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Jessica Charlotte Kawalek & F. Gobet

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Expertise in Contemporary Dance: The Roles of Cognition, Talent, and Deliberate Practice

Jessica Charlotte Kawalek, PhD [a,b] and F. Gobet, PhD [c]

[a]University of Leeds, Leeds; [b]Psychology, University of Liverpool, Liverpool; [c]Centre for Philosophy of Natural and Social Science, London School of Economics and Political Science, London

ABSTRACT

This paper examines the link between cognitive processes and superior performance in contemporary dance. In the first study, thirty-six participants (professional dancers, nonprofessional dancers, and non-dancers) carried out a task in which they were asked to reproduce a sequence of dance steps while being recorded on a camcorder. Analysis revealed a significant effect of skill and task difficulty on performance. Performance correlated with individual practice, group practice, rehearsing hours, sleep, concentration, enjoyment, dyslexia, and height, but not handedness. In the second study, the same group of participants augmented by 26 participants (a total of 62 participants) completed a questionnaire. There were skill differences on deliberate practice, sleep, concentration, enjoyment of dance tasks, dyslexia, handedness, and gender differences on group practice and height. Overall, the results suggest that both practice and talent play a role in the acquisition of expertise in contemporary dance.

KEYWORDS

Expertise; innate talent; deliberate practice; cognition; contemporary dance

Introduction

The current study provides insight into the cognitive processes underpinning learning contemporary dance skills. It contributes to the fields of cognitive psychology, dance education, and dance science. The main focus is to investigate, through a cognitive psychology lens, how expertise in dance develops.

A number of studies carried out since 1970 shaped research examining the psychology of expertise and led to more modern insights. In order to understand the development of expertise, cognitive psychology researchers have explored both practice and innate factors (Chase and Simon 1973; Geschwind and Galaburda 1987). These mechanisms have typically been explored independently, although recent attempts have been made to investigate how they interact (Meyers, van Woerkom, and Dries 2013; Gobet 2016). Past research focusing on cognition in chess indicated that experts have superior perceptual processing compared to non-experts, allowing them to carry out tasks automatically (Chase and Simon 1973). The extent to which practice and innate factors determine this superior automatic processing remains unclear.

The present study expands on research which examines interactions between innate aspects underpinning expertise and factors associated with deliberate practice (DP) using a unique population–dancers. Dancers are unique because they display superior physical and mental abilities in comparison to non-experts as well as high levels of creativity and co-ordination (Hutchinson, Sachs-Ericsson, and Ericsson 2013; Mohamed and Aal 2014). Examining these abilities can deepen insight into how innate components and factors associated with DP interact and enhance skill. This can provide insight into the cognitive processes underpinning expertise in physical domains including sport and dance, an area that is under-researched (Gobet 2016). Such understanding is important in helping us to develop more efficient teaching strategies (Alfassi 2004).

Psychology research into how dancers engage in the learning process at dance school is an under-researched area (Buckroyd 2001; Laws 2005). Previous research has explored acquisition of motor skills and movement memory (Wing and Smyth 2013). Additionally, there are a number of studies concerning the link between motivation, confidence, and performance of dancers which have contributed to improvements in dance education (Quested and Duda 2010; Quin, Rafferty, and Tomlinson 2015). However, research into the cognitive processes which underpin dance performance is lacking.

CONTACT Jessica Charlotte Kawalek jessica.kawalek@gmail.com Montrose, 31 Stumperlowe Crescent Road, Fulwood, Sheffield, S10 3PQ

Deliberate Practice

The current study examines how different types of DP (Ericsson, Krampe, and Tesch-Römer 1993) impact performance and how factors that affect DP (such as sleep) influence skill acquisition. This can increase knowledge about how skill acquisition in contemporary dance occurs. Factors associated with DP can often be controlled. Exploring variables that can be controlled by dancers can enhance dancers' performance.

Within contemporary dance, three main practice types which play distinct roles in skill acquisition have been identified: individual practice, group practice, and show rehearsals (Hutchinson, Sachs-Ericsson, and Ericsson 2013; Mohamed and Aal 2014). According to the DP framework (Ericsson, Krampe, and Tesch-Römer 1993), expert performance can only be attained through long-term engagement in activities designed to improve performance, and it takes 10 years to become an expert. Practice is effortful, not necessarily motivating or enjoyable, and can only be sustained for limited periods. Recent research has shown limitations with this framework, suggesting that other factors beyond DP are important. For example, expertise can be reached much more quickly than 10 years in chess (Gobet and Ereku 2014) and in track and field (Staff, Gobet, and Parton 2019).

Sleep is another crucial factor underpinning expertise (Bratzke et al. 2012). When violinists were asked about the amount of time they spent carrying out a range of activities, DP and sleep were the most important factors determining skill level (Ericsson, Krampe, and Tesch-Römer 1993). As duration of sleep significantly impacts cognition and movement (Bratzke et al. 2012), sleep is likely to affect visual perception, sound perception, and motor functions (O'Brien et al. 2012). Sleep patterns and quality have been found to impact dancers' performance (McCloughan et al. 2015). Daytime napping has been associated with increased performance in ballet dancers during stressful training periods (McCloughan et al. 2015).

There are many studies in the field of dance education exploring how teaching practices can generate efficient performance outcomes (Laws 2005; Zeller 2017). Laws (2005) proposed a number of guidelines aimed at improving dancers' health and performance. While many aspects of dancers' training and health were considered, sleep was not discussed as part of these guidelines. Therefore, given the past work on dancers' sleep, we are interested in finding out whether sleep might be another relevant factor influencing dance ability.

Furthermore, research suggests that concentration is needed to improve the quality of an individual's DP (Ericsson, Krampe, and Tesch-Römer 1993). However, high-quality concentration can be sustained only for a limited amount of time, in part because it is not necessarily enjoyable. While dance-specific research into the level of concentration required for performance is limited, some studies have suggested that restrictive eating and making social comparisons with other dancers lowers concentration, leading to reduced performance (Quested and Duda 2010; Quin, Rafferty, and Tomlinson 2015; NHS 2018).

The role of sex and gender has also been explored in relation to expertise. Dance is thought to be associated with females and there is a certain gay stereotype attached to male dancers (Fisher 2007; Haltom and Worthen 2014). As a consequence, male dancers often face criticism for their decisions to engage in an occupation that is frequently viewed as unconventional, which can lead to emotional struggles (Fisher 2007). Additionally, research shows that teachers often perceive male dancers' concentration to be lower. However, this may be associated with pedagogies that incorporate female gender stereotypes in which girls are considered to be obedient in the context of dance. Males often struggle with this stereotype and find it difficult to display this high level of obedience. Therefore, males will often take a more relaxed approach to learning compared to females, which teachers often perceive as a lack of concentration (Clegg, Owton, and Allen-Collinson 2018). This suggests that one's gender may influence contemporary dance practice through gender stereotypes (which affect access to DP) rather than innate differences between males and females. However, it is important to consider genetic origins relating to sex as well as gender stereotypes that impact the differences in learning between male and female dancers. This is examined in more depth within the discussion section.

Innate Factors

In contrast to the DP framework, another line of research argues that at least some elements of expertise can be accounted for by innate factors (Tucker and Collins 2012). In contemporary dance, factors such as physique and levels of "turn out" play a significant role in expertise (Hutchinson, Sachs-Ericsson, and Ericsson 2013). "Turn out," or how much a dancer can rotate their legs within their hip sockets, is naturally limited in some individuals and therefore can put restraints on performance. Additionally, research exploring the way in which gravity influences a dancer's ability to *pirouette* has suggested that height plays a role in determining this ability (Lott and Laws 2012). Research indicates that smaller dancers may be more successful in acquiring such skills (Suzovic and Porcic 2012). Therefore, innate factors such as height and leg rotation play a role in determining contemporary dance ability.

Other innate factors such as handedness have been considered to play a role in creative domains such as mathematics, painting, music, and dance (Chakravarty 2009; Sala et al. 2017). Geschwind and Galaburda (1987) suggested that handedness has an innate basis. Increased testosterone in the uterus causes the right hemisphere of the brain to develop more than normal, resulting in the individual being left-handed or ambidextrous. This alternative brain anatomy allows the left-handed or ambidextrous individual to exercise a greater degree of bilateral control. In order to be an expert in the domain of contemporary dance, bilateral control is essential as it allows dancers to achieve good coordination, spatial awareness, and movement control (Hutchinson, Sachs-Ericsson, and Ericsson 2013). Therefore, it may be advantageous for contemporary dancers to have these neurological processes associated with left-handedness and ambidexterity (Hutchinson, Sachs-Ericsson, and Ericsson 2013).

If innate neurophysiological processes play a role in handedness, then expertise could to some extent be influenced by innate factors (Christman 1993). Sex hormones are strongly linked with handedness: males are significantly more likely to be left-handed or ambidextrous compared to females (Hausmann 2017). Arning et al. (2015) reported that the androgen receptor gene, located on the X chromosome, plays a significant role in determining handedness. Our view that handedness is mostly innate in origin is justified by the substantial literature suggesting that handedness is more impacted by genetic than environmental factors (Geschwind and Galaburda 1987; McDowell et al. 2016; Hausmann 2017; Fagard et al. 2021). Moreover, prioritizing handedness for inclusion in the analysis over other innate factors, such as weight, follows up on past work (Singg and Martin 2016) that has emphasized the impact of handedness on creative skills such as dance performance.

Cultural pressures can result in an individual's innate tendency toward left-handedness to be repressed, meaning that, in some instances, left-handed individuals can become ambidextrous over time (Papadatou-Pastou et al. 2020). Therefore, we acknowledge that there are some limitations to viewing handedness as purely innate in cases where cultural pressures cause left-handed individuals to develop the ability to use both hands. Such individuals will still score significantly lower on the Edinburgh questionnaire for assessing handedness (used in the current study) compared to right-handed individuals. Therefore, the genetic trait toward left-handedness can still be captured within the present research despite cultural factors coming into play.

Furthermore, expertise has been linked to dyslexia. The majority of recent studies indicate that dyslexia is genetic in origin (Peterson and Pennington 2015; Helland and Morken 2016; Lachmann and Weis 2018). Chakravarty (2009) indicated that dyslexia results in a developmental delay in the dominant hemisphere, causing the non-dominant parietal lobe to become disinhibited. This disinhibition favors the development of visuospatial processes, mathematical deliberation processes, and processes associated with imagery movement. Dyslexia could therefore be positively associated with contemporary dance performance since contemporary dance is a skill that requires creativity and draws on visuospatial processes (Mohamed and Aal 2014). Research exploring neurological patterns of individuals with dyslexia has indicated that dyslexia is associated with creative thinking (Beck 2013). It has been pointed out that many famous creative people had developmental disorders, for example, Leonardo da Vinci and Albert Einstein (Chakravarty 2009).

It would be stereotypical to argue that all people with dyslexia display cognitive impairment which cannot be changed through environmental factors or that all dyslexic people will have creative talents. Many studies point out that environmental factors can influence how dyslexia presents itself (Peterson and Pennington 2015; Lachmann and Weis 2018). We aim to avoid a stereotypical position by acknowledging that individuals who have the genetic composition for dyslexia will have different experiences, influenced by environmental factors. However, ultimately, an understanding of dyslexia in terms of being largely determined by genetic factors is reasonable given the vast body of research pointing to the innate basis of dyslexia (Peterson and Pennington 2015; Helland and Morken 2016; Lachmann and Weis 2018). This forms the rationale for examining dyslexia as an innate variable within the current study.

Cognition and Dance Performance

Little is known about expert memory in dance. Understanding the cognitive processes, such as recall of dance steps, that underlie expertise might help dance teachers to engage in efficient teaching strategies which could enhance learning outcomes. To our knowledge, only four studies have been carried out on this topic. Starkes et al. (1987) compared expert ballet dancers with novices on the memory for sequences of ballet steps. Recall was tested by asking participants to perform the dance steps motorically. Experts recalled sequences better, and structured sequences were better recalled than unstructured ones. Starkes et al. (1990) carried out a similar experiment with creative modern dancers.

While experts performed better than novices, both groups recalled structured and unstructured sequences of movements equally well. However, this result was not replicated by Jean, Cadopi, and Ille (2001), who found that structured sequences were recalled better than unstructured ones by expert dancers, suggesting that it is not just the knowledge base of the dancer that determines their level of expertise but also the way information is encoded in memory. Finally, Cortese and Rossi-Arnaud (2010) asked participants to carry out spatial interfering tasks when memorizing a sequence of ballet steps. They found that such interfering tasks did not impair short-term memory, which evokes the possibility that working memory includes a subsystem dedicated to the encoding of motor configurations.

The Present Study: Rationale and Research Questions

The purpose of the current study was to gain an understanding of the nature of expertise in contemporary dance. Study 1 aimed to demonstrate that experts show superior abilities in dance compared to non-experts. Study 2 aimed to gain an understanding of how DP and innate factors may influence expertise in this domain. The first hypothesis was that the higher the number of accumulated hours dedicated to dance practice (including individual practice, group practice, and rehearsal), the greater the contemporary dance ability. The second hypothesis was that a number of factors with an innate basis (dyslexic tendencies, left-handedness or ambidexterity, being female, and a being shorter in height) result in a higher overall performance score. The final hypothesis was that overall performance scores are higher when factors which positively impact cognitive functioning (including increased sleep, higher concentration, and greater enjoyment) are greater. The two main research questions (RQs) were: 1) What can examination of the interaction between innate factors and DP tell us about cognitive processes underpinning talent in contemporary dance? 2) How can studying the interaction between innate factors and DP in contemporary dancers enhance dance education?

Study 1

Method

Overview

While previous research has investigated the differential recall of structured and unstructured dance steps (as detailed above), the level of difficulty of the dance routines had not been manipulated in earlier studies. The current experiment used three levels of difficulty. The rationale for having three levels was to allow participants with varying levels of expertise to achieve their highest potential score on the performance tasks. For example, participants with minimal dance experience may be able to achieve a high score on a dance task with a low/medium level of difficulty if they were innately talented. However, if skill acquisition in dance requires a significant amount of DP, it would be unlikely that beginners would be able to achieve a high score on a difficult routine which requires a significant level of technical ability in dance. An expert in dance, on the other hand, would be able to achieve high scores on all tasks. In addition, previous research has compared novices to experts; our study added an intermediate group, which enabled us to see whether increase of performance is linear. In the current study, participants saw videos containing sequences of modern dance steps, with three difficulty levels. Like in previous experiments, participants did not recall the steps verbally, but actually performed them, which is ecologically more valid.

Participants

Thirty-six participants (21 females and 15 males) took part in the experiment. Age ranged from 19 to 34 years (M = 23.2 years; SD = 3.6 years). The participants were allocated to three different skill groups as a function of their dance experience: professional contemporary dancers from various contemporary dance companies across the United Kingdom (N = 12, M age = 25.7 years, SD = 3.6 years, range = 13 years), participants with a strong dance background without professional performance experience (this means that the individual engaged in at least two forms of dance regularly; the styles of dance included ballet, tap, modern, jazz, and contemporary) (N = 11, M = 20.8 years, SD = 1.3 years, range = 4 years) and participants with no experience in dance (N = 13, M = 23.0 years, SD = 3.7 years, range = 10 years).

The participants of the two studies were recruited via opportunity sampling in dance companies, dance classes, and universities in the North West of England and South Yorkshire. They completed a consent form prior to participating and were debriefed following participation. This study was approved by the Ethics Committee of the Psychology Department at the University of Liverpool.

Design

A 3 × 3 mixed design was used. The within-subject variable was task difficulty (easy, medium, or difficult) and the between-subject variable was the level of skill (professional contemporary dancers, nonprofessional dancers, and non-dancers). The dependent variable was the overall task performance.

Videos

Three different videos were used, each lasting 1 minute and 30 seconds. Each video displayed a dancer performing contemporary dance routines with background music. The routines displayed in the three videos, choreographed by a professional dancer, were of varying difficulty: easy, medium, and hard. Participants were asked to attempt to reproduce these dance steps whilst being recorded on a camcorder. An LCD PC was used to show the videos to the participants. A video camera (Samsung HMF-F90) recorded their performance.

Procedure

Participants were asked to read an information sheet and sign an informed consent form. They were then asked to fill in a questionnaire (see Study 2). Participants then watched a video of a contemporary dance routine twice. They were then given one minute of practice time. They then watched the video again and were given 30 seconds longer to practice. Following this, they saw the video one additional time and were asked to attempt to reproduce the dance steps whilst being recorded on a camcorder. This process was repeated for the easy, medium, and hard routines. Each experiment took approximately 40 minutes to complete. In order to reduce order effects and thereby increase the ecological validity of the study, the order of the three routines was counterbalanced. Each skill group was split into three subgroups: The first was shown the easy routine first, followed by the medium routine, and then finally the hard routine. The second was shown the medium routine first, followed by the hard routine, and finally they were shown the easy routine. The third was shown the hard routine, then the easy routine, and finally they were shown the medium routine.

Video Scoring

Using the video recordings, participants' performance on each task was scored by two different markers with strong contemporary dance and teaching backgrounds, using a mark sheet designed by a dance examiner. The mark sheet consisted of the following subscales: performance, technique, musicality, overall presentation, ability to perform contemporary routine consistently as set, and dynamic, with a maximum overall score of 100. The average across the subscales and between the two judges was taken. The inter-rater reliabilities between the two judges were moderate to excellent: $r(34) = .736$ for the easy items, $r(34) = .938$ for the medium-difficulty items, and $r(34) = .918$ for the hard items, all ps < .001.

Results

Analysis showed that the data were approximately normally distributed and met the assumption of homogeneity of variance; therefore, ANOVAs were conducted. As no assumptions were violated, no corrections were applied. Post hoc analyses used Bonferroni correction for multiple comparisons.

Table 1 shows the descriptive statistics of performance as a function of skill level and task difficulty. It can be seen that the easy task elicited the greatest total score ($M = 66.71$, $SD = 23.89$) compared with both the medium ($M = 57.90$, $SD = 28.04$) and hard tasks ($M = 50.47$, $SD = 29.46$). Overall, the greatest scores were from the professional group when carrying out the easy task ($M = 93.00$, $SD = 6.92$) and the lowest scores were from the no-experience group when carrying out the hard task ($M = 26.46$, $SD = 18.23$).

In order to test the statistical significance of these differences, a 3 × 3 mixed ANOVA was conducted with skill level (non-dancers, nonprofessional dancers, and professional dancers) as the between-subject factor and task difficulty (easy, medium, hard) as the within subjects factor. The results showed a significant main effect of skill, $F\ (2, 33) = 55.80$, $p < .001$, $n_p^2 = .77$, as well as a significant main effect of task difficulty $F\ (2, 66) = 29.38$, $p < .001$, $n_p^2 = .47$. The linear contrast was significant, $F\ (1, 33) = 48.71$, $p < .001$, $n_p^2 = .60$. An interaction between task difficulty and skill was also observed, $F\ (4, 66) = 2.58$, $p = .046$, $n_p^2 = .135$. As can be seen from Table 1, the interaction is due to the fact that performance difference between the three tasks increases as skill decreases.

Table 1. Means and standard deviations of dance steps performance scores as a function of task difficulty and skill level (study 1).

Task difficulty	Skill level	Mean (± SD)	N
Easy	Professional	93.00 (± 6.91)	12
	Some experience	59.50 (± 20.19)	11
	No experience	48.54 (± 13.58)	13
	Total	66.71 (± 23.89)	36
Medium	Professional	90.04 (± 5.90)	12
	Some experience	52.68 (± 19.50)	11
	No experience	32.65 (± 13.98)	13
	Total	57.90 (± 28.04)	36
Hard	Professional	84.38 (± 8.88)	12
	Some experience	41.86 (± 18.49)	11
	No experience	26.46 (± 18.23)	13
	Total	50.47 (± 29.46)	36

Post hoc analysis using multiple comparisons showed significant differences between all skill groups: Professional vs. Some experience, mean differences *(MD)* = 37.79, *SE* = 5.37, $p < .001$; Professional vs. No experience, *MD* = 53.25, *SE* = 5.15, $p < .001$; Some experience vs. No experience, *MD* = 15.46, *SE* = 5.27, $p = .018$. The greatest mean difference was observed between Professional and No experience groups, with professionals scoring greater (*M* = 89.14, *SE* = 3.71) than the No-experience group (*M* = 35.89, *SE* = 3.57).

Post hoc analysis using pairwise comparisons showed significant differences between all task difficulties: Easy vs. Medium, *MD* = 8.56, *SE* = 1.67, $p < .001$; Easy vs. Hard, *MD* = 16.11, *SE* = 2.31, $p < .001$; and Medium vs. Hard, *MD* = 7.56, *SE* = 2.27, $p = .006$. The greatest mean difference was observed between the easy and hard tasks, with easy tasks eliciting a greater score (*M* = 67.01, *SE* = 2.40) than the hard tasks (*M* = 50.9, *SE* = 2.65).

The results reported so far used a holistic measure of performance. Similar effects are found when focusing on recall, using only the subscale "Ability to perform contemporary routine consistently as set," which consists of two measures (contemporary styling and accurate repetition of steps): main effect of experience, $F\ (2, 33) = 32.06$, $p <.001$, $n_p^2 = .66$, main effect of task difficulty $F\ (2, 66) = 15.35$, $p < .001$, $n_p^2 = .32$, and interaction between task difficulty and experience, $F\ (4, 66) = 2.90$, $p = .028$, $n_p^2 = .150$.

Study 2

Method

Overview

Study 2 assessed the joint roles of innate factors and DP on contemporary dance expertise. In order to investigate the role of innate factors, we examined how dyslexia, handedness, and height impact dance performance. In order to investigate the role of DP, we examined how group practice, individual practice, rehearsing hours, sleep, required concentration, enjoyment, and gender impact contemporary dance performance. Each participant completed a questionnaire about DP and a number of other variables.

Participants

The study consisted of 62 participants (31 females and 31 males), including the 36 participants from Study 1. Participants' ages ranged from 19 to 34 years with a mean age of 22.90 (*SD* = 3.42). Like Study 1, participants were allocated to three skill groups using their dance experience: professional contemporary dancers from various contemporary dance companies across the UK (*N* = 20, *M* = 25.6 years, *SD* = 3.3 years, range = 13 years), participants with a strong dance background without professional performance experience (*N* = 28, *M* = 21.0 years, *SD* = 1.8 years, range = 9 years) and participants with no experience in dance (*N* =14, *M* = 22.8 years, *SD* = 3.6 years, range = 10 years).

Materials

Elements of the following three questionnaires were combined in order to produce an appropriate questionnaire for the current study.

Questionnaire about DP and Other Key Variables. This questionnaire had the same structure as the questionnaire designed by Urena (2004). Urena's questionnaire, which focused on ballet, included demographics, milestones, yearlong training and summer training, performance career, other activities, social and family support, perceived talent, goals, concentration required when dancing, enjoyment in dance activities, and importance of dance. We added questions about height and weight, and rephrased the questions so that the focus changed from ballet to contemporary dance.

Dyslexia Checklist. Snowling et al.'s (2012) Adult Reading Questionnaire was used. This is an updated version of Smythe and Everatt's (2002) dyslexia checklist for Adults. Three of the subscales of the Adult Reading Questionnaire have good reliability (Attention, α = 0.81; Reading, α = 0.81; and Word Finding, α = 0.60) and one subscale (Hyperactivity) has modest reliability, α = 0.58 (Snowling et al. 2012).

Questionnaire on Handedness. The Edinburgh Questionnaire was used to measure handedness. This is a standard Questionnaire often used in laterality research. It consists of ten questions asking which hand is preferred for activities such as writing or using scissors (Christman 1993). Extreme right-handedness is scored 100, no preference (ambidexterity) is scored 0, and extreme left-handedness is scored −100. The Edinburgh Questionnaire has an excellent reliability (α = .95; Veale 2014).

Procedure

Participants were asked to fill out a questionnaire assessing, among other variables, handedness, dyslexia, and the number of accumulated hours of contemporary dance practice per year that they had undertaken. The latter was calculated by taking the average number of hours of dance practice per week for each year spent dancing and taking the sum of these averages multiplied by 52.

Design

The design consists of two parts. A first analysis examined whether there was a gender and skill (professional dancers, nonprofessional dancers, and non-dancers) effect with respect to individual practice, group practice, rehearsing hours, sleep, required concentration in dance tasks, enjoyment of dance tasks, dyslexia, handedness, and height. For this purpose, a two-way independent groups multivariate design was used, with gender and skill as the independent variables and the other factors as dependent variables. A second analysis, carried out only with those participants who also took part in Study 1, used a correlational design in order to assess the relationship between overall task performance in Study 1 and individual practice, group practice, rehearsing hours, sleep, required concentration in dance tasks, enjoyment of dance tasks, dyslexia, handedness, and height.

Data Analysis

Outliers were identified using boxplots. All typographical mistakes were corrected, and the remaining outliers could be explained. Outliers for performance scores can be explained because participants' experience and ability ranged significantly even within each of the skill levels. Outliers for practice can be explained because some professionals engaged in a lot more hours of practice depending on the type of work that they were involved in. Also, in the nonprofessional dancers' group, the amount of practice is likely to depend on factors such as the type of dance schools, workshops or classes participants had attended, the level of enthusiasm, and the reasons why they chose to dance. Post hoc analyses used Bonferroni correction for multiple comparisons.

Predicting Performance in Study 1

The analyses described in Study 1 relied on participants' experience for allocating them to three levels of expertise. Even though the results of that experiment show that this method offers a reliable measure of skill, research on different fields of expertise has shown that experience is not an ideal way to measure expertise (e.g. Gobet 2016). We thus carried out further analyses with the subset of participants having taken part in Study 1 and used the score they obtained in the performance task as a more direct measure of expertise. The presence of continuous scores also made it possible to use correlational analyses. Specifically, we computed Pearson's correlations in order to establish whether individual practice, group practice, rehearsal hours, sleep, concentration, enjoyment, dyslexia, handedness, and height are associated with overall performance in the first study. (Overall performance was defined as the mean score between the easy, medium, and hard tasks, across the two markers.) We also used a multiple regression analysis to estimate the extent to which the former variables predict overall performance.

Results

Gender and Skill Difference (Full Sample)

In order to examine whether there was a gender and skill effect with respect to group practice, individual practice, rehearsal hours, sleep, concentration, enjoyment, dyslexia, handedness, and height, exclusive of dance performance, a two-way multivariate analysis was conducted. This included the full sample of 62 participants, including those who did not partake in Study 1. The descriptive results are presented in Table 2 and the inferential analyses are presented in Table 3.

There was a significant main effect of gender on group practice, F (1, 56) = 5.84, p = .019, η_p^2 = 0.094 and on height, F (1, 56) = 9.28, p = .004, η_p^2 = .142. For the skill factor, there was a significant effect on all variables, Fs (2, 56) > 6.93, ps < .003, η_p^2 > .197, apart from height, F (1, 56) = 0.677, p = .512, η_p^2 = .024. A significant interaction between gender and skill was observed for variables of group practice, F (2, 56) = 5.14, p = .009, η_p^2 = .155, individual practice, F (2, 56) = 5.55, p = .006, η_p^2 = .17 and height, F (2, 56) = 5.08, p = .009, η_p^2 = .156. The interaction with group practice was occasioned by professional females showing a greater number of hours of group practice (M = 9,019.64) than professional males (M = 3,313.56), with no difference in the other two groups. A similar pattern was observed with individual practice: M = 2,604.73 for professional females vs. M = 742.44 for professional males. The interaction with height was due to males being taller (M = 175.2) than females (M = 155.9) in the professionals only.

The post hoc analysis for the effects of skill on individual practice, group practice, rehearsal hours, dyslexia scores, and sleep showed that professionals scored higher than the other two skill levels on all of these variables (ps < .001). With rehearsing hours, individuals with some experience scored marginally higher than individuals without any experience (p = .087). With enjoyment, professionals scored less that individuals without any experience (p < .02), and individuals with some experience scored lower than individuals without any experience (p < .001). With handedness, professionals had higher scores (i.e., were more right-handed) than individuals with some experience (p < .002). For concentration, both professionals and the some-experience group scored lower than the no-experience group (both p < .001).

Table 2. Descriptive statistics of the dependent variables used in study 2.

	Gender	Group	Mean	Std. Deviation	N
Individual practice (Cumulative number of hours)	Female	Professional	2604.73	2361.56	11
		Some experience	184.00	338.08	13
		No experience	118.86	166.38	7
		Total	1028.26	1823.00	31
	Male	Professional	742.44	659.95	9
		Some experience	388.27	761.42	15
		No experience	178.29	230.33	7
		Total	443.68	664.87	31
	Total	Professional	1766.70	2005.53	20
		Some experience	293.43	601.81	28
		No experience	148.57	195.48	14
		Total	735.97	1392.36	62
Group practice (Cumulative number of hours)	Female	Professional	9019.64	7099.83	11
		Some experience	804.00	1379.98	13
		No experience	133.71	98.92	7
		Total	3567.87	5875.90	31
	Male	Professional	3313.56	876.04	9
		Some experience	426.40	1125.31	15
		No experience	193.14	262.95	7
		Total	1211.94	1638.66	31
	Total	Professional	6451.90	5944.41	20
		Some experience	601.71	1240.87	28
		No experience	163.43	193.34	14
		Total	2389.90	4439.71	62
Rehearsing hours (hours per week)	Female	Professional	6.45	6.41	11
		Some experience	1.00	1.63	13
		No experience	.14	.38	7
		Total	2.74	4.77	31
	Male	Professional	5.22	1.72	9
		Some experience	3.53	2.33	15
		No experience	.00	.00	7
		Total	3.23	2.64	31
	Total	Professional	5.90	4.82	20
		Some experience	2.36	2.38	28
		No experience	.07	.27	14
		Total	2.98	3.83	62
Sleeping (hours per day)	Female	Professional	8.55	.93	11
		Some experience	6.62	1.33	13
		No experience	5.86	2.27	7
		Total	7.13	1.80	31
	Male	Professional	9.00	.71	9
		Some experience	5.87	1.55	15
		No experience	5.71	1.70	7
		Total	6.74	2.00	31
	Total	Professional	8.75	.85	20
		Some experience	6.21	1.47	28
		No experience	5.79	1.93	14
		Total	6.94	1.90	62
Concentration	Female	Professional	18.18	2.79	11
		Some experience	19.38	7.62	13
		No experience	26.00	5.29	7
		Total	20.45	6.40	31
	Male	Professional	18.44	2.30	9
		Some experience	18.67	3.66	15
		No experience	26.29	4.54	7
		Total	20.32	4.74	31
	Total	Professional	18.30	2.52	20
		Some experience	19.00	5.73	28
		No experience	26.14	4.74	14
		Total	20.39	5.59	62
Enjoyment	Female	Professional	20.55	.82	11
		Some experience	18.23	8.26	13
		No experience	28.00	.00	7
		Total	21.26	6.50	31
	Male	Professional	20.78	.67	9
		Some experience	16.27	6.03	15
		No experience	25.00	7.94	7
		Total	19.55	6.52	31
	Total	Professional	20.65	.75	20
		Some experience	17.18	7.08	28
		No experience	26.50	5.61	14
		Total	20.40	6.51	62

(*Continued*)

Table 2. (Continued).

	Gender	Group	Mean	Std. Deviation	N
Dyslexia	Female	Professional	42.45	6.04	11
		Some experience	26.23	5.43	13
		No experience	23.57	13.07	7
		Total	31.39	11.35	31
	Male	Professional	42.56	6.80	9
		Some experience	24.33	5.68	15
		No experience	23.57	11.59	7
		Total	29.45	11.27	31
	Total	Professional	42.50	6.22	20
		Some experience	25.21	5.55	28
		No experience	23.57	11.87	14
		Total	30.42	11.26	62
Handedness	Female	Professional	86.39	20.27	11
		Some experience	29.40	49.05	13
		No experience	73.00	46.12	7
		Total	59.47	47.17	31
	Male	Professional	83.53	11.50	9
		Some experience	43.95	59.92	15
		No experience	50.61	46.59	7
		Total	56.94	49.50	31
	Total	Professional	85.10	16.56	20
		Some experience	37.19	54.64	28
		No experience	61.80	46.03	14
		Total	58.21	47.97	62
Height (in cm)	Female	Professional	155.90	3.78	11
		Some experience	167.72	10.61	13
		No experience	167.29	11.32	7
		Total	163.43	10.38	31
	Male	Professional	175.17	4.89	9
		Some experience	169.67	10.33	15
		No experience	169.90	15.72	7
		Total	171.32	10.58	31
	Total	Professional	164.57	10.69	20
		Some experience	168.76	10.31	28
		No experience	168.59	13.23	14
		Total	167.37	11.13	62

Correlation Analysis

Table 4 reveals a large cluster of inter-correlations, with handedness, dyslexia, individual practice, group practice, rehearsing hours, and sleeping all positively correlated (all *p*s < .05), with the exception of handedness with group practice (p = .072). In particular, the more individuals practiced, the more they slept, and the more right-handed they were. Concentration and enjoyment strongly correlated positively together, but correlated negatively with dyslexia, rehearsing hours, and sleeping (for concentration) and with rehearsing hours (for enjoyment). Finally, height correlated negatively with individual practice and group practice.

Five variables correlated positively with performance in Study 1 (dyslexia, individual practice, group practice, rehearsing hours, and sleeping). Three variables correlated negatively (concentration, enjoyment, and height). Finally, there was no correlation between handedness and performance in Study 1.

Multiple Regression Analysis

To reduce the number of predictors and thus issues related to collinearity, we summed individual practice and group practice to create a new variable, total practice. A stepwise regression carried out with handedness, dyslexia, sleeping hours, concentration, enjoyment, height, age, and total practice kept only total practice and sleeping hours as predictors of performance in Study 1. A multiple regression analysis (method "Enter") using these two predictors indicated that the two predictors explained 52.4% of the variance (adjusted R^2 = .524, F (2, 33) = 20.269, p < .001). Performance was predicted slightly more by Total Practice (B = .002, β = .465, p < .001) than by Sleeping Hours (B = 6.07, β = .433, p = .002).

Discussion

The first study obtained a linear relationship between skill and performance. Participants performed the dance routines rather than just recalling them, which provides a high level of ecological validity. In addition to its intrinsic interest, this experiment supported our measure of expertise (measured as experience), given that skill level closely predicted performance scores. While previous research has investigated the recall of dance steps (Starkes et al. 1990; Jean, Cadopi, and Ille 2001), the level of difficulty of the dance routines had not been

Table 3. Effects of skill and gender on individual practice, group practice, rehearsal hours, sleep, concentration, enjoyment, dyslexia, handedness and height (study 2).

IV	DV	F	DF	Sig	ηp^2
Gender	*Individual practice*	3.274	1	0.076	0.055
	*Group practice**[1]	5.840	1	0.019	0.094
	Rehearsal hours	0.219	1	0.641	0.004
	Sleep	0.146	1	0.704	0.003
	Concentration	0.002	1	0.965	0.000
	Enjoyment	1.158	1	0.287	0.020
	Dyslexia	0.85	1	0.772	0.002
	Handedness	0.092	1	0.762	0.002
	*Height**	9.277	1	0.004	0.142
Error			56		
Skill	*Individual practice**	11.243	2	0.000	0.286
	*Group practice**	22.298	2	0.000	0.443
	*Rehearsal hours**	15.170	2	0.000	0.351
	*Sleep**	23.876	2	0.000	0.460
	*Concentration**	12.978	2	0.000	0.317
	*Enjoyment**	13.038	2	0.000	0.318
	*Dyslexia**	35.571	2	0.000	0.560
	*Handedness**	6.933	2	0.002	0.198
	Height	0.677	2	0.512	0.024
Error			56		
Skill * gender	*Individual practice**	5.555	2	0.006	0.166
	*Group practice**	5.138	2	0.009	0.155
	Rehearsing hours	2.289	2	0.111	0.076
	Sleep	1.020	2	0.367	0.035
	Concentration	0.081	2	0.922	0.003
	Enjoyment	0.395	2	0.675	0.014
	Dyslexia	0.122	2	0.886	0.004
	Handedness	0.830	2	0.441	0.029
	*Height**	5.075	2	0.009	0.153
Error			56		

* = The main effect or the interaction was statistically significant.

manipulated in past work. In the current study, the difficulty level was manipulated and it was found that individuals performed worse on harder tasks. Furthermore, individuals with a lower level of skill displayed more variability between the three types of task than individuals with a higher level of skill.

The second study was interested in the practice and non-practice factors that are associated with expertise. The results indicated that more skilled individuals devote more time, on average, to individual and group DP, thus supporting the DP framework (Ericsson, Krampe, and Tesch-Römer 1993). The results also revealed an effect of gender. Females showed greater mean hours of group practice compared to males. In support of past research, one possibility as to why this is the case is that stereotypes (such as associating being gay with males engaging in dance) may influence engagement in DP (Fisher 2007; Haltom and Worthen 2014; Clegg, Owton, and Allen-Collinson 2018).

The findings cannot directly confirm that stereotypes associating dance with femininity are what prevent male dancers from engaging in as many hours of group practice as females. However, since there is a vast amount of literature suggesting that male dancers sometimes struggle with dance engagement due to gender stereotypes and difficulties associated with negotiating their gender identity, exploring how this impacts DP in professional dance schools and companies is an area which should be examined in more depth (Fisher 2007; Haltom and Worthen 2014; Clegg, Owton, and Allen-Collinson 2018). Additionally, it is important that innate aspects of gender are considered too when examining dance expertise. A future research project might therefore examine the impact of innate factors and environmental factors that are associated with gender on engagement in dance. Overall, investigating why males engage in fewer hours of group practice compared to females would be beneficial from a cognitive psychology perspective. This would help to develop further insights into the role of gender in skill acquisition in the domain of dance.

The study also found that professionals require less concentration than nonprofessionals in dance tasks. This may be because experts have advantageous perceptual processing, which enables them to carry out tasks nearly automatically (Chase and Simon 1973). This is inconsistent with Ericsson, Krampe, and Tesch-Römer's (1993) claims that professionals concentrate more in tasks relating to their own skill domain than nonprofessionals. It is also inconsistent with claims that reduced concentration limits dance performance (Quested and Duda 2010; Quin, Rafferty, and Tomlinson 2015).

With the sub-sample having taken part in the first study, and in line with our hypothesis, the results of the second study showed a positive relationship between scores on the dance performance task and individual practice, group practice, and rehearsal hours. In addition, it was found that those who scored higher on the performance task sleep on average for longer than participants with lower scores. (This correlation remains when the contribution of age is partialled out: $r = .543$, $p < .001$). This supports research suggesting that duration of sleep impacts on cognition, thereby influencing expertise (Bratzke et al. 2012; McCloughan et al. 2015). In line with Ericsson, Krampe, and Tesch-Römer's (1993) DP framework, this result supports the hypothesis that sleep impacts the quality, duration, and number of hours of deliberate contemporary dance practice since DP influences performance.

Further analysis indicated that contemporary dance performance increased as dyslexia scores increased. This result is consistent with existing research indicating that certain factors beyond DP play a role in determining contemporary dance expertise (Hutchinson, Sachs-Ericsson, and Ericsson 2013). Research has suggested that people with dyslexia have innate brain differences causing certain regions to become disinhibited (Chakravarty 2009). This disinhibition results in creative thinking (Beck 2013). Creative thinking is required in contemporary dance, as dance requires a significant

Table 4. Correlation matrix (study 2).

	Statistics	Handedness	Dyslexia	Ind. practice	Group practice	Rehearsing hours	Sleep	Concentration	Enjoyment	Height	Score
Handedness	Pearson's r	1	.433**	.315*	.188	.315*	.217	.056	.098	−.010	.067
	Sig. (2-tailed)		.000	.013	.144	.013	.089	.667	.449	.938	.699
Dyslexia	Pearson's r	.433**	1	.457**	.420**	.433**	.553**	−.324*	−.060	−.016	.469**
	Sig. (2-tailed)	.000		.000	.001	.000	.000	.010	.642	.899	.004
Individual practice	Pearson's r	.315*	.457**	1	.483**	.716**	.396**	−.175	−.046	−.329**	.373*
	Sig. (2-tailed)	.013	.000		.000	.000	.001	.174	.723	.009	.025
Group practice	Pearson's r	.188	.420**	.483**	1	.516**	.387**	−.185	−.040	−.240	.599**
	Sig. (2-tailed)	.144	.001	.000		.000	.002	.149	.758	.060	.000
Rehearsing hours	Pearson's r	.315*	.433**	.716**	.516**	1	.379**	−.319*	−.221	−.172	.583**
	Sig. (2-tailed)	.013	.000	.000	.000		.002	.011	.084	.181	.000
Sleep	Pearson's r	.217	.553**	.396**	.387**	.379**	1	−.384**	−.130	.026	.603**
	Sig. (2-tailed)	.089	.000	.001	.002	.002		.002	.312	.843	.000
Concentration	Pearson's r	.056	−.324*	−.175	−.185	−.319*	−.384**	1	.766**	−.062	−.425**
	Sig. (2-tailed)	.667	.010	.174	.149	.011	.002		.000	.633	.010
Enjoyment	Pearson's r	.098	−.060	−.046	−.040	−.221	−.130	.766**	1	−.077	−.286
	Sig. (2-tailed)	.449	.642	.723	.758	.084	.312	.000		.554	.090
Height	Pearson's r	−.010	−.016	−.329**	−.240	−.172	.026	−.062	−.077	1	−.296
	Sig. (2-tailed)	.938	.899	.009	.060	.181	.843	.633	.554		.080
Score	Pearson's r	.067	.469**	.373*	.599**	.583**	.603**	−.425**	−.286	−.296	1
	Sig. (2-tailed)	.699	.004	.025	.000	.000	.000	.010	.090	.080	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Note: N = 62, except for the correlations with score, where N = 36.

degree of visuospatial processing which has been associated with creativity (Mohamed and Aal 2014). There are a number of possible explanations for these findings. It is important to reflect upon these in order to increase insight into cognition in dance. For example, the findings support past neuropsychology research (such as Chakravarty 2009) which suggested that the disinhibition in certain brain regions causing dyslexia can enhance expertise in the arts. Innate factors may also play a role in the decision to engage in creative arts such as dance; those with dyslexia may be more attracted to contemporary dance because of the high level of creativity associated with engagement in dance, leading to more hours of DP. These reflections provide insight into the innate basis of cognition in dance, which provides a starting point to conceptualizing how dancers develop expertise in their field from a cognitive psychological perspective.

The results indicated that other innate factors influenced dance performance. It was found that those of shorter height exhibited increased performance. If height impacts contemporary dance expertise, it is also likely that other innate components (such as specific body compositions and "turn out") may also influence contemporary dance skill (Hutchinson, Sachs-Ericsson, and Ericsson 2013). Handedness positively correlated with dyslexia, individual practice, and rehearsing hours, but not with scores in the performance task. However, contrary to the hypothesis, these correlations were positive, meaning that they indicated that right-handed individuals are likely to show a greater level of expertise. Therefore, these innate factors require further exploration.

In summary, the current study partly supports the DP framework, in that the greater the number of hours of dance DP (this includes group practice and individual practice), the greater the individual's contemporary dance performance ability and level of professionalism. However, the study suggests that further research should explore the role of innate factors, specifically focusing on how dyslexia and height impact contemporary dance performance. The role of disinhibition of some regions of the brain may benefit from being explored further in relation to creative skills such as dance.

It is important to consider one limitation in this research. In the samples of the two studies, the professional dancers were statistically significantly older than the participants with dance experience and those with no dance experience. However, as all means are between 20.8 years and 25.7 years, it is unlikely that these differences have affected the results. For example, it is known that memory starts declining in the third decade of life (Nelson et al. 2016). Thus, given its memory component, performance in Study 1 should have been affected negatively by age. By contrast, the results show a substantial superiority of the (older) professionals. In addition, age was excluded when entered in the stepwise regression analysis.

Conclusions

RQ 1: What can examination of the interaction between innate factors and DP tell us about cognitive processes underpinning talent in contemporary dance?

This study has provided insights into how the DP framework for expertise can be applied to dancers, enabling a deeper understanding of aspects of cognition in the context of dance education. Individual and group practice as well as rehearsal are likely to contribute to superior perceptual processing and the ability to carry out dance tasks automatically. This suggests that the more hours a dancer puts into their training, the greater their performance; this is an important message that should be emphasized to dance students which could enhance motivation. This provides useful insight into recent work focusing on dance students' motivation (for example, Quested and Duda 2010; Quin, Rafferty, and Tomlinson 2015). In addition, the findings strongly support past work which suggests that considering the interaction between innate and environmental factors is important in order to gain a full insight into the psychology of expertise (Tucker and Collins 2012; Meyers, van Woerkom, and Dries 2013; Gobet 2016). Further neuropsychology study into the link between dyslexia, creativity, and superior performance in dance is likely to be of benefit in providing a full overview of how superior dance performance is achieved. Examining this has the potential to enhance the research into expertise through a cognitive psychology lens.

RQ 2: How can studying the interaction between innate factors and DP in contemporary dancers enhance dance education?

Our research adds valuable insights into past research which explored the learning process in dance (Quested and Duda 2010; Quin, Rafferty, and Tomlinson 2015). The findings also provide evidence that sleep should be heavily considered and emphasized to dancers (by their teachers) as an important part of their lifestyle. Sleep should be discussed within dance educational settings alongside the other recommendations which have been used to guide dance education (Laws 2005). Overall, from a cognitive psychology perspective, both innate and environmental factors contribute to achieving a high level of skill in dance. Therefore, in order to enhance learning and performance outcomes within dance education, teachers must discuss the importance of individual practice, group practice, rehearsal and sleep.

Note

1. * = There was a significant main effect of the IV on the DV.

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ORCID

Jessica Charlotte Kawalek http://orcid.org/0000-0001-8678-9804
F. Gobet http://orcid.org/0000-0002-9317-6886

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