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Why experts can do what they do: The effects of exogenous resources on the Domain Impact Level of Activities (DILA)

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Abstract

In many domains, it is estimated that approximately 10,000 hours of planned learning activities are required to reach an expert level of performance. However, this poses a challenge for learners to balance such extensive learning times with the demands of everyday life. In our study we focused on activities in the domain of chess. We hypothesized that chess-related activities could be better integrated in an individual's life if exogenous resources – specified in the educational capital approach (Ziegler & Baker, 2013) – are sufficiently available. In order to test this hypothesis we introduced the concept of the Domain Impact Level of Activities (DILA), that is, the degree to which a learner's activities are influenced by a certain domain. As expected, we found that the more exogenous resources (educational capital) chess players had at their disposal, the higher was their DILA in regard to social and everyday activities. Concerning social activities, we also found a direct effect of playing time hours and a small indirect effect of educational capital on the DILA via playing time hours. In the model predicting the DILA of everyday activities, these effects were not found. It was concluded that the availability of educational capital facilitates the integration of domain-related activities in a learner's life.

Keywords: Educational capital, actiotope, chess, expertise

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In order to attain expertise in a competitive domain like mathematics, music, sports or chess, a person has to spend many hours on practice. Research has clearly shown that the total lifetime amount of practice is related to performance in a variety of domains (Macnamara, Hambrick, & Oswald, 2014). With regard to the particular example of chess, Simon and Chase (1973) claimed that nobody can play on an internationally competitive level "with less than about a decade's intense preparation with the game" (p. 402), which corresponds to approximately 10,000 hours of planned learning (Simon & Chase, 1973a, 1973b).

This 10-year rule has proved to be a valid estimation in virtually all domains in which studies have been conducted (e.g., Baker, Cote, & Abernethy, 2003; Ericsson, Krampe, & Tesch-Römer, 1993; Gobet & Campitelli, 2007; Hayes, 1981). For example, Gobet and Campitelli (2007) found in their sample of chess players that, on average, they needed 11,053 hours of deliberate practice in order to reach master level. The slowest player needed as much as 23,608 hours of deliberate practice. Thus, it is safe to conclude that a significant amount of time is needed to become an expert, whereby the aforementioned time estimations only relate to serious training hours. In fact, experts would have spent much more time on activities related to their domain of expertise. These include domain-specific activities not intended for improvement (and thus not accounted for in the deliberate practice assessments; e.g. Gobet & Campitelli, 2007), such as, commuting to the training venue, passively enjoying the domain (e.g., a music expert listening to music, a sports expert watching sports events, or a sculptor visiting art exhibitions), or talking about the domain with friends and family.

Time management demands in chess

Chess expertise is for a number of reasons an appropriate focus to address the question of how time demands can be met by future chess experts. First, chess has already attracted many research studies so that it has now a reputation as the "drosophila of cognitive psychology" (Grabner, Stern, & Neubauer, 2007). It might be the domain for which we have most data available and that is currently best understood. Secondly, expertise levels are quantifiable through a valid rating system (Elo, 1986; Hambrick et al., 2014). Thirdly, from a practical perspective the access to a larger number of experts, which is important for such research, is relatively easy. Finally, the highly motivating character of the game makes it especially suited for the study of our research aim. With its strategic depth, its somewhat glorified reputation and its competitive environment, chess seems predestined to lead motivated players to a state in which their lives are increasingly influenced by chess. Puddephatt (2008) found in interviews with chess players of a wide skill range that many of his participants expressed concerns about over-involvement with chess. According to Puddephatt (2008), it had become for many chess players an "all-consuming activity" (p. 160), which constrained other life commitments including work or university studies. One player reported that he became totally absorbed in chess and was reading more than 100 books on the topic per year. Another player stated that he kept a chess book in his desk at work and when he went to the bathroom he took a look at it. Even for hobby players, chess can be classified as a so-called 'serious leisure activi-

ty' (Stebbins, 1992): " 'serious leisure' refers to the cultural practices of amateur gamers, hobbyists, and the like as they invest so much time, money, and effort into their respective amateur careers that the conceptual line between leisure and work begins to blur" (Puddephatt, 2008, p. 156). However, with increasing skill level, the expenditure of time increases further. In chess (Campitelli & Gobet, 2008), as well as in other sports (Baker et al., 2003; Baker, Côté, & Deakin, 2005), experts train more than do non-experts and a steady increase of weekly training hours (at least to a certain plateau) could be observed in the training histories of experts over time. It seems plausible that more training hours would be accompanied by more thinking about the domain of interest and subsequent limitations in other areas such as social activities. Space has to be created to fit in the increasing amount of training hours (plus the time and effort needed to reach training facilities multiple times a week, for example) in the daily schedules of aspiring chess players. To make room for their training time, chess players (Puddephat, 2008) and experts from other domains (e.g., Goodsell & Harris, 2011) reported, for example, that they rose earlier in the morning to get additional practice.

From a certain level of expertise, the commitment to a domain can lead to conflicts with the environment (e.g., Goff, Fick, & Oppliger, 1997). While these conflicts may often start with having less time for other activities, other potential problems may be an increased financial demand to get to competitions or even talking about the domain at every possible opportunity. It seems clear from these considerations that chess, and most domains in which an expert level is desired, makes high demands on the time expenditure of a person.

In general, research shows that the attrition rate in any competitive domain is high and most individuals are not able to maintain the high levels of time-consuming activities over a sufficiently long period of time in order to attain expert levels of performance (Ericsson, Charness, Feltovich, & Hoffman, 2006). There is ample, but unfortunately scattered, evidence in the literature that various environmental resources such as mentors, understanding spouses and parents may facilitate the continuance of time investment (e.g., Green & Chalip, 1997; Goff et al., 1997; Goodsell & Harris, 2011). Nevertheless, a theory-based approach would offer a better and more complete understanding of the environmental resources that would be needed. Such an approach was recently introduced by Ziegler and Baker (2013) based on the Actiotope model (Ziegler, 2005; Ziegler, Vialle, & Wimmer, 2013).[3] Ziegler and Baker (2013) lay claim that their Educational Capital approach describes exhaustively the exogenous resources necessary for the acquisition of expertise. The underlying assumption of this contribution is that exogenous resources facilitate the integration of a domain in someone's actiotope.

[3] Ziegler, Vialle, and Wimmer (2013) offered a straightforward definition of an actiotope: "An actiotope includes an individual and the material, social and informational environment with which that individual actively interacts" (p. 3).

The Educational Capital approach of Ziegler and Baker (2013)

Initially excellence has been regarded as a function of internal factors such as genius, intelligence, talents, and so on (Ziegler & Phillipson, 2012). However, it is now widely accepted that the development of extraordinary achievements requires successful learning that, in turn, requires an optimal learning environment (Ziegler, Grigorenko, & Harder, 2014). Various attributes of such an optimal learning environment have been identified, including personal mentors (Grassinger, Porath, & Ziegler, 2011), social promoters (Gruber, Jansen, Marienhagen, & Altenmueller, 2010), learning support (Stoeger, Steinbach, Obergriesser, & Matthes, 2014). Recently, Ziegler and Baker (2013) proposed to conceptualize these attributes of optimal learning environments as resources. By definition, resources are the means to an end (in this case, learning in a domain) that can, but are not necessarily used. The authors proposed five forms of resources, which they termed 'educational capital'. As there are no systematic studies on the pivotal role of the different forms of educational capital for the development of expertise in chess, we have to rely on anecdotal evidence. However, as chess has received a lot of attention in the public, media and also in science, there are ample data available. We will limit ourselves to an investigation of the two presently leading chess players in the world ranking: Magnus Carlsen (personal highest Elo rating of 2889.2 from April 1st 2014) and Fabiano Caruana (personal highest Elo rating of 2851.3 from October 8th 2014). Ziegler and Baker (2013) postulate that the development of very high levels of expertise requires a high amount of all five types of resources and this is what should be found in biographical analyses of top chess players.

Economic educational capital is defined as all types of "wealth, possession, money or valuables that can be invested in the initiation and maintenance of educational and learning processes" (Ziegler & Baker, 2003, p. 27). While the important role of economic resources is largely neglected in most concepts of talent development, some categorize it as a chance factor (see Gagné, 2009; Gulbin, Oldenziel, Weissensteiner, & Gagné, 2010). However, economic resources are resources that are purposeful and systematically invested in skill development, thus rendering it odd to conceptualize them as a random factor (Kirk, Carlson, O'Connor, Burke, Davies, & Glover, 1997). Without large investments, particularly in chess, world-class performances are out of reach. For example, Lou Caruana, the father of Fabiano Caruana, stated in a New York Times interview that the family had made huge financial investments in the career of their son. The yearly costs at age 10 amounted to a total of around 50,000 U.S. Dollars for chess lessons, coaching, and so on (Hernández, 2003). There are also reports on the huge investments of Norwegian native Magnus Carlsen's parents who sold their second car or rented out their house until they finally found a sponsor (Microsoft) (Berntsen, 2004). Nevertheless, training partners, coaches, chess seconds, and so on, continue to pose high financial challenges throughout the chess player's career.

Chess is a board game, which is especially suited to study the influence of the second postulated exogenous resource (see also Stoeger & Gruber, 2014), 'cultural educational capital'. It "[…] includes value system, thinking patterns, models and the like, which can facilitate – or hinder – the attainment of learning and educational goals" (Ziegler &

Baker, 2003, p. 27). Currently chess is dominated by players who are from countries from the former Soviet Union. The high value placed on chess in this country goes back to the attempts of the Bolsheviks to raise the intelligence of the rural people (Lenin: "Chess is the gymnasium of the mind"). The game of chess was systematically promoted (Soltis, 2000) to the effect that nowadays more than half of the top 100 players in the world come from this region. In situations where players from Western countries were able to compete with these players, they usually grew up in an environment in which chess was highly valued. Extension of their social circles invariably included memberships in chess clubs and personal chess mentors who also valued chess. This connects to the next proposed resource of 'social educational capital'.

Social educational capital is a learning resource that is defined as "[…] all persons and social institutions that can directly or indirectly contribute to the success of learning and educational processes" (Ziegler & Baker, 2013, p. 28). Interestingly, both Carlsen and Caruana from an early age had extremely strong personal chess mentors. Carlsen was coached from the age of 10 by the country's top player, Grandmaster Simen Agdestein. Later the FIDE master, Torbjørn Ringdahl-Hansen, joined the coaching team (Agdestein, 2004). Caruana's first chess coach was National Master Bruce Pandolfini who trained him from age 6 to 8. Following Pandolfini, Grandmaster Miron Sher trained Caruana until age 12. Subsequently, the Caruana family relocated from Brooklyn to Madrid to allow Caruana to pursue a professional chess career. Later coaches, until Caruana was 18, were International Master Boris Zlotnik and Grandmaster Alexander Chernin.

It is clear that coaching by these masters gave the two currently top ranking chess players access to superb 'didactic educational capital' which is defined as "[…] the assembled know-how involved in the design and improvement of educational and learning processes" (Ziegler & Baker, 2013, p. 29). However, chess is also well known for two more potent didactic sources. According to Ericsson, a key feature of effective deliberate practice is immediate feedback (Ericsson, 2007; Ericsson et al., 1993). Chess players receive feedback also by replaying games of master players. The usual practice is to analyze the position on the board, determine the strongest move and compare it with the master move. Another possibility is to analyze positions and compare one's own evaluations with the evaluations made by a chess program. Indeed, computers currently play one standard deviation stronger than the world chess champion.

The fifth learning resource postulated by Ziegler and Baker (2003) is 'infrastructural educational capital', which "[…] relates to materially implemented possibilities for action that permit learning possibilities for action and education to take place" (p. 28). From what is known, both top players, Carlsen and Caruana, had a perfect infrastructure for developing their chess skills. In the case of Carlsen it is known, for example, that he had access to chess very early. He also had access to books (his first book was "Find the Plan" by Bent Larsen and his first book on openings was "The Complete Dragon" by Eduard Gufeld). Carlsen played chess for hours, predominantly with his chess computer but he also had access to chess tournaments. He played his first serious chess tournament at the age of eight. Caruana had access to an after-school chess program at the age of five. In the very same year, he attended his first chess tournament at the Susan Polgar Chess Center in New York (Chessbase, 2007). He played at many clubs within the New

York City area including the world famous Marshall Chess Club in Manhattan. Like Carlsen, from an early age, Caruana made extensive use of chess books, chess journals, chess software and the Internet (Atarov, 2012). For example, he used to train via the Internet with GM Gregory Kaidanov (Chessbase, 2007).

Taken together, the anecdotal evidence on Caruana and Carlsen suggests that they had ample access to all forms of educational learning capital during the process of skill acquisition. Moreover, what is striking is not only the quantity of resources, but also their quality. Both grew up in a learning environment that was perfect for the development of chess skills.

It is a reasonable assumption that the possession of educational capital in chess also facilitates and promotes the integration of chess in the everyday life of a person. For example, the availability of an infrastructure to engage in chess-related (infrastructural educational capital) activities in various ways, people (social educational capital) who value chess offer constant opportunities to get into contact with chess. Due to the cultural capital, the integration of chess in daily life might not only be fostered, but even be reinforced. Didactic education in the environment might, for example, help to overcome motivational problems and phases of burn-out. Economic educational capital, as in the cases of Carlsen and Caruana, could be used for maintaining a lifestyle that is totally focused on chess.

Current study

The study at hand initially assessed how much social and everyday activities were influenced in any way by chess. We denoted the degree to which activities are influenced by a certain domain (in our study chess) as their Domain Influence Level of Activities (DILA). Based on the Actiotope model (Ziegler, 2005; Ziegler et al., 2013) we consider an activity influenced by a domain when it fulfills any of three criteria: 1) performing actions already in the action repertoire of an individual in order to attain domain-related goals (e.g., going to bed earlier because the next day an important chess tournament is scheduled); 2) Modification of actions already in the action repertoire with regard to a domain (integration, e.g., talking at breakfast about chess instead of politics or eating healthier food in order to get higher levels of fitness); and, 3) Extension of an individual's action repertoire by a domain-related activity (e.g., learn to play blindfold chess).

For the main analysis, we hypothesized the model shown in Figure 1. We assumed an effect of educational capital on the DILA of the two activity areas. When one's environment system is beneficial for chess, for example, it offers more opportunities to talk about chess with one's friends, relatives and/or partner, which should lead to more influence on thoughts and activities. The effect of educational capital on the activities was expected to be partially mediated by the sheer amount of hours played weekly. A beneficial environment should give the opportunity to play and train longer, which in turn is supposed to influence activities because that time cannot be used for something else. The recent skill level in chess – assessed via the Elo rating number (Elo, 1986), an interna-

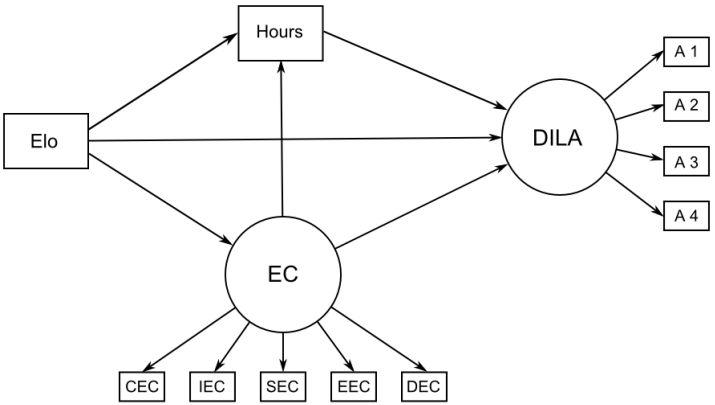

Figure 1:
Hypothesized Model. Elo = Elo-Rating; Hours = playing time hours; EC = Educational Capital; CEC = Cultural Educational capital; IEC = Infrastructural Educational Capital; SEC = Social Educational Capital; EEC = Economic Educational Capital; DEC = Didactic Educational Capital; DILA = Domain Influence Level of Activities; A 1-4 = activities items

tionally used, objective chess skill measure which predicts tournament success very well (Hambrick et al., 2014) – was included as a control variable in the model because a positive relationship with all other variables was expected. The better and more successful individuals are in chess, the more hours they are expected to train (Campitelli & Gobet, 2008), the more educational capital they should have at their disposal and the more their thoughts and activities should be influenced by chess. We analyzed the models for the DILA of the social activities and the DILA of the everyday activities separately. Our main focus in both models was on the following three hypotheses:

Hypothesis 1: There is a direct, positive effect of Educational Capital on the DILA of the two activity areas.

Hypothesis 2: There is a direct, positive effect of the amount of hours played weekly on the DILA of the two activity areas.

Hypothesis 3: There is a positive, indirect effect of Educational Capital on the DILA of the two activity areas via the amount of hours played weekly. This implies the assumption of a positive effect of Educational Capital on the amount of hours played weekly.

Method

Sample

The participants in our study were 219 tournament chess players who reported their recent Elo rating. The Elo rating is a valid quantitative indicator of organized chess players' relative expertise (Elo, 1986; Hambrick et al., 2014) and the official rating system of

the World Chess Federation (FIDE). We excluded participants who seemed to have language problems (e.g., phrases which made no sense written in the space for estimated hours) or reported unrealistic estimates (such as practicing 150 hours per week). Because the answers of these participants were not trustworthy the only option was to exclude their data, which led to a sample of 207 players. The data of two more individuals were removed because they were too influential on the functions being optimized during the initial analyses (Cook & Weisberg, 1982). These two were the players with the highest Elo ratings and had by far the most playing time hours (5.34 SDs above the mean, using the data of the two participants increased our effects. We took the more conservative route by excluding them). Thus, the final sample consisted of 205 players. The six missing values were handled using the default four-step-procedure in MPlus for the robust weighted least squares estimator (WLSMV) we applied. The average Elo rating of the final sample was 2011.66 (SD=232.0), which corresponds to the 97th percentile of all organized chess players (U.S. Chess Federation, 2004). The range was from an Elo ranking of 861 (45th percentile) to one of 2557 (99.9th percentile).

Procedure and measures

The participants completed an online survey, which took about 12 minutes. After answering some demographics and reporting their Elo ratings, participants were asked to estimate the hours they spend weekly playing chess (in the following addressed as "playing time hours") and how many of these hours were serious practice with the aim of improvement. We used the more extensive playing time hours which included the serious practice hours for our analysis. Subsequently they were asked to mark the extent to which certain activities are influenced by chess and they answered a short version of the *Questionnaire of Educational and Learning Capital* (QELC; Vladut, Liu, Leana-Tascilar, Vialle, & Ziegler, 2013) adapted to the domain of chess.

Domain Influence Level of Activities (DILA). The task in the items was to report "how often the execution of this activity is influenced during everyday life in any way by chess". The DILA of social activities (sample item: "enjoy something in the community") was assessed by four items and another four items were used to measure the DILA of everyday activities (sample item: "daily food intake"). All items were 5-point rating scales ranging from "1=rarely or never" to "5=daily" and can be found in Table 1.

Educational Capital. A short version of the *Questionnaire of Educational and Learning Capital* (QELC; Vladut et al., 2013) adapted to the domain of chess was used to assess educational capital. In a pre-study it was discovered that the full version of the questionnaire would substantially reduce the willingness of potential participants to complete the whole survey, and so each form of capital was assessed by one item for economic ("If the further improvement of my chess abilities would necessitate financial resources, I would summon them up [e.g. buying chess software or literature]"), cultural ("I live in a social environment that appreciates chess"), social ("My social environment supports my passion for chess with personal commitment [e.g. motivational support, rides to training facilities, training partners]"), didactic ("I am receiving individual, high quality support [either] through training at a chess club, with a chess partner or otherwise"), and infra-

structural ("I have good access to a multitude of high quality learning possibilities [e.g. libraries, chess club, internet]") educational capital. All items utilized 5-point rating scales ranging from "fully does not apply" to "fully applies".

Statistical analysis

We calculated structural equation models using MPlus Version 6.0.04 (Muthén & Muthén, 1998-2010) to model the effect of Educational Capital and playing time hours on the DILA. We included the current Elo rating to control for its assumed relationships with the other variables in the model (Figure 1). The DILAs of the two fields of activities were modeled as latent variables with their four indicators each. Educational capital was also modeled as a latent variable with its five indicators previously described. We evaluated two separate models for social activities (Model 1) and everyday activities (Model 2) respectively. The Delta method was used to assess the standard errors and the significance of the indirect effects. Because the measurement level of the indicators of our latent variables was ordered categorical we used the robust weighted least squares estimator (WLSMV) in Mplus for our models (Flora & Curran, 2004; Muthén & Muthén,1998-2010). The two models are shown in figure 2 and figure 3.

Results

Descriptive statistics can be found in Table 1. It is interesting to note that social activities were more influenced by chess than were daily activities. However, as we cannot make any claim regarding the representativeness of the items, we should be cautious to draw any inferences from this result. Another interesting aspect is that although the average player of our sample ranked at the 97th percentile of all organized chess players, the reported mean availability of resources was, with the exception of infrastructural educational capital, surprisingly low. The fact that most players in our sample reported a high degree of infrastructural capital led to a reduced variance in this item.

Reliabilities and measurement models

Regarding the Elo rating, an average validity concerning tournament success of .91 was found (Hambrick et al., 2014) which means its reliability cannot be less than .91. The reliability of self-reported cumulative life-time practice is typically assumed to be around .80 (Ericsson, 2013; Hambrick et al., 2014). The self-reported recent playing time hours in our study therefore should at least reach this value. The reliabilities of the two activities scales were good (DILA social activities: α = .85, N = 204; DILA everyday activities: α = .92, N = 203) as were the fit indices of the measurement models of the corresponding latent constructs (see Table 3) (Hu & Bentler, 1999). The suboptimal fit statistics and the loadings of the Educational Capital measurement model indicated some problems with the model. Most of the correlations among the five educational capitals

Table 1:
Descriptive statistics.

	M	*SD*	Min	Max
Elo-Rating (Elo)	2011.66	232.00	861	2557
Playing time hours (Hours)	8.07	7.41	0	40
DILA of social activities (DILA-S)				
Meeting friends (SA 1)	2.82	1.16	1	5
Talking about important things (SA 2)	2.52	1.33	1	5
Having a chat/ Small talk (SA 3)	3.10	1.34	1	5
Enjoying sth. in community (SA 4)	2.47	1.18	1	5
DILA of everyday activities (DILA-E)				
Daily food intake (EA 1)	2.07	1.49	1	5
Getting dressed/ Changing clothes (EA 2)	1.69	1.34	1	5
Daily personal hygiene (EA 3)	1.68	1.34	1	5
Going to the toilet (EA 4)	1.85	1.47	1	5
Educational Capital (EC)				
Cultural EC (CEC)	3.60	1.10	1	5
Infrastructural EC (IEC)	4.53	.70	1	5
Social EC (SEC)	3.15	1.32	1	5
Economic EC (EEC)	3.87	1.23	1	5
Didactic EC (DEC)	2.49	1.26	1	5

Table 2:
First order correlations of the variables

	Elo	hours	DILA-S	DILA-E	CEC	IEC	SEC	EEC	DEC
Elo	-								
hours	.11	-							
DILA-S	.09	.27**	-						
DILA-E	-.07	.14*	.52**	-					
CEC	.13	.08	.21**	.12	-				
IEC	.02	.12	.14*	.08	.23**	-			
SEC	.08	.29**	.23**	.19**	.53**	.22**	-		
EEC	.00	.22**	.15*	.14	.12	.25**	.29**	-	
DEC	-.04	.19**	.29**	.21**	.15*	.15*	.23**	.23**	-

Note. *$p < .05$; **$p < .01$; Elo = Elo-Rating; hours = playing time hours; DILA-S mean = mean DILA of the four social activities; DILA-E mean = mean of the four everyday activities; CEC = Cultural educational capital; IEC = Infrastructural educational capital; SEC = Social educational capital; EEC = Economic educational capital; DEC = Didactic educational capital

Table 3:
Goodness of fit indices for the models

	χ^2	*df*	*p*	CFI	TLI	RMSEA	WRMR
MModel DILA-S	20.87	2	<.001	.985	.954	-	.693
MModel DILA-E	5.41	2	.067	1.000	.999	-	.260
MModel EC	21.39	5	<.001	.932	.863	-	.699
Model 1	95.83	40	<.001	.965	.952	.083	.833
Model 2	71.72	40	.002	.996	.995	.062	.715

Note.df = degrees of freedom; CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = the root mean square error of approximation; WRMR = weighted root mean square residual.

(Table 2) were low compared to previous studies. However, this result is not unexpected (see discussion).

The modification indices of the Educational Capital measurement model indicated the need to allow for residual correlations between the social educational capital and the cultural educational capital. We calculated the two hypothesized structural equation models with the suggested additional correlation and found the effect of educational capital on the DILA of the two activities to be even stronger. We decided to report the more conservative models regarding this main hypothesis without the post-hoc modifications.

Structural equation models

The goodness of fit indices of the two structural equation models are shown in Table 3. Most of the model 1 indices fulfilled the established criteria for a good model fit and all of the model 2 indices, except the χ^2-value, surpass these criteria (Hu & Bentler, 1999).

Figures 2 and 3 present the standardized solutions of the two models. Because MPlus does not calculate standard errors and *p*-values for the standardized solutions of models with latent variables, which include manifest control variables when using the WLSMV estimator, the following *p*-values are the corresponding values of the unstandardized solution.

Concerning hypotheses 1 and 2 in both models, the best predictor of the influence level of the activities was the educational capital (Model 1: $\beta = .37$, $p < .001$; Model 2: $\beta = .33$, $p = .001$). In Model 1 the path from playing time hours to the influence level on the social activities was significant as well ($\beta = .16$, $p < .05$) whereas in Model 2 it was not ($\beta = .05$, $p = .536$). So hypothesis 2 was only confirmed in Model 1.

With regard to hypothesis 3, the path from educational capital to the playing time hours was significant in both models (Model 1: $\beta = .32$, $p < .001$; Model 2: $\beta = .32$, $p < .001$). However, the assumed indirect effect was only found in Model 1 and was of low magnitude (.05, $p < .05$).

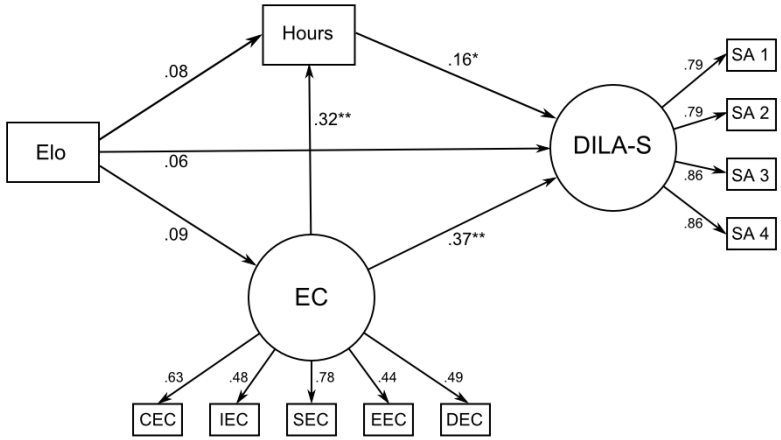

Figure 2:
Model 1: Social activities. *$p < .05$; **$p < .01$; Elo = Elo-Rating; Hours = playing time hours; EC = Educational Capital; CEC = Cultural Educational Capital; IEC = Infrastructural Educational Capital; SEC = Social Educational Capital; EEC = Economic Educational Capital; DEC = Didactic Educational Capital; DILA-S = Domain impact level of social activities; SA 1-4 = DILA of social activities items, see Table 1

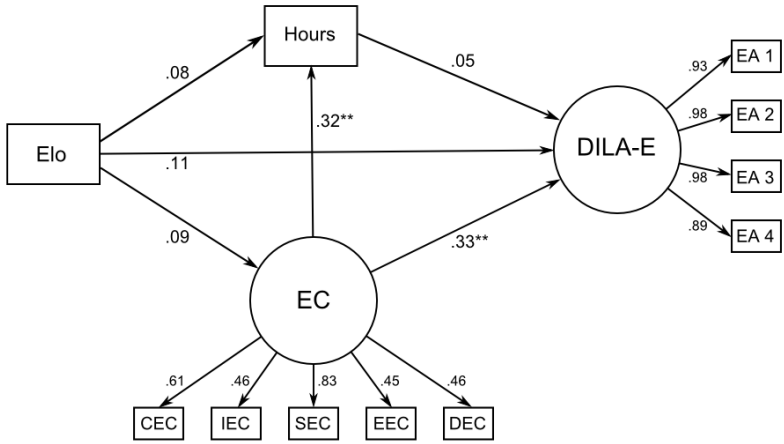

Figure 3:
Model 2: Everyday activities. *$p < .05$; **$p < .01$; Elo = Elo-Rating; Hours = playing time hours; EC = Educational Capital; CEC = Cultural Educational Capital; IEC = Infrastructural Educational Capital; SEC = Social Educational Capital; EEC = Economic Educational Capital; DEC = Didactic Educational Capital; DILA-E = Domain impact level of everyday activities; EA 1-4 = DILA of everyday activities items, see Table 1

Discussion

Future experts have a long way to go until they reach their full skill level. Research shows that this process usually takes at least 10 years, which include on average around 10,000 hours of deliberate practice but does not include all other activities related to their domain of expertise (e.g., Baker, Cote, & Abernethy, 2003; Ericsson, Krampe, & Tesch-Römer, 1993; Gobet & Campitelli, 2007; Hayes, 1981). This enormous investment of time necessitates large adaptions of the actiotopes of the experts. Chess has to be integrated in their personal life with consequences for other activities that subsequently have to be reduced (Puddephatt, 2008; Stebbins, 1992). The basic assumption of this contribution is that exogenous resources facilitate the integration of a domain in someone's actiotope. In particular, we postulated that the possession of educational capital could predict the integration of domain-related activities in experts' actiotopes (Ziegler & Baker, 2013).

Participants in our study were a sample of extremely strong chess players. Their strength was on average at the 97th percentile of organized chess players. However, most of the correlations between the educational capitals and other variables, in particular those with the Elo rating, were low when compared to previous studies (e.g., Vladut et al., 2013; Ziegler, Strasser, Pfeiffer, & Wormald, 2014). There are three possible methodological reasons for this result. First, in this online survey we used single item indicators for the five capitals, whereas in the three studies reported by Vladut et al. (2013) and in the study by Ziegler et al. (2014), more comprehensive scales had been used. Another plausible explanation is the restricted variance of our sample whose playing strength was on average at the 97th percentile. Finally, it could well be that our items were interpreted by the participants from an individual reference frame, and thus assessed whether the resources were sufficiently available to attain their current aspirations in chess. Thus, in further studies one would have to assure that all participants would use a comparable reference frame when assessing their possession of resources.

In order to determine the facilitating effect of the possession of resources on the DILA, we tested three hypotheses. Confirming our first hypothesis, we found that the more relevant exogenous resources (educational capital) chess players had with regard to chess, the more that social and everyday activities were influenced by the domain of chess (DILA). In the area of social activities, we also found a direct effect of playing time hours on the DILA and a small indirect effect of educational capital on the DILA via playing time hours. In the model predicting the DILA of everyday activities, these effects were not found. Thus, our hypotheses 2 (direct effects of playing time hours on DILA) and 3 (indirect effects via playing time hours) were only confirmed in the model predicting the DILA of social activities. In both models we found the expected positive effect of a beneficial environment system on the amount of hours played weekly. Thus, as expected, a domain-specific beneficial environment system seems to facilitate the "infection" of one's activities with one's domain of passion. Such beneficial and supporting environment systems create opportunities to more easily engage in activities related to the domain in question. For example, if one's closest friends are chess enthusiasts, it is more likely they will talk about chess in situations outside of the chess club. Future re-

search could test the assumption that being able to integrate passions in an individual's private and everyday life should lead to positive long-term benefits for skill development.

Limitations

One of the limitations of the study is that the choice of our measurement reflected a trade-off between recruiting an expert sample big enough to test our hypotheses and compromising with the measurement instruments. Thus, we decided to use shorter instruments with tacit acceptance of lower reliabilities. For example, the different educational capitals were assessed with single items instead of a scale for each capital as in previous studies. Another known problem is the reliability of self-reported estimates for training hours. Consequently, the relationships with this manifest variable, in particular, should be interpreted with caution because they are likely underestimated.

References

Agdestein, S. (2004). *Wonderboy: How Magnus Carlsen became the youngest Chess Grandmaster in the world.* Alkmaar: Interchess.

Atarov, E. (2012). *Fabiono Caruana: "A lot of hard work…" Why Chess.* Online: http://whychess.com/node/2908. Retrieval date: 18 January 2015.

Baker, J., Cote, J., & Abernethy, B. (2003). Sport-specific practice and the development of expert decision-making in team ball sports. *Journal of Applied Sport Psychology, 15*(1), 12–25. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/10413200305400

Baker, J., Côté, J., & Deakin, J. (2005). Expertise in Ultra-Endurance Triathletes Early Sport Involvement, Training Structure, and the Theory of Deliberate Practice. *Journal of Applied Sport Psychology, 17*(1), 64–78. doi:10.1080/10413200590907577

Berntsen, M. (2004). *The Mozart of chess.* Online: http://en.chessbase.com/post/the-mozart-of-che-. Retrieval date: 06.01.2015

Campitelli, G., & Gobet, F. (2008). The role of practice in chess: A longitudinal study. *Learning and Individual Differences, 18*(4), 446–458. doi:10.1016/j.lindif.2007.11.006

Chase, W. G., & Simon, H. A. (1973a). Perception in chess. Cognitive Psychology, 4, 55-81.

Chase, W. G., & Simon, H. A. (1973b). The mind's eye in chess. In W G. Chase (Ed.). *Visual information processing* (pp. 215-281). San Diego, CA: Academic Press.

Chessbase (2007). *Who was the future GM? Fabiano Caruana, Italy's top grandmaster!* http://en.chessbase.com/post/who-was-the-future-gm-fabiano-caruana-italy-s-top-grandmaster. 2007-10-18. Retrieved 2015-01-12.

Chessbase (2003). *Fabulous Fabiano.* http://en.chessbase.com/post/fabulous-fabiano. 2007-05-19. Retrieved 2015-01-12.

Cook, R. D., & Weisberg, S. (1982). *Residuals and influence in regression.* New York: Chapman and Hall.

Elo, A. E. (1986). *The rating of chessplayers, past and present* (2nd ed.). New York: Arco chess.

Ericsson, K. A. (2007). Deliberate practice and the modifiability of body and mind: Toward science of the structure and acquisition of expert and elite performance. *International Journal of Sports Psychology, 38*, 4–34.

Ericsson, K. A. (2013). Training history, deliberate practice and elite sports performance: an analysis in response to Tucker and Collins review--what makes champions? *British Journal of Sports Medicine, 47*(9), 533–5. doi:10.1136/bjsports-2012-091767.

Ericsson, K. A., Charness, N., Feltovich, P. J., & Hoffman, R. R. (2006). *The Cambridge handbook of expertise.* New York, NY: CUP.

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*(3), 363-406.

Flora, D., & Curran, P. (2004). An empirical evaluation of alternative methods of estimation for confirmatory factor analysis with ordinal data. *Psychological Methods, 9*(4), 466–491. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3153362&tool=pmcentrez&rendertype=abstract

Gagné, F. (2009). Building gifts into talents: Detailed overview of the DMGT 2.0. In B. MacFarlane & T. Stambaugh (Eds.), *Leading change in gifted education: The festschrift of Dr. Joyce VanTassel-Baska* (pp. 61-80). Waco, TX: Prufrock Press.

Gobet, F., & Campitelli, G. (2007). The role of domain-specific practice, handedness, and starting age in chess. *Developmental Psychology, 43*(1), 159–172. doi:10.1037/0012-1649.43.1.159

Goff, S. J., Fick, D. S., & Oppliger, R. A. (1997). The moderating effect of spouse support on the relation between serious leisure and spouses' perceived leisure-family conflict. *Journal of Leisure Research, 29*(1), 47–60.

Goodsell, T., & Harris, B. (2011). Family life and marathon running: Constraint, cooperation, and gender in a leisure activity. *Journal of Leisure Research, 43*(1), 80–109. Retrieved from http://js.sagamorepub.com/jlr/article/view/11

Grabner, R. H., Stern, E., & Neubauer, A. C. (2007). Individual differences in chess expertise: A psychometric investigation. *Acta Psychologica, 124,* 398-420.

Grassinger, R., Porath, M. & Ziegler, A. (2010). Mentoring: A review. *High Ability Studies, 21*, 27-46.

Green, B. C., & Chalip, L. (1997). Enduring Involvement in Youth Soccer : The Socialization of Parent and Child. *Journal of Leisure Research, 29*(1), 61–77.

Gulbin, J. P., Oldenziel, K. E., Weissensteiner, J. R., & Gagne, F. (2010). A look through the rear view mirror: Developmental experiences and insights of high performance athletes. *Talent Development & Excellence, 2,* 149-164.

Hambrick, D. Z., Oswald, F. L., Altmann, E. M., Meinz, E. J., Gobet, F., & Campitelli, G. (2014). Deliberate practice: Is that all it takes to become an expert? *Intelligence, 45,* 34–45. doi:10.1016/j.intell.2013.04.001

Hayes, J. R. (1981). *The complete problem solver.* Philadelphia, PA: Franklin Institute Press.

Hernández, D, (2003). A chess player's challenge: Opponents his own age. *The New York Times,* May 17 2003. Online: http://www.nytimes.com/2003/05/17/nyregion/17CHES.html?ex=1053835200&en=b0910f15c53e882f&ei=5062&partner=GOOGLE. Retrieval date: 06 January 2015.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55. doi:10.1080/10705519909540118

Kirk, D., Carlson, T., O'Connor, A., Burke, P., Davies, K., & Glover, S. (1997). The economic impact on families of children's participation in junior sport. *Australian Journal of Science and Medicine in Sport, 29*, 27-33.

Macnamara, B. N., Hambrick, D. Z., & Oswald, F. L. (2014). Deliberate Practice and Performance in Music, Games, Sports, Education, and Professions: A Meta-Analysis. *Psychological Science.* doi:10.1177/0956797614535810

Muthén, L. K. & Muthén, B. O. (1998-2010). Mplus User's Guide. Sixth Edition. Los Angeles, CA: Muthén & Muthén.

Puddephatt, A. J. (2008). Incorporating ritual into greedy institution theory: The case of devotion in amateur chess. *Sociological Quarterly, 49*(1), 155–180.

Simon, H. A., & Chase, W. G. (1973). Skill in chess. *American Scientist, 61,* 394–403.

Soltis, A. (2000). *Soviet Chess 1917–1991.* Jefferson, NC: McFarland.

Stoeger, H., & Gruber, H. (2014). Cultures of expertise: The social definition of individual excellence. *Talent Development and Excellence, 6*(1), 1–10

Stoeger, H., Steinbach, J., Obergriesser, S., & Matthes, B. (2014). What is more important for fourth-grade primary school students for transforming their potential into achievement: the individual or the environmental box in multidimensional conceptions of giftedness? *High Ability Studies, 25*, 5–21.

U.S. Chess Federation (2004). *USCF ratings distribution charts.* Online: http://archive.uschess.org/ratings/ratedist.php. Retirieval date: 25 January, 2015.

Vladut, A., Liu, Q., Leana-Tascilar, M. Z., Vialle, W., & Ziegler, A. (2013). A cross-cultural validation study of the Questionnaire of Educational and Learning Capital (QELC) in China, Germany and Turkey. *Psychological Test and Assessment Modeling, 55*(4), 462–478.

Ziegler, A. (2005). The actiotope model of giftedness. In R. Sternberg & J. Davidson (Eds.), *Conceptions of giftedness* (pp. 411-434). Cambridge, UK: Cambridge University Press.

Ziegler, A., & Baker, J. (2013). Talent development as adaptation: The role of educational and learning capital. In S. N. Phillipson, H. Stoeger, & A. Ziegler (Eds.), *Exceptionality in East Asia: Explorations in the Actiotope model of giftedness* (pp. 18-39). London: Routledge.

Ziegler, A., Grigorenko, E. & Harder, B. (Eds.) (2014b). The significance of learning contexts in talent development. *High Ability Studies, 25* [Special Issue].

Ziegler, A. & Phillipson, S. (2012). Towards a systemic theory of giftedness. *High Ability Studies, 23*, 3-30.

Ziegler, A., Strasser, S., Pfeiffer, W. & Wormald, C. (2014). The Nuremberg Music-Ecological Approach: Why are some musicians internationally successful and others not? *TJGE, 4*(1), 2-9.

Ziegler, A., Vialle, W. & Wimmer, B. (2013). The Actiotope Model of Giftedness: A short introduction to some central theoretical assumptions. In S. Phillipson, H. Stoeger, & A. Ziegler (Eds.), *Exceptionality in East-Asia: Explorations in the Actiotope model of giftedness* (pp. 1-17). London: Routledge.