self-efficacy and improve the home literacy environment in families with young children by increasing parental engagement in language development activities.

What are the main insights that the paper provides?

The paper reveals that the intensity of app use is positively related to an increase in language-related parental self-efficacy, which in turn increases the frequency of language-stimulating activities in the home literacy environment, emphasising the importance of digital support tools (e.g., parenting apps) for parenting abilities.

INTRODUCTION

In the context of early childhood development, the family constitutes the primary and most influential learning environment. In terms of language stimulation, activities or interactions in the home learning environment are of crucial relevance for children's language development (Bronfenbrenner & Morris, 2006; Niklas & Schneider, 2017). Furthermore, national and international studies highlight the importance of the home learning environment for early childhood education (Kluczniok et al., 2013; Melhuish et al., 2008; Sammons et al., 2008). A prominent model for gaining insights into early childhood education in the family is the structure–process model of the home learning environment (Kluczniok et al., 2013; Melhuish et al., 2008). This model differentiates between three dimensions: structural characteristics (e.g., household income, parental education level), parental beliefs like parental self-efficacy (PSE) and processes. Processes here are defined as parent–child activities or interactions which have a direct impact on children's formal and informal learning outcomes (e.g., their language and literacy skills) (Kluczniok et al., 2013).

Toddlers who have not yet experienced institutional education outside the family are highly dependent on a stimulating home learning environment. Considering this, the World Health Organisation (WHO) emphasises the relevance of parental engagement for early learning in the first 3 years of life (the first 1000 days) and sees this period as crucial for effective interventions (WHO, 2020). At the same time, research findings indicate that there are considerable differences in the ways families encourage children's language and literacy skills (Lehrl et al., 2020; Morgan, 2005; Wirth et al., 2023) and that these are already evident in early childhood (Ginsborg, 2006; Hirsh-Pasek et al., 2015). One approach to counteract this inequality could be to implement family support services that promote children's language development as early as possible (Niklas et al., 2024), and thus increase the quantity and quality of children's early literacy experiences in the home learning environment (Ebert et al., 2012; Linberg et al., 2020; Melhuish et al., 2008; Son & Morrison, 2010).

However, many family support programmes fall short of their potential in terms of fostering an effective home learning environment through parent–child activities that stimulate learning (Anders et al., 2019); consequently, a further valuable approach would be to implement programmes to enhance PSE, which has been shown to be an important predictor of successful child development (for an overview, see Gessulat, 2021; Wittkowski et al., 2016). Furthermore, as digital media only continue to grow in relevance, programmes aimed at supporting the family environment can use this development as an opportunity to make existing services more flexible. In addition, via digital forms of family support, information can be made available more quickly and new knowledge can be obtained faster (Biber et al., 2019). At the same time, studies demonstrate that supporting parents with notifications on digital devices is a promising approach for family support programmes: on the one hand, they help parents provide early language stimulation and, on the other hand, they strengthen the perception of PSE (Jelley & Sylva, 2018; Jelley et al., 2016; York et al., 2019).

The Carina Foundation, a German charitable organisation, has begun to address the promising potential of digital family support by developing a parenting app for their family support programme *Chancenreich* (www.carina-stiftung.de/chancenreich). In Germany, empirical evidence regarding family support programmes is still limited, and especially so for programmes that use digital approaches to support families (Cohen et al., 2020; Prokupek & Cohen, 2020). Furthermore, studies often do not examine long-term relations between programmes and their results (Van der Stede, 2014). Therefore, the present study tested, in families with toddlers, the longitudinal relations between the intensity of parents' use of the *Chancenreich* app, language-related PSE and language-stimulating activities in the home literacy environment (HLE).

THEORY AND RESEARCH STATUS

The home learning environment as a place of early language development

In early childhood research, various conceptualisations of the home learning environment exist. The model of the home learning environment (Kluczniok et al., 2013; Melhuish et al., 2008) on which this paper is based is a multidimensional concept that defines three different dimensions and their relationship to each other: structural characteristics, parental beliefs and processes.

Structural characteristics describe stable, enduring aspects of a family (e.g., household income or parental education level). The second dimension comprises parental beliefs (e.g., self-reported perceptions of PSE). It is assumed that parental beliefs develop over the course of a lifetime, are mediated by enculturation processes and are stable in the medium term

(Melhuish et al., 2008). Therefore, they are subject only to slow changes. A central assumption in this model is that both a family's structural characteristics and the parents' beliefs are directly related to the third dimension—the processes within a family. Processes, which in turn directly influence the child's development (Melhuish et al., 2008), include not only global processes in a family, like warmth and parental responsiveness (Foster et al., 2005; Lehrl et al., 2020), but also domain-specific processes (e.g., home literacy activities, like the frequency of reading aloud, which are considered key characteristics for successful language development in childhood) (de Bondt et al., 2020; Niklas & Schneider, 2013).

Early cognitive skills are among the most crucial determinants of children's successful participation in education, and the first years of life are particularly important in their development. Studies, including longitudinal analyses, show that cognitive skills correlate strongly with literacy skills and can be influenced by various factors such as a family's household income. The targeted promotion of these skills can be encouraged in the family, for example by focusing the child's attention on a specific task or by offering learning-stimulating activities (for an overview, see Birtwistle et al., 2025).

In the literature, learning-stimulating activities are often categorised according to their actual subject matter (Niklas & Schneider, 2013; Sénéchal & Young, 2008)—a valid approach, as the development of different competence areas in early childhood is domain-specific (Wellman & Gelman, 1998). Accordingly, a differentiated model of the home learning environment, one that includes a home literacy model referring specifically to early literacy acquisition, is widely accepted in domain-specific early childhood research (Raikes et al., 2006; Sénéchal et al., 1998). This distinction is also used in German-language studies on the home learning environment (e.g., Lehrl et al., 2013; Niklas & Schneider, 2013).

The theoretical framework of the home literacy model, proposed by Sénéchal et al. (1998), is an empirically tested model that explains the relations between certain children's development and learning-stimulating activities in the family environment. In categorising the processes within the family, the model distinguishes between formal and informal literacy activities at home. Formal activities involve activities with printed material (e.g., learning letter sounds), while informal activities (e.g., reading aloud) focus on the content of the material rather than on the printed word itself. Accordingly, a central assumption of the home literacy model is that experiences of informal activities, especially with books and shared reading in the first years of life, play a crucial role in furthering children's language skills and vocabulary, again underlining the importance of language-stimulation activities in the first years of life for subsequent language development (Niklas et al., 2024).

There are also a number of theoretical assumptions about the relationships between processes and child development, with studies showing that informal literacy experiences—such as reading aloud, singing songs or reciting rhymes—can be of particular importance for language development at a very early stage (Baker, 2013; de Bondt et al., 2020; Niklas et al., 2016). The positive effects of reading aloud on children's language and reading skills have been established by numerous studies (Raikes et al., 2006; Sénéchal & Young, 2008; Sénéchal et al., 1996; Van Steensel et al., 2011).

Research also shows that it is not only the frequency of reading aloud that is relevant, but also the age at which it first occurs: looking at picture books together with children under the age of three is positively related to their language and reading skills (Attig & Weinert, 2020; Karrass & Braungart-Rieker, 2005; Niklas et al., 2016; Rodriguez & Tamis-LeMonda, 2011), with both the active linguistic input of parents and their responsiveness to their children's vocalisations playing a particularly influential role (Goldstein & Schwade, 2008; Tamis-LeMonda et al., 2014). As Niklas et al. (2016) show, many parents start reading to their children when they reach the age of about 6 months, making it a reasonable and potentially fruitful undertaking to investigate the early HLE of toddlers in depth. Rodriguez and Tamis-LeMonda (2011), for example, examined children's home

learning environments in a low-income sample of 1852 children and families when children were 15, 25, 37 and 63 months; they found that children who grew up in a stimulating learning environment in their first year of life had a significantly richer vocabulary than children who received less language-related stimulation or started later. These findings indicate that learning-stimulating activities have a direct influence on children's language development.

The theoretical assumptions about the relationships between the three dimensions of the home learning environment in early childhood often focus on the influence of structural characteristics on family processes. For instance, the number of adults or siblings living in the household (family setting) serves to explain disparities regarding the resources, such as parental attention or patience, available to each child (Öberg, 2017). Furthermore, educational disadvantage can partly be attributed to insufficiently stimulating learning at home (e.g., language-stimulating activities rarely take place) (Melhuish et al., 2008; Silinskas et al., 2020). Still, research repeatedly shows that structural characteristics have an influence on processes, but they do not fully explain their variance (Bornstein & Bradley, 2008; Sylva et al., 2004): what is important is how committed parents are to their child-rearing tasks and how intensively they engage with their children (Sylva et al., 2004). However, more recent empowerment approaches also focus on parental abilities and PSE. In this regard, growing importance is ascribed to family support programmes that improve the quality of the overall home learning environment by furthering parental abilities, thus also positively influencing children's (language) development (Kuger et al., 2012).

PSE as a significant predictor of language-stimulating activities

Transferring Bandura's theory of self-efficacy to parenting, the concept of PSE refers to parents' beliefs regarding the adequacy of their own parenting abilities. It encompasses parents' self-perception of their parenting role and their beliefs regarding how to engage in specific parenting tasks (e.g., encouraging a child's language development) (Bandura, 1997). Thus, parents who are characterised by a strong sense of PSE find it easier to guide their children competently through different developmental milestones, while those with lower levels of PSE may find it challenging to handle the complex demands of parenting (Gessulat, 2021).

PSE is integrated into the model of the home learning environment as part of the aspect ‘parental beliefs’. Following the central assumption of this model, PSE is directly related to processes within a family. In fact, studies show that PSE is a significant predictor of enriching parenting, learning-stimulating activities and ultimately successful child development (Gessulat, 2021; Jones & Prinz, 2005; Peacock-Chambers et al., 2017; Vukovic et al., 2013). Furthermore, Bojczyk et al. (2018) were able to demonstrate that PSE is domain-specific and that language-related PSE must be supported specifically in order to strengthen the HLE. Regarding the relationship between structural characteristics of the home learning environment and PSE, research shows that parents with low income, low educational level or who are of migrant origin have been found to experience low PSE (Ardelt & Eccles, 2001; Peacock-Chambers et al., 2017; Wittkowski et al., 2016). Structural characteristics, such as a family's income and the parents' level of education, are relatively stable characteristics of the home learning environment (Melhuish et al., 2008) and can rarely be changed. Therefore, to improve the quantity and quality of children's early literacy experiences, it is necessary to focus on PSE and to consider how to strengthen it in a domain-specific way.

Family support programmes and emerging digital approaches

Very young children in particular are highly dependent on the stimulating character of the home learning environment. This increases the importance of early interventions that specifically strengthen PSE, to help parents feel competent enough to encourage their children's domain-specific skills (e.g., early language development) (Ereky-Stevens et al., 2019; Kuger et al., 2012). To our knowledge, little research has been conducted into how this can be realised for parents of children in their first year of life.

Family support services can face problems like the lack of accessibility for certain target groups (socially disadvantaged families or families with major language problems) (Anders et al., 2019). Additionally, the content of family support programmes is not always geared towards the actual needs of families (Anders et al., 2019). Lastly, the rigid time structures and 'come and go' nature of traditional family support programmes—with families often having to go to a certain place at a certain time for support—frequently lead to non-participation, so that the transfer of educational content and support into everyday family life is often unsuccessful (Cadima et al., 2017). For these reasons, and because of the rapid development and spread of digital media, parents are increasingly seeking support for parenting issues digitally. This is driven by the fact that digital media offers parents various ways to further their children's education and offer their support, while at the same time providing quick access to information and a potentially huge increase in knowledge (Biber et al., 2019). In this way, the continuing digitalisation of everyday life also extends to the home learning environment (Chaudron, 2015; Cieciura et al., 2019). Moreover, today's parents are naturally familiar with digital media and enjoy engaging with them (e.g., by using it to cope with boredom or stress) (Plowman et al., 2010; Radesky et al., 2015). Digital media have, in sum, become a constant companion, fully integrated into everyday routines and permanently available (Brito et al., 2017).

This development also offers new opportunities for family support programmes, particularly with regard to app-based support. The unique added value of digital media lies in the broad wealth of experience and knowledge that can be accessed flexibly in terms of both time and place, and thus at a low threshold. In addition, digital programmes and products can be used to address specific, potentially hard-to-reach, target groups (Breitenstein et al., 2014). Digital media, such as parenting apps, can therefore be used as an innovative approach to family support programmes, and there is evidence that family support programmes are increasingly making use of this (Prokupek & Cohen, 2020).

Some studies that have investigated the potential of digital media in helping parents promote a stimulating home learning environment have already shown that parenting apps represent a promising approach for providing early language stimulation. York et al. (2019) were able to confirm that notifications on smartphones, laptops or tablets are particularly effective. As part of their study, a text message intervention was conducted for parents of preschool children in a control group design. The notifications addressed a range of topics, comprising knowledge transfer, motivation and reinforcement of parenting, activity suggestions or recognition of progress. Results show that the intervention improved the engagement of parents from the intervention group, and in doing so positively influenced their children's early literacy skills (e.g., awareness of first sounds, vocabulary and rhymes, building quality parent–child book interaction).

It was also found that parenting apps can have an impact not only on parent–child activities, but also on PSE in the specific context of children's literacy development. The parenting app *EasyPeasy* (www.easypeasyapp.com) promotes educationally stimulating parent–child interactions by suggesting joint activities. Parents receive regular reminders via the app that include brief notifications regarding their children's development and appropriate ideas for educationally stimulating activities in different developmental areas (e.g., language and

number skills). Studies reveal a significant positive influence of usage of the app on PSE in terms of a parental sense of control (Jelley & Sylva, 2018; Jelley et al., 2016). As PSE is a broad concept that can include diverse parental tasks and perceptions (Bojczyk et al., 2018), there is a need to examine task-specific measures of PSE more generally, and—following on from the findings on parenting apps like *EasyPeasy*—to investigate the relationship between PSE and usage of parenting apps in a domain-specific context.

In summary, studies indicate that supporting parents through notifications on digital devices is a promising approach for family support programmes. Moreover, findings highlight the realistic potential of parenting apps for both PSE and HLE. However, the relationship between the three components intensity of app use, PSE and language-stimulating activities has not yet been analysed in detail. In addition, the findings presented relate to children aged two to six. Their significance for families with considerably younger children is still unclear. Particularly with regard to parents with toddlers, it is important to take into account that the daily demands of family life can make it quite challenging for families to persevere with support programmes and not drop out prematurely. For the design of need- and reality-based family support, it is therefore also important to determine the minimum intensity of an intervention (threshold value) that must be provided in order for programmes to achieve their goals.

The family support programme *Chancenreich*

The Carina Foundation, a German charitable organisation (www.carina-stiftung.de/chancenreich), in cooperation with the German city of Herford (North Rhine-Westphalia), created the family support programme *Chancenreich* in 2009. The programme specifically addresses the parents of newborns and supports them until their child is 3 years old. It is one of the few family support programmes in Germany that has been extensively and scientifically evaluated for its impact and has been proven to positively influence learning-stimulating activities and PSE in the home learning environment (Anders et al., 2015, 2017, 2023). As part of the *Chancenreich* programme, participating families receive personalised support in caring for their child. In addition to counselling from family visitors, the programme provides parenting courses, a parent handbook and networking opportunities.

As part of the emerging digitalisation of family support and to expand *Chancenreich*, a smartphone app for parents of newborns was developed. It contains organisational elements (e.g., appointment reminders) and an educational component, with the latter aspect of direct relevance for the home learning environment. The educational component was designed to improve children's early literacy experiences in the first years of life by encouraging both parents' own beliefs (like their language-related PSE) and more concretely the type, frequency and quality of the language-stimulating activities they engage in with their children. In light of the strong focus on early language development, the app content was primarily addressed to parents with children at a particularly language-sensitive age (from birth to 24 months).

All parents who participate in the programme can download the app on their own digital devices and log into it. The app contains weekly topics (for an overview, including summaries of the specific message content, see Table A1 in Appendix A) and sends three push messages per week to parents' smartphones or tablets. When parents click on the message, they are taken to a personal dashboard that presents them with an overview of the current weekly topic, weekly tasks that they have already completed and those that can still be done. These tasks encourage parents to engage in specific language-stimulating activities with their child or contain further information regarding language development, stressful experiences or strengthening one's own role as a parent. Parents will then receive a series of push messages throughout the week, with new weekly topics published regularly, and three

corresponding tasks encouraging parents to improve the early literacy experiences of their child.

Based on the study by Doss et al. (2018), different message types were developed as a basic framework for the *Chancenreich* app. Message type 1, referred to as 'FACTS and TIPS', is sent out at the start of every week and provides families with information and tips on everyday language-stimulating activities to promote children's language development. These activities are designed to be effortlessly integrated into parents' daily routines, with a focus on using materials already available in their home. Towards the middle of the week, parents receive a type 2 message—'GROWTH'—that contains suggestions for developing their own language-promoting abilities and strengthening their language-related PSE. Finally, the week concludes with a 'SPECIAL' message (type 3), which expands upon information and practical tips in the 'FACTS and TIPS' message. An input field under each app task also gives parents the opportunity to reflect on their experiences after completing it. Since multisensory experiences can help infants and toddlers acquire new words (Lewkowicz et al., 2015; Yu & Smith, 2012), some of the tasks include activities in which parents encourage their children to associate things they see, feel, hear or taste with new words. The trial lasts 10 weeks in total, in which time parents could complete up to 30 tasks within the app. To maintain motivation to continue using the app, parents can collect pictorial 'language development rewards' in the app for completing tasks. In addition, this allows them to track their progress within the app.

In summary, research has shown that the promotion of PSE can be an important predictor of successful child development, and especially so in the context of early cognitive and language skills (Gessulat, 2021; Wittkowski et al., 2016); equally, the influence of app-based programmes on PSE and learning activities in the HLE has also already been shown to be effective (Jelley & Sylva, 2018; Jelley et al., 2016; York et al., 2019). This paper therefore deals with the potential of parenting apps for both language-related PSE and HLE, using the example of *Chancenreich*. In particular, the focus is on relations between the following three components: intensity of app use, language-related PSE and language-stimulating activities, as well as on their importance for families with toddlers. The investigation of the potential of the *Chancenreich* app for the HLE, especially regarding changes in language-related PSE, represents an important contribution to the differentiation of further research results on digital support for parents. Based on the existing research discussed here, we assume that intensive app use will lead to increased PSE (i.e., that parents will feel more effective in engaging with their child's language development). Such a change in perceived or actual parenting abilities could be particularly relevant for those parents who tend to have low language-related PSE.

Research questions

This study examines relations between the intensity of app use, language-related PSE and HLE of families with toddlers. The research questions (RQs) and hypotheses are as follows:

RQ1 What is the relation between the intensity of use of the *Chancenreich* app and changes in language-related PSE?

We expect the number of completed app tasks in the *Chancenreich* app to be positively related to increases in language-related PSE (*H1a*). Furthermore, we assume that a minimum number of app tasks (i.e., a certain threshold value) must be completed for there to be positive relations with increases in language-related PSE (*H1b*).

RQ2 How are changes in language-related PSE related to changes in the frequency of language-stimulating activities in the HLE?

Based on the empirical research literature, it can be assumed that an increase in language-related PSE is associated with increases in the frequency of language-stimulating activities in the HLE (*H2*).

RQ3 Are there direct and/or indirect relations between the intensity of use of the *Chancenreich* app and changes in the frequency of language-stimulating activities in the HLE, mediated by changes in language-related PSE?

Based on H1a and H2, we hypothesise that the intensity of use of the *Chancenreich* app is related to increases in the frequency of language-stimulating activities in the HLE, mediated by increases in language-related PSE (*H3*).

METHOD

Study design

Data come from the DIGIFam study, which examined the different digital approaches of the *Chancenreich* family support programme (Anders et al., 2023). Our analyses are based solely on those surveys that deal with the use of the *Chancenreich* app. The study was conceived as a quasi-experimental comparison group design, conducted longitudinally over three data collection time points. The first online survey (t_1) took place directly before the start of the app intervention to collect information on families' initial situations. After the intervention, all parents answered the second online survey (t_2) to record the direct effectiveness of their usage of the app. After about 3 months, the third online survey (t_3) was administered to all parents to track the longer-term effectiveness of app usage. The following analyses of language-related PSE and language-stimulating activities refer to the results at t_1 and t_2, and the change between these two measurement points. In addition to the survey, data were collected on app usage behaviour, which permitted the number of tasks completed in the app to be determined. The research project was reviewed and approved by an ethics committee in accordance with local legislation and institutional requirements.

Sample

Between September 2021 and September 2022, parents were recruited through the family support programme *Chancenreich*, at day care centres and family centres, and via social media. In addition, flyers were distributed in public places, resulting in a convenience sample. To enable comparability between the groups and to avoid confounding, and thus distortion of the results, diverse background characteristics of the families (e.g., their child's age, the family's language, the household income) were gathered in the online surveys and taken into account in the analyses. The 220 participating families consisted of an intervention group (app users) and a comparison group. Parents in the intervention group had access to the *Chancenreich* app and received information on their child's language development. Additionally, 69 parents of the intervention group participated in an online parenting course on early language development. Please note that differences between these parents and parents from the app-only group are not the focus of this paper. Parents in the comparison group did not use the app or receive any other language-related family support from *Chancenreich*. We

excluded all cases without children in the household ($n = 5$), children who were in quarantine due to the COVID-19 pandemic at t_1 ($n = 15$) and households without toddlers ($n = 16$).

To answer the research questions, our main sample thus comprises 184 families with children aged 3–24 months ($M = 12.5$, SD = 3.5). Of these, 131 parents belong to the intervention group and 53 to the comparison group. An overlap of the groups was statistically excluded. Some 95% of participating parents were mothers. The average age of parents was 34 years (SD = 4.2, age range 24–49 years). The majority of parents showed a somewhat higher level of education than the general German population (German Federal Statistical Office, 2024): 75% had a high school diploma (general population: 34%) and 62% a university degree (general population: 19%). This sample information indicates a highly privileged, homogeneous group of parents, which is why the consideration of parental education has little added value for subsequent analyses.

Measures

Language-stimulating activities

Using an eight-point response scale (from 1 = never to 8 = several times a day), we asked parents about the frequency of language-stimulating activities (e.g., reading or looking at picture books together) that they or another family member engaged in with the target child. In the longitudinal questionnaire, we asked parents to refer solely to the child with whom they participated in the *Chancenreich* app programme. This scale consists of nine items (t_1: $\alpha = 0.80$, $\Omega = 0.81$; t_2: $\alpha = 0.75$, $\Omega = 0.75$). Using the scales of frequency of language-stimulating activities (partly adapted from Caldwell & Bradley, 1984) at t_1 and t_2, we created a change variable for the frequency of language-stimulating activities. In our analyses, we will consider this change variable as a dependent variable.

Language-related PSE

Because self-efficacy is goal-directed (Bong & Skaalvik, 2003), we constructed a scale for language-related PSE, inspired by Coleman and Karraker (2003). This scale contains five items directing parents to rate their level of confidence in their ability to provide early language support (t_1: $\alpha = 0.84$, $\Omega = 0.84$; t_2: $\alpha = 0.90$, $\Omega = 0.90$). Using a five-point response scale (from 1 = strongly disagree to 5 = strongly agree), parents agreed or disagreed with statements such as ‘I am confident that I can support my child's language development in an age-appropriate manner’. Using the language-related PSE scale at t_1 and t_2, we created a change variable for language-related PSE.

Intensity of use of the *Chancenreich* app

We measure the intensity of use of the *Chancenreich* app with the number of completed app tasks offered during the 10-week intervention as a predictor (0–30 tasks). Week 2, for example, focused on the topic ‘picture books’. Here, parents received suggestions and information revolving around the fact that even in their first year of life, children are sensitive to learning language, emphasising that parents have a great influence on how their children learn to speak. Consequently, the app suggests that—for instance—parents look at books together with their toddlers; in this way, babies can learn new words through play (Table A1). For the comparison group we set the missing values of the app tasks to zero.

This allows us not only to differentiate between the intervention group and the comparison group, but also to differentiate more clearly between the intensity of app use and non-use.

Control variables

As control variables, we included the age of the target child (in months) at t_1, the family language (1 = not predominantly German, 0 = predominantly German), socioeconomic status (SES) measured by the family's net equivalent income and the number of children (0–17 years) and adults (18 years and older) living in the household.

Statistical analyses

We computed descriptive analyses and determined interrelations between the intensity of use of the *Chancenreich* app, changes in language-related PSE and changes in frequency of language-stimulating activities with linear regression and mediation analysis in Mplus (Version 8.3; Muthén & Muthén, 1998–2012). Corresponding correlations are included in the online supporting information (Table S1). The mediation model was tested by analysing confidence intervals of the multiple regression to determine the significance of the total, direct and indirect effect. We used bias-corrected bootstrapping with 2000 iterations (MacKinnon et al., 2004) to estimate confidence intervals and inferential statistics. Effects were considered significant if the confidence interval did not include zero. In order to determine the minimum number of app tasks that parents must have completed for there to be positive effects on language-related PSE, a threshold value analysis was carried out in Ggplot/R.

To verify whether data for the relevant variables were systematically missing, we conducted a missing data analysis. We used Little's (1988) test for completely missing values at random (MCAR). The pattern of missing values is included in the online supporting information (Tables S2 and S3). Results of the MCAR test showed that data were not missing at random (MNAR) in the continuous variables relevant to us (6% net equivalent family income in euros [SES], 22% frequency of language-stimulating activities at t_2 and 23% change of language-related PSE: $\chi^2 = 90.69$, df = 42, $p = 0.000$). Results like these often occur when surveying income. Additionally, the dropout of some parents from the study between t_1 and t_2 ($n = 40$) may explain the missing data regarding the frequency of language-stimulating activities at t_2 and changes in language-related PSE. To understand the impact of dropouts on the data and the overall results of the study, we also performed a selection analysis in Mplus. This demonstrated that parents who completed fewer app tasks were more likely to drop out before the second measurement point (OR = 0.9, $p = 0.000$). Also, families who spoke a language other than German appeared to be 4.3 times more likely to drop out at t_2 ($p = 0.008$). However, Shin et al. (2009) argue that even under MNAR, the full information maximum likelihood (FIML) approach yields the least biased parameter estimates and the lowest parameter estimation error. Following this, FIML estimation was used in all our following analyses.

RESULTS

Descriptive results

The descriptive results (Table 1) showed that already at t_1, pronounced ceiling effects were evident in the scales for language-related PSE and language-stimulating activities. A large proportion of participating parents achieved very high or near-maximum scores: before

TABLE 1 Descriptive results.

	App users ($N = 131$)					Comparison group ($N = 53$)				
	Min	Max	*M*	SD	%	Min	Max	*M*	SD	%
Age of the child (in months)	3	24	12	3.23	—	4	21	13	3.98	—
Family language										
Predominantly German					86					89
Not predominantly German					14					11
Family's net equivalent income in euros (SES)	446	4063	1998	703	—	385	3182	1958	642	—
Number of people in the household										
Total	2	12	4	1.17	—	2	5	3	0.64	—
Number of adults (18 years and older)	1	8	2	0.61	—	1	2	2	0.24	—
Number of children (0–17 years)	1	5	2	0.89	—	1	3	1	0.56	—
Language-related PSE (1 = strongly disagree; 5 = strongly agree)										
t_1	2.00	5.00	4.00	0.62	—	3.40	5.00	4.24	0.56	—
t_2	3.00	5.00	4.29	0.56	—	2.20	5.00	3.90	0.65	—
Change in language-related PSE (from t_1 to t_2)	−2.00	2.20	0.26	0.71	—	−2.20	0.60	−0.34	0.53	—
Frequency of language-stimulating activities (1 = never; 8 = several times a day)										
t_1	2.60	7.80	6.01	1.14	—	3.80	7.70	6.65	0.81	—
t_2	3.80	8.00	6.60	0.56	—	3.60	8.00	6.94	0.78	—
Change in frequency of language-stimulating activities (from t_1 to t_2)	−1.56	4.11	0.63	0.93	—	−1.37	1.78	0.28	0.65	—

Note: According to the Shapiro–Wilk test, variables are mostly not normally distributed.

using the *Chancenreich* app, app users engaged in language-stimulating activities several times a week on average, while parents in the comparison group did so almost daily. At t_1, all parents perceived themselves as highly self-efficacious in terms of their confidence in their ability to provide early language support.

After 10 weeks, app users had completed an average of 21 out of 30 tasks in the app (70% of all tasks). Furthermore, the frequency of language-stimulating activities increased on average in both groups. However, this change was more pronounced in the app user group. At t_2, app-using parents perceived themselves as even more self-efficacious than before. The language-related PSE of parents in the comparison group decreased slightly over time.

Relations between the intensity of app use, language-related PSE and HLE

RQ1: What is the relation between the intensity of use of the *Chancenreich* app and changes in language-related PSE?

Consistent with H1a, regression analyses revealed positive relations between the intensity of app use and increases in language-related PSE ($\beta = 0.36$, SE = 0.08, $p = 0.000$, $d = 0.90$)

(Table 2). This means that the more app tasks parents completed, the more their language-related PSE increased; parents felt more self-efficacious regarding early language support. For the control variables, the families' net equivalent income ($\beta = -0.18$, SE = 0.09, $p = 0.044$, $d = -0.37$), as well as the number of children living in the household ($\beta = -0.25$, SE = 0.08, $p = 0.001$, $d = -0.52$), were negatively related to changes in language-related PSE. Thus, these families showed fewer increases in language-related PSE. However, the family language showed a (slight) positive statistically relevant relationship to changes in language-related PSE ($\beta = 0.15$, SE = 0.08, $p = 0.039$, $d = 0.41$). This means that families whose family language was not predominantly German evinced stronger increases in language-related PSE. This regression explained 21% of variance.

In addition, we performed a threshold analysis in Ggplot/R using locally estimated scatterplot smoothing (LOESS). We visually determined the relation between the number of completed app tasks and changes in language-related PSE. The results (Figure 1) showed that even a small number (10–12) of completed app tasks positively influenced changes in language-related PSE. Above this threshold, language-related PSE largely stabilised and a plateau effect with minimal variations can be observed. If respondents had completed between 15 and 25 app tasks, there were also changes in language-related PSE. However, these were too vague to allow any further conclusions to be formulated. Overall, the shape of the LOESS curve indicated an exponential positive relation between the number of app tasks completed and increases in language-related PSE visible when 10–12 tasks are completed, thus confirming H1b.

RQ2: How are changes in language-related PSE related to changes in the frequency of language-stimulating activities in the HLE?

Further analyses indicated that changes in language-related PSE were, in turn, significantly positively related to changes in the frequency of language-stimulating activities in the HLE. It can therefore be seen that an increase in language-related PSE is associated with an increase in the frequency of language-stimulating activities. This relation remained stable even when controlling for the app tasks completed ($\beta = 0.30$, SE = 0.08, $p = 0.000$, $d = 0.75$) (Table 3). H2 could thus be confirmed. The analyses also showed that the number of children living in the household ($\beta = 0.20$, SE = 0.10, $p = 0.050$, $d = 0.52$) was positively related to changes in frequency of language-stimulating activities. This regression explained 14% of variance.

TABLE 2 Relations between intensity of app use and changes in language-related PSE.

	β	SE
Control variables		
Age of the child (in months)	0.01	0.09
Family language (0 = predom. German, 1 = not predom. German)	0.15*	0.08
Family's net equiv. income in euros (SES)	−0.18*	0.09
Number of children (0–17 years)	−0.25***	0.08
Number of adults (18 years and older)	0.07	0.04
Predictor		
Number of completed app tasks	0.36***	0.08
R^2	0.21***	

Note: Displayed are standardised regression coefficients, standard errors and the explained variance. $N = 184$.
*$p < 0.05$. ***$p < 0.001$.

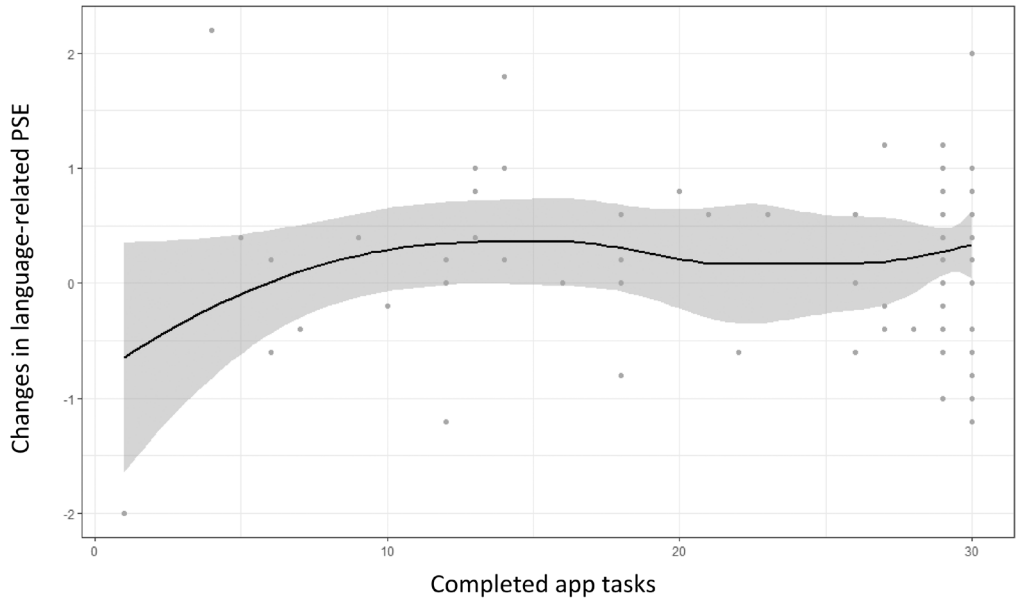

FIGURE 1 LOESS curve showing the relation between completed app tasks and changes in language-related PSE. A total of 41 cases were excluded due to missing values (−999), $N = 131$ (only app-using parents).

TABLE 3 Relations between changes in language-related PSE and changes in frequency of language-stimulating activities.

	β	SE
Control variables		
Age of the child (in months)	−0.10	0.08
Family language (0 = predom. German, 1 = not predom. German)	0.07	0.10
Family's net equiv. income in euros (SES)	−0.08	0.09
Number of children (0–17 years)	0.20*	0.10
Number of adults (18 years and older)	−0.06	0.09
Number of completed app tasks	−0.03	0.08
Predictor		
Changes in language-related PSE	0.30***	0.08
R^2	0.14**	

Note: Displayed are standardised regression coefficients, standard errors and the explained variance. $N = 184$.
*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

RQ3: Are there direct and/or indirect relations between the intensity of use of the *Chancenreich* app and changes in the frequency of language-stimulating activities in the HLE, mediated by changes in language-related PSE?

The results of the mediation analysis (Table 4) showed no significant direct effect between the number of completed app tasks and changes in language-stimulating activities ($\beta_{direct} = 0.03$ [95% CI: −0.14, 0.20], $p = 0.737$, $d = 0.16$). Nevertheless, since the total indirect effect ($\beta_{indirect} = 0.10$ [95% CI: 0.04, 0.17], $p = 0.003$, $d = 0.30$) was significant, this confirmed an indirect-only mediation. In line with a new mediation approach outlined by Zhao

TABLE 4 Results of the mediation analysis.

Effect	Path	β	SE	95% CI	
				Lower	Upper
Total	Sum app tasks ➔ Change in language-stimulating activities	0.13	0.08	−0.03	0.28
Total/specific indirect	Sum app tasks ➔ Change in language-stimulating activities	0.10**	0.03	0.04	0.17
Direct	Sum app tasks ➔ Change in language-stimulating activities	0.03	0.09	−0.14	0.20

Note: Displayed are standardised regression estimates. Dataset contains cases with missing on all variables except *x*-variables. These cases were not included in the analysis. Number of cases with missing on all variables except *x*-variables: 40. Since the model contains only one mediator, the total indirect effect and the specific indirect effect are numerically identical. $N = 144$.

**$p < 0.01$.

et al. (2010), indirect mediation can be defined as a situation where the mediator construct is responsible for explaining the entirety of the observed relationship between two variables. Our study is an excellent example of this mechanism, as changes in language-related PSE were shown to account for the entire observed relationship between the number of completed app tasks and changes in language-stimulating activities. These findings confirmed that the intensity of app use is related to increases in the frequency of language-stimulating activities in the HLE, mediated by increases in language-related PSE (H3). The effect of the number of completed app tasks on changes in language-stimulating activities was attributable to 77% of the changes in language-related PSE. The diagram of indirect-only mediation is included in the online supporting information (Figure S1).

DISCUSSION

In this study, direct and indirect relations between the intensity of app use, language-related PSE and HLE were analysed, investigating the extent to which digital approaches to family support are able to improve the HLE by increasing the language-related PSE of families with toddlers.

With regard to the first question, as expected, positive relations between the intensity of app use and changes in language-related PSE were found: the more app tasks parents completed, the more their language-related PSE increased. This finding is in line with previous international studies (Jelley & Sylva, 2018; Jelley et al., 2016; York et al., 2019) and confirms the assumed potential of digital parenting apps for strengthening domain-specific PSE. These results also indicate that PSE, particularly in the domain of language development, can be specifically strengthened using digital parenting apps. However, our analyses focused on the overall change in language-related PSE, and as such we need to interpret them more broadly: in the comparison group, descriptive findings showed that this group consists of parents who already assigned themselves high levels of language-related PSE at the beginning of the study. For these parents, we observed that the mean value of language-related PSE decreased between t_1 and t_2. It cannot be ruled out that participating in the three online surveys led parents to reconsider their self-assessment, potentially because the survey instrument broadened their perceptions of what constitutes effective language activities. From a measurement analysis perspective, this result could also be explained by a 'regression towards the mean': with repeated measurements, the effect is observed that extreme initial measurements tend towards the centre of the distribution.

In addition, our results revealed that the completion of a small number of app tasks had a positive influence on language-related PSE, which increased exponentially. This suggest that language-related PSE increases significantly within the first 4 weeks (0–12 tasks) with each task completed. The subsequent plateau suggests that further exercises primarily serve to consolidate confidence in one's own parenting abilities without further increasing language-related PSE. For future interventions, this could mean that other modes of support are needed to further increase language-related PSE (e.g., through more intensive support by family support programmes combined with feedback on the actual implementation of parenting abilities in everyday life). Furthermore, with 30 tasks, the *Chancenreich* app intervention was quite extensive; the results indicate that even less extensive app interventions can successfully strengthen language-related PSE. This is a particularly valuable finding, because less extensive interventions can presumably reach more parents and are less cost intensive. Additionally, this supports the findings of Biber et al. (2019), who argue that information can be made available more quickly and new knowledge can be gained faster via digital forms of family support. This again emphasises the potential of digital (and in particular app-based) approaches to family support.

The results further show that changes in language-related PSE were significantly positively associated with changes in the frequency of language-stimulating activities in the HLE. The study thus replicated findings of earlier national and international studies (Gessulat, 2021; Peacock-Chambers et al., 2017; Vukovic et al., 2013). It also confirms the theoretical assumptions of the model of the home learning environment (i.e., that PSE is directly linked to family processes and that PSE needs to be addressed in a domain-specific way if the HLE is to be strengthened) (Bojczyk et al., 2018). Furthermore, we can derive from the results that domain-specific PSE can be addressed very effectively even in the first year of a child's life. Finally, these results also show that parental beliefs are specifically linked to what parents do with their children. This is particularly important for gaining knowledge about the processual nature of the HLE, as the existing research suggests that only processes are directly related to child development.

With regard to the third research question, the mediation analyses revealed no direct effect between the intensity of use of the *Chancenreich* app and changes in language-stimulating activities. The construct of the HLE is considered to be very dynamic, even early in a child's life (Burgess, 2011). The absent direct effect between app usage and changes in language-stimulating activities may also conceivably be explained by the fact that language-related PSE and the frequency of language-stimulating activities increase at different rates in very early childhood, so that direct effects may only be measurable at a later stage. More in-depth studies could investigate the extent to which support programmes for parents initially lead to increases in PSE and subsequently to increases in the frequency of language-stimulating activities. In addition, the app did not address all items of the HLE scale equally, and included other constructs in addition to the HLE construct (e.g., parental knowledge, parental stress). Further, the app's tasks were not only related to frequency, but also emphasised qualitative aspects of language-stimulating activities. Therefore, we also need to consider whether the language-stimulating activities assessed in this study would show different results if they had been captured using other methods (e.g., through observations of the quality of the reading or play situations in the families).

Another possible explanation for the unobserved direct effect between the intensity of use of the *Chancenreich* app on changes in frequency of the language-stimulating activities in the HLE of toddlers might be the composition of the group of app users themselves: these parents already engaged actively in language-stimulating activities before participating in the study. Such 'ceiling effects' occur when variable values (in this study, the language-stimulating activities and language-related PSE) are concentrated in the upper scale of the measurement instruments, leading to relatively limited variability. Also, they may indicate a self-selection effect, whereby those parents who perceive themselves more self-efficacious and highly engaged in HLE are more likely to reflect on their abilities and activities, while parents with lower self-efficacy beliefs and low engagement may be less likely to participate in surveys. Therefore, follow-up studies should focus on families in which there are lower levels of language stimulation and self-efficacy beliefs. Unfortunately, in Germany, parents in this target group are generally difficult to reach (Wilke et al., 2014).

Moreover, further research could look at what family interventions need to provide in order to directly strengthen processes in the HLE; it is questionable whether the mere provision of the necessary structures for a sustainable digital parent support programme is sufficient to directly facilitate more or better language-stimulating activities. Further possible approaches may lie in the more comprehensive communication of content (more in-depth information, even more interactive design of digital support services through chat options, supplementary learning videos or an online consultation accompanying the intervention). However, our results showed a small positive and statistically significant indirect effect between the intensity of use of the *Chancenreich* app and changes in the frequency of language-stimulating activities, mediated by changes in language-related PSE. This confirms previous findings

postulating that family support programmes strengthen the home learning environment precisely by improving (actual or perceived) parenting abilities (Kuger et al., 2012).

In summary, the findings reflect the fundamental relevance of language-related PSE to the HLE and suggest that families with toddlers benefit from support approaches that build on their parenting abilities and beliefs. To support parents effectively, it is not enough to focus only on suggestions for parent–child activities. Parents also need to be encouraged to feel that they have the ability to support and promote their children's language development.

LIMITATIONS

The data for the present study were drawn from a rather small and geographically limited German sample, which was conducted online; it is a convenience sample. Even though great efforts were made to reach disadvantaged groups of parents as well, parents with a low level of education or low SES are under-represented within the sample compared to the German average (German Federal Statistical Office, 2024). Recruiting parents from this target group is often a challenge for research on intervention studies in Germany (Wilke et al., 2014). Potential ceiling effects associated with this may bias the estimation of relations between the intensity of app use, language-related PSE and HLE in this study. The research team used different recruitment strategies in the respective groups, which means that parents could only decide whether they wanted to participate in the study, but not in which group. In addition, we would point out the different group sizes in the intervention and comparison groups. Due to the small group size, parents who only used the app and parents who simultaneously took part in an online parenting course on the app were considered together as the intervention group. It should be noted that those parents in the intervention group who also took part in the online parenting course showed more intensive app use compared to parents who only used the app. In the present study, we therefore cannot rule out the possibility that the course content was also relevant for the relations described. Details of the influence of the course on the use of the app are discussed in further analyses (Anders et al., 2023).

During the implementation phase, however, it was also observed that a broad range of potential users were excluded by the conceptual focus (families and children with support needs in other developmental domains or in other age groups, and also non-German-speaking families). Despite the reference to the age-related nature of the app content, parents with children in other age groups used the app. Additionally, as the *Chancenreich* app was only implemented in German, families of migrant origin or who were not fluent in German were only addressed to a limited extent in this study. It is also worth noting that, as self-assessment was used for the measurement of the frequency of language-stimulating activities, responses may be biased by social desirability. Finally, this database does not permit us to make any statements about the quality of the home learning environment or allow SES to be mapped using classic constructs such as the International Standard Classification of Education (ISCED) or similar.

CONCLUSIONS AND IMPLICATIONS

The findings of the present study emphasise the relevance of new digital media such as parenting apps for strengthening parental abilities, and thus the home learning environment of families with toddlers. Today's parents use digital devices more intensively than previous generations of parents (Prensky, 2001), making digital media part of the reality of family life. App-based family support programmes are likely to experience significant developments in the coming years. This is where new kinds of intervention programmes

may emerge, offering great potential for strengthening families in their parenting abilities. Of course, the programmes should be utilised in a practical and scientifically beneficial way (Wilke et al., 2014): however, it should be noted that the implementation and scientific evaluation of these programmes is still in its infancy. It would therefore be prudent for further research to also address the question of the extent to which parenting apps have the potential to enhance accessibility for families, foster trusting parenting partnerships and facilitate the provision of stable and flexible support services.

Moreover, our findings indicate that app-based programmes designed to strengthen PSE represent a promising approach to enhancing parenting abilities. The implications of this pattern of evidence for early childhood education practice are that, when designing support programmes, it is also important to consider how to ensure intensive—or at least effective—use by the target group. In case of the *Chancenreich* app, additional support services could be provided (e.g., an online platform for social communication, a service hotline, a private chat group or *Chancenreich* online parents' evenings). In addition, the app offers a good basis for adaptive app components that can, for example, use AI to adapt to the respective skills and resources of the users. A further development of this kind would be unique in the early childhood education sector and offers a forward-looking perspective to designing programmes which correspond to individual needs.

Equally, though, the use of a parenting app is, in and of itself, by no means a guarantee of successful family support, and it cannot be denied that parental screen time will be increased by digital family support programmes. However, studies on parental use of digital devices show that some parents critically reflect on their media use behaviour and regulate it in family contexts (Brito et al., 2017). Ultimately, however, children will also benefit from digital programmes which enhance their parents' abilities and increase the quality of the home learning environment. Parental beliefs have been shown to be directly linked to processes in the home learning environment (i.e., to the key characteristics for successful language development in early childhood): the influence that parents have on children's early literacy acquisition can scarcely be overstated (Tamis-LeMonda et al., 2014), with their own estimations of their parenting abilities playing a central role in the effectiveness of language-stimulating activities both in the first years of life and for later language development (de Bondt et al., 2020; Niklas et al., 2024). In this way, parenting apps that aim to strengthen parental abilities and thus the home learning environment represent a crucial contribution to the successful support of families with toddlers.

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CONFLICT OF INTEREST STATEMENT

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

DATA AVAILABILITY STATEMENT

The datasets presented in this paper are not freely available because the data are currently reserved for scientific qualifications (PhD and Master's theses). Requests to access the datasets should be directed to yvonne.anders@uni-bamberg.de.

ETHICS STATEMENT

Ethical review and approval for the study on human participants was obtained in accordance with local legislation and institutional requirements. Written consent was obtained from the participants prior to their involvement in the study.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX A

TABLE A1 Topics in the *Chancenreich* app.

Week	Weekly topic	Description (summarised content of the three weekly app tasks)
1	Oral explorers	The app focuses on the fact that babies and toddlers are like little explorers, discovering the world by putting things in their mouths. This is important for their development, because this is how they gather information about their environment
2	Picture books	Even in the first year of life, children are sensitive to learning language. The app explains that parents have a great influence on their children's learning to speak—right from the start! Parents can look at books even with young babies. In this way, babies learn new words through play. Parents can try to draw their child's attention to a specific picture or motif
3	Dialogue reading & sound diary	During the period of 'pre-linguistic development', babies begin to experiment with their voice. This includes squeaking, humming and cooing. By reading to very young children and asking questions, parents can encourage them to imitate syllables or first words. Progress in speech can be recorded in a sound diary. In this way, the first speech patterns of babies can also be recognised
4	Language opportunities in daily life	In this week, the app focuses on how, in everyday life, attention can be paid to what children are exploring. This can help reveal language opportunities to talk about what children are experiencing and discovering
5	Language stimulation during diapering	The app encourages parents to 'bathe' children in language in their first year of life. By accompanying everyday situations that are experienced together with language, the child's language development can be supported quite incidentally
6	Finger games & self-efficacy	The app informs parents about finger games and why they are good for language development. With their help, babies can enjoy high-quality speech and touch experiences. Parents have a great influence on how their child learns to speak. The sound diary can help parents to recognise language developments
7	Parental stress	Many parents struggle with overload and perceptions of stress. The app encourages parents to talk to friends and close confidants in such circumstances. It explains that this is important to mitigate the negative impact of stress on the family. In the app-integrated family handbook of the *Chancenreich* family programme, helpful contacts can be found when parents are looking for support
8	Meals as a language occasion	To 'bathe' children in language, all situations in everyday family life are suitable (e.g., mealtimes). The app addresses the fact that parents can explain to their children what is happening during feeding and that they can also use this situation to name the different foods
9	Language & movement	In the app, parents can learn more about how babies naturally enjoy movement. This joy of movement is a fantastic method for teaching language in a playful way. More information about children's motor development can be found in the relevant section of the app-integrated family handbook of the *Chancenreich* family programme
10	Closing	In the final week, the app gives parents the opportunity to reflect on all the activities of the last 10 weeks and to name their favourite activity. Parents are encouraged to continue to engage with their children's language development and to note further steps in their children's language development in the sound diary