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A brief research report on the efficacy of a RAN training in elementary school age children

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Numerous studies could prove that children with reading disorders show RAN deficits and that RAN is especially strongly connected to the automatization of word recognition. In contrast intervention studies so far have provided little convincing evidence for the trainability of RAN or even a transfer effect on reading competence. The aim of this study is therefore to evaluate the efficacy of an adaptive, software-based RAN-training in a group of 57 children aged 9.3 years (SD 1.10 years) with a RAN-Deficit and/or difficulties with word-reading-speed and to determine if there is a transfer effect to reading speed of words and pseudowords as well as to reading comprehension on the word-, sentence and text level. The software-based training of RAN letters, numbers and colors is an intervention over 18 training days. Children were encouraged to name visually presented items in a serial format as fast as a red rectangle jumping from item to item. The speed of the red rectangle was successively increased with each successful training session. Univariate ANOVAs with repeated measures showed that children had a significantly higher naming speed for letters and numbers both immediately after completion of the intervention and in the follow-up measures. A transfer of the training effect to reading speed for words, reading comprehension on the word- and sentence-level, but not to reading speed for pseudowords and text comprehension, could be demonstrated. Due to the missing of a control-group comparison, it remains to be proven in subsequent research whether this effect is a maturation-related change or a training effect.

KEYWORDS
Rapid Automatized Naming (RAN), software-based training, elementary school age, reading fluency, reading comprehension

1 Theoretical positioning

1.1 "Phonological-core-deficit-hypothesis" and "double-deficit-hypothesis"

Developmental Dyslexia, i.e., a specific disorder in reading that cannot be accounted for by low IQ, poor educational opportunities or obvious sensory or neurological damage (World Health Organization, 2008), affects about 6–8% of the population (Shaywitz et al., 1990; Galuschka and Schulte-Körne, 2016).

Reading Researchers generally agree that deficits in the processing of phonological information underlie a large portion of specific reading disorders (Galuschka et al., 2020). According to Wagner and Torgesen (1987), the abilities to perceive, consciously manipulate, store, and process information about the sound structure of language or to access phonological representations in long-term memory during the production and processing of spoken and written language are allocated to phonological processing. Accordingly, phonological processing includes phonological awareness, phonological working memory, and Rapid Automatized Naming (RAN). In German-speaking countries, when considering the fundamental (meta-)linguistic-cognitive competencies for successful literacy acquisition, the construct of phonological awareness, i.e., the conscious identification, analysis, synthesis, and manipulation of linguistic units at the sublexical level (Mayer, 2021), is the focus of attention, while RAN-deficits and resulting difficulties with automatized word recognition and reading fluency are hardly considered. RAN is the ability to visually process a sequence of simultaneously visible familiar symbols (e.g., letters, numbers, colors) as quickly as possible, and to name the corresponding word (or phone) (Mayer, 2021).

While the importance of phonological awareness on the acquisition of reading and spelling is not disputed by proponents of the "double-deficit hypothesis," Wolf and Bowers (1999) for example postulate that phonological awareness and RAN each make specific contributions to explaining differences in written language skills despite correlative relationships of moderate magnitude, and serve largely independently as predictors of reading and spelling difficulties (Mayer, 2014; Torppa et al., 2013; Vaessen and Blomert, 2010; Swanson et al., 2003; Wolf et al., 2002). The influence of RAN on reading should not be reduced to its phonological component, i.e., the speed of access to phonological representations in long-term memory; rather, a naming speed deficit represents a second "core-deficit" of reading difficulties that is at least partly independent of phonological skills (Wolf et al., 2002).

Evidence for this assumption can be derived from empirical surveys of the "double-deficit hypothesis." Children with below-average performance in both functions ("double deficit") usually experience significantly greater difficulties with reading as compared to children with isolated weaknesses in phonological awareness or naming speed (Furnes et al., 2019; Araújo and Faísca, 2019; Ozernov-Palchik et al., 2017; Cronin, 2013; Mayer, 2014; Torppa et al., 2013; Kirby et al., 2003). Moreover, the two functions appear to be associated with different written literacy subskills to varying degrees. Research findings from countries with different levels of orthographic transparency suggest that phonological awareness is primarily correlated with reading accuracy and spelling, while RAN is the best predictor for the development of reading automaticity and reading fluency for words and pseudowords (da Silva et al., 2020; Furnes et al., 2019; Mayer, 2018; Moll et al., 2014; Kirby et al., 2003, 2010; Georgiou et al., 2008, 2009; Wimmer and Mayringer, 2002).

The fact that naming speed is largely independent of phonological information processing is justified in the theory by the complexity of the RAN-construct. In addition to the speed of access to the phonological lexicon, visual processing speed and discriminative ability as well as executive functions (attention control) are involved. Finally, a finely tuned, highly automated interplay of the underlying perceptual, lexical, phonological, and cognitive components as well as the fastest possible execution of the subprocesses is necessary (Wolf and Bowers, 1999).

Research studies have shown that children with reading difficulties perform significantly worse on RAN Tests than do children with typical reading and writing skills (Araújo and Faísca, 2019; Mayer, 2014, 2018).

In a meta-analysis that included data from a total of 22,418 children and 216 comparisons between children with average and below-average reading and spelling skills, Araújo and Faísca (2019) found an average effect size of $d = 1.19$, meaning that children with reading difficulties performed more than one standard deviation worse on RAN-Tests than children of the same age with typical reading skills.

Given that word recognition speed differentiates best between poor and average readers in countries with relatively transparent orthographies, and that impairments in reading fluency are the core problem of German-speaking children with poor reading skills (Wimmer, 1993), which in turn are significantly related to reading comprehension, RAN is crucial for the early detection, diagnosis and intervention of (impending) reading and spelling difficulties in German-speaking countries.

1.2 Explaining the relationship between RAN and reading

Various hypotheses explain the relationship between RAN and literacy, suggesting multiple factors may be involved (Kirby et al., 2010). The phonological deficit hypothesis explains RAN's influence on reading via its component of speed of access to phonological representations in long-term memory.

An alternative explanation interprets the (impaired) speed of access to phonological entries as the consequence of a global processing-speed-deficit (Kail and Hall, 1994), a specific visual processing-speed-deficit (Stainthorp et al., 2010) or an impaired "timing mechanism" (Wolf and Bowers, 1999), which sets a limit to rapid and automated execution and fine-tuned interplay of underlying executive functions. Finally Bowers et al. (1994) suggest that a RAN deficit affects reading through slower visual processing of the single letters in a word or delayed activation of the corresponding phonemes. This delay hinders the recognition and storage of frequently co-occurring letters as orthographic patterns, crucial for word recognition. Affected children may remain at the stage of phonological recoding and require specific support focusing on holistic processing of orthographic patterns for an automation of word recognition.

Assuming that RAN and phonological awareness are two functions that influence word recognition largely independently and that RAN cannot be reduced to the phonological components, it can be expected that children whose reading difficulties are associated with a RAN deficit do not benefit sufficiently from phonologically oriented support, but rather need a RAN-training.

1.3 Approaches for training RAN

To date however, there is hardly any empirical evidence for the effectiveness of training RAN.

For example, Berglez (2003) attempted to improve preschoolers' naming speed by asking them to name printed colors and simple objects on the same templates at high frequency as quickly as possible. The fact that the naming speed of the trained children and a control group improved to a comparable extent over a period of 6 months is interpreted as evidence that the improvement is less a result of the training but more a consequence of developmental progress due to maturation. A similar conclusion was drawn by de Jong and Vrielink (2004), who failed to improve rapid letter naming in a group of Dutch first graders after 10 days of daily training comparable to Berglez (2003). Conrad and Levy (2011) were also unable to demonstrate an increase in RAN, let alone effects on reading and spelling performance, by training children with a naming speed deficit through high-frequency letter naming.

Initial evidence for the trainability of RAN with positive effects on reading fluency are provided by Vander Stappen and van Reybroeck (2018) and Pecini et al. (2019). Vander Stappen and van Reybroeck (2018) trained 18 s-grade children from Belgium on the naming speed of objects, while training in the control group ($n = 18$) focused on phonological awareness. In the RAN training group, participants were motivated in a playful way to name printed objects of different word lengths and syllable structures of varying complexity as quickly as possible. The children in the RAN training group improved their naming performance significantly more than the control group. Moreover, a transfer of RAN training to reading speed was demonstrated.

Pecini et al. (2019) offered a RAN-training for objects and colors with the help of a software-based program to 22 children with impaired naming speed and reading difficulties between the second and the fifth grades. The intervention was delivered exclusively at home under the supervision of caregivers over a three-month period, with sessions occurring three to five times per week and lasting approximately 10 minutes. In a comparison group ($n = 22$) students were asked to read texts with the syllables of each word visually highlighted one at a time. The results demonstrate the effectiveness of the RAN training. Both groups were able to significantly increase their reading speed at the word, sentence, and text levels. There were no detectable differences between the two conditions. The authors interpret their finding as evidence of the effectiveness of RAN training, whose particular advantages include the simple implementation in a family context.

2 Summary and aims of the study

With the above in mind, an adaptive, software-based training program for the improvement of naming speed was developed in cooperation with the company Trout GmbH (Kassel, Germany) for the research project documented here. It was carried out with 57 students with reading difficulties and a naming-speed-deficit between January and July 2023, and it was evaluated with regard to its effectiveness and its impact on word recognition and reading comprehension on the word-, sentence- and text-level.

The intervention study sought to answer the following research questions:

(1) Can the adaptive, software-based training improve naming speed?
(2) To what extent do improvements in RAN performance positively impact reading speed and reading comprehension?

3 Method

3.1 Sample

Three special education centers (schools for children with special educational needs in the areas of learning, language, emotional, and social development) and four elementary schools from a metropolitan area in Southern Germany agreed to participate in the study. The training group sample consists of students for whom parental consent was obtained: 27 children (47.4%) from elementary schools and 30 children (52.6%) from special education centers participated in the training. The children mainly attended grades 2 (elementary school) and 3 (special education center). Students from grades 4 and 5 ($N = 10$) accounted for a total percentage of 17.6%.

The students (54.5% female) had a mean age of 9.3 years (7.2–12.1 years, SD: 1.5 years).

3.2 Design

The study features a pre-/post-/follow-up design. At the first measurement date in December 2022 167 children were tested for RAN and reading speed using the standardized Test for Phonological Awareness and Naming Speed (TEPHOBE, Mayer, 2020) as well as the subtests real word reading and pseudoword reading of the Salzburg Reading and Spelling Test (SLRT II, Moll and Landerl, 2014). Reading comprehension at the word-, sentence-, and text-level was assessed using ELFE II (Lenhard et al., 2022) (see Measurements, Chapter 3.3).

All children who scored below-average (PR < 16) in at least one of the three RAN tests (letters, numbers, colors) and/or reading speed of real words in the pretest were included in the training group. The training was carried out twice a week and it took place at school during class hours. A training session usually lasted 10–15 min.

The posttest was administered immediately after the completion of the 18 training sessions. In the posttest, RAN, the reading speed, and the reading comprehension were tested once again. Three children had to leave the program early because they changed schools or moved. A follow-up test was conducted in July 2023. The purpose of this test was to demonstrate a possible long-term effect of the training. It once again assessed RAN, reading speed, and reading comprehension. 32 children took part in the follow-up test.

Both the measurement and the training were carried out by university students of special education and speech therapy (master's degree), who were thoroughly familiarized with the diagnostic tools and the training program.

The study was approved by the ethics committee of LMU Munich and by the responsible Bavarian district and school authorities.

3.3 Measures

To evaluate the potential effects of the training, performance in the rapid naming of letters, numbers, and colors was assessed using TEPHOBE (Test for Phonological Awareness and Naming Speed, Mayer, 2020). The children had to name five different numbers, letters, and colors each repeated 10 times and all presented simultaneously in a serial format as quickly as possible. The interpretation of the results is based solely on the time taken by the child to complete each subtest. Reliability for the naming speed tests in the TEPHOBE is in the satisfactory to good range (Cronbach's alpha = 0.78 and 0.86, respectively).

Both reading speed and reading comprehension were measured in order to evaluate the possible transfer of the training to reading skills.

The two "One-minute reading fluency tests" from the "Salzburg Reading and Spelling Test" (SLRT II, Moll and Landerl, 2014) were used to measure reading speed for words and pseudowords. In both subtests, students have 1 min each to read aloud a list of 156 (pseudo-) words. The list of pseudowords is designed to reveal possible difficulties in the use of phonological recoding, while the automatization of word recognition is measured via the reading speed for real words.

Reading speed [number of (pseudo-)words read correctly per minute] is the key metric for scoring and interpreting both reading tests. The parallel test reliability for the one-minute reading fluency tests is between $r = 0.90$ and 0.98 in the different age groups.

ELFE II (Lenhard et al., 2022) was used to assess reading comprehension, at word-, sentence-, and text-level in grades 1 to 7. Word comprehension is tested by assigning as many as possible correct words from four alternatives to a picture in 3 min. For the sentence comprehension test, children are presented with a sentence in which one word is missing. The gap has to be completed from a choice of five different alternatives (time allowed: 3 min). The text comprehension test contains short factual and narrative texts. Questions on the content of these texts must be answered in a single-choice format (time allowed: 7 min).

Both the values for split-half reliability and the retest reliability are in the "*very good*" range, with values between $r = 0.81$ and 0.96 for the word and sentence comprehension test and the overall test. The values for text comprehension are in a satisfactory to good range.

3.4 Training

The training measure used in this study is an adaptive, software-based RAN training in which the usual RAN matrices are presented on the screen in a serial format (five lines of ten items each). The letter category uses 13 different elements (M, T, E, S, P, F, U, O, R, A, L, N, B), the number category uses the numbers 0 to 9, and the color category uses red, green, blue, yellow, black, purple, and brown.

The intervention comprises 18 sessions lasting approximately 10–15 min each, including an assessment of the children's baseline performance in naming letters, numbers and colors on day 1.

The first 2 days of the training (day 2 and 3) familiarize the students with the format of the training: the children had to name the templates with all three categories on her own pace, while the number of different symbols per category successively were increased. From the following session on (day 4–20), participants complete three rounds per category with the software generating a new matrix for each trial, such that the order of the symbols is constantly changing during training.

In order to motivate the children to continuously speed up their processing, the presentation time of each symbol is reduced by 3 msec/item after each successful trial. For this purpose, the symbols are framed by a red rectangle that jumps (increasingly faster) from item to item, thus guiding the children's naming speed.

To determine changes in naming speed and reading competence as a result of the intervention, repeated measures ANOVAs were conducted with the three test times (pretest, posttest, follow-up test) as factors.

4 Results

4.1 Descriptive statistics

First, descriptive statistics for naming speed, reading speed, and reading comprehension performance at the time of the pre-, post- and follow-up test are presented to characterize the group (Table 1).

Deviations in the number of students participating at the time of the pretest are due to illness or refusal to complete individual tasks.

For naming speed, only raw values are available. TEPHOBE does not provide Percentile Ranks or T-Scores for children from the middle of second grade onwards. However, a comparison with the orientation values published by van Ermingen-Marbach et al. (2015) for the naming speed of children with an average age of 9.7 years (SD: 0.54) (RAN letters: 2.18 items/s [SD: 0.37], RAN numbers 1.93 items/s [SD: 0.39], RAN colors: 1.02 items/s [SD: 0.18]) shows that the values achieved by the participants in this study are clearly below average. Therefore, it can be assumed that this is indeed a sample with a RAN deficit.

Furthermore, at the time of the pretest, the group exhibited significantly below-average performance in terms of reading speed (words: PR 7.56 [SD: 7.08], pseudowords: PR 12.33 [13.55]) and reading comprehension (T-score: 30.91–37.29 [SD: 5.1–7.42]).

4.2 Inferential statistics

The results of the univariate repeated measures ANOVAs indicate significant differences for RAN letters [F (2, 60) = 35.16, $p < 0.01$, $\eta^2 = 0.54$], RAN numbers [F (2, 60) = 22.06, $p < 0.01$, $\eta^2 = 0.42$] but not for RAN colors [F (2, 60) = 2.99, $p = 0.06$] for the three test times. Bonferroni-corrected post-hoc tests show significantly ($p < 0.01$) higher values for RAN letters ($M_{Diff} = 0.51$ and 0.43; 95%-CI [0.66, 0.36], and [0.55, 0.30]) and RAN numbers ($M_{Diff} = 0.32$ and 0.27; 95%-CI [0.44, 0.21], and [0.38, 0.26]) at the posttest and follow-up test compared to the pretest, while no significant differences were found between the posttest and follow-up test. Thus, the participating students significantly improved their naming speed, for the categories of letters and numbers, and this effect persisted at the follow-up assessment. Furthermore, the calculated effect sizes (Cohen's d) indicate substantial differences between the pretest and posttest as well as between the pretest and the follow-up test. A large effect was found for RAN letters ($d = 1.22$–1.30) and RAN numbers ($d = 0.91$–0.98), while only a small effect was found for RAN colors ($d = 0.28$–0.37) (Table 1).

Additionally, a repeated measures ANOVA shows statistically significant differences in reading speed for real words across the three test times [F (2, 60) = 33.81, $p < 0.01$, $\eta^2 = 0.53$]. The results of the Bonferroni-corrected post-hoc tests indicate a significant difference between the pretest and posttest, as well as between the pretest and follow-up test ($M_{Diff} = 6.16$ and 6.36, 95%-CI [9.13, 3.19], and [9.13, 3.58], $p < 0.01$), while no significant differences were found between the posttest and follow-up test. No changes were found in the reading speed of pseudowords [F (2, 60) = 2.56, $p = 0.08$]. The calculated effect sizes (Cohen's d) indicate a medium to large effect for reading speed

TABLE 1 Descriptive statistics of the pre- post- and follow-up-test.

	Pretest (n = 57)	Posttest (n = 54)	Follow-up (n = 31)	Cohen's d (pre- post-test)	Cohen's d (pre- follow-up-test)
	MW (SD)	MW (SD)	MW (SD)		
RAN[1]					
RAN letters[2]	1.31 (0.32)	1.89 (0.43)	1.81 (0.29)	1.37**	1.22**
RAN numbers[2]	1.27 (0.33)	1.59 (0.43)	1.56 (0.26)	0.98**	0.91**
RAN colors[2]	0.75 (0.20)	0.83 (0.27)	0.90 (0.38)	0.28*	0.37*
Reading speed[3]					
Real words[4]	18.70 (10.41)	25.58 (10.77)	27.39 (10.87)	0.54**	1.04**
Pseudowords[4]	16.37 (7.29)	20.11 (6.63)	20.77 (6.28)	0.47**	0.37*
Reading comprehension[5]					
Word comprehension[4]	22.20 (9.27)	29.76 (9.66)	31.94 (9.12)	1.17**	1.32**
Sentence comprehension[4]	5.30 (3.57)	8.83 (6.83)	8.94 (4.93)	0.63**	1.00**
Text comprehension[4]	2.38 (3.03)	3.7 (5.33)	2.71 (1.85)	0.25[n.s.]	.00[n.s.]
Total score[6]	31.70 (5.10)	33.77 (6.06)	33.10 (6.70)	0.29**	.03[n.s]

[1]RAN Test (TEPHOBE, Mayer, 2020), [2]Items/s, [3]Salzburger Lesetest (SLRT II, Moll and Landerl, 2014), [4]Raw Scores, [5]ELFE II (Lenhard et al., 2022), [6]T-score, **$p < 0.001$, *$p < 0.05$, [n.s]non significant.

of real words ($d = 0.54–1.04$) but only a small effect for reading speed of pseudowords ($d = 0.37–0.48$) (Table 1).

Regarding word comprehension, the repeated measures ANOVA also showed a statistically significant change [F (2, 60) = 27.97, $p < 0.01$, $\eta^2 = 0.65$], with Bonferroni-corrected post-hoc tests indicating significantly higher values for the posttest and follow-up test compared to the pretest ($M_{Diff} = 6.4$ and 8.7, 95%-CI [9.5, 3.2], and [11.7, 5.7]) with a large effect size ($d = 1.17–1.32$) (Table 1).

According to sentence comprehension, the repeated measures ANOVA also indicates statistically significant changes [F (2, 60) = 7.6, $p < 0.01$, $\eta^2 = 0.21$], with Bonferroni-corrected post-hoc tests showing significantly higher values for the posttest and follow-up test compared to the pretest ($M_{Diff} = 5.5$ and 3.4, 95%-CI [6.5, 0.5], and [4.9, 1.8]). The calculated effect sizes indicate a medium to large effect for sentence comprehension ($d = 0.63–1.00$) (Table 1).

No changes were found for text comprehension across the three test times.

5 Discussion

We could show that 18 training sessions conducted twice a week, each lasting 10 to 15 min, significantly improved the RAN performance of children with reading difficulties and a naming-speed-deficit. In particular, the improvements for RAN letters and digits, which are particularly relevant to the acquisition of literacy, showed large effects ($d = 1.37$ and $d = 0.98$). Moreover, repeated measures of ANOVA revealed significant gains in reading speed for words and comprehension at the word- and sentence-level between pre-, post- and follow-up tests.

Thus, the results of the present study are in line with the first promising results on the trainability of naming speed. While the effectiveness of RAN training in the studies by Vander Stappen and van Reybroeck (2018) and Pecini et al. (2019) were limited to naming speed for colors and objects, to our knowledge the present study is the first to show that naming speed for alphanumeric symbols can also be trained.

Studies that failed to show positive effects of RAN training took a methodological approach which asked children to name templates with visual symbols (letters, numbers, colors, objects) frequently (at their own pace) without supporting them in processing the symbols successively faster (de Jong and Vrielink, 2004; Berglez, 2003). In contrast the software used in this study tried to motivate children to improve their speed of visual processing and phonological activation. Three points are particularly important here.

First of all, the software supported attention-focusing, inhibition and control (i.e., "executive functions"), highlighting each item with a red rectangle jumping from item to item. This is important, because according to Wolf and Bowers (1999), RAN tasks require continuously focusing the attention on one symbol, while the information of the distracters must be inhibited.

Secondly, new RAN-matrices are generated for each session by the software in order to maintain the children's attention during the intervention. In the studies of de Jong and Vrielink (2004) and Berglez (2003) children had to always name the same templates during the whole training.

Finally, to speed up visual and phonological processing the speed of the jumping red rectangle was increased after each successful session. A similar program with comparable results was used in the study by Pecini et al. (2019).

As far as highlighting items is concerned, the developed RAN-training is comparable to the text fading paradigm, which has shown its effectiveness in aiding reading development (Korinth and Nagler, 2021; Nagler et al., 2015; Breznitz, 1987). The text fading paradigm is a method designed to help children progressively read words, sentences, and texts faster by gradually fading out letters or syllables of a word in the reading direction (adjusted to the current reading speed). Comparable to our RAN-training, the fading speed is increased slightly after each successful reading attempt.

The advantage of the RAN training (at least for the categories of colors and objects) can be seen in the possibility to use the RAN training with younger, i.e., preschool children than text fading programs, which require basic reading skills. Therefore, the RAN-training should be seen as a preventative method alongside phonological interventions for at-risk children to help develop reading and spelling.

As the training does not place any major demands on practicability, it is conceivable that the training could also be carried out outside of school settings. In the study by Pecini et al. (2019) for example, the entire measure was carried out exclusively at home with parental support.

However, RAN training should not be interpreted as a new magic bullet for preventing reading and spelling disorders. Rather, it is a new, easy-to-implement intervention that could be used to supplement phonological awareness instruction in preschool or explicit reading instruction in school-age children. RAN training practices the linguistic and cognitive processes reading is based on (attention, visual processing speed, speed of access to phonological representations). However, students learn to read exclusively in the symbol system of the written language and not through naming digits and letters.

6 Limitations

The study's evidence is limited to the progress of one group of children with reading difficulties and a naming-speed-deficit without a control group comparison, so we cannot be sure if the progress is the consequence of our training or due to maturation. Future studies must compare the development of a training group with a non-supported control group to confirm the method's efficacy. Furthermore, the calculations do not yet consider whether there are differences in children's performance depending on the type of school. It is conceivable that increases in performance can be explained by the specific support given (particularly for children in special education centers).

Nonetheless, RAN training's theoretical importance should not be underestimated, as it integrates sub-functions related to automatic word recognition. Measures aimed at integrating these sub-functions should be interpreted as an opportunity to provide preventative support in the automation of word recognition for children with impaired naming speed, for whom phonologically oriented support measures alone are obviously not sufficient. However, despite the promising results of the present study, affected children also need specific support in the development of appropriate reading fluency through measures aimed at the holistic and simultaneous processing of orthographic patterns and frequently occurring words (e.g., Mayer, 2002).

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of the Faculty of Psychology and Education, LMU Munich. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

Author contributions

JW: Writing – review & editing, Writing – original draft. AM: Writing – review & editing, Writing – original draft.

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Conflict of interest

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.

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