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Extending the scope of the 'cognitive advantage' hypothesis: multilingual individuals show higher flexibility of goal adjustment

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ABSTRACT

The cognitive advantage (CA) hypothesis claims that multilingualism promotes the development of several basic cognitive capacities. A large number of empirical findings support this hypothesis, but recently there have also been numerous contradictory findings and methodological objections. The present paper extends the investigation of possible cognitive advantages from basic cognitive (executive) functions to broader cognitive competencies such as cognitive flexibility. A promising candidate for this is 'flexibility of goal adjustment' (FGA), a capacity of developmental regulation that solves problems through flexible adaptation processes. In a study with $N = 119$ monolingual and multilingual adults we found the predicted positive correlation between multilingualism and FGA. However, the mediator function of executive capacities entailed in the CA hypothesis operationalised as Stroop and flanker tasks could not be demonstrated.

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Although the old conjecture that multilingualism may not only decrease competence in each individual language but also harm cognitive functions in general is obviously inaccurate in this simple form, the thesis that multilingualism has positive consequences for cognitive capabilities of speakers ist also controversial; interrelationships of these processes are complex (Antoniou 2019). In the present paper, we will argue that the discussion could benefit from extending the perspective on possible cognitive benefits of multilingualism beyond single concrete skills to complex functional groups of skills, especially cognitive flexibility.

The 'narrow' cognitive advantage hypothesis: inconclusive findings

The 'cognitive advantage' (CA) hypothesis claims that multilingualism,[1] due to constant high cognitive demands (e.g. language switching), promotes and enhances not just those cognitive functions that are particularly related to language (e.g. metalinguistic awareness, Baker and Wright 2017; Adesope et al. 2010) but at the same time several more basic underlying multi-purpose cognitive functions such as working memory or information inhibition (Antoniou 2019; Bialystok 2017; Bialystok and Barac 2013; De Groot 2011, 385ff; Valian 2015; Zhang 2018). A number of findings support this hypothesis (Bialystok 2015; Bialystok et al. 2009; Bialystok, Craik, and Luk 2012; Van den Noort et al. 2019; for meta-analyses see Adesope et al. 2010; Grundy and Timmer 2017), especially for those cognitive abilities required to inhibit cognitive content that is constantly activated but not

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currently needed (Bialystok and Viswanathan 2009; Kroll et al. 2012; Poarch 2018; Poarch and van Hell 2012), but also for cognitive resources and abilities required in task switching (Bialystok and Martin 2004; Wisehart, Viswanathan, and Bialystok 2016) and for resources and regulations of working memory (Grundy and Timmer 2017).

On the other hand, an increasing number of studies did not find support for the CA hypothesis (e.g. Paap and Greenberg 2013; for recent examples see Czapka, Klassert, and Festman 2019; Czapka et al. 2020; for overviews see Festman, Czapka, and Winsler 2021; Hilchey and Klein 2011; Paap, Johnson, and Sawi 2015; Poarch and Krott 2019; Van den Noort et al. 2019; Zhou and Krott 2016). The comprehensive meta-analysis by Lehtonen et al. (2018) concludes that the available evidence does not provide systematic support for the CA hypothesis concerning executive functions (EFs; e.g. inhibition). The recent large study by Nichols et al. (2020) including a sample of 11,000 people supports this position. Although the critical stance towards the CA hypothesis has not remained without response (Titone et al. 2017; for a summary see Antoniou 2019), the call for more differentiated methodological designs and measurements and more differentiated theoretical explanations with respect to possible conditions (i.e. moderators; Antoniou and Wright 2017; Festman, Czapka, and Winsler 2021) is certainly reasonable and appropriate (Laine and Lehtonen 2018).

A conclusion of the controversial debate on how the inconsistent results in the empirical literature can be explained is made difficult (apart from a possible publication bias; de Bruin, Treccani, and Della Sala 2015) by the fact that the available studies focus on different basic cognitive functions (executive functions, capacities of working memory, etc.) and, in particular, pursue different methodological approaches with respect to the assessment of the cognitive functions investigated (with not always comparable methodological rigour; Poarch and Krott 2019; Van den Noort et al. 2019; Zhou and Krott 2016). In addition, samples are often small (especially in studies which corroborate the CA hypothesis: Paap, Johnson, and Sawi 2015; Nichols et al. 2020), and are oftentimes not really comparable (Van den Noort et al. 2019) with regard to age and social characteristics of the mono- and multilingual subsamples (Czapka et al. 2020; Nichols et al. 2020; Poarch and Krott 2019) and the involved languages (Antoniou 2019; Bialystok 2017; De Groot 2011; Titone et al. 2017; Valian 2015). Methodological objections extend to some of the available meta-studies on the topic (Paap et al. 2020). Even the premise of the CA hypothesis that regular switching between languages is cognitively demanding (which in turn leads to the presumed promotion effect) may need to be evaluated in a more differentiated way (Blanco-Elorrieta and Pylkkänen 2018), for instance with respect to typological differences between the respective languages (Antoniou and Wright 2017).

Mental flexibility beyond basic cognitive mechanics: making the case for an extension of the CA hypothesis

However, the current debate on the CA hypothesis is mainly focused on cognitive functions in a narrow ('mechanical') sense, including in particular executive and memory functions (Nichols et al. 2020). In contrast, the perspective that advantages of multilingualism may manifest themselves in more general mental abilities (Fan et al. 2015; Festman and Kersten 2010; Festman and Schwieter 2019; Titone et al. 2017) has received less attention.

The main argument of the present paper claims that the stimulating and hence promoting effect of multilingualism goes far beyond its 'narrow' cognitive demands with respect to executive functions. Rather, multilingualism involves a regular change of perspective and focus not only in linguistic terms (grammar, vocabulary, pronunciation), but also in sociolinguistic, socio-cultural and pragmatic terms, e.g. the social connotations of concepts, the social etiquette of using certain words, phrases, and idioms, the implicit rules of behaviour associated with them, and the cultural concepts and associations underlying and intertwined with a linguistic system ('cultural frame switching', Hong et al. 2000; see also Baker and Wright 2017; Kramsch 2004; Pavlenko 2011, 2014). To be able to use such varying perspectives in a competent way is an important part of advanced multilingual competence. This requires a much more far-reaching mental flexibility

than simply inhibiting a lexical item or selecting a correct grammatical form or syntactical structure from the respective linguistic systems (Fan et al. 2015). Rather, multilingual competence might improve the general ability to flexibly change perspective and focus. For instance, Kovács (2009) found that bilingual 3-year-old children were better at 'theory of mind'-tasks (for similar results with respect to adults: Rubio-Fernandez and Glucksberg 2012). Similarily, Fan et al. (2015) found that monolingual children failed to interpret a speaker's meaning more often than both bilingual children and children who were exposed to a multilingual environment but were not bilingual themselves. Plausibly, such 'broader' cognitive or mental flexibility envisioned here entails or supports divergent, creative, elastic and open-ended thinking (Baker and Wright 2017, see p. 142; Fan et al. 2015; see also Festman and Kersten 2010). A number of studies indicate indeed that multilinguals show improved abilities of divergent and creative thinking, e.g. the ability to find numerous answers to a given problem (Kharkhurin 2007, 2009, 2015; Lee and Kim 2011). Accordingly, bilingualism predicts individual flexibility, that is, the ability to learn from new experiences or to adjust behaviour according to contingency (Dewaele and Botes 2019). Given that such abilities are valuable or even necessary prerequisites for solving problems and coping with challenges (Adesope et al. 2010), the CA hypothesis can be expanded to the question whether multilingualism may promote problem-solving competencies and abilities for which the ability to change perspectives and focus (in a broader sense) is also characteristic or relevant.

Flexibility of goal adjustment as a possible beneficiary of multilingualism

In the present study, we argue that the individual flexibility of goal adjustment (FGA) as a particular means of solving problems might be a prototypical sample case of such a general ability of problem solving through using, and flexibly altering and changing, a variety of perspectives. The individual's FGA is conceptualised in the framework of the two-process model of developmental regulation (Brandtstädter 2006, 2007, 2015; Brandtstädter and Renner 1990; Brandtstädter and Rothermund 2002). According to this model, people regulate problems in two basic ways. In the 'assimilative' mode of tenacious goal pursuit, people strive to alter the perceived state of affairs with the available resources and skills in such a way that the situation fits better to one's goals or wishes. Within this mode, the goals pursued remain unaffected. However, if goals appear permanently blocked and wishes become unattainable, tenacious persistence will not be sufficient to overcome limitations. Here, the 'accommodative' mode reduces or resolves problems by adjusting the goals, desires, normative orientations and preferences to the (perceived) circumstances by devaluing unattainable goals or desires, replacing them by attainable goals or strivings, or altering one's standards and norms. According to the model, the accommodative mode is not one single process but encompasses a broad variety of different processes (Brandtstädter 2006; Brandtstädter and Rothermund 2002; Thomsen 2016). This sometimes involves letting go of the previous goal or reorienting towards a new (reachable) one (e.g. 'If I cannot become a medical doctor, I may become a salesman or an artist'), but often means changing the perspective on the previous goal (e.g. reinterpretation: 'Maybe I can achieve the goal of wanting to help people in a different way than through my failed medical studies – perhaps as a nurse?') or broaden the perspective (e.g. downward comparison: 'What happened to me is depressing and painful – but many other people have been through much worse things!'). One important – and oftentimes necessary – element of such accommodative processes can be seen in the change of perspective on the problem.

A number of studies have shown that individuals vary considerably with respect to their preparedness and ability to accommodate their goals or values (for an overview see for example Brandtstädter 2006, 2015; Brandtstädter and Rothermund 2002; Heckhausen, Wrosch, and Schulz 2010, 2019; Haase, Heckhausen, and Wrosch 2013). Accordingly, the individual's FGA (Brandtstädter and Renner 1990) is a predictor for the stability of the self and well-being (Brandtstädter and Greve 1994), and a buffer against aversive circumstances and experiences both for adolescents (Thomsen et al. 2015) and adults (e.g. Greve, Leipold, and Kappes 2017; Rühs, Greve, and Kappes 2017).

The very fact that individual differences can be found indicates that FGA depends on developmental processes and conditions (Meyer and Greve 2012). In order to explain these developmental preconditions of individual FGA, earlier studies have investigated several conditions (Greve and Thomsen 2013; Thomsen and Greve 2013; Meyer and Greve 2012) such as individual capabilities of emotion regulation (Lessing et al. 2017) and social transfer processes (e.g. social learning; Kappes and Thomsen 2020; Thomsen et al. 2017). For the present context, however, two presumed developmental conditions for FGA are of particular importance:

(1) Contextual conditions of individual ontogenesis of FGA. Some findings suggest that heterogeneous life experiences and developmental stimulations, especially in the first two decades of life, seem to be related to the development of FGA. Several studies show that heterogeneous leisure activities and the experience of free and unrestrained play in childhood are linked to individual FGA (Greve and Thomsen 2013, 2016; Greve, Thomsen, and Dehio 2014; Thomsen and Greve 2013). A constraint of these studies, however, is that retrospectively reported childhood experiences may be influenced by recollection biases. In particular, individuals who are more strongly disposed to react to challenges in an accommodative manner (i.e. with higher FGA) may also tend to remember more (and more accurately) unrestrictive play in their childhood (Greve and Thomsen 2016). A second caveat concerns the fact that leisure activity choices (even in childhood) may also be confounded with the individual's FGA. Moreover, in these studies the heterogeneity of developmental conditions is limited to one domain of life (leisure). Thus, it would be stronger evidence for the hypothesis of flexibility-stimulating effects of heterogeneous experiences if biographical information can be collected which is, arguably, independent of the individual's FGA.

In the present study, we claim that multilingualism is a prototypical example for contextual heterogeneity. Multilingualism entails heterogeneous 'cognitive contexts' as multilinguals have, by definition, to switch between two or more languages and their cultural contexts in which they are embedded: Multilingualism is, as a rule, associated with cultural diversity (Bialystok 2017; Grosjean 2015) and thus entails 'cultural frame switching' (Hong et al. 2000). For instance, in the case of migration-related multilingualism, the cause of multilingualism is oftentimes the experience of more than one socio-cultural environment (Bialystok et al. 2009). At the same time, the self-assessment of multilingualism is not likely to be confounded with FGA. Hence, if multilingualism is used as a predictor in empirical studies (even in a cross-sectional ones), it could counteract both objections with respect to the developmental explanation of FGA.

(2) Cognitive conditions of FGA. The ability to think divergently and change perspectives is a necessary, possibly a constitutive condition to be able to generate alternative goals and relieving perspectives on obstacles and problems (such as cognitive reinterpretations or downward comparisons, Brandtstädter and Rothermund 2002). For instance, adolescents who succeed in looking at tasks from different perspectives and solving them with creative or divergent thinking show higher FGA scores than adolescents who tend to approach such tasks in a more rigid manner (Greve and Thomsen 2013; Thomsen and Greve 2013). If such competencies of divergent thinking rest on 'basic' cognitive abilities as referred to in the CA hypothesis (e.g. task switching), it is plausible to assume that such basic cognitive functions might be supporting conditions for (the development of) FGA. As to date, studies that have tested this assumption are rare. With respect to preschool children, the assumption that executive functions could play a direct supporting role in the development of accommodative processes could not be confirmed (Lessing et al. 2019; Piekny et al. 2017). However, the development of capabilities of divergent thinking and (as a possible consequence) of FGA might need some more time and become assessable only at a later age. So far, however, this assumption has not been tested with adults. Thus, the significance of 'basic' cognitive functions (EFs) for the development of FGA as mediated through divergent thinking has still to be investigated.

Hypotheses

It is the intention of the present paper to investigate a (possible) advantage of multilingual individuals with respect to accommodative self-regulation (FGA). Moreover, we will test the hypothesis that this relationship is mediated by basic cognitive functions (EFs).

Hypothesis 1: Multilingualism predicts FGA . If the assumption is correct that heterogeneous life experiences and conditions promote FGA (Greve and Thomsen 2013, 2016; Thomsen and Greve 2013), then the heterogeneity of linguistic, contextual, social and cultural experiences associated with multilingualism (Bialystok 2017; Grosjean 2015) should promote (the development of) FGA. Hence, multilingualism is expected to predict FGA.

Hypothesis 2: The relationship between multilingualism and FGA is mediated by EFs. If cognitive (executive) functions were supporting or even necessary conditions for FGA, and if the 'narrow' CA hypothesis was tenable (i.e. if multilingualism enhances EFs), then the assumed relationship between multilingualism and FGA (hypothesis 1) is expected to be partly mediated by the 'basic' cognitive functions addressed in the 'narrow' CA Hypothesis (i.e. mediated through EFs).

Note that hypothesis 1 neither presupposes an effect of multilingualism on EFs nor does it assume EFs to be supportive or constitutive for FGA (see Fan et al. 2015, for a similar argument). Accordingly, the test of hypothesis 1 neither depends on the corroboration nor on the refutation of hypothesis 2. However, hypothesis 2 entails hypothesis 1. Furthermore, hypothesis 2 entails a test (replication) of the 'narrow' CA hypothesis. We would like to emphasise that testing the CA hypothesis in its narrow sense is not the main intention of the present study. If it were the intention to refute the CA hypothesis, a much larger sample with greater statistical power would be necessary (among several other conditions; see discussion). If, on the other hand, a corroboration of the CA hypothesis would be the aim of the study, the choice of methods of assessment for executive functions that were used in earlier studies supporting the (narrow) CA hypothesis might be to less severe (beyond mere replication). Rather, the central intention of hypothesis 2 of the present study is to test an explanation of the development of FGA (which entails a re-test of the (narrow) CA hypothesis).

Empirical study

Participants

The sample consisted of 119 participants between 19 and 79 years of age ($M = 36.4$), 77 of them were female. Data were elicited through an online study (from May to July 2019), resulting in an 'incidental' sample. The largest group of participants lives in Germany (95 participants, 79.8%), with the United States as the second largest group (10 participants, 8.4%), followed by the United Kingdom (6 participants, 5%). Other countries include Canada, Sweden, Belgium, Denmark, Italy and Switzerland with one or two participants per country. The statistics on the country of birth are similar, with the largest group again being born in Germany (90 participants, 75.6%), the United States as the second largest group (6 participants, 5%), followed by the United Kingdom (5 participants, 4.2%). Other countries of birth are China, Sweden and Switzerland with 2 participants (1.7%) each, followed by Belgium, Canada, Denmark, India, Italy, Kazakhstan, Mexico, the Netherlands, Russia, Slovakia, Vietnam and Tunisia with 1 participant (0.8%) each.

Method

Questionnaire

Participants were asked to give information about their socioeconomic status (education and occupation of the participants and their parents [ISEI, Ganzeboom 2010]), their handedness, whether their eyesight is impaired and whether they have any neurological impairments or disabilities.

These questions were important to rule out outside factors that could influence the results from the measures of executive functions (see below).

Degree of multilingualism. Anderson et al. (2018) developed the language and social background questionnaire (LSBQ) to measure degree of multilingualism. The questionnaire was originally developed for young adults. For the purpose of this study and in order to keep the questionnaire as brief and simple as possible, parts of the LSBQ were adapted to assess the participants' degree of multilingualism: We used the questions on language background (section two of the LSBQ, items 15–17.2) and slightly adapted the wording of the questions. Explanations were added as the questionnaire was carried out online without an interviewer to help clarify items. The possibility to add more than two languages was given to accommodate for multilingual speakers. The questionnaire was then translated into German, and participants were asked to choose between the English and German version of the questionnaire. Many participants reported speaking more than two languages, but their proficiency in these languages varied greatly. It was therefore decided to only include the languages with the highest proficiency and usage ratings and to calculate the value for the (up to) three best languages. The resulting indicator for degree of multilingualism used in this study thus comprises the mean of the respective self-ratings for speaking, understanding, reading, and writing for each of the (up to) three best languages ('Relative to a native speaker (who learned the language from birth), how would you rate your proficiency level on a scale of 0–10 for the following activities in this particular language: speaking, understanding, reading, writing?') and of intensity of usage ('Please indicate how much time on average you spend each week on this skill in this particular language for speaking, listening, reading, and writing (none – little – some – most – all)'). Some participants did not rank the languages according to their (self-assessed) fluency and competence. In those cases, all ratings (including L4 or L5, if applicable) were used to determine the three best languages, if necessary.

Multilingual competence groups. Participants were classified as (mainly) monolingual if they did not indicate another language, or if their ratings of an L2 were low (i.e. less than 5 on a 10-point scale). In order to be able to differentiate within the multilinguals between persons with (relatively) early and (somewhat) later language acquisition, persons whose multilingual language acquisition started before the age of three (early childhood multilinguals; ECM) were distinguished from persons whose mutlingual language acquisition had started after the age of three years (late childhood or adulthood multilinguals; LCAM). For the purposes of this study, it seemed less important to distinguish between simultaneous and sequential second language acquisition (boundaries would also be arbitrary here and are used differently), but rather to address in particular the early developmental stimulation of executive functions (before they can be differentially diagnozed, which is the case from about the third year of life onwards; for comprehensive overviews see Bjorklund and Causey 2018, 260ff; Goswami 2008, 295ff). The chosen age limit follows the reasoning that the influence of the demands associated with multilingual language acquisition should be particularly strong at early, formative cognitive developmental stages (in addition, the earlier the multilingualism begins, the longer its (presumed) effects can 'operate'). According to this differentiation, the sample contained three multilingual competence groups (MLC groups): 35 (mainly) monolinguals (MM), 17 early childhood multilinguals (ECM; age of acquisition before age 3) and 67 late childhood or adulthood multilinguals (LCAM; age of acquisition after age 3).

As Table 1 shows, (self-reported) language proficiency for L2 and L3 is not generally lower for relatively late multilinguals; this might indicate that the incidental sampling was differentially selective for these MLC groups. In addition, the mean age of relatively early multilinguals is significantly lower than the mean age of monolinguals ($F = 3.86$, $p = .024$; monolinguals and late multilinguals do not differ significantly). Table 2 gives more detailed information about the number of monolinguals and multilinguals in three different age groups.

Based on information concerning occupation, socioeconomic status (SES) was measured using ISEI (Ganzeboom 2010), which was averaged across participants and their parents (where scores were available). Although SES is somewhat lower for early multilinguals than for late multilinguals

Table 1. Means and standard deviations for participants' age and language proficiency (self-reports) for multilingual competence groups (MLC groups).

MLC group	MM	ECM	LCAM
Age (years)	41.72 (16.56)	29.47 (10.83)	34.60 (15.48)
age of acquisition L2	10.13 (1.73)	1.67 (3.20)	9.57 (3.71)
age of acquisition L3	11.17 (3.92)	8.29 (5.25)	14.94 (7.10)
L1	7.01 (2.19)	8.49 (1.24)	8.83 (1.29)
L2	3.55 (1.34)	6.38 (1.82)	7.01 (1.71)
L3	3.44 (.09)	5.63 (2.26)	4.65 (1.99)
use of 3 'best' languages	8.89 (3.53)	20.33 (3.49)	18.66 (3.82)

Note: MM: (mainly) monolinguals; ECM: early childhood multilinguals (age of acquisition < 3 yrs.), LCAM: late childhood or adulthood multilinguals (age of acqusition > 3 yrs.)

and for monolinguals, the differences with respect to the SES of the participants and their families between the three language groups are not significant ($F = 2.51$; $p = .086$). Separate ANOVAs for the ISEI of the participants and their parents showed no significant differences between MLC groups as well.

Flexible Goal Adjustment. FGA was measured using the scale from Brandtstädter and Renner (1990). This scale consists of 15 items. Sample items for the FGA scale are: „In general, I am not upset very long about an opportunity passed up; 'I can adapt quite easily to changes in a situation;' 'After a serious disappointment, I soon turn to new tasks;' 'Even if everything goes wrong, I still can find something positive about the situation'.[2] The internal consistency of the FGA scale was $\alpha = .86$. It is worth mentioning that, contrary to the majority of earlier studies (e.g. Brandtstädter and Greve 1994; Brandtstädter and Rothermund 2002), we found no bivariate correlation for age and FGA (possibly as a consequence of a selective sample).

Assessment of executive functions (EFs)

In the present study, two assessments for executive functions were administered to operationalise executive functions, a Stroop task and a flanker task. Both of these tasks were used in several previous studies to investigate the CA hypothesis (flanker task: Kousaie and Phillips 2017; Paap and Greenberg 2013; Poarch and Bialystok 2015; Emmorey et al. 2008; Costa et al. 2009; Stroop task: Bialystok and DePape, 2009; Blumenfeld and Marian 2014; Duñabeitia et al. 2014; Kousaie and Phillips 2017; for overviews see Antoniou 2019; Bialystok 2017; Valian 2015; Van den Noort et al. 2019; see also Poarch and Krott 2019). For the present study, it is of particular importance that both tasks were used in a similar form in studies that had provided supporting evidence for the CA hypothesis.

Flanker. The flanker task was adapted from a study from Luk, de Sa, and Bialystok (2011). In their study, participants were presented with four black and one red chevron and were asked to indicate the direction the red chevron was pointing to by pressing a mouse button on either side of the screen. In the control condition, only the red chevron appeared in the middle of the screen. In the congruent and incongruent conditions, the red chevron was always flanked by four black chevrons. The red chevron could appear in any one of the three central positions. In congruent trials, the chevrons all pointed in the same direction, whereas in the incongruent trials, the red chevron would point in the direction opposite of the flanking chevrons. The experiment consisted of two

Table 2. Age of participants for MLC-groups.

MLC group	N	MM	ECM	LCAM
19–30	55	12	10	33
31–45	22	7	4	11
46–79	28	13	1	14

Note: MM: (mainly) monolinguals; ECM: early childhood multilinguals (age of acquisition < 3 yrs.), LCAM: late childhood or adulthood multilinguals (age of acqusition > 3 yrs.)

control blocks with 12 trials in each block, and two conflict blocks with 24 congruent and 24 incongruent trials per block. The order of the trials in each block was randomised and they were counterbalanced for direction of the target arrow and trial type. In the present study, the procedure corresponds to the one used by Luk, de Sa, and Bialystok (2011), but instead of answering by pressing a mouse button, participants indicated the direction of the red chevron by pressing a key on the left ('A') or right side ('K') of the keyboard. The stimulus was presented with a maximum of 2000 ms or until a response was detected, and with a 500 ms break in between trials. The blocks appeared in the order 'control – conflict – control – conflict' with a break in between the first conflict and the second control block. The participants had to press a key when they wanted to continue with the second control block. This was unavoidable due to restrictions on the length and amount of trials that could be programmed into one question in the online survey programme. The reaction times and accuracy were measured for each trial, and only trials where a correct response was given were analysed. Across all trials, the reliability of the flanker task is rather high (Cronbach's $\alpha = .971$, split half (Guttman) = .935).

Stroop. Since the publication of Stroop's original article in 1935, the Stroop Task has been used by many researchers in many variations (MacLeod 1991). Some researchers still use the original Stroop Color Word Test, but a single stimulus version is more common in recent research, in which only one colour word is presented at a time. For this paper, a single-stimulus version with a manual response was chosen, as participants were completing the task on their own computers. The Stroop task was adapted from Bialystok, Craik, and Luk (2008). In this study, the stimuli consisted of the words 'red', 'green' and 'blue'. They were presented in the centre of the screen, and participants responded orally. The experiment consisted of four conditions, and their order was counterbalanced across participants. In the control condition, an array of four Xs in one of the target colours was presented to account for colour-naming speed, and in the word reading condition, participants were asked to read the target colour words presented in black font. In the congruent condition, the colour words presented corresponded with the font they were presented in, and in the Stroop condition, the colour words presented were conflicting with the font they were presented in. There were two blocks for each condition, with 24 four trials in each block. For the present study, the task was changed slightly in order to collect the responses within an online survey. Participants had to respond manually by pressing a key on the keyboard. Each colour was assigned to a key, with the key 'X' for the colour blue, 'V' for the colour green and 'L' for the colour red. Furthermore, the word reading speed condition was left out since it could not be controlled for in this setting as there was no way to control whether participants read the words aloud; measurement would have been inaccurate as participants would have to read the word and press a key simultaneously. Therefore, the adapted experiment consisted of 6 blocks with 24 trials in each block. The order the blocks appeared in was always the same (colour control – congruent – Stroop – congruent – Stroop – colour control) in contrast to the random order of blocks in the original trial. Similar to the flanker task, after the first three blocks participants had to press a button to start with the last three blocks due to constraints in the design of questions in the web application. Across all trials, the reliability of the Stroop task is rather high (Cronbach's $\alpha = .997$, split half (Guttman) = .999).

The assessment for both indicators for EFs was conducted using the same online platform used to collect self-report data (SoSci Survey; Leiner 2020; version 3.2.16; www.soscisurvey.de). Socisurvey states (https://www.soscisurvey.de/help/doku.php/de:create:questions:assignment) that reaction times are recorded with an accuracy of 10 ms (JavaScript based).

For both tasks, participants were excluded if they produced too many errors (i.e. 3rd quartile + 1.5 * interquartile-difference). Additionally, for each participant reaction times were excluded if either the response was wrong or if the reaction time were too long (i.e. 3rd quartile + 1.5 * interquartile-difference). No significant differences between the MLC-groups regarding EFs were found in an ANOVA ($F(2,102) = 0.76$, $p = .472$). (Table 3).

Table 3. EF means and SDs for MLC-groups.

	MM	ECM	LCAM
M	358.05	305.63	345.58
SD	143.80	66.22	146.37

Note: MM: (mainly) monolinguals; ECM: early childhood multilinguals (age of acquisition < 3 yrs.), LCAM: late childhood or adulthood multilinguals (age of acqusition > 3 yrs.)

Results

To test hypothesis 1, in a first step the bivariate relationship between language competence and FGA was calculated. For degree of multilingualism, this results in a bivariate correlation of $r = .28$, $p = .004$ (see Figure 1).

In addition to this individual correlation, an analysis of variance (oneway) for the MLC groups yielded a significant effect (F (2, 102) = 81.77; $p < .001$; see Table 4 for means and SDs); the post-hoc analysis shows that the FGA scores of monolinguals differ significantly from both multilingual groups ($p < .001$), whereas the two multilingual groups do not differ from each other.

This confirms and enhances the result of the bivariate correlation: The significant contrast between monolinguals and multilinguals particularly supports the assumption that multilingualism can be seen as (a proxy for) a promoting condition for (the development of) FGA.

To test hypothesis 2, several mediator analyses were calculated. To that end, in a first step, both the flanker and the Stroop task were calculated as single indicators of the EFs, respectively. In a second step, we calculated the (standardised) mean of both tasks as a common EF indicator in order to overcome possible weakness of each of these two measures (actually, both tasks assess separate aspects of EFs, as a weak correlation indicates: $r = .15$, $p = .146$). The bivariate examination shows that neither the relationship between degree of multilingualism and EF (averaged over both indicators) becomes significant ($r = -.08$, $p = .396$ (power = .55, as calculated with G*Power; Faul et al. 2007)) nor the bivariate relationship between EF and FGA ($r = -.04$, $p = .656$ (power = 0.69)). Accordingly, we found no mediating effect of cognitive control on the relation between degree of multilingualism and FGA, as the simple mediation model analysis proved to be not significant. The mediator path coefficients were not significant ($a = -1.92$, $p = .396$; $b < -.001$, $p = .827$). Accordingly, the indirect effect was not significant ($ab = .00$, 95% $CI = -.0009, .0040$). However, the direct effect (multilingualism to FGA) was significant ($c' = .03$, $p = .005$), corroborating hypothesis (1) controlling for EFs. Very similar results occur if the flanker and the Stroop indicators

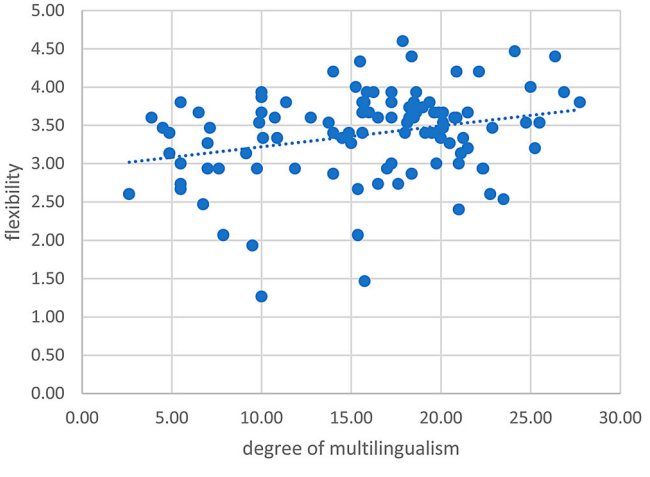

Figure 1. Scatterplot with individual results and regression from FGA on language proficiency (degree of multilingualism).

Table 4. FGA means and SDs for MCL groups.

	MM	ECM	LCAM
M	9.08	21.58	18.97
SD	3.78	3.52	4.07

Note: MM: (mainly) monolinguals; ECM: early childhood multilinguals (age of acquisition < 3 yrs.), LCAM: late childhood or adulthood multilinguals (age of acqusition > 3 yrs.)

were used as EF indicators separately (flanker: $a = -1.74$ ($p = .399$), $b = .0005$ ($p = .277$), indirect effect $ab = -.0009$ (LL: −.0037; UL: .0013), $c' = .03$ ($p = .003$); Stroop: $a = -2.25$ ($p = .177$), $b = -.001$ ($p = .067$), indirect effect $ab = .002$ (LL: −.0010; UL: .0095), $c' = .02$ ($p = .012$)).

Although this rejects hypothesis 2, we analysed exploratively whether the mediator hypothesis could be demonstrated considering age as an influential factor, with regard to two aspects. If the assumption is correct that especially early-onset multilingualism during the cognitively formative years is influential for the development of EFs, then it would be conceivable that the effect of multilingualism on EFs – and thus the first mediation pathway – occurs especially or only for relatively early acquired multilingualism. To check whether age of acquisition has a moderating effect on the CA hypothesis, we added MLC group as a moderator to the mediator analysis, i.e. as a moderator to the path from multilingualism to the integrated EF indicator. However, this extended model also showed no significant moderated direct effects ($p = .997$), and the index of moderated mediation also did not reach significance (index = −.0001, 95% $CI = -.0014, .0019$). This suggests that the age of acquisition of the second language (with a cut-off around the age of three years) does not seem to have an influence on the relationship between multilingualism and EFs in this study.

Second, the testing of the mediator hypothesis might be influenced by the fact that EFs are subject to development beyond childhood (i.e. decrease with age). Actually, several authors (e.g. Antoniou 2019; Bialystok et al. 2009) suggest that age might influence CA effects (studies indicate stronger CA effects in (late) adulthood, whereas effects seem to be weaker for adolescent participants). Actually, EF (mean) showed a significant correlation with participants' age ($r = .55$, $p < .001$). To check whether age of participants has a moderating effect on the CA hypothesis, we added the participants' age as a moderator to the mediator analysis, i.e. as a moderator to the path from multilingualism to the integrated EF indicator and as a moderator to the path from EFs on FGA. A moderated mediation showed that age does not moderate the effect of multilingualism on EFs ($b = .00$, $p = .251$) nor moderates the effect of EFs on FGA ($b = .01$, $p = .059$). However, a positive main effect of age on FGA was found ($b = .01$, $p = .005$), as claimed by the two process model (Brandtstädter and Rothermund 2002). In this model, multilingualism again shows a direct effect on FGA ($b = .03$, $p = .003$), confirming hypothesis 1 even if controlled for age of participants.

Discussion

The present study aims to extend the CA hypothesis with regard to a broader perspective on more general cognitive abilities, in particular to FGA. FGA is conceptualised as the individual's ability to dissolve blocking of goals or life problems through various cognitive adaptations such as reinterpretations or selective comparisons. It involves, thus, the ability to change, vary, and integrate perspectives. In particular, we hypothesised that multilingualism may enhance FGA either as an indicator for more heterogeneous developmental conditions (hypothesis 1) or via a promotion of executive functions (hypothesis 2). With respect to hypothesis 1, the predicted correlation between multilingualism and FGA was confirmed although monolinguals are somewhat older in the present sample, which should work against this relationship since older individuals show, in general, higher FGA scores (Brandtstädter 2006; Brandtstädter and Rothermund 2002; we did not find a significant correlation with age in the present sample; however in the moderated mediation analysis with respect to hypothesis 2, an age affect proved significant). These findings support the suggestion to extend

the CA hypothesis from 'narrow' cognitive effects (e.g. on EFs) to a broader view on cognitive flexibility promoted by multilingualism (Fan et al. 2015).

With respect to hypothesis 2, the present study was not able to confirm a mediating role of EFs on the relationship between multilingualism and FGA, although it examined two different indicators for EFs. If these analyses were controlled for age of participants (which was substantially correlated with the EFs: $r = .55$) we found that the effect of EF on FGA proved significant. These effects of EFs could indeed be an indication that the recording of EFs (despite a certain imprecision due to the survey instrument) actually had a sufficient degree of validity. This, in turn, adds a bit of weight to the possible interpretation that the lacking mediator effect (hypothesis 2) might be due to the lack of an effect from multilingualism to EFs (i.e. the non-significant CA, as it were). (In additional regression analyses, for which the multilinguals are grouped together and tested against the monologuals as potential predictors of EFs, neither an effect for multilingualism – even when controlling for participant age – nor a moderation of this path by age could be demonstrated.)

In fact, finding a corroboration of hypothesis 1 and a refutation of hypothesis 2 is consistent with the results from Fan et al. (2015) with preschool children, indicating that multilingualism enhances cognitive flexibility (in a broader sense) without an improving effect of multilingualism on EFs (i.e. without presuming the narrow CA hypothesis). Although the failed replication of the (narrow) CA was conducted using EF assessements (flanker and Stroop tasks) which have been used in previous studies that support the CA hypothesis (Bialystok, Craik, and Luk 2008; Luk, de Sa, and Bialystok 2011), lack of evidence must not be misinterpreted as evidence for lack (in particular, since the power for the analysis of the relationship between degree of multilingualism and EF is rather low in our study). However, it is fair to say that this result certainly does not add any evidence in favour of the narrow CA hypothesis, although the procedures obtained were selected in favour of it.

Limitations

Several caveats should be noted with respect to the interpretation of the present findings. First, the present study was conducted as an online study, resulting in an 'incidental', self-selective sample, an hence in unbalanced distributions with respect to socio-cultural variables. In particular, the unequal group sizes with respect to language proficiency implies a limitation of the robustness of the findings with respect to group comparisons (less so for correlationel/regression analyses). This certainly underscores the need for replication (and extension) of this study. Moreover, as in many other studies, in the present sample multilingualism is most probably confounded with social and/or cultural conditions (e.g. Bialystok 2017; Bialystok and Barac 2013). Although we did not find significant differences between the multilingual competence groups with respect to their socioeconomic status, it cannot be excluded that social or cultural heterogeneity beyond mere linguistic heterogeneity could be an important developmental condition for the individual FGA and could therefore (partially) explain the results confirming hypothesis 1. Unfortunately, the present sample is too small to allow a systematic matching according to important indicators of SES and other socio-cultural conditions (Czapka et al. 2020). As a consequence, the present study cannot disentangle which of these possible factors are causally relevant for the promotion of FGA. Thus, a larger and more balanced or stratified sample is certainly an important requirement for future studies.

Second, with respect to the (narrow) CA hypothesis, the online approach of the present study implies several adaptations in the assessment procedure of the EFs: The procedure for both the flanker and the Stroop task deviate in some details from the classical procedure (for a critical discussion of the lack of methodological rigour in this respect see Zhou and Krott 2016; for a recent example of an online study with a very large sample and high methodical rigour see Nichols et al. 2020). We chose online data collection mainly for practical reasons: A comparable sample would not have been available regionally in direct contact. Moreover, the assessment of the EFs with a module downloadable to the respective local computer (such as psychopy) would in all probability

have resulted in an additional selection (mistrust regarding data security or anonymity). The reduction in the reliability of the measures of central executive functions (which was, to be sure, not detectable with respect to the internal consistency of both indicators) accepted with this procedure is presumably unsystematic – there is nothing to suggest that it systematically biases in favour or to the disadvantage of the CA hypothesis (actually, in one of the moderated mediator analyses, we found, as expected, an effect from EF to FGA). However, the reduction of reliability with respect to the EF assessments makes testing of the (narrow) CA hypothesis more conservative: If the effect could have been shown with this procedure, this would have been strong evidence in favour of the CA hypothesis, but the absence of the effect is not a strong argument against it. One can read this constellation in a way that the less reliable recording of the central executive functions increases the beta error of the interpretation of the null effect, but it is also true to say that (in this sample) the CA effect could not have been strong (enough).

Third, the assessment of (the degree of) multilingualism leaves some room for improvement as well. In particular, it is certainly appropriate to distinguish not only degrees but also various forms (e.g. performances, contexts, type and frequency of switching) of multilingualism (Antoniou 2019). For instance, it seems plausible to assume that the linguistic (dis)similarity of the respective languages a multilingual individual uses might influence both the narrow and the broad CA (see Antoniou and Wright 2017). With respect to the test of hypothesis 2 (i.e. CA hypothesis narrow) in particular, it would be certainly necessary to assess the individuals' language (and cultural) proficiency by objective test or indicators.

As a consequence, both the assessment of degree of multilingualism and of the EF's capacities are to a certain degree vulnerable to methodological objections. We hold, however, that this objection does not render the confirmation of hypothesis 1 invalid – even if its interpretation remains to be clarified.

A particular reason to report the results with respect to hypothesis 2, despite possible objections against the reliability of the online assessment of the EFs, was that in order to at least partially compensate for the reliability reduction of the EF assessment to the disadvantage of the CA hypothesis, we adopted the procedure from two available confirmatory studies of some of the prominent proponents of the CA hypothesis (Bialystok, Craik, and Luk 2008; Luk, de Sa, and Bialystok 2011). This procedure should have given the CA hypothesis an overall fair chance of being corroborated, despite of some error-related 'noise' in the measurement of the online data collection. In order to reduce the publication bias discussed in relation to the CA hypothesis (de Bruin, Treccani, and Della Sala 2015), it seemed right and important to us not to omit it.

Heterogeneity as a promoting factor for flexibility of goal adjustment

The finding of a prediction of FGA by multilingualism both individually (correlation) and by MLC group (ANOVA) converges with earlier findings that heterogeneity (mediated by divergent thinking) is a promoting condition for FGA (Greve and Thomsen 2013, 2016; Thomsen and Greve 2013). Due to the confounding of linguistic, social and cultural heterogeneity in the variable multilingualism (Grosjean 2015), the factors that are actually effective cannot be examined more closely here. Therefore, in addition to the necessity of a replication of these findings and improvement of the measures both for multilingualism and EFs, a further demand for future research is the systematic separation of possible stimulating developmental factors through systematic sampling with respect to cultural and social conditions.

It is important to note that we did not find a significant correlation for age with FGA, contrary to what many other studies have reported (Brandtstädter 2006; Brandtstädter and Rothermund 2002). Although we actually found an age effect for one of the moderated mediation analyses (see above), this underscores the necessity of a replication of the finding of the present study with a larger and more representative sample. Additionally, such a replication study should include an indicator for divergent thinking as a possible mediator of the relationship between multilingualism and FGA.

Moreover, the investigation of the role of certain cognitive capacities for FGA is an important requirement for future studies. In this respect, particularly the use of prospective longitudinal studies is essential for tests of causal hypotheses (e.g. cross-lagged panel); this applies to the investigation of the developmental conditions of FGA as well as the developmental consequences of multilingualism.

Overcoming the (too) narrow cognitive advantage hypothesis

Hence, the present study, with the limitations discussed above, must not be seen as conclusive evidence against the (narrow) CA hypothesis. A severe test of it would certainly need a systematic study with a large sample (i.e. sufficient power) of various types of multilinguals and monolinguals, a comprehensive test battery (including Stroop and Flanker tasks, among several others), and, in particular, valid and objective language tasks. However, given that the present sample includes a majority of adults (which, as a rule, have produced more CA-confirming results: Antoniou 2019), and given that we selected EF indicators from confirming studies, our results certainly do not add support for the narrow CA hypothesis. In view of recent results and current meta-studies (Lehtonen et al. 2018; Nichols et al. 2020; Paap, Johnson, and Sawi 2015; as well as the methodological criticism of CA-supporting meta-analyses: Paap et al. 2020), the possibility that the narrow CA hypothesis might depend on several conditions (i.e. moderators; Antoniou and Wright 2017; Festman, Czapka, and Winsler 2021) should be seriously considered. In addition, beyond the ubiquitous criticism with respect to the methodical rigour in the application of Stroop and flanker tasks (Zhou and Krott 2016), there are numerous indications that allegedly EF-assessing measures such as these are reliably replicable as a phenomenon at the group level, but are not sufficiently reliable as individual diagnostics (Hedge, Powell, and Sumner 2018). This might also explain, at least partially, the incoherent findings with respect to the relationship between these EF indicators and multilingualism, even beyond the much-discussed influence of moderating factors (Paap, Johnson, and Sawi 2015; Lehtonen et al. 2018).

Irrespective of these considerations, the present study can be seen as supporting a case for the extension of the (narrow) CA hypothesis. Irrespective of the lacking EF-mediator effect in this study, we found a cognitive advantage for multilinguals with respect to one prototypical facet of cognitive flexibility in a broader sense: flexibility of goal adjustment. In addition to recent proposals to extend the CA debate into a neuroscientific direction (Antoniou 2019) or with respect to the individual's self-concept (Festman and Schwieter 2019), and in line with previous studies concerning an advantage of multilinguals with respect to (cognitive) flexibility (Dewaele and Botes 2019; Fan et al. 2015), we propose to take into account other and broader cognitive advantages that may be promoted by multilingualism. The results of our study suggest that the inclusion of indicators for cognitive flexibility (e.g. divergent thinking) as possible mediators in a replication study could be interesting as a possible extension of the CA hypothesis beyond the explanation of the developmental conditions of FGA.

Notes

1. Terminology concerning the terms *bilingualism, tringualism* and *multilingualism* is not consistent across publications. While some authors use the term *bilingualism* as an umbrella term for all types of additional languages (L2, L3, … Ln, e.g., Ellis 2003), other authors differentiate between these terms (e.g., Festman 2019). In this paper, we use the term *multilingualism* to include the knowledge of more than one language (two, three, or more languages) independent of the time of acquisition (at birth or later in life).
2. The entire questionnaire from Brandtstädter and Renner (1990) comprises two scales: In addition to the FGA scale, the scale for tenacious goal pursuit (TGP) consists of 15 items as well. This scale was not analysed in the present study.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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