Klauer’s Inductive Reasoning Training as a Cognitive Apprenticeship Approach for Special-Needs Students

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Abstract: The inductive reasoning trainings by K. J. Klauer are characterized as a German cognitive apprenticeship approach for all age groups. The effects of program I were compared across two field studies with special-needs students. The paper-pencil-based training version (N_1 = 34 students; M = 8;9 years) resulted in no improvement of the students’ cognitive (CFT 1: d_{mean} = -0.17; $\beta_{meanTrain\text{-}Int}$ = -.08) and verbal abilities (HSET: d_{mean} = -0.02, $\beta_{meanTrain\text{-}Verb}$ = .04). However, the PC version (N_2 = 27; M = 7;8 years) resulted in a small positive effect on intelligence (CFT 1: d_{mean} = 0.28; $\beta_{meanTrain\text{-}Int}$ = .13) and verbal performance (HSET: d_{mean} = 0.25, $\beta_{meanTrain\text{-}Verb}$ = .12). Compared to childhood cognitive development, even the small training effects observed in Study 2 are practically meaningful because they correspond to more than half a year of schooling and maturation. Integrating cognitive trainings in preschool to lifelong learning programs is recommended.

Impact of Cognitive Trainings

Cognitive competence is the ability to think, to possess relevant and accurate knowledge and to apply this knowledge intelligently. This competence is required in order to solve complex problems successfully which can range from language learning to other academic or professional and everyday tasks (e.g., Rindermann, Flores-Mendoza, & Mansur-Alves, 2010; Rindermann, Michou, & Thompson, 2011). One aspect of cognitive competence is reasoning, that is, identifying rules and transferring these rules to new problems. According to Klauer and Phye (2008), inductive reasoning consists of detecting regularities and irregularities by finding out similarities and differences of attributes and relations with differently coded contents (e.g., verbal, pictorial, numerical).

Thinking abilities can be improved by different kinds of interventions, for example, by means of educational methods like trainings (e.g., Irwing, Hamza, Khaleefa & Lynn, 2008; Jaeggi, Buschkuehl, Jonides & Shah, 2011; Schmiedek, Lövdén, & Lindenberger, 2010), early education and preschool (e.g., Campbell & Ramey, 1994) or schooling in general (Ceci, 1991). Especially Klauer has developed cognitive trainings for several age groups (e.g. Klauer, 1989, 1991, 2008), and he has empirically investigated their effectiveness. In numerous studies applying individual, dyadic or small group settings to whole classes, positive effects of the training programs were found on academic learning, concentration and intelligence (e.g. Marx, 2005; Sonntag, 2004). The effectiveness of the programs for children and teenagers across 78 evaluation studies was on average d = 0.52 regarding intelligence gains, and d = 0.69 on average across 38 studies regarding academic learning (corrected for dependencies within samples, respectively; Klauer & Phye, 2008). For example, for children with special needs, positive effects were found which were beyond coaching effects and which turned out to be stable in the long-term (e.g., Marx, 2005).

Assuming that positive effects can spread, even a relatively short training could result in positive long-term effects (cf. Klauer & Phye, 2008). Previous studies on the cognitive training with children and teenagers with special needs showed that the positive effects transfer to further areas, for example, language acquisition, reading literacy or academic learning (e.g., Marx, 2006; Sonntag, 2006).

Although previous studies from different groups of researchers have illustrated the effectiveness of Klauer’s cognitive trainings with special-needs students, these studies have researched quite homogeneous samples, for example, regarding competence level or regarding clinical pictures (e.g., senior classes of a special school; Sonntag, 2004). However, children attending special education centers mostly have rather different needs. Therefore, studies are needed for answering the research question whether a cognitive training has positive effects with a quite heterogeneous group of special-needs students.

Klauer’s Inductive Reasoning Training as a Cognitive Apprenticeship Approach

Cognitive apprenticeship is an instructional approach which aims at fostering not only domain-specific prior knowledge but also general and transferable problem solving strategies such as learning strategies, control strategies, and heuristics as well as the positive experience of intrinsically motivating, cooperative learning tasks (Collins, Brown, & Newman, 1989). The role of teachers is to demonstrate how tasks can be solved, to explain their solution steps and express their thoughts as experts in this process, to structure suitable exercises for their learners, to help them by providing feedback or further information in case of problems, and to reduce guidance gradually in the course of learners becoming more experienced and independent. These processes can be summarized by the often-cited keywords of *modeling – coaching – scaffolding – fading* (Collins et al., 1989). The role of learners is to discuss about their knowledge (*articulation*), to compare their approach with other learners' approach (*reflection*), and to explore new problems and strategies (*exploration*; Collins et al., 1989).

This approach has proven to be highly effective for improving students' reading comprehension (Palincsar & Brown, 1984), for acquiring mathematical problem solving strategies (Schoenfeld, 1985), for teaching causal reasoning (Hendricks, 2001), for developing writing skills (Bereiter & Scardamalia, 1987), and for knowledge building in general (Scardamalia & Bereiter, 2006). On a conceptual level, as teaching of inductive reasoning, and on the methodological level, Karl Josef Klauer's cognitive trainings can also be characterized as a cognitive apprenticeship approach. The following steps are common to all of his training programs developed for all age groups from preschool till seniority (e.g. Klauer, 1989):

(1) *Exposition:* This is the starting point of each cognitive training program. Klauer (1989) recommends to present authentic tasks in order to illustrate the relevance of inductive reasoning for everyday life. In this phase, the first tasks are solved by analyzing the initial variables, formulating an aim and a plan how to reach it, testing one's hypotheses, and self-reflecting upon the results.
(2) *Development:* The function of this stage is to understand the general structure of inductive reasoning tasks which is to identify similarities or differences between features, to develop and test rules, to describe and compare task categories, to articulate their features, to learn to use the concepts correctly (e.g. 'features', 'relations', 'sameness', 'differentness' etc.), and to link the task categories with solution strategies.
(3) *Application:* This stage serves four functions. First, through practicing to solve many tasks, the skills and strategies are deepened. Second, learners practice to identify task categories upon being confronted with new tasks. Third, a transfer of prior knowledge to new tasks is achieved. Fourth, all skills should be automatized so that tasks can be solved quickly and effortlessly.

Klauer (1989) recommends the following training methods which can, like the abovementioned training steps, clearly be classified into a cognitive apprenticeship approach:

Guided discovery. The learners mainly work in a self-regulated manner during exploring the task classes with their specific features. Only in case of problems, the trainer gives hints by asking helpful questions and correcting errors. Special-needs students may need more guidance than other learners. The aim is to make the learners think aloud or explain to the trainer as much as possible. Core aspects should be summarized and repeated, for example, solution procedures and control strategies. Klauer (1989) emphasizes the importance of developing and using a common language (O'Donnell & O'Kelly, 1994; Rogoff et al., 2003; Vygotsky, 1978) which supports memorization of the learned strategies.

Verbalization and *self-reflection*. The aim of this training method is that learners should think aloud and justify their task solutions. This should induce a more analytic strategy (than mere guessing), activate and strengthen control strategies, and reduce cognitive load. Self-reflection can be supported by asking the learner why he or she made a specific step etc. This method is more effective in dyadic compared to individual settings because peers can learn from each other by mutually adopting the partner's strategies (Lou, Abrami, & d'Apollonia, 2001).

Verbal self-instructions. This method is especially recommended with special-needs students (Klauer, 1989, p. 99) and has proven to be highly effective (e.g. Masendorf & Klauer, 1987). The trainer first models the task solution by making his or her thinking visible. Further, the trainer shows how he or she reacts to own errors and corrects them. For example, he or she can compliment himself or herself for working accurately. In the second step, the learner should instruct the trainer to solve a task by using the directions he or she has heard before. In the third step, the learner uses self-instructions by verbalizing them aloud, then whispery, and finally, by means of inner speech (Vygotsky, 1978).

Thus, external regulation decreases and self-regulation increases in the order of the training methods: verbal self-instructions – verbalization and self-reflection – guided discovery (Klauer, 1989). Depending on the age of the target group, Klauer recommends different forms of a social training. For example, in kindergarten age, he prefers individual trainings with a maximum duration of 20 minutes (Klauer, 1989, p. 111). Dyadic training settings can be applied from the age of primary school; however, the trainer needs to ensure that the learners alternate during task solution so that both learners receive enough practice. Reciprocal teaching (Palincsar & Brown, 1984) can be used by letting one learner self-comment on his or her strategies and the other learner check and question the strategies applied. After each phase, the roles are changed. This is also possible in small groups of 3-4 learners. Klauer recommends learning in homogeneous groups because this supports achievement motivation and prevents competence threats by more knowledgable learners (Butera, Caverni, & Rossi, 2005). Further, a suitable procedure could be to use direct instruction in groups during the exposition phase, small groups during the development phase, and individual training during the application phase (Klauer, 1989).

Further commonalities of all training programs are the six task categories of inductive reasoning (e.g. Klauer, 1989; Lenhard, Lenhard, & Klauer, 2012):

(1) *Generalization:* These tasks require identifying that different objects share at least one common feature (e.g. what is the commonality of a butterfly, a kite, and a helicopter?).
(2) *Discrimination:* The differences between features need to be found out (e.g. pick the odd one out: spade – watering can – telephone – garden hose).
(3) *Cross-classification:* In these cases, at least two features are crossed, and their commonalities and differences need to be identified (e.g. where does the banana fit best: to an apple, a pear, a ball of wool or a bucket?).
(4) *Relationship identification:* These tasks require that commonalities between relationships, for example, commonalities of sequences, are identified (e.g. arrange pictures of a comic strip story in the correct order).
(5) *Relationship differentiation:* In contrast to the previous category, differences between relationships need to be found out (e.g. disturbed sequence: objects are ordered according to increasing size except one object which does not follow this rule and which has to be sorted out).
(6) *System composition:* Both the commonalities and the differences of relations need to be identified (e.g. complete a matrix in which two features of objects need to be crossed).

Since the graphics of the paper-pencil-based training program I for preschool, primary school and special-needs students became out-dated displaying objects unknown to today's children (e.g. picture of a typewriter), Lenhard and colleagues (2012) developed a modern computer-based version. A further difference between the former paper-pencil-based version and the new computer-based version is that in the PC version, the training is embedded in a fantasy story: The learners are asked to help two elves to search for the "blue diamond of wisdom" (Lenhard et al., 2012).

In the following, two field studies are presented investigating the effectiveness of two forms of Klauer's cognitive training program I with special-needs students on cognitive and verbal development. In the first field study, a paper-pencil version of program I was applied in an Austrian sample, whereas in the second study, the computer-based version of program I was applied in a German sample. Within each study, it was assumed that:

1) the inductive reasoning training enhances fluid intelligence and results in increased intelligence test scores (*Hypothesis 1*);
2) due to the large amount of verbal activity, the training program should also result in improvements of verbal performance (*Hypothesis 2*);
3) the effects should be similar in an experimental group (first training group) and a waiting control group (second training group), that is, the increase in intelligence and verbal performance should be similar. This similarity of effects should ideally result in a 'rhomb pattern' of results (*Hypothesis 3*; cf. Figure 1). This is important in order show that the training results in an effect which is universal for all participants and rather independent of aptitude-treatment interactions (Cronbach & Snow, 1977);
4) the effects should be stable across a time period of six weeks (*Hypothesis 4*).

Comparing both studies, it was postulated that the computer-based version in which the cognitive training is embedded in a fantasy story (Lenhard et al., 2012) should be more effective than the paper-pencil version (*Hypothesis 5*) because the computer-based version should be more motivating and the objects should be easier to identify for the students.

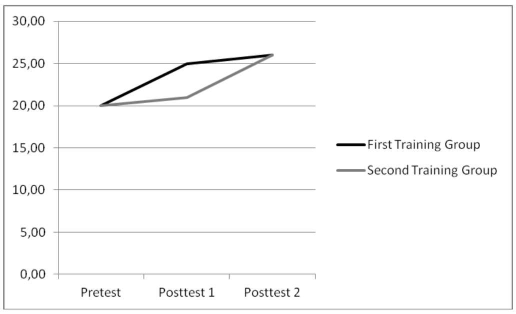

Figure 1. Hypothetical 'Rhomb Pattern' of Results of the Raw Scores.

Method

Across both studies, different trainers were used. However, within each study, the trainers also administered the tests.

Study 1

The study was conducted at three special-needs centers in Graz (Austria). The participants were nine girls and 25 boys at the age of 7;0 to 10;5 years (*M* = 8;9 years, *SD* = 1;1 years) visiting the first to fourth class of primary school. The parents and/or the teachers reported at least one of the following diagnoses (DSM-V) for each student, respectively: Autism spectrum disorder (e.g. Asperger syndrome); specific developmental disorder; expressive language disorder; reading disorder; disorder of written expression; mathematics disorder; conduct disorder; attention deficit hyperactivity disorder.

The children were matched to the first and second training group according to their pretest scores on the CFT 1 (Fiechtl, 2010). Cognitive ability was assessed in group settings by means of the three subtests Classifications, Similarities, and Matrices of the 'Culture Fair Test' CFT 1 (duration: 30-40 minutes; Cattell, Weiß, & Osterland, 1997), and verbal development was assessed by means of the four subtests Imitation of Grammatical Structure Forms, Generation of Morphemes, Sentence Generation, and Word Finding of the 'Heidelberger Sprachentwicklungstest' HSET (Grimm & Schöler, 1991), a German-speaking test which we adapted slightly to Austrian terms. Both tests were administered three times, as a pretest and as a first and second posttest. Due to several participants being ill in winter, less data were collected for the HSET. After the pretest, dyads of children of the first training group (n_1 = 17 children) took part in the cognitive training for children I by Klauer (1989). The training phase lasted for four weeks, with 2 sessions per week (each 30-40 minutes) and 15 tasks, respectively. Four weeks after the pretest, the first posttest was conducted. Only after this first posttest did the cognitive training start in the waiting control group (i.e., the second training group: n_2 = 17 children) for four weeks. After the waiting control group had finished the training, the second posttest was administered to all participants, twelve weeks after the pretest.

Results of Study 1

The effect size 'd_{corr}' in former evaluation studies on K. J. Klauer's cognitive training programs (e.g. Klauer & Phye, 2008) is corrected for pre-training differences (i.e., differences of the first post test are corrected for differences of the pretest, and differences of the second post test are corrected for differences of the first posttest; Cohen, 1988) and uses the pooled standard deviation. In addition, regression analyses are reported using the results of the previous test, respectively, and the experimental group (first training group vs. second training group) as predictors (see Table 1 for means and standard deviations).

On the first posttest, a small negative effect of the training on cognitive ability was found showing a superior performance of the waiting control group who did not train in this phase over the first training group (d_{corr} = -0.21, $\beta_{Train\text{-}Int}$ = -.17; see Figure 2). On the second posttest, the waiting control group who had received the training now, again scored slightly higher than the first training group who did not train in this phase, but the training effect also turned out to be slightly negative (d_{corr} = -0.13, $\beta_{Train\text{-}Int}$ = .02). The mean effect averaged across both training groups was d_{mean} = -0.17 ($\beta_{meanTrain\text{-}Int}$ = -.08).

A more inconsistent finding emerged for verbal development: On the first posttest, the waiting control group scored higher than the first training group (see Figure 3); thus, a small negative effect of the training on verbal ability was found (d_{corr} = -0.19, $\beta_{Train\text{-}Verb}$ = -.05); however, on the second posttest, the effect of the cognitive training on the second training group (i.e. the former waiting control group) was small but positive, (d_{corr} = 0.15, $\beta_{Train\text{-}Verb}$ = .13). This resulted in a mean effect of d_{mean} = -0.02, $\beta_{meanTrain\text{-}Verb}$ = .04).

Table 1: Means (and standard deviations) of the CFT 1 and the HSET scores used in Study 1.

	Pretest		Posttest 1		Posttest 2	
	CFT 1	HSET	CFT 1	HSET	CFT 1	HSET
First Training Group	22.41 (5.28) (*n* = 17)	31.24 (19.83) (*n* = 17)	24.59 (6.19) (*n* = 17)	40.56 (22.42) (*n* = 16)	25.76 (5.50) (*n* = 17)	39.47 (21.86) (*n* = 17)
Second Training Group	24.81 (7.38) (*n* = 16)	31.33 (20.60) (*n* = 15)	28.24 (4.68) (*n* = 17)	44.71 (23.59) (*n* = 14)	28.71 (5.30) (*n* = 17)	47.00 (19.61) (*n* = 17)

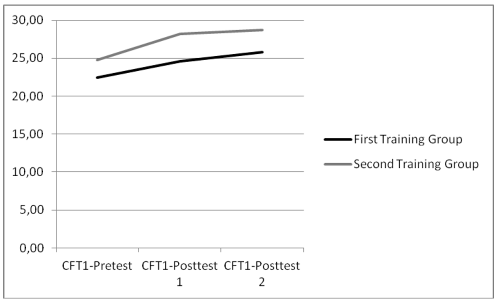

Figure 2. Raw Scores of the Intelligence Test Across Three Times of Measurement.

Figure 3. Raw Scores of the Verbal Competence Test Across Three Times of Measurement.

Thus, in contrast to Hypotheses 1 and 2, the paper-pencil-based version did neither support the inductive reasoning processes of special-needs students nor their verbal development. Consequently, no 'rhomb pattern' of results emerged, rejecting Hypothesis 3. Instead, the slight and relatively stable increases in cognitive and verbal ability (Hypothesis 4) can be traced back to (1) naturally occurring developmental effects and (2) a re-test or practice effect (i.e. getting used to work on the performance tests; Hasselhorn, 1995; Colom et al., 2010). In order to find out whether the modernized PC version (Lenhard et al., 2012) is more effective than the paper-pencil version (Hypothesis 5) of training program I (Klauer, 1989), Study 2 was also conducted with special-needs students.

Study 2

This study was conducted at a kindergarten with remedial education and at a special-needs school in Chemnitz (Germany). Seven girls and twenty boys participated who were about 5;2 to 9;7 years old (M = 7;8 years, SD = 1;5 years). As in Study 1, the parents and/or the teachers reported at least one of the following diagnoses (DSM-V) for each student, respectively: Autism spectrum disorder (e.g. Asperger syndrome); specific developmental disorder; expressive language disorder; reading disorder; disorder of written expression; mathematics disorder; conduct disorder; attention deficit hyperactivity disorder; learning difficulties.

The same tests as in Study 1 were used, that is, the CFT 1 measuring cognitive ability and the HSET assessing verbal development, as pretest and first and second posttest. The modernized, computer-based version of the cognitive training for children I (Lenhard et al., 2012) was conducted mostly in dyads (first training group: n_1 = 13; waiting control / second training group: n_2 = 14) with three units per week and ten tasks per unit (duration: 30 minutes, respectively). As in Study 1, the children were matched to the first and second training group according to their pretest scores on the CFT 1 (Jung, 2012; Voigt, 2012).

Results of Study 2

Again, the effect size 'd_{corr}' was used corrected for pre-training differences (i.e., differences of the first post test are corrected for differences of the pretest, and differences of the second post test are corrected for differences of the first posttest; Cohen, 1988), respectively, using the pooled standard deviation. Similarly, the regression analyses used the results of the previous test, respectively, and the experimental group (first training group vs. second training group) as predictors (see Table 2 for means and standard deviations).

On the first posttest, the first training group showed a superior performance than the waiting control group; thus, a small positive effect of the training on cognitive ability was found (d_{corr} = 0.20, $\beta_{Train\text{-}Int}$ = .10; see Figure 4). Similarly, in the second training group, a small positive effect of the training on cognitive ability was found on the second posttest (d_{corr} = 0.36, $\beta_{Train\text{-}Int}$ = .15). The mean effect, averaged across both training groups was d_{mean} =0.28 ($\beta_{meanTrain\text{-}Int}$ = .13) and equals to +4.2 IQ points.

In addition, a small positive effect of the training on verbal development was found in the first training group (d_{corr} = 0.12, $\beta_{Train\text{-}Verb}$ = .06), and also a small positive effect was found in the second training group (d_{corr} = 0.37, $\beta_{Train\text{-}Verb}$ = .18). This resulted in a mean effect of d_{mean} = 0.25, $\beta_{meanTrain\text{-}Verb}$ = .12).

Table 2: Means (and standard deviations) of the CFT 1 and the HSET scores used in Study 2.

	Pretest		Posttest 1		Posttest 2	
	CFT 1	HSET	CFT 1	HSET	CFT 1	HSET
First Training Group	19.46 (7.09) (n = 13)	38.87 (11.19) (n = 13)	22.38 (5.77) (n = 13)	41.26 (10.81) (n = 13)	21.85 (7.21) (n = 13)	42.28 (11.85) (n = 13)
Second Training Group	19.93 (7.07) (n = 14)	38.88 (9.10) (n = 14)	21.50 (7.35) (n = 14)	40.14 (8.06) (n = 14)	23.29 (5.31) (n = 14)	44.69 (7.52) (n = 14)

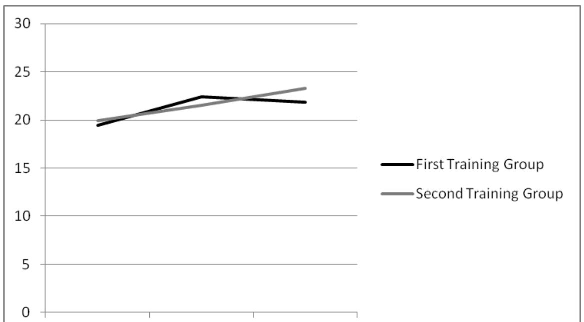

Figure 4. Raw Scores of the Intelligence Test Across Three Times of Measurement.

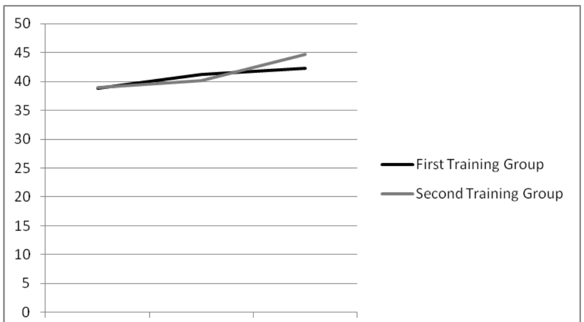

Figure 5. Raw Scores of the Verbal Competence Test Across Three Times of Measurement.

The PC version slightly improved the cognitive and verbal abilities of the special-needs students, supporting Hypotheses 1 and 2. Further, although the effects are not very pronounced, a slight 'rhomb pattern' of results was observable (see Figures 4 & 5); thus, the PC version should work relatively independently from further characteristics of the participants, supporting Hypothesis 3. The effects seem to be stable (Hypothesis 4); however, studies with more prolonged follow-up phases are needed in order to corroborate this assumption. Finally, comparing the paper-pencil-based (Study 1) and the PC version (Study 2) of the training, the latter version was more effective, confirming Hypothesis 5.

Discussion

Inductive reasoning is the ability to identify similarities and differences of attributes and relations (Klauer & Phye, 2008), and it is a core feature of human intelligence (Klauer & Phye, 2008; Lenhard & Lenhard, 2011; Rindermann & Baumeister, 2013). Inductive reasoning trainings for all age groups have been developed and tested by K. J. Klauer. His training programs can be characterized as a German approach to cognitive apprenticeship (e.g. Collins et al., 1989) because the classical methods of modeling, coaching, scaffolding, fading, articulation, reflection, and exploration are applied.

In two field studies, we tested the effectiveness of the paper-pencil-based version of program I and compared it to the effectiveness of the PC version with regard to improving the cognitive and verbal abilities of special-needs students. The first field study (N_1 = 34; paper-pencil version) was conducted in Austria, the second field study (N_2 = 27; PC version) in Germany.

In the first field study, no positive effect of the training on intelligence and verbal development was found. Instead, all students improved their cognitive and verbal abilities across the three times of measurement independently of the cognitive training. One reason why no positive training effect was found could be that the tasks were not motivating enough for the students. In addition, the training tasks were similar to the tasks of the intelligence test (CFT 1) which resulted in boredom and decreased motivation during the test phase. That is, although the training and performance test tasks seemed to be too easy for the students, no ceiling effect of their cognitive and verbal performance was observable. Therefore, further studies should use broader intelligence tests (e.g. the Wechsler Intelligence Scale for Children; Wechsler, 2004) which offer farther transfer between training tasks and test tasks.

In the second field study, a PC version of the training program I was used (Lenhard et al., 2012). In this PC version, out-dated graphics of the paper-pencil version had been exchanged, and a motivating fantasy story had been built around the cognitive training tasks. Thus, this PC version is even more typical of a cognitive apprenticeship approach than the previous version because situated learning is more strongly applied when the students participate in the fantasy story. The PC version had a small and positive impact on the students' cognitive and verbal abilities, over and above the developmental gains which were also observable for all participating students. Although only a small effect of the cognitive training was found on the students' intelligence, this small effect is still practically meaningful because an increase of four IQ points corresponds to more than half a year of schooling and maturation combined (Rindermann, 2011)!

Since our small training effects are in contrast to those reported by Klauer and Phye (2008), it is important to identify moderating variables (e.g. type of developmental disorder, IQ levels, motivation etc.) which support or hinder training gains. In addition, it is important to include studies like our two in future meta-analyses in order to reduce publication biases. Different assumptions exist regarding the question for which target groups such cognitive trainings would be especially effective: According to Klauer and Phye (2008), students with learning disabilities should profit more than students without learning disabilities (w.r.t. intelligence: d = 0.54 vs. d = 0.52; w.r.t. academic performance: d = 0.94 vs. d = 0.69; Klauer & Phye, 2008). Similarly, large effects of cognitive trainings were shown in developmental countries (e.g. Irwing et al., 2008: Sudan, d = 0.47, this equals to 7 IQ points). In further own studies, however, we found larger effects of Klauer's training for students who show higher academic performance and for elderly people with higher levels of education compared to less educated seniors of the same age (Rindermann & Baumeister, 2013) – thus, 'Matthew effects' ("the rich get richer, and the poor get poorer"; Matthew 25:29) seem to be more common for the cognitive training programs by Klauer than ceiling effects.

Limitations of both studies were the small sample sizes. Further, there was no follow-up phase for the second training group. Therefore, it is possible that in the first study, positive effects of the training would have emerged in later phases after the students had more opportunities to apply the trained skills in daily life. Future studies should try to investigate the training's effectiveness with larger samples and longer follow-up phases (e.g. 3 to 15 months; Klauer & Phye, 2008).

Finally, a problem of the statistical method of effect estimation is that different effect sizes result in different interpretations: Several variants for calculating d-values exist depending on the homogeneity or heterogeneity of the sample and the resulting standard deviations (cf. Rindermann & Baumeister, 2013). In addition, d-values as effect levels are numerically higher than r- or β-values (e.g. small effect according to

Cohen, 1988: d = .20 vs. r / β = .10). Therefore, it is recommended to report at least two variants for calculating the effect size, for example, d and β. If the performance test (e.g. intelligence test) was conducted completely, test norms should be used to quantify the effectiveness in IQ points based on the population variance.

A further methodological challenge is to use a suitable control group, for example, in the form of a further training program pursuing different aims (e.g. Jaeggi et al., 2011) or by separating and comparing the different components of one and the same training program (e.g. Dorbath, Hasselhorn, & Titz, 2011).

Since K. J. Klauer's cognitive training programs are the most often evaluated ones with more than 100 experimental studies and more than 4.000 participating children from Europe and the USA, the potential effects are undoubted (Klauer, 2014). Thus, it can be recommended to integrate the training in the curriculum of kindergartens and schools, including refreshing sessions several months later (Möller & Appelt, 2001) – this would take no longer than 10 lessons and could substantially help children to improve their cognitive abilities and academic performance.

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