

Expertise in Trained Dogs

William S. Helton (wshelton@mtu.edu)

Michigan Technological University, Department of Psychology, 1400 Townsend Dr.
Houghton, MI 49931 USA

Abstract

The acquisition of expertise is an area of controversy between those seeing a strong influence from genetics, inherent talent, and those who deny that genetics plays much of a role. Because the genetics and early life experiences of humans are not open to direct manipulation, human studies are of limited utility in this debate. Studies employing non-humans as expert models may prove useful in resolving this dispute. In order for non-humans to be considered proper models of human experts, the methods employed in human studies of expertise need to be demonstrated to be applicable to the study of non-humans as well. The expert-novice comparison research method was applied to dogs competing in the sport of agility. Differences in performance characteristics between expert, advanced, intermediate and novice dogs were investigated. There were statistically significant differences between dogs of different competitive levels. Highly skilled dogs may prove useful in investigating expertise and its development.

Introduction

Skoyles (1999) argues that the environmental demands for the development of expertise were the primary catalysts for the rapid increase in brain size among early homo ancestors. Rossano (2003), moreover, proposes expertise as an indicator of consciousness. Undoubtedly, understanding expertise and how it develops in biological systems is critically important for cognitive science. Human expertise research has been continuously plagued, however, by a fundamental debate over the role of inherited abilities, or talent, in expertise development.

There is continuing debate between those advocating a role for inherent talent in the acquisition of expertise, with an emphasis on individual differences and genetics (Gardner, 1997; Greenwood & Parasuraman, 2003; Winner, 1996), and those disparaging talent (Howe, Davidson, & Sloboda, 1998), who instead emphasize practice. Ericsson and his colleagues are the most critical of the role inherent talent-biology plays in expertise development (Ericsson & Charness, 1994; Ericsson, Krampe, & Tesch-Romer, 1993). Aside from the role genetics has on physical size, in particular height, which may be important for some fields, like athletics, they are very skeptical of the influence of genetics on expertise development. Instead they propose the theory of deliberate practice.

Training and practice were always regarded as important to the acquisition of expertise. Ericsson et al.'s theory is novel in specifying the kind of practice necessary for skill development, deliberate, and in their assertion of its central,

overwhelming role in expertise acquisition. According to Ericsson (2001) deliberate practice entails four elements: (1) the trainee is motivated to improve, (2) the trainee is given well-defined tasks, (3) the trainee is given feedback, and (4) the trainee is provided ample opportunity for repetition. From this perspective, despite genetic differences, anyone could commit themselves to a long period of deliberate practice and achieve mastery. Findings from research studies on neural plasticity make this perspective biologically plausible, despite the many "common-sense" talent-oriented objections raised by critics.

Studies directly testing the competing perspectives of expertise development, talent versus deliberate practice, are, unfortunately, nonexistent. Although data have been gathered to support one position or the other, the data have not been decisive. The data are only suggestive because they are correlational in nature. Experiments that truly test competing theories of expertise development, for practical and ethical reasons, cannot be employed with humans.

Expertise takes a long time to develop, 7-10 years in humans (Ericsson, 1996), or in other words, it consumes a large percentage of the life span of the individual. In human experimentation it would be unfeasible to randomly assign people to different training groups and force them to stay with these groups for a long period of time. The primary problem with human studies of expertise development is they are hopelessly confounded by the participants' willingness to partake in the training. The unfortunate reality is the participants' willingness to stay in the experiment, to continue training, may be due to their ease of mastery, or what many call talent. Hence, the role of talent in expertise development continues to irk researchers promoting the strong learning view. Although researchers can discover a great deal about expertise by studying humans, an exclusive human focus will leave many questions unanswerable.

Most conceivable attempts to design proper experiments of human expertise development are going to fail because of methodological or ethical constraints. An alternative solution is to employ non-human animal models (Helton, 2004; 2005; Shaffer, Krauchunas, Eddy, & McBeath, 2004; Terrace, Son, & Brannon, 2003). While no one denies that other animals become highly skilled, there have been some objections raised to them being labeled as experts (Rossano, 2003). Expertise acquisition requires practice to be oriented towards skill improvement; it is designed with achieving a performance goal in mind. Some researchers argue that non-human animals are incapable of deliberately practicing, as it

would require them to be capable of mental time-travel into the future. This is a hotly debated area involved with the overall philosophical question of animal consciousness (Roberts, 2002; Zentall, 2005). Helton (2005), however, attempts to avoid this philosophical quagmire by asserting that the animal's conscious state is irrelevant as long as the actual practice activities engaged in are objectively goal-oriented. This is the case, for example, in the training of working dogs.

Canine experts, similarly to human experts, undergo a long period of formal skill training and practice, varying from six months to several years (Fjellanger, Andersen, & McLean, 2000; Helton, 2005). Their training fits the criteria set by Ericsson (2001) for practice to be considered deliberate: (1) the dogs are motivated to improve; (2) they are given well-defined tasks; (3) they are given feedback; and (4) they have ample opportunity for repetition. The practice of skilled dogs fit these criteria, whether the skill is narcotic detection (Slabbert & Rasa, 1997), explosive detection (Gazit & Terkel, 2003; Fjellanger, Andersen, & McLean, 2000), or herding (Marschark & Baenniger, 2002).

Trained canines are good candidate models of human expertise because dogs share many individual differences in common with humans, like personality traits (Gosling & John, 1999). Dogs' basic cognitive abilities are similar enough to those of humans that they have become useful models for studying the effects of aging on cognition, and dogs, like humans, vary in these abilities (Adams, Chan, Callahan, & Milgram, 2000). Recent research also suggests that dogs differ in cerebral lateralization (Wells, 2003), an individual difference variable that has been of interest among human expertise researchers (Winner, 1996). Dogs may be useful in determining the role of individual differences in expertise acquisition, because unlike humans, they are subject to genetic control and their early life experiences can be manipulated (Schmutz & Schmutz, 1998; Slabbert & Rasa, 1997).

In order for dogs to be considered proper models of human experts, they need to be subject to a similar methodology as employed in studying human expertise. The most frequently employed method in the study of human expertise is the expert-novice paradigm, also sometimes referred to as the exceptional performance approach (Williams & Ericsson, 2005). Experts in the field are identified, usually by using socially defined criteria, e.g. the experts are labeled as experts by a societal group. Then novices and others of various skill levels are compared to the experts on representative domain-specific tasks. In this manner, verifiable performance differences between experts and novices can be elucidated. This allows researchers to get at what objectively defines expertise in the domain; expert-novice comparison enables the researcher to determine what is actually being improved in expertise acquisition.

The popularity of training dogs for highly skilled activities makes finding canine experts easy. Dogs are trained in a number of tasks, such as accelerant detection,

blind assistance, epilepsy detection, explosive detection, forensic tracking, guarding, hearing assistance, herding livestock, narcotic detection, detection of insect infestations and microbial growth (Brooks, Oi, & Koehler, 2003; Wells & Hepper, 2003). They, like humans, are also trained for a number of athletic activities, such as agility, dock diving, earth-dog, flyball, frisbee, lure-racing, obedience, schutzhund, skijoring, sled-racing, and weight-pulling.

Performance in the sport of agility was chosen for the present investigation. Agility, unlike some other canine sports, is open to all breeds and agility is one of the most popular canine sports. Agility is, moreover, of practical importance, as many law enforcement and military agencies incorporate agility training in their canine programs. Sentry dogs, for example, must be able to negotiate various obstacles, while simultaneously taking commands from their human handlers.

The sport of agility involves a dog running through an obstacle course made up of inclined walls (A-frames), hurdles, tunnels, chutes (collapsed cloth tunnels), elevated dog walks, weave-poles, and see-saws. The jumps' heights are determined by the dogs' height class. The dogs must follow a prescribed path through the obstacles and are directed by a handler using gestures and/or vocal commands. Faults are given for mistakes and speed is calculated. The sport involves endless variation as the placement of the obstacles is not static. The sport requires both precision and speed.

An advantage of investigating agility is that it involves two simultaneous tasks: control of motor movement and the detection/recognition of handler signals. The actual faults made by the dogs may be diagnostic of underlying skill differences between dogs of differing levels of ability on these two tasks. Agility may prove useful as a task for investigating the development of the coordination between perception and motor control. Expert and novice dogs are predicted to significantly differ on objective measures of skill in agility performance. In particular, expert dogs will differ in their capacity to correctly detect handler signals while simultaneously controlling their movements.

Methods

Participants

Participants were 40 dogs and their handlers. The dogs and handlers were recruited at an event held at the Queen City Dog Training Club in Cincinnati, Ohio, an American Kennel Club (AKC) affiliated center. The Queen City Dog Training Club is nationally recognized as a premiere agility training facility, having produced a number of AKC champions. The dogs consisted of 10 each from four levels of ability: novice, intermediate, advanced, and expert, matched approximately for height, a factor which may influence running speed. The determination of a dog's competitive level was made using the AKC's pre-established competitive designations. A list of dogs by breed is provided for each group in Table 1. The dogs

Table 1. Breeds in the four levels.

Height Class	Novice	Intermediate	Advanced	Expert
8 in.	Dachshund	Yorkshire Terrier	Minature Poodle	Miniature Pinscher
12 in.	Papillon	King Charles Spaniel	Minature Schnauzer	Welsh Corgi
12 in.	Cocker Spaniel	King Charles Spaniel	Shetland Sheepdog	Minature Poodle
16 in.	Shetland Sheepdog	Minature Schnauzer	Shetland Sheepdog	Shetland Sheepdog
16 in.	Standard Schnauzer	English Springer Spaniel	Shetland Sheepdog	Shetland Sheepdog
16 in.	English Cocker Spaniel	Welsh Springer Spaniel	Norwegian Buhund	Minature Poodle
20 in.	Border Collie	Border Collie	Australian Cattle Dog	Border Collie
20 in.	Border Collie	Australian Shepherd	Australian Shepherd	Border Collie
21 in.	Standard Schnauzer	Labrador Retriever	Labrador Retriever	Australian Cattle Dog
24 in.	Golden Retriever	Labrador Retriever	Golden Retriever	Golden Retriever

ranged in age from 2 years to 7 years ($M = 3.6$ years, $SD = 1.5$ years).

Procedure

Instead of relying on the handlers reports of their dogs' performance, the dogs were assessed in an actual competitive event held at the training club over 3 days. The dogs competed in an agility course consisting of all obstacle types. The agility course, having a number of contact obstacles where the animal must touch a particular spot, tunnels-chutes, and tables where the animal must stop for a specified period of time, emphasizes precision and control. Course length and number of obstacles employed depended on the dogs' competitive abilities. Novice dogs are usually unable to complete the more challenging expert runs. The height of jumping obstacles is adjusted for the height of the dog. All dogs completed 2-3 runs of the course.

In the majority of actual agility competitions the primary goal is to qualify. Faults are given for a number of inappropriate actions by the dog and for the dog failing to meet the maximum time set for the course. If the dog exceeds the number of faults allowed, which depends on the dog's level of ability, then the dog fails to qualify. Only dogs who qualify are rated for placement, which is then determined by quickest time. Thus in agility competitions the emphasis is first on precision, not faulting, and then on speed; overall performance is a mixture of the two. In this study, three primary performance measures were assessed from the dogs' runs, in order to examine both speed and precision:

1. Precision – all faults, aside from time faults, were summed for each dog and divided by the total number of runs the dog ran. A constant (1) was added to these values and they were inverted ($1/(x+1)$) to ensure normality. A higher value reflects more precision.
2. Raw speed – the best time for a run, regardless of number of faults made, calculated by dividing the distance of the course measured in yards by the time of the run measured in seconds (yd/sec).

3. Adjusted speed – the best time for a run calculated by dividing the distance of the course measured in yards by the time of the run measured in seconds adjusted for faults (each fault made adds 5 seconds to total time).

Best times were examined rather than an average measure of typical performance because this has been the practice in human studies of athletic expertise (Ericsson, 1993; Hodges et al., 2004). In addition to the three primary performance measures, within precision, four different types of faults can be distinguished:

1. Refusals/Runouts (R) – a refusal is when a dog starts towards an obstacle and ceases forward movement. A runout is when the dog passes the plane of the next correct obstacle.
2. Wrong course (W) – a wrong course is when a dog engages any obstacle that is not the next one in the correct sequence, or enters the correct obstacle the wrong way.
3. Table (T) – a table fault is when a dog leaves the table zone prematurely.
4. Obstacle Failure (O) – an obstacle failure is given when the dog fails to perform on an obstacle, for example, not touching contact zones or knocking bars on jumps.

Separating out the types of faults for analysis may aid in further distinguishing experts from novices. The faults were summed for each dog and divided by the total number of runs the dog ran. A constant (1) was added to these values and they were inverted ($1/(x+1)$) to ensure normality. A higher value reflects more precision.

Results

Primary Performance Measures

The three primary performance measures were analyzed with analyses of variance (ANOVAs), in order to investigate differences between the four competitive levels. There was a significant effect for competitive level in all cases, for precision, $F(3,36) = 6.3$, $p < .001$, $\eta^2 = .35$, raw speed,

$F(3,36) = 22.1, p < .001, \eta^2 = .65$, and adjusted speed, $F(3,36) = 29.7, p < .001, \eta^2 = .71$. The means of the three performance measures for the four competitive levels are displayed in Figure 1.

Tukey post-hoc analyses were performed. In the case of precision, there was a significant difference between experts and novices, and experts and intermediates ($p < .05$). In the cases of both raw and adjusted speed, there were significant differences between experts-advanced dogs and novices-intermediates ($p < .05$). On all three performance measures, experts were consistently different from novices and intermediates. The three performance measures significantly intercorrelated, precision - raw speed ($r = .47, p < .01$), precision - adjusted speed ($r = .58, p < .01$), and raw speed - adjusted speed ($r = .97, p < .01$), respectively.

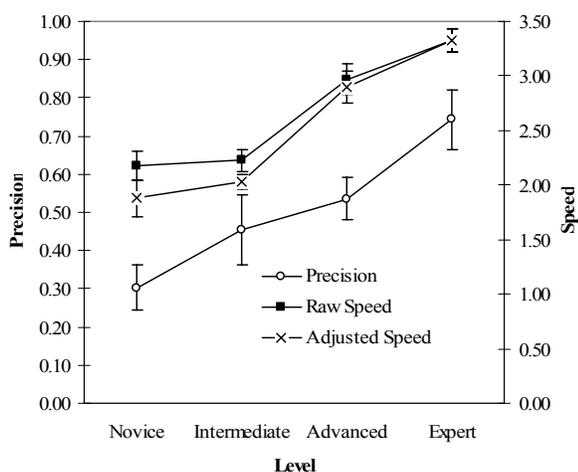


Figure 1: The means of the three performance measures for the four competitive levels (error bars are standard errors). Speed is measured in yd/sec.

Fault Types

The precision scores for the four fault types were further analyzed with ANOVAs, in order to investigate differences between the four competitive levels. There was a significant main effect for competitive level in R faults, $F(3,36) = 5.5, p < .01, \eta^2 = .32$, W faults, $F(3,36) = 3.9, p < .05, \eta^2 = .25$, and O faults, $F(3,36) = 4.0, p < .05, \eta^2 = .25$. For T faults, competitive level was not statistically significant, $p > .05$. The precision scores for the four fault types for each level can be seen in Figure 2.

Tukey post-hoc analyses were performed. In the case of R faults, there was a significant difference between experts and novices-intermediates ($p < .05$). In the case of W faults, there was a significant difference between expert-advanced dogs and novices. In the case of O faults, there was only a significant difference between experts and novices.

Discussion

As was predicted, dogs of different competitive levels significantly differed in objective measures of their performance. There was a steady improvement in

performance across competitive levels with novices being the slowest, both in raw and adjusted measures, and the least precise. Experts were both the fastest and the most precise. The precision measure, moreover, significantly correlated with both measures of speed. The experts are apparently not making tradeoffs of speed for precision performance or vice-versa; they are showing reliably overall better performance.

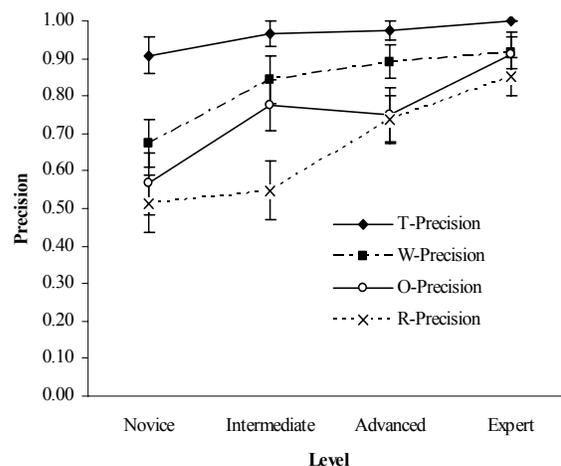


Figure 2: The means precision values for fault types (error bars are standard errors).

When examined in more detail, in particular the types of faults or errors made, there were noticeable differences between experts and others, in particular novices. The actual faults made may be diagnostic of underlying skill differences between dogs of differing levels of ability. The exact underlying nature of the causes of these faults is open to speculation; however, they are objectively different in nature. R faults are made when the dog is not committing to an obstacle. These errors may indicate an underlying state of signal uncertainty. In the case of a refusal, the dog is second guessing the handler's signal, turning back to the handler for verification. In the case of a run-out, the dog most likely missed a handler signal. W faults, on the other hand, are indicative of decision mistakes, were the dog confuses object categories. The handler may, for example, indicate "tunnel" and the dog may misinterpret the signal as a "jump" or "climb" command. The dog is committed to the obstacle, engaging with it, but it is the wrong obstacle. T faults are impulsive errors, in which the dog moves from the table before being released. O failures are physical skill errors; the dog while engaging with the obstacle, fails to do so appropriately.

There were differences between these types of faults in frequency of occurrence. Overall, across levels, a table fault was the least-likely to be made. Undoubtedly, training dogs improves self-control. Dogs quickly master this, as there were no statistically significant differences in T-faults across the competitive levels. The most likely fault to be made, overall, was a R (refusal or runout) fault. The

differences between experts and novices ($M_{\text{difference}} = .34$) on the amount of R faults indicate that a major aspect of dog agility expertise is learning to accurately detect handler signals, to not miss them. Differences in W faults also implicate the need to correctly interpret handler signals.

The clear speed and O-fault differences between experts and novices indicates that along with the perceptual-cognitive skill learning, agility expertise entails substantive changes in motor control. The expert dogs are not only more careful when moving through and on obstacles (more O-precision), they are also moving more efficiently. An expert dog weaving through the weave-poles is noticeably different than a novice. Whereas the novice appears to be trotting around the poles, the expert appears to be bounding through them.

Agility is, perhaps, interesting for studies of expertise, because these perceptual-motor skills are occurring simultaneously. Studies in human movement control indicate that motor control is cognitively demanding and susceptible to dual-task interference by other cognitive tasks (Woollacott & Shumway-Cook, 2002). In essence, the agility dog is performing a dual-task, listening and looking for commands while simultaneously controlling movement. Perhaps, the dogs' motor control while engaging the obstacles over extensive practice becomes increasingly automatic and less cognitively demanding, allowing them to invest more cognitive resources in attending to and interpreting the handler's signals.

As can be seen in Figure 2, the gain in R-precision (signal detections) occurs much later in skill development than the gains in the other forms of precision. Perhaps, the relatively late onset of this ability indicates an underlying freeing up of attentional resources necessary for accurate signal detections. Although improvement in motor control continues throughout the levels, the majority of the gains in these abilities occur prior to attaining the expert designation. This may indicate that earlier in skill development motor control is attentionally demanding and then later becomes increasingly automated.

Agility may indeed prove useful as a dual task that reveals changes in attentional allocation during skill development. If this is the case, then agility may enable researchers to search for underlying biological factors related to the efficient allocation of attentional resources. The influence of genetics and practice on dual task performance would be open to future investigation because dogs' early life experiences and genetics can be controlled. This is not the case when studying humans.

In any case, the findings of the present study support Helton's (2004; 2005) proposal that dogs are viable models of human expertise. The findings of this study provide evidence that the expert-novice approach can be applied to trained dogs. A researcher could have proposed that expert agility dogs differ from novice dogs in basic obedience, or the ability to follow simple commands, but this is apparently not the case. Expert and novice dogs probably do not differ

in their ability to follow simple commands (obedience), but differ in more much more complex ways.

The implications of this study are not only important for the future study of human expertise, where dogs serve as research models, but also for the study of canine expertise itself. Trained dogs are employed in many settings. Whether herding sheep or searching for mines, these dogs have serious jobs, and yet there is little formal study of canine expertise acquisition. Dogs are used widely, for example, to detect explosives (Fjellanger, Andersen, & McLean, 2000; Furton & Myers, 2001). More specific to the present study, K-9 law-enforcement dogs are actually trained in agility, in a manner very similar to the dogs in this study. The K-9s need to navigate quickly through all types of obstacles, while they simultaneously process the verbal and gestural commands from their human partners.

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