

Practice with anxiety improves performance, but only when anxious: evidence for the specificity of practice hypothesis

Lawrence, G.P.; Cassell, V.E.; Beattie, S.J.; Woodman, Tim; Khan, M.A.; Hardy, L.J.; Gottwald, V.M.

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1 2 3	Running Head: LEARNING	G WITH ANXIETY
4 5 6	Practice with anxiety imp	roves performance, but only when anxious: Evidence for the specificity of practice hypothesis
7		
8		Gavin P. Lawrence ¹
9		Victoria E. Cassell ¹
10		Stuart Beattie ¹
11		Tim Woodman ¹
12		Michael A. Khan ²
13		Lew Hardy ¹
14		Vicky M. Gottwald ¹
15		
16	1. Institute for the Psychology	ogy of Elite Performance
17	School of Sport, Health and	Exercise Sciences, Bangor University
18	2. Department of Kinesiolo	ogy, Faculty of Human Kinetics, University of Windsor
19	Date of resubmission: 08.10	0.13
20 21 22 23 24 25 26 27 28 29 30 31 32 33	Correspondence address:	Dr Gavin Lawrence School of Sport, Health & Exercise Sciences Institute for the Psychology of Elite Performance Bangor University George Building Holyhead Rd Bangor Gwynedd LL57 2PX Email: <u>g.p.lawrence@bangor.ac.uk</u> Tel: +44 (0)1248 388283 Fax: +44 (0)1248 371053

1	Abstract
$\frac{2}{3}$	We investigated for the first time whether the principles of specificity could be
4	extended to the psychological construct of anxiety and whether any benefits of practicing
5	with anxiety are dependent on the amount of exposure and timing of that exposure in
6	relation to where in learning the exposure occurs. In Experiment 1, novices practiced a
7	discrete golf-putting task in one of four groups: all practice trials under anxiety (anxiety),
8	non-anxiety (control), or a combination of these two (i.e., the first half of practice under
9	anxiety before changing to non-anxiety conditions, anxiety-control, or the reverse of this,
10	control-anxiety). Following acquisition, all groups were transferred to an anxiety
11	condition. Results revealed a significant acquisition-to-transfer decrement in
12	performance between acquisition and transfer for the control group only. In Experiment
13	2, novices practiced a complex rock climbing task in one of the four groups detailed
14	above, before being transferred to both a high anxiety condition and a low anxiety
15	condition (the ordering of these was counterbalanced across participants). Performance
16	in anxiety transfer was greater following practice with anxiety compared to practice
17	without anxiety. However, these benefits were influenced by the timing of anxiety
18	exposure since performance was greatest when exposure to anxiety occurred in the latter
19	half of acquisition. In the low anxiety transfer test, performance was lowest for those
20	who had practiced with anxiety only, thus providing support for the specificity of practice
21	hypothesis. Results demonstrate that the specificity of learning principle can be extended
22	to include the psychological construct of anxiety. Furthermore, the specificity advantage
23	appears dependent on its timing in the learning process.
24	Keywords: Learning, Training, Choking, Sport

Practice with anxiety improves performance, but only when anxious: Evidence for the
 specificity of practice hypothesis

3 The failure to perform to one's normal ability as a result of state anxiety occurs 4 regularly in numerous perceptual and psychomotor domains. In attempts to explain this 5 phenomenon, two somewhat competing theoretical positions have emerged in the 6 literature: one that is based on distraction; and one that is based on self-focus. Distraction 7 theorists (e.g., Wine, 1971) propose that pressure causes an individual's attention to be 8 partially consumed by task-irrelevant stimuli (e.g., worry) that consume resources of the 9 working memory system, thus leading to decrements in performance (see also Baddeley, 10 1986; Eysenck, Derakshan, Santos, & Calvo, 2007). Self-focus theorists (e.g., 11 Baumeister, 1984) propose that pressure raises self-consciousness/awareness thus 12 increasing the attention that is allocated to the skill. However, the net result of this 13 increase in self-awareness is a breakdown of normal automatic processes and skilled 14 performance. While both distraction and self-focus theories have received empirical 15 support (e.g., Beilock & Carr, 2001; Hardy, Mullen, & Jones, 1996; Hardy, Mullen, & Martin, 2001; Mullen, Hardy, & Tattersall, 2005; Pijpers, Oudejans, & Bakker, 2005), 16 17 surprisingly little research attention has been paid to understanding how practicing with 18 anxiety could minimize the likelihood of performance breaking down under anxiety. 19 Henry (1968) proposed that the best learning experiences are those that most 20 closely approximate the movements of the target skill and the environmental conditions 21 of the target context (i.e., specificity of practice). In support of this, research has shown 22 specificity effects for both the source of sensory information available during practice 23 and the emotional state of the learner during practice. For example, when participants

1	practice under specific sensory conditions during acquisition, a change in these
2	conditions during transfer causes a significant decrement in performance both early and
3	late in practice, with the effect often being greater the more experience one has gained
4	under specific practice conditions_(Proteau & Cournoyer, 1990; Proteau & Marteniuk,
5	1993; Proteau, Marteniuk, Girouard, & Dugas, 1987; Tremblay & Proteau, 1998, 2001).
6	It has been proposed that participants develop a movement plan to optimize the sensory
7	information present during acquisition and that this movement plan is specific to the
8	information that is available during practice (Elliott, Chua, Pollock, & Lyons, 1995; Khan
9	& Franks, 2000; Khan, Franks, & Goodman, 1998; Mackrous & Proteau, 2007). Hence,
10	if the practice conditions are changed, the movement plan previously developed is no
11	longer appropriate for successful performance.
12	Similarly, research has shown that learning is enhanced when there is high
13	congruity between a learner's mood state during acquisition and subsequent recall. The
14	rationale here stems from Gilligan and Bower's (1983) network theory of affect, which
15	states that emotions can be regarded as units within a semantic network that connects
16	related events, ideas, and muscular patterns. The activation of a unit results in a
17	spreading of this activation through the network to related units. As such, associations
18	are formed between units relating to the skill to be learned (i.e., a particular muscular
19	pattern) and the unit activated due to the learner's mood state. When the learner is
20	required to recall what was learned, the mood state at that time leads to the activation of
21	the appropriate emotion unit and subsequently to those units associated with it. If there is
22	a match between mood at learning and mood at the time of recall, then the activation of
23	the units of what is to be remembered is increased and recall is enhanced (Bower,

Monteiro, & Gilligan, 1978; Schare, Lisman, & Spear, 1984). Thus, recall performance
 is greatest when the mood at the time of recall matches the mood that was present at the
 time of learning.

4 Although anxiety has been shown to adversely affect performance (e.g., Craft, 5 Magyar, Becker, & Feltz, 2003; Woodman & Hardy, 2003) no previous research has 6 explicitly investigated anxiety effects under a specificity of learning framework. To date, 7 the focus has been directed towards investigating the skill acquisition conditions under 8 which anxiety may subsequently have less of an adverse effect on performance. Studies 9 that have sought to investigate this process have primarily chosen to manipulate the 10 learning environment such that the learners' knowledge associated with movement 11 production of the skill is either developed implicitly (i.e., unconsciously) or explicitly 12 (i.e., consciously; Hardy, Mullen, & Jones, 1996; Masters, 1992). Using this paradigm, 13 researchers have shown that tasks are more likely to break down under anxiety if 14 performers have accumulated accessible and conscious task-relevant knowledge used to 15 control movement (Masters & Maxwell, 2008). Specifically, Masters (1992) proposed 16 that if explicit learning can be minimized (i.e. knowledge of learning is reduced) then the 17 typically observed breakdown of automatic processes under pressure is less likely to 18 occur in future pressure situations, as the performer has no access to explicit knowledge. 19 The notion that proceduralized motor skills (acquired *with* explicit knowledge) are 20 more likely than non proceduralized motor skills to break down under conditions of 21 anxiety was further investigated by Beilock and Carr (2001). After practicing a golf 22 putting task under one of three conditions (control; self-consciousness; dual-task) 23 participants were required to perform the task under a high pressure situation both early

1	and late in practice. When pressure was introduced early, performance was improved in
2	all training conditions. Since novices are assumed to be concerned with the step-by-step
3	procedures of skill performance (Fitts & Posner, 1967), it was suggested that the increase
4	in attention to movement control (as a result of the increased pressure) served to enhance
5	performance. Conversely, in the latter stages of learning, the presence of pressure
6	resulted in a performance decrement, thus supporting the notion that proceduralized
7	motor skills break down under pressure. Interestingly however, this performance
8	decrement was only observed in the control and dual task conditions. Those individuals
9	in the self-consciousness condition were unaffected by the presence of pressure. As such,
10	the results demonstrated an alternative skill acquisition technique to that of adopting
11	implicit learning strategies in order to reduce the negative performance effects of anxiety.
12	That is, it appears training under conditions of self-consciousness can lead to a reduction
13	in the performance decrements typically experienced under anxiety.
14	More recently, Oudejans and colleagues have shown that following training under
15	conditions of mild anxiety, performance on hand gun shooting (Oudejans, 2008),
16	basketball free throws (Oudejans & Pijpers, 2009) and dart throwing (Oudejans &
17	Pijpers, 2010) did not deteriorate in subsequent anxiety-inducing conditions. Whilst
18	these experiments demonstrate that performers can more effectively acclimatize to
19	anxiety following practice under anxiety, the methodologies were designed such that
20	participants in the anxiety training conditions completed all training under conditions of
21	anxiety. Thus, it is not clear whether the positive effects of training with anxiety are due
22	to specificity effects i.e., whether the performance in the anxiety post test increases as a
23	function of the amount of practice experienced when anxious. Furthermore, by asking

1	participants to complete all their practice under conditions of anxiety, Oudejans and
2	colleagues were unable to investigate if it is important to consider where during the
3	learning process anxiety should be introduced in order to achieve the most efficacious
4	training effects. Thus, in the present investigation we were interested in whether the
5	positive effects of practicing with anxiety shown by Oudejans and colleagues (Oudejans,
6	2008; Oudejans & Pijpers, 2009; 2010) adhere to the principles of specificity i.e., whether
7	they are dependent on the amount of exposure to anxiety and the timing of that exposure
8	in relation to where in learning the exposure occurs.
9	To achieve this, participants practiced a golf putting task under anxiety
10	throughout practice, anxiety either in the early or late stages of acquisition, or without
11	anxiety (i.e., control condition). Following acquisition, all participants were transferred
12	to an anxiety condition. The anxiety condition during acquisition should result in greater
13	congruity between the conditions at learning and the conditions of the anxiety transfer
14	test. Thus, it was hypothesized that this increased congruity (i.e., greater specificity of
15	learning) would result in performance benefits under subsequent anxiety conditions.
16	Also, if the protective effect of practicing with anxiety is dependent on the amount of
17	exposure to anxiety during acquisition, one would expect the participants in the anxiety
18	throughout acquisition condition to show greater performance robustness under the
19	anxiety transfer test compared to when anxiety is induced only in the early or late stage of
20	acquisition.

As well as investigating the exposure effects of practicing with anxiety, we were interested in whether the timing of exposure to anxiety during learning influences the efficacy of practicing with anxiety. To achieve this we investigated performance

1	differences between the groups that experienced only half of acquisition with anxiety
2	(i.e., during either the first half of or the second half of learning) to see whether the
3	benefits of exposure to anxiety during acquisition are greater if participants begin
4	practicing under conditions of anxiety from the start of learning or only once they have
5	achieved a certain level of proficiency at the task (without anxiety). It was expected that
6	the benefits of practicing with anxiety would be greater for those participants who were
7	exposed to anxiety from the start of learning. This is due to one or a combination of two
8	possibilities (1) performers' developing a strong and robust semantic network that
9	connects the mood state, ideas, and muscular patterns associated with the golf putt early
10	in the learning process (2) participants develop a representation of the skill that is adapted
11	to the conditions from the start of learning (i.e., anxiety). As such, the earlier in the
12	learning process that the mood is associated with the task, the more robust the
13	performance will be in relation to that mood.
14	Method
15	Participants
16	Thirty-two right-handed university students participated in the experiment (12
17	women, 20 men; mean age = 20.2 ± 1.6 yrs, age range = $18-26$ yrs). All participants
18	were novice golfers, naïve to the hypothesis being tested and provided written informed
19	consent before taking part in the study. The experiment was carried out according to
20	institutional ethical guidelines for research involving human participants.
21	Apparatus
22	Golf putts were performed on an Astroturf surface using a standard KT25
23	Prosimmon putter and a standard Slazenger Raw Distance 432 dimple pattern golf ball.

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1	The start position was a 3 cm diameter circle located on the center line of the putting
2	surface 40 cm from the rear edge (see Figure 1). The target hole (10 cm diameter) was
3	located 225 cm (centre to centre) from, and directly in line with, the start position. To
4	increase task complexity, the putting surface included a 90cm incline slope of 22 degrees
5	that started 72 cm from the start position. The surface was then flat for the remaining
6	distance to the target hole (65cm). Final ball position was recorded using a Casio Digital
7	Camera (QV-2900UXCF) which was mounted to the ceiling 295cm directly above the
8	target hole. Digital images were relayed directly to a Compusys 3.00GHz computer for
9	analysis.
9 10	analysis. Anxiety Questionnaire
9 10 11	analysis. <i>Anxiety Questionnaire</i> Cognitive anxiety was assessed via the Mental Readiness Form-3 (MRF-3; Krane,
9 10 11 12	analysis. <i>Anxiety Questionnaire</i> Cognitive anxiety was assessed via the Mental Readiness Form-3 (MRF-3; Krane, 1994). The MRF-3 comprises three single-item factors that are each scored on an 11-
9 10 11 12 13	analysis. <i>Anxiety Questionnaire</i> Cognitive anxiety was assessed via the Mental Readiness Form-3 (MRF-3; Krane, 1994). The MRF-3 comprises three single-item factors that are each scored on an 11- point Likert scale: cognitive anxiety from 1 (<i>not worried</i>) to 11 (<i>worried</i>); somatic
9 10 11 12 13 14	 analysis. Anxiety Questionnaire Cognitive anxiety was assessed via the Mental Readiness Form-3 (MRF-3; Krane, 1994). The MRF-3 comprises three single-item factors that are each scored on an 11-point Likert scale: cognitive anxiety from 1 (<i>not worried</i>) to 11 (<i>worried</i>); somatic anxiety from 1 (<i>not tense</i>) to 11 (<i>tense</i>); and self-confidence from 1 (<i>confident</i>) to 11 (<i>not</i>
 9 10 11 12 13 14 15 	analysis. Anxiety Questionnaire Cognitive anxiety was assessed via the Mental Readiness Form-3 (MRF-3; Krane, 1994). The MRF-3 comprises three single-item factors that are each scored on an 11- point Likert scale: cognitive anxiety from 1 (<i>not worried</i>) to 11 (<i>worried</i>); somatic anxiety from 1 (<i>not tense</i>) to 11 (<i>tense</i>); and self-confidence from 1 (<i>confident</i>) to 11 (<i>not</i> <i>confident</i>). For the purpose of the present study only the cognitive anxiety factor was

17 Task and Procedure

18 At the start of testing, participants were informed that the purpose of the 19 investigation was to examine the accuracy of golf putting over a period of practice trials. 20 It was explained that the goal of the task was to putt the ball as accurately as possible and that putting performance would be assessed by the number of successful putts and the 21 22 distance from the hole on unsuccessful putts. In all conditions participants completed a total of 300¹ acquisition putts consisting of six blocks of 50 putts each. Following each 23

1 block, participants were given a short break (approximately 5 minutes) in order to 2 minimize potential fatigue effects. Each participant was randomly assigned to one of 3 four acquisition conditions: (1) in the *control group* participants completed all 300 4 acquisition putts under normal (low anxiety) conditions; (2) in the anxiety group 5 participants were informed that each put was being recorded for later analysis by a 6 professional golfer. They were also informed, before the start of putting, that they had 7 been awarded ± 30 and that ten pence (± 0.10) would be removed from this total for each unsuccessful putt²; (3) in the *anxiety-control group*, participants performed the first 150 8 9 trials under conditions of anxiety identical to those described above except that total prize money was reduced from £30 to £15.³ Following the putts under anxiety, participants 10 11 then completed a final 150 putts under normal (low anxiety) conditions identical to that 12 of the control group; (4) in the *control-anxiety group*, participants followed the same 13 procedure to that of the anxiety-control group with the exception that the order of the 14 anxiety and the control putting conditions was reversed.

15 Immediately following acquisition, all participants were given a 15-minute break 16 after which they completed a transfer test that consisted of 25 putts under conditions of 17 anxiety. Specifically, participants were informed of their mean putting performance from 18 the final 25 trials of their acquisition and told that they would be eligible to win $\pounds 30$ if 19 they improved their performance by 15% over the next 25 putts. However, it was also 20 made clear to participants that in order for them to secure the £30, their percentage of 21 improvement would need to be the highest of all individuals partaking in the experiment. 22 In order to ensure that anxiety had been successfully manipulated, all participants 23 completed the MRF-3 on three separate occasions: immediately before the start of

1	acquisition; at the start of the 4 th block (i.e., following the removal or the addition of
2	anxiety in the anxiety-control and control-anxiety conditions, respectively); and at the
3	start of transfer (i.e., before the competition block of 25 putts).
4	Performance and analyses
5	Putting performance was measured via number of successful putts (NSP) and
6	mean radial error (MRE). MRE was the absolute distance from the ball to the center of
7	the hole (cf. Mullen, Hardy, & Tattersall, 2005).
8	Analyses
9	The effectiveness of the anxiety interventions, as measured by the MRF-3, was
10	assessed by a 4 (group: control; anxiety; anxiety-control; control-anxiety) \times 3 (time: pre
11	[immediately before acquisition]; mid [immediately prior to block 4]; and transfer
12	[immediately prior to transfer]) ANOVA with repeated measures on the second factor.
13	Performance data (NSP and MRE) were analyzed during the acquisition phase using
14	separate 4 Groups (control; anxiety; anxiety-control; control-anxiety) × 6 Blocks (1-6)
15	ANOVAs with repeated measures on the second factor. In order to assess the effect of
16	anxiety on performance in the transfer test, both NSP and MRE were further submitted to
17	separate 4 Group (control; anxiety; anxiety-control; control-anxiety) \times 2 Experimental
18	Phase (acquisition; transfer) ANOVAs with repeated measures on the second factor. The
19	last 25 putts of the acquisition phase and the 25 transfer putts were used in this analysis.
20	To investigate the effects of introducing anxiety at different stages of learning we
21	compared the change in performance of the control-anxiety group at the midpoint of
22	acquisition (i.e., the last 25 trials of the final block of control conditions to the first 25
23	trials following the introduction of anxiety) to the change in performance of the control

1	group between the last 25 trials of acquisition and the 25 trials of the anxiety transfer test
2	using an independent <i>t</i> -test. The rationale here is that the change from control conditions
3	to anxiety conditions occurred half way through learning (early transfer) in the control-
4	anxiety group whereas the control group were not transferred to the anxiety condition
5	until the end of acquisition (late transfer). Thus, greater performance decrements in late
6	transfer compared to the early transfer would demonstrate specificity of practice.
7	All significant effects were broken down using Tukey's HSD post hoc procedures
8	(<i>p</i> < .05)
9	Results
10	Anxiety
11	The anxiety data are shown in Table 1. The ANOVA revealed a significant main
12	effect of group (F _{3, 28} = 11.66, $p < .001$, $\eta^2 = .55$) and time (F _{2, 56} = 45.68, $p < .001$, $\eta^2 =$
13	.62). Of more central interest, there was a significant group \times time interaction (<i>F</i> _{6,56} =
14	19.53, $p < .001$, $\eta^2 = .67$). Breakdown of this interaction revealed that the anxiety
15	manipulation was successful within the acquisition and transfer phases where targeted
16	and that the anxiety levels reported within the acquisition and transfer anxiety phase
17	manipulations were not significantly different from one another.
18	Number of successful putts
19	Acquisition. Means and SDs are reported in Table 2. The analysis revealed no
20	significant main effect for group ($F_{3, 28} = .21, p = .89, \eta^2 = .02$) or block ($F_{5, 140} = 1.46, p$
21	= .21, η^2 = .05) and no significant interaction between the two factors (<i>F</i> _{15, 140} = 1.46, <i>p</i> =
22	$.13, \eta^2 = .14).$

1 Acquisition versus Transfer. Similar to the acquisition analysis, no significant main effects or interactions were observed (group main effect F $_{3,28} = 1.86$, p = .16, $\eta^2 =$ 2 .16; experimental phase main effect $F_{1,28} = .19$, p = .66, $\eta^2 = .01$; group × experimental 3 phase interaction F _{3,28} = 1.20, p = .33, $\eta^2 = .11$). 4 5 Mean radial error 6 Acquisition. Means and SDs are reported in Table 2. The ANOVA revealed a 7 significant main effect for block ($F_{5, 140} = 9.54$, p < .001, $\eta^2 = .25$) (See Figure 2). 8 Specifically, all participants significantly improved putting accuracy over each block of 9 trials for the first 150 putts (block 1 (mean = 473.65mm); block 2 (mean = 444.01); block 10 3 (mean = 410.41mm) after which putting accuracy reached asymptote since blocks 4 11 (mean = 398.48), 5 (mean = 376.96), and 6 (mean = 358.38) were not significantly 12 different to one another. Thus, similar to previous research (e.g., Beilock & Carr, 2001; 13 Hardy et al., 1996; Masters, 1992), performance asymptote occurred after approximately 200 practice trials. No group main effect or interaction was revealed ($F_{3,28} = 0.58$, p =14 .63, $\eta^2 = .06$ and $F_{15, 140} = 1.38$, p = .17, $\eta^2 = .13$, respectively). 15 Acquisition versus transfer. As shown in Figure 2, the MRE transfer ANOVA 16 revealed a significant group × experimental phase interaction (F 3, 28 = 3.23, p < .05, $\eta^2 =$ 17 18 .26). Breakdown revealed that the control group showed a significant decrement in 19 performance from acquisition to transfer whilst the anxiety group showed a significant 20 improvement. The performance of the other two groups did not significantly change 21 from acquisition to transfer. Finally, performance at transfer was significantly worse for

22 the control condition compared to the other three conditions.

1	Introducing anxiety early and late in practice. Comparison of the changes in
2	performance from inducing anxiety half-way through acquisition (i.e., control-anxiety
3	group) and at the end of acquisition (i.e., control group) revealed that the decrement in
4	performance was greater in the late transfer (MRE = -108.96) compared to the early
5	transfer (MRE = -54.89) (t_{14} = -2.84 p = .089) but only at the .1 alpha level.
6	Discussion
7	The objective of the current investigation was to examine whether the principles
8	of specificity (Gilligan & Bower, 1983; Henry, 1968, Proteau, 1992) could be extended to
9	the psychological construct of anxiety. Whilst specificity effects have previously been
10	shown to be robust when examining sensory information (Proteau & Cournoyer, 1990;
11	Proteau & Marteniuk, 1993; Proteau et al., 1987; Tremblay & Proteau, 1998, 2001) the
12	hypothesis has not previous been explored in the anxiety and stress and performance
13	literature. As such, we investigated whether acquiring a motor skill under conditions of
14	anxiety removed the performance decrement typically observed in skilled movement
15	production when anxiety is present (i.e., choking). We also tested whether any positive
16	effects of practicing with anxiety on subsequent anxious performances are dependent on
17	the amount of exposure to anxiety during acquisition and the timing of that exposure.
18	The results demonstrated that learning under conditions of anxiety led to more robust
19	performance under future conditions of anxiety and that learning without exposure to
20	anxiety leaves one particularly vulnerable to its effects in subsequent performances ⁴ .
21	Hence, consistent with studies that have shown that learning is specific to sensory
22	conditions (Elliott et al., 1995; Khan & Franks, 2000; Khan et al., 1998; Mackrous &
23	Proteau, 2007) and mood state (Bower et al., 1978; Gillian & Bower, 1983; Schare et al.,

1984) during acquisition, the present results indicate that specificity of learning extends
 to the psychological construct of anxiety.

3 Interestingly, and somewhat surprising, was the finding that missed putts actually 4 finished closer to the hole in transfer compared to acquisition in the anxiety group. Whilst 5 this may be an artifact of variability within the data set, another possible explanation for 6 this increase in performance is that the time period, although relatively short, between 7 acquisition and transfer allowed for some learning consolidation in the anxiety group and 8 that the continued exposure to anxiety during acquisition increased post-acquisition stress-9 hormone which lead to an increase in learning (also see Cahill, Gorski, & Le, 2003). 10 While one might also expect an increase in performance in the mixed practice groups 11 following the period of consolidation, it is possible that these groups had less increases in 12 stress-hormone compared to the anxiety only group because of the reduced exposure to 13 anxiety period during practice. Future research may wish to investigate this possibility 14 further.

15 Further support that learning is specific to the amount of exposure to anxiety during acquisition was revealed from the comparison between the change in performance 16 of the control-anxiety group when anxiety was induced at the midpoint of acquisition and 17 18 the change in performance of the control group between the end of acquisition to the 19 anxiety transfer test. Here performance decrements were greater in late transfer 20 compared to early transfer suggesting that the more participants practiced in non-anxious 21 conditions the more they were dependent on the presence of those conditions for 22 successful performance. This finding is consistent with observations from studies on 23 manual aiming in which removing visual feedback was more detrimental late in learning

1	compared to early in practice (Proteau et al., 1987; Khan et al., 1998) suggesting that the
2	specificity effect could also be extended to the psychological construct of anxiety.
3	While the results of the present study demonstrated evidence for specificity of
4	learning, there were no performance differences between the anxiety-control and control-
5	anxiety groups at the final transfer phase. A possible explanation for this could be due to
6	the complexity of the to-be-learned task. That is, a golf putt can be described as a simple
7	discrete skill that is closed in nature (i.e., the task involves relatively few movements, has
8	a very obvious beginning and end and is not subject to external factors such as time
9	constraints; Schmidt & Lee, 2008). Thus, although anxiety from the start of acquisition
10	negatively affected performance, possibly due to consuming resources of working
11	memory (Eysenck et al., 2007), this was not sufficient to reduce learning. Perhaps
12	introducing anxiety from the start of practice in a more complex and open skill would
13	disrupt the acquisition process to such a degree as to increase learning time and reduce
14	the benefits of training with anxiety from the start of practice as seen in the present
15	investigation. This possibility was investigated in Experiment 2.
16	Experiment 2
17	The purpose of Experiment 2 was twofold: (1) to investigate when learning with
18	anxiety is most appropriate for a complex task; (2) to further investigate whether the
19	principles of specificity (Gilligan & Bower, 1983; Henry, 1968, Proteau, 1992) should be
20	extended to the psychological construct of anxiety. The results of Experiment 1 revealed
21	no performance differences in the anxiety transfer test between participants who practiced
22	either with anxiety from the start or from the midpoint of acquisition; only the control

was a result of the low complexity of the to-be-learned skill, Experiment 2 investigated
whether similar findings would be observed when the to-be-learned skill was of a more
complex nature.

4 The design and procedure of Experiment 2 were largely similar to those of 5 Experiment 1. However, two major methodological changes were made. First, in order 6 to investigate whether the movement developed when practicing with anxiety is specific 7 to those conditions we introduced a second (low anxiety) transfer test. If specificity of 8 learning extends to practicing with anxiety, one would expect a decrement in 9 performance for participants who practice with anxiety when they are transferred to a non 10 anxious condition (i.e., they experience a change in the environmental context or mood 11 under which the task was learned). Second, a more complex whole body climbing task 12 (involving the control of multiple movement components that were subject to a time 13 pressure constraint) was adopted to investigate whether performance is influenced by the 14 timing of anxiety induction during acquisition. 15 Method

16 Participants

17Thirty-two novice climbers participated in Experiment 2 (4 women, 28 men;18mean age = 26.35, SD \pm 2.22 yrs, age range = 18-49 yrs). All participants reported no19prior climbing experience, were naïve to the hypothesis being tested and gave their20informed consent prior to taking part in the study. The experiment was carried out21according to the institutional ethical guidelines for research involving human participants.22Apparatus

1	Climbing moves were performed wearing well-fitted standard rock shoes (Scarpa
2	Vantage) on an indoor climbing wall, the floor of which was covered by a standard safety
3	crash mat. The wall itself contained a 5.5 m long low-level traverse (a horizontal
4	sequence of climbing movements where the mean hold height was 1.23 m from the floor,
5	SD \pm .46m) with a UK technical difficulty of 4a (easy) ⁵ . The height of the traverse meant
6	that participants could simply step on and off the climb with ease at any point without
7	safety risk. Consequently, the safety equipment typically associated with vertical
8	climbing was not required. The 4a easy difficulty of the traverse was determined by three
9	independent expert climbers who each held an up-to-date Mountain Instructor Award and
10	had more than 10 years of climbing experience (37 years combined experience).
11	Cognitive anxiety was measured using the MRF-3 and task effort was measured using a
12	retrospective 1 (no effort) to 10 (maximal effort) Likert scale (see Mullen et al., 2005).
13	All climbs were recorded on a Sony Digital Video Camera Recorder (DCR-DVD106)
14	positioned at a height of 1.2 m, in line with the middle of the traverse and at distance
15	from the climbing wall such that the entire 5.5 m traverse was clearly visible.
16	Task and Procedure

At the start of testing, participants were informed that the purpose of the investigation was to examine the speed and accuracy of climbing over a period of practice trials. It was explained that the goal of the task was to climb as quickly and as fluently as possible. In all conditions participants completed a total of 100 acquisition climbs consisting of ten blocks of 10 trials split equally over two days. A 1-minute break was given between trials and participants were afforded a 10-minute break between blocks within which they were required to perform forearm recovery stretching exercises.

1 Participants were instructed to perform each stretch three times and to hold the stretch for 2 a total of 20 seconds. Similar to Experiment 1, each participant was randomly assigned to one of four acquisition conditions (each containing an equal number of males and 3 females): (1) In the control group all acquisition trials were performed under normal (low 4 5 anxiety) conditions; (2) in the anxiety group participants were informed that they were 6 being videoed and that recordings would be watched and evaluated by an elite 7 professional climber. They were also informed that the evaluations of their performance 8 and the other participants would be displayed on a poster in text format for all other 9 participants to view and that the best performer would be rewarded with the choice of one 10 of four outdoor activity sessions (e.g., a day's climbing with a qualified mountain guide 11 for two); (3) in the anxiety-control group the first half of acquisition was performed under 12 conditions identical to that of the anxiety group and the remaining half were conducted 13 under conditions that matched those of the control group (low anxiety); (4) in the control-14 anxiety group, participants followed the same procedure to that of the anxiety-control 15 group with the exception that the order of the anxiety and the control conditions was 16 reversed.

Immediately following acquisition, all participants were given a 1-hour break after which they completed two transfer tests that consisted of 10 climbs each. Anxiety transfer was performed under anxiety conditions and low anxiety transfer was performed under normal conditions (the order of the transfer tests was counterbalanced across participants). To manipulate anxiety, participants were informed of their mean climbing performance from the last 10 trials of acquisition and told that if they improved their performance by 15% over the next 10 trials they would be eligible to win a choice of

outdoor activity sessions (these were identical to those available during the acquisition
 phase). However, it was also made clear to participants that in order for them to secure
 the prize, their percentage of improvement would need to be the highest of all individuals
 partaking in the experiment.

In order to ensure that anxiety had been successfully manipulated all participants completed the MRF-3 on four separate occasions: immediately before the start of acquisition; at the start of the 6th block (i.e., following the removal or the addition of anxiety in the anxiety-control and control-anxiety conditions, respectively); and at the start of both transfer tests. To measure effort, participants completed the self report effort scale following block 5 and block 10 of acquisition and at the end of both anxiety transfer and low anxiety transfer.

12 Performance and analyses

13 Similar to Pippers et al. (2005), for each trial, the time of traverse (TOT), number 14 of performed movements (NOPM), number of explored movements (NOEM) and number 15 of ventured movements (NOVM) were determined from the DVD recordings⁶. TOT was 16 calculated as the time interval between the release of the first hold until the grasp of the 17 final hold on the traverse. NOPM was defined as the number of moves made during the 18 climb; a move was classified as the releasing of a hold and making contact with another 19 hold that was used for support. NOEM was defined as the number of times a hold was 20 touched without that hold being subsequently used as support. NOVM was calculated as 21 the number of times a hold was released and then the limb was returned to the same hold. 22 In order to accurately determine each dependent variable, the DVD recordings of 23 each trial were rated simultaneously by two assessors. Both assessors were blind to the

experimental hypotheses, competent with the calculation of all measures, and had access
 to this information during their assessments⁷.

3 Analysis

4 MRF-3 data were assessed separately by a 4 (group: anxiety; control; anxiety-control; 5 control-anxiety) \times 4 (time: pre [immediately prior to acquisition]; mid [immediately prior 6 to acquisition block 6]; anxiety transfer [immediately prior to anxiety transfer]; and low 7 anxiety transfer [immediately prior to low anxiety transfer]) ANOVA with repeated 8 measures on the second factor. Effort data were submitted to a similar 4 (group: anxiety; 9 control; anxiety-control; control-anxiety) $\times 4$ (time: mid [immediately following trial 50 10 of acquisition]; end [immediately following the final trial of acquisition]; anxiety transfer 11 [immediately following anxiety transfer]; and low anxiety transfer [immediately 12 following low anxiety transfer]) ANOVA with repeated measures on the second factor. 13 Performance data (TOT, NOPM, NOEM and NOVM) were analyzed during the 14 acquisition phase using separate 4 (group: anxiety; control; anxiety-control; control-15 anxiety) $\times 2$ (day: day 1, day 2) $\times 5$ (block: blocks 1-5) ANOVAs with repeated measures 16 on the last two factors. In order to assess the effect of the transfer tests (anxiety and 17 normal conditions) on performance, TOT, NOPM, NOEM and NOVM were further 18 submitted to separate 4 (group: anxiety; control; anxiety-control; control-anxiety) $\times 3$ 19 (experimental phase: acquisition; anxiety transfer; low anxiety transfer) ANOVAs with 20 repeated measures on the second factor. The final 10 trials of the acquisition phase (i.e., 21 the last block of day 2) and the 10 trials in both transfers were used in these analyses. 22 Similar to Experiment 1, to investigate the effects of introducing anxiety at different 23 stages of the learning process we conducted an independent t-test on the change in TOT

1	from block 1 to 5 for the control-anxiety group and block 10 to anxiety transfer for the
2	control group.
3	All significant effects were broken down using Tukey's HSD post hoc procedures (p
4	< .05).
5	Results
6	Anxiety
7	Means and SDs are reported in Table 3. The ANOVA revealed a significant main
8	effects of group (F 3, 28 = 117.92, $p < .001$, $\eta^2 = .99$) time (F 3, 84 = 331.74, $p < .001$, $\eta^2 =$
9	.92) together with a significant group × time interaction (<i>F</i> 9, 84 = 97.62, <i>p</i> < .001, η^2 =
10	.91). As in Experiment 1, breakdown of this interaction revealed that the anxiety
11	manipulation was successful in the acquisition and transfer phases where targeted and
12	that the anxiety levels experienced in both the acquisition and transfer phase anxiety
13	manipulations were not significantly different from one another.
14	Effort
15	Analysis of the effort data revealed no significance for either the main effects
16	(group: F 3, 28 = .88, $p = .46$, $\eta^2 = .09$; time: F 3, 84 = 2.12, $p = .095$, $\eta^2 = .07$) or the
17	interaction (<i>F</i> 9, 84 = .79, $p = .61$, $\eta^2 = .07$). Thus, effort was similar for all groups and did
18	not differ between anxiety and low anxiety situations (see Table 4).
19	Performance Variables
20	For reasons of brevity, statistical values for all performance dependent variables
21	have been omitted from the text and reported in Table 5.

22 Time of Traverse (TOT)

1	Acquisition. All means and SDs are reported in Table 6. As shown in Figure 3,
2	significant main effects for group, day and block were observed, in addition to significant
3	group × day, group × block, day × block, and group × day × block interactions. The
4	breakdown of the triple interaction indicated that whilst traverse times in all groups
5	significantly decreased over day 1 (blocks 1 to 5) this decrease was significantly greater
6	in the control and control-anxiety groups compared to both the anxiety and anxiety-
7	control groups. Furthermore, traverse times significantly increased from the end of day 1
8	(block 5) to the start of day 2 (block 6) for the anxiety, control and control-anxiety groups
9	with this increase being significantly greater in the control-anxiety group. In the anxiety-
10	control group however, time of traverse significantly decreased from block 5 to block 6.
11	Finally, whilst time of traverse significantly decreased over day 2 from block 6 to block
12	10 in all groups, this decrease was significantly greater in the control and anxiety-control
13	groups compared to the anxiety and control-anxiety groups.
14	Acquisition versus transfer. As shown in Figure 4, the analysis revealed a
15	significant main effect of group and experimental phase as well as a significant group \times
16	experimental phase interaction. Breakdown of this interaction revealed that the transfer
17	performance of the control and anxiety groups significantly decreased when the
18	conditions at transfer did not match those of acquisition. Specifically, the traverse times
19	of the control group were significantly greater in the high anxiety transfer test compared
20	to both acquisition and low anxiety transfer (acquisition and low anxiety transfer were not

21 significant different). Whereas, the time of traverse for the anxiety group remained

22 constant between acquisition and the anxiety transfer and significantly increased from

23 these levels in the low anxiety transfer test. Traverse times in the anxiety-control group

1	significantly increased between acquisition and anxiety transfer whereas those of the
2	control-anxiety group remained constant and significantly decreased between acquisition
3	and the low anxiety transfer test. Between group comparisons revealed that, time of
4	traverse at anxiety transfer was significantly lower in both the control-anxiety and
5	anxiety-control groups (mean = 32.00 and 33.25, respectively) compared to the remaining
6	groups (control mean = 39.00; anxiety mean = 34.75; the anxiety group was significantly
7	lower than the control group). Furthermore, the control-anxiety group had significantly
8	lower traverse times compared to both the anxiety and control group, whilst the control
9	group had significantly longer traverse times compared to all other groups. Finally,
10	traverse times in all groups were significantly different at low anxiety transfer.
11	Specifically, time of traverse was fastest in the control group (mean = 23.63) followed by
12	the control-anxiety (mean = 28.38), anxiety-control (mean = 33.25) and anxiety groups
13	(mean = 38.63).
14	Introducing anxiety early and late in practice. The results of the t-test between
15	the change in TOT from block 1 to 5 (early transfer) for the control-anxiety group and
16	block 10 to anxiety transfer (late transfer) for the control group revealed that the
17	decrement in performance was significantly greater in late transfer (TOT = -16.00)
18	compared to early transfer (TOT = -10.50) (t_{14} = -6.07 p = .001).
19	Number of performed movements (NOPM), number of explored movements (NOEM) and
20	number of ventured movements (NOVM)
21	Acquisition. Means and SDs are reported in Table 6. As shown in Table 5 and
22	Figure 5, the analyses of the NOPM, NOEM and NOVM all revealed significant main

23 effects for group, day, and block, as well as significant group \times day, group \times block, day \times

1 block, and group \times day \times block interactions. Breakdown of the interactions revealed that 2 number of movements significantly decreased during acquisition when trials were being 3 performed only under control conditions. Specifically, number of movements decreased 4 over day 1 (blocks 1-5) for the control-anxiety group, day 2 (blocks 6-10) for the anxiety-5 control group and over both days (from block 1 to block 10) for the control condition. 6 Acquisition versus transfer. The acquisition versus transfer data for the NOPM, 7 NOEM and NOVM are shown in Figure 6. The analyses of all variables (see Table 5) 8 revealed significant main effects for group and experimental phase as well as significant 9 group \times experimental phase interactions. These main effects and interactions showed the 10 same significant pattern of results to that of the time of traverse data. Thus, for reasons of 11 brevity the data have been summarized; the control group experienced only a significant 12 decrease in performance from acquisition to anxiety transfer; the anxiety group 13 experienced only a decrement in performance between acquisition and low anxiety 14 transfer; the control-anxiety maintained performance between acquisition and anxiety 15 transfer whereas performance was significantly greater in the low anxiety compared to both the anxiety transfer and acquisition phases; the anxiety-control group significantly 16 decreased performance from acquisition to anxiety transfer. 17 18 Discussion 19 The purposes of Experiment 2 were to further investigate the possibility that the 20 specificity of learning theoretical framework (Gilligan & Bower, 1983; Henry 1968, 21 Proteau, 1992) can explain the positive effects of practicing with anxiety and to examine 22 when in the learning process practicing with anxiety is most appropriate for a complex 23 task. Similar to Experiment 1, results showed that the manipulation of anxiety was

successful where targeted. In addition, task effort was similar for all groups and did not
 change as a result of the presence of anxiety.

3 Results of the performance data between acquisition and anxiety transfer for the 4 control and anxiety groups are consistent with findings from Experiment 1. That is, 5 practice under conditions of anxiety leads to more robust performance under future 6 conditions of anxiety compared to non anxiety practice conditions and learning without 7 exposure to anxiety leaves one particularly vulnerable to its effects in subsequent 8 performances. The results at the additional low anxiety transfer test revealed that 9 climbing times of the anxiety group significantly increased from acquisition to transfer 10 whereas there was no change between acquisition and transfer for the control group. 11 Thus, performance decreased in both the control group and anxiety group when the 12 transfer test resulted in a change in the conditions under which the skill had been 13 practiced. These findings support a specificity perspective since those participants who 14 practiced under conditions of anxiety likely created associations during acquisition 15 between the emotions of anxiety and the movements of the to-be-learned skill. As such, 16 they developed representations of the movement during acquisition that were adapted to 17 the presence of anxiety, whereas those participants in the control group developed 18 movement representations that were adapted to the absence of anxiety. These findings 19 are again consistent with evidence from manual aiming studies in which performance 20 decrements have been observed following both the withdrawal (Proteau et al., 1987; 21 Khan et al., 1998) and the addition of visual feedback (Proteau et al., 1992). Experiment 22 2 thus offers further direct evidence for the principles of specificity of practice in the 23 context of affect, namely anxiety.

1 Comparison between the anxiety-control and control-anxiety groups enabled us to 2 investigate when in the learning process practicing with anxiety is most appropriate. 3 Unsurprisingly, traverse times for these groups only significantly improved during the 4 low anxiety (control) acquisition conditions and the analysis of the performance data at 5 the midpoint of acquisition (i.e., the removal of anxiety and the introduction of anxiety 6 for the anxiety-control and control-anxiety groups, respectively) revealed that the 7 presence of anxiety negatively affected performance. Specifically, the control-anxiety 8 group significantly increased traverse times following the introduction of anxiety whereas 9 the opposite was true for the anxiety-control group. Of more interest, with regard to 10 investigating when in acquisition introducing anxiety is most appropriate, were the 11 between group differences in performance at anxiety transfer and low anxiety transfer. 12 Here, traverse times were greater in the low anxiety transfer test for the anxiety-control 13 group compared to the control-anxiety group. Thus, for practice conditions which 14 included both anxiety and non anxiety training, experiencing anxiety from start of 15 learning was less effective in subsequent low anxious situations compared to practice 16 where anxiety was not introduced until later in the learning process. Importantly, the 17 performance at anxiety transfer was significantly greater in both the anxiety-control and 18 control-anxiety groups compared to the anxiety group alone. These findings indicate that 19 a mix of both anxiety and control conditions during learning results in more robust 20 performance in subsequent anxiety situations compared to practicing only with anxiety. 21 The specificity and the timing of anxiety introduction findings of time of traverse

data are also supported by the number of movements performed (NOPM) and number of
 uncertain movements performed (NOEM, NOVM). Here data revealed that the

1	performance at low anxiety transfer was greatest in the control condition (acquisition to
2	transfer congruent condition) and lowest in the anxiety condition (acquisition to transfer
3	incongruent condition). Revealing that a change in learning conditions (i.e., the removal
4	of anxiety) resulted in both a significant decrement in performance and a significantly
5	reduced performance compared to situations where acquisition and transfer conditions
6	were matched. Furthermore, the significant difference between the anxiety-control and
7	control-anxiety groups at the low anxiety transfer test (anxiety-control being significantly
8	lower than control-anxiety) suggests that anxiety from the start of learning is detrimental
9	to subsequent low anxiety performance conditions.
10	General Discussion
11	The main purpose of the present study was to investigate if the positive effects of
12	practicing with anxiety (Oudejans 2008; Oudejans & Pijpers, 2009; 2010) can be
13	explained through a specificity of learning perspective by investigating if these effects are
14	dependent on the amount of exposure to anxiety and the timing of that exposure in the
15	learning process. We investigated these issues using both a discrete golf putting task
16	(Experiment 1) and a more complex climbing (Experiment 2) task.
17	The finding from both Experiments that learning with anxiety eliminated choking
18	provided support for both mood and condition-congruent learning theories (e.g., the
19	network theory of affect (Gilligan & Bower, 1983); specificity of learning (Henry, 1968);
20	specificity of practice (Proteau, 1992)). As explained earlier, the network theory of affect
21	proposes that emotions be regarded as units within a network connecting related events,
22	ideas, and muscular patterns. The activation of a unit creates somewhat of a 'domino'
23	effect and other related units are also activated. As a result, a network is created between

1 the emotional mood state at the time of learning and the muscular patterns of the to-be-2 learned skill (i.e., anxiety and the movements involved in golf putting in Experiment 1 3 and climbing in Experiment 2). In the present investigation, it may have been that the 4 anxiety condition in the transfer test served to activate the emotions associated with this 5 mood state which in turn resulted in the activation and subsequent recall of the muscular 6 patterns required during transfer of the learned golf putting action of Experiment 1 and 7 the climb in Experiment 2. As such, those participants who created a network during 8 acquisition between the emotions of anxiety and the movements of the to-be-learned skill 9 (i.e., those who experienced anxiety while practicing) were better able to recall the 10 required action during the subsequent anxiety transfer test. Further support for these 11 mood congruent learning effects can be found in the results of the control (low anxiety) 12 transfer introduced in Experiment 2. Here, participants who had received all practice 13 under anxiety significantly increased climbing times from that of acquisition to the non 14 anxiety transfer test. Thus, when the transfer test resulted in a change in the conditions 15 under which the skill had been learned (i.e., the absence of anxiety), a decrement in 16 performance was observed.

These pattern of results can also be explained by the specificity principle. Henry (1968) proposed that the best learning experiences are those that most closely approximate the movements of the target skill and the environmental conditions of the target context, whilst Proteau (1992) and other researchers (Elliott et al., 1995; Khan & Franks, 2000; Khan et al., 1998; Mackrous & Proteau, 2007) suggest that participants develop movement plans during acquisition that are adapted and specific to the conditions available at the time of learning. As such, a change in the conditions under

1 which the skill has been learned results in these movement plans no longer being 2 appropriate for successful performance. This may explain why the only group to 3 experience a decrement in performance during transfer to an anxious condition in 4 Experiment 1 and Experiment 2 was that of the control. The movements developed by 5 the participants in these groups were likely adapted to the conditions experienced during 6 learning (i.e., the absence of anxiety) and thus a change in the conditions experienced 7 between learning and transfer resulted in the movement no longer being effective for 8 accurate performance.

9 Research investigating the specificity hypothesis has revealed that the effect is 10 enhanced through increased practice (Khan et al, 1998; Proteau & Cournoyer, 1990; 11 Proteau et al., 1987; Proteau, Marteniuk, & Levesque, 1992; Proteau, Tremblay, & 12 DeJaeger, 1998). The results of the current investigation support this phenomenon when 13 one considers the analyses of the early and late transfer effects. Specifically, we 14 compared the change in performance of the control-anxiety group at the midpoint of 15 acquisition (i.e., the last block of control conditions to the introduction of anxiety) to the change in performance of the control group between the end of acquisition and the 16 17 anxiety transfer test. Since, the change from control conditions to anxiety conditions 18 occurred at the midpoint of practice (early transfer) in the control-anxiety group and at 19 the end of practice (late transfer) for the control group, greater performance decrements 20 in late transfer compared to the early transfer would demonstrate specificity of practice. 21 The results of these analyses revealed that the decrement in performance was greater in 22 late transfer for both Experiment 1 and Experiment 2. These findings offer support for the 23 specificity exposure effects hypothesized in that of the current investigation and the

1 findings of previous research on specificity of practice (Proteau & Cournover, 1990; 2 Proteau & Marteniuk, 1993; Proteau, Marteniuk, Girouard, & Dugas, 1987; Tremblay & 3 Proteau, 1998, 2001) and thus lend further support for considering this hypothesis when 4 attempting to explain the choking phenomenon. 5 Investigating the effects of introducing anxiety at different stages of the learning 6 process revealed in both experiments that those participants in the anxiety-control group 7 significantly increased performance following the switch in acquisition conditions, 8 whereas those in the control-anxiety groups decreased performance. Furthermore, the 9 performance (for all dependent variables) in both the anxiety and low anxiety transfer 10 tests of Experiment 2 was greater in the control-anxiety group compared to anxiety-11 control group. These findings suggest that training with anxiety from the start of learning 12 may actually be detrimental to skill learning. It is likely that the presence of anxiety at 13 this cognitive stage of learning increases the task demands to a level that reduces the 14 efficiency of the learner (Eysenck et al., 2007) and the effectiveness of the performer's 15 learning strategies. However, this notion is task dependent, since the performance 16 differences between the anxiety-control and control-anxiety groups seen at the mid-point 17 of acquisition were only present at transfer in Experiment 2 (the more complex climbing 18 task). As such, introducing anxiety from the beginning of acquisition disrupts the 19 learning process to such a degree as to reduce the benefits of training with anxiety from

20 the start of learning only in the more complex task.

Whilst the present investigation demonstrated specificity effects, both
experiments adopted short delays between the completion of acquisition and the start of
the transfer test (15 minutes in Experiment 1 and 1 hour in Experiment 2). This was to

1 ensure that the methodologies were in line with the seminal articles investigating 2 specificity in manual aiming (e.g., Proteau et al., 1987, Proteau, 1992) and the 3 experiments of Oudejans and Pijpers (2009) investigating training with anxiety on 4 basketball and dart throwing. However, subsequent to completion of the current 5 investigation, personal communication from the pioneer of the specificity hypothesis 6 (Luc Proteau) clarified that the rationale for short delays in the manual aiming studies 7 were due to the nature of the control group (typically a no vision condition). If longer 8 delays between acquisition and transfer tests had been utilised participants in the control 9 group would have had visual feedback to control their everyday movements between the 10 end of practice and the retention/transfer test. The availability of this feedback would 11 have likely washed out any potential differences in transfer between the experimental 12 group, where visual feedback is available during practice, and the no vision control 13 group. It appears that in the present investigation, longer delays between acquisition and 14 transfer would unlikely result in the same confounding factor since the independent 15 variable (anxiety) would not likely be experienced during that period to the same extent 16 as the independent variable (vision) of the manual aiming studies. As such, future 17 research should investigate the anxiety specificity effect with greater time intervals 18 between the completion of training and the start of transfer to see if the specificity effects 19 reported are more permanent in nature.

In conclusion, the specificity principle that has emerged from the motor learning literature offers an explanation for choking. That is, performance decrements occur due to a change in the conditions under which the task is practiced, both when conditions change from control to anxiety and anxiety to control. As such, the specificity principle

1	should be considered in future research investigating the choking phenomenon. In
2	addition, results revealed that training under anxiety should be adopted as a process for
3	eliminating choking. Whilst performers and practitioners may find it difficult to replicate
4	the anxiety experienced in 'real' high pressure situations (i.e., a soccer penalty shoot out
5	in the final of a cup game), utilizing anxiety manipulations similar to those in the present
6	investigation (i.e., both internal and external competition together with incentives for
7	loss) can still provide an effective training environment. Finally, the significantly greater
8	performance of the control-anxiety group compared to the anxiety-control group in both
9	the anxiety and low anxiety transfer tests of Experiment 2, indicate that for more complex
10	skills one should avoid introducing anxiety into training until later in the learning
11	process. These findings highlight that introducing anxiety from the start of acquisition
12	disrupts the learning strategies and results in less than optimum performance both in
13	subsequent anxious and non anxious situations.
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1	Footnotes
2	1. This amount of putting trials was chosen on the basis that pilot studies in the
3	same laboratory had revealed performance asymptote with this amount of practice.
4	Furthermore, Beilock and Carr (2001) have demonstrated performance that is asymptotic
5	in nature following a total of 270 trials from 9 different putting locations (i.e., 30 trials
6	from each); the present experiment contained only one putting location resulting in a less
7	complex learning task.
8	2. 30 GBP is equivalent to 60.06 USD; 0.10 GBP is equivalent to 0.20 USD
9	(exchange rates taken from the interbank rate on the last day of data collection (20.03.08).
10	3. The reduction in the potential prize was in line with the reduction in the
11	number of trials where anxiety was present (i.e. 300 for the anxiety condition and 150 for
12	the anxiety control condition). Thus, a single putt in either of the anxiety conditions had
13	the same loss associated with an unsuccessful performance.
14	4. The results referred to centre around the findings of the MRE variable. Given
15	the observations of previous pioneering research that have adopted golf putting tasks to
16	investigate stress and performance (Mullen, Hardy & Tatersall, 2005; Mullen & Hardy,
17	200), it is not unusual to observe null effects between groups in the dichotomous variable
18	of NSP. For this reason the outcome performance dependent variables of the present
19	experiment were both dichotomous (NSP) and continuous (MRE) in nature. Since
20	performance was the primary objective of the present investigation, the inclusion of a
21	continuous variable was essential to measure performance in objective detail. This is
22	especially important given that participants were explicitly aware that the task only

1	afforded a single putt and that performance was measured on both the number of
2	successful putts and the distance the ball finished from the hole on unsuccessful putts.
3	5. Strictly speaking. UK technical climbing grades are open ended, but typically
4	start at 4 are subdivided into "a", "b", and "c" and progressively increase in difficultly up
5	to 8c.
6	6. Since the instructions given to participants were to climb as quickly and as
7	fluently as possible, good performance would be indicative of lower traverse times and
8	fewer movements (the latter is particularly true for both the number of explored and
9	number of ventured movements that are indicative of uncertain movements) (See Pijpers
10	et al., 2005).
11	7. In order to ensure the reliability of both the performance measure and judges
12	competency at using it, we conducted inter-judge reliability at each trial block for each
13	performance dependent variable. For the time of traverse the mean R^2 for the 12 trial
14	blocks (10 acquisition and 2 transfer) was .95 (SD \pm .04), whereas the mean R ² was .85
15	(SD \pm .05), .89 (SD \pm .03) and .89 (SD \pm .06) for the number of performed, number of
16	explored and number of ventured movements, respectively.
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1Table 1. Experiment 1 Mean (SD) anxiety immediately before the start of acquisition2(Pre); at the start of the 4th block (i.e., following the removal or the addition of anxiety in3the anxiety-control and control-anxiety conditions, respectively) (Mid); and at the start of4transfer (i.e., before the competition block of 25 putts) (Transfer). * signifies a significant5within subject change in anxiety from the previous time point at 95% (p < 0.05).

	Group	Time								
		Pre	Mid	Transfer	—					
	Control	2.50 (1.20)	2.00 (0.54)	6.00 (1.31)*						
	Anxiety	5.25 (1.28)	5.88 (1.25)	5.75 (1.75)						
	Anxiety-control	5.75 (1.04)	2.50 (0.92)*	6.00 (0.93)*						
	Control-anxiety	2.50 (0.93)	5.87 (1.13)*	7.00 (0.92)						
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1 Table 2. Experiment 1 Means and *SD*s for all performance dependent variables as a

2 function of group (c = control; a = anxiety; a-c = anxiety-control; c-a = control-anxiety)

- 3 and experimental phase.
- 4

		Experimental Phase									
Variable	Group	Acquisition Block									
		1	2	3	4	5	6	High			
NSP	с	6.88 3.52	8.25 3.20	7.88 2.80	7.75 3.45	9.63 4.90	10.13 5.03	4.25 1.16			
	a	6.50 1.07	8.88 <i>3.52</i>	8.50 2.45	9.13 3.04	9.13 2.42	6.00 1.51	6.63 2.62			
	a-c	8.25 1.04	7.25 1.67	9.13 2.03	10.25 3.15	8.00 2.20	8.63 <i>3.66</i>	5.63 0.92			
	c-a	8.25 1.67	8.00 2.33	8.88 4.26	7.25 2.55	7.25 1.67	7.63 2.45	4.88 0.64			
MRE	c	471.17 <i>134.41</i>	429.59 128.06	434.76 135.85	431.96 <i>133.60</i>	408.72 167.33	342.21 118.19	466.20 236.88			
	a	518.67 203.19	517.41 236.59	449.09 198.95	430.33 <i>150.14</i>	440.67 183.94	425.88 222.50	300.89 113.33			
	a-c	491.41 128.95	426.17 <i>134.30</i>	391.97 188.01	310.94 <i>185.76</i>	307.47 212.76	341.88 258.89	335.93 198.78			
	c-a	413.34 <i>144.30</i>	402.89 120.71	365.81 122.69	420.71 122.55	350.89 105.87	323.57 115.15	302.09 105.26			

5

1 Table 3. Experiment 2 Mean (*SD*) anxiety immediately before the start of acquisition

2 (Pre); at the start of the 6th block (i.e., following the removal or the addition of anxiety in 3 the anxiety-control and control-anxiety conditions, respectively) (Mid); at the start of the 4 anxiety transfer test (Transfer 1); and at the start of the low anxiety transfer test (Transfer 5 2)* signifies a significant within subject change in anxiety from the previous time point at 6 95% (p < 0.05).



	Group					
		Pre	Mid	Transfer1	Transfer 2	•
	Control	1.00 (.83)	1.00 (.85)	9.50 (.75)*	2.00 (1.07)*	
	Anxiety	9.38 (.74)	8.38 (.52)	9.50 (.76)	2.75 (1.28)*	
	Anxiety-control	8.75 (.88)	1.50 (.92)*	9.50 (.75)*	2.00 (1.06)*	
	Control-anxiety	1.13 (.84)	9.38 (.74)*	8.75 (.89)	2.13 (1.25) *	
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Table 4. Experiment 2 Mean (SD) effort scores immediately following the end of block 5

2 (i.e., following the 50th trial of acquisition) (Mid); immediately following the end of

3 acquisition (i.e., the 100th trial) (End); immediately following the end of the anxiety

4 transfer test (Transfer 1); immediately following the end of the low anxiety transfer test

5 (Transfer 2).

6

	Group					
		Mid	End	Transfer1	Transfer 2	-
	Control	7.75 (1.03)	8.00 (.75)	8.25 (.46)	7.88 (.84)	-
	Anxiety	8.00 (.75)	7.75 (.46)	8.00 (.76)	7.63 (.74)	
	Anxiety-control	8.13 (.99)	8.00 (.53)	8.63 (.51)	7.88 (.64)	
	Control-anxiety	7.88 (.64)	8.13 (.64)	8.25 (.71)	8.38 (.74)	
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- 1 Table 5. Experiment 2 statistical values for each performance dependent variable for
- 2 both acquisition and acquisition versus transfer analyses.

	Experimental Phase										
		Acqu	isition		A	equisition ve	ersus Tran	sfer			
Variable	Factor(s)	Statistical Value				Factor(s)	Statistical Value				
		F	df	р	η^2		F	df	р	η^2	
TOT	Group	281.08	3, 28	< .001	.97	Group	51.98	3, 28	< .001	.85	
	Day	23.43	1, 28	< .001	.46	Experimental Phase	137.90	2, 56	< .001	.83	
	Block	86.12	4,112	< .001	.76	Group x Experimental Phase	85.73	6, 56	< .001	.90	
	Group x Day	838.07	3, 28	< .001	.99						
	Group x Block	4.45	12,112	< .001	.32						
	Day x Block	6.16	4,112	< .001	.18						
	Group x Day x Block	8.42	12,112	< .001	.47						
NOPM	Group	12.36	3, 28	< .001	.57	Group	19.34	3, 28	< .001	.68	
	Day	4.88	1, 28	< .05	.15	Experimental Phase	5.73	2, 56	< .05	.17	
	Block	198.64	4,112	< .001	.88	Group x Experimental Phase	14.17	6, 56	< .001	.60	
	Group x Day	9.31	3,112	< .05	.50						
	Group x Block	3.32	12,112	< .001	.26						
	Day x Block	4.42	4,112	< .05	.13						
	Group x Day x Block	1.98	12,112	< .05	.18						
NOEM	Group	62.93	3, 28	< .001	.87	Group	80.26	3, 28	< .001	.89	
	Day	13.74	1, 28	< .001	.72	Experimental Phase	153.86	2, 56	< .001	.85	
	Block	68.29	4,112	< .001	.71	Group x Experimental Phase	89.15	6, 56	< .001	.91	
	Group x Day	284.34	3,112	< .001	.97						
	Group x Block	3.45	12,112	< .001	.27						
	Day x Block	7.85	4,112	< .001	.22						
	Group x Day x Block	2.69	12,112	< .05	.22						
NOVM	Group	82.21	3, 28	< .001	.89	Group	17.51	3, 28	< .001	.65	
	Day	17.25	1, 28	< .001	.38	Experimental Phase	240.87	2, 56	< .001	.90	
	Block	139.77	4,112	< .001	.83	Group x Experimental Phase	120.54	6, 56	< .001	.93	
	Group x Day	80.30	3,112	< .001	.90						
	Group x Block	6.56	12,112	< .001	.41						
	Day x Block	4.57	4,112	< .05	.14						
	Group x Day x Block	13.85	12,112	< .001	.59						

- 46
- 1 Table 6. Experiment 2 Means and *SD*s for all performance dependent variables as a
- 2 function of group (c = control; a = anxiety; a-c = anxiety-control; c-a = control-anxiety)
- 3 and experimental phase.

	Experimental Phase												
Variable	Group					Acquis	ition bloc	ck				Anz Trai	kiety nsfer
		1	2	3	4	5	6	7	8	9	10	High	Low
ТОТ	c	28.5 0.92	27.6 1.59	26.8 0.99	25.8 0.64	24.1 0.99	28.0 1.41	25.8 1.36	24.2 1.04	23.7 1.03	23.0 0.93	39.0 1.77	23.6 0.52
	a	34.7 0.88	34.6 1.06	33.7 0.71	33.7 1.03	33.3 1.59	35.7 0.46	34.3 0.52	34.2 1.28	34.2 1.58	33.6 1.59	34.7 1.39	38.6 1.69
	a-c	35.2 0.71	34.7 1.03	34.2 1.04	34.0 <i>0.53</i>	34.6 <i>0.91</i>	28.8 1.12	27.5 0.76	25.7 1.28	24.7 1.28	24.1 0.83	33.2 2.12	30.2 4.09
	c-a	28.2 1.03	27.7 0.70	27.2 0.71	25.8 0.83	24.6 0.92	35.1 0.64	34.5 0.93	34.0 0.53	33.7 0.89	33.5 1.06	32.0 1.51	28.3 1.06
NOPM	с	27.6 0.74	27.0 0.76	25.8 1.13	24.5 0.76	23.3 1.06	25.1 0.64	23.5 1.06	23.3 0.92	22.5 0.53	21.8 1.12	28.6 3.66	21.8 1.55
	a	31.3 <i>3.11</i>	30.0 2.67	28.7 3.06	28.0 2.32	28.1 2.16	29.8 2.10	29.13 2.23	28.5 1.77	28.4 2.26	28.5 1.90	27.88 1.88	29.5 2.61
	a-c	31.2 2.76	30.2 2.96	28.6 2.77	28.5 2.56	28.1 2.90	27.8 0.64	27.0 0.75	25.8 1.22	25.3 1.16	24.87 0.99	26.7 1.28	27.2 1.48
	c-a	27.6 0.74	27.1 0.83	26.1 1.36	25.6 0.74	23.7 0.07	29.8 3.72	29.63 4.24	28.1 2.99	27.5 2.61	27.1 2.29	24.6 0.74	24.6 1.06
NOEM	c	4.8 0.35	4.5 0.75	3.8 0.64	3.6 0.51	2.9 0.35	4.0 0.76	3.5 0.92	3.0 0.53	2.3 0.46	1.6 0.51	11.1 0.83	2.3 0.74
	a	9.2 1.48	8.25 1.04	8.6 1.06	9.0 1.69	8.0 0.76	9.8 1.88	9.0 1.19	7.5 0.53	8.1 <i>0.83</i>	7.8 0.71	7.3 0.46	8.0 0.01
	a-c	10.5 1.69	10.6 2.06	9.1 1.35	9.0 1.19	9.5 1.77	5.3 1.06	4.3 1.18	3.3 1.03	3.1 <i>0.64</i>	3.0 <i>0.53</i>	8.1 <i>0.83</i>	5.8 1.03
	c-a	5.1 <i>1.12</i>	4.0 0.01	3.8 0.64	2.8 0.64	2.25 0.71	11.1 2.36	9.5 1.51	7.9 0.64	7.6 0.51	7.9 0.35	7.0 1.06	5.1 <i>1.25</i>
NOVM	с	6.7 1.67	5.8 2.25	4.8 2.49	3.8 2.76	2.9 2.36	4.1 1.24	2.3 0.70	1.0 1.41	0.6 <i>0.91</i>	0.1 0.35	14.4 1.69	1.1 0.99
	a	10.6 0.91	10.5 0.76	10.0 0.53	9.5 0.92	9.6 1.06	10.5 0.76	9.7 1.16	9.5 0.93	8.8 2.18	8.6 2.33	9.0 2.14	8.9 2.10
	a-c	11.3 1.03	11.1 0.99	10.4 0.92	9.9 1.12	9.8 1.16	6.8 1.35	4.3 0.70	3.0 1.42	1.13 <i>1.36</i>	1.0 0.93	9.6 <i>0.91</i>	6.6 1.41
	c-a	6.3 <i>0.92</i>	5.8 1.39	4.4 2.13	3.9 1.55	1.9 1.24	10.5 0.75	10.4 0.92	10.8 1.04	9.75 1.16	10.4 0.92	8.8 1.91	6.1 <i>1.13</i>







Figure 3. Experiment 2 Time of traverse (seconds) during acquisition as a

Figure 6. Experiment 2 Number of performed movements (top), number of
explored movements (middle) and number of ventured movements (bottom) as a function
of group and experimental phase; acquisition (last 10 trials), transfer 1 (anxiety) and
transfer 2 (low anxiety/control).