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Don't Stress me out! Anxiety, Information Processing and Learning

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Key words: arousal, anxiety, instruction, learning, inverted U hypothesis

Abstract

High levels of arousal and anxiety can affect an individual's ability to process information and learn new skills. The present study used a high platform lunge task to examine the effect of task repetition on state anxiety and how an individual's ability to process visual and auditory information is affected by arousal level. Twenty-six females (21.8 ± 2.8 yrs) performed six lunges from a six-meter platform to a suspended trapeze. Measures of state anxiety were recorded during the 5-minute rest period between each attempt. During the 10-second countdown to jump, the subjects were exposed to five visual and five auditory pieces of information that they were asked to recall 60 seconds after the lunge. The results indicated that individuals' response to repeating an anxiety-evoking task is highly variable. When performing skills that induce anxiety, optimal information processing appears to occur in the third or forth attempt, as high levels of anxiety occur in earlier attempts and complacency can occur with further attempts. Visual cues are processed more readily than auditory cues at all levels of arousal, highlighting the importance of the inclusion of visual instructional strategies. The findings are informative for understanding best practice when teaching and learning skills that evoke anxiety.

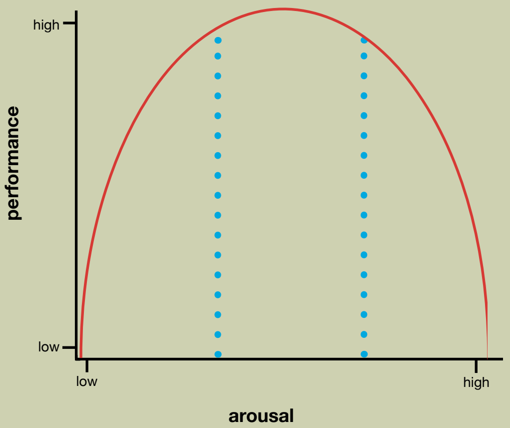
"High levels of arousal and anxiety can affect an individual's ability to process information and learn new skills."

Introduction

Over one century ago, Yerkes and Dodson (1908) observed an "inverted U" relationship between arousal level and performance in various skills and tasks. The "Inverted U Hypothesis" asserts that performance improves with increasing levels of arousal up to an optimal point, after which it declines with further increases in arousal (see Figure 1). Accordingly, the Inverted U Hypothesis implies a zone of optimal functioning (Farnbach & Farnbach, 2001; Hanin, 2000; Morris & Summers, 2004; Schmidt & Wrisberg, 2004). Over the past century, several other theories have been developed to explain the arousal-performance relationship and its implications in the execution of both physical and mental tasks (Arent & Landers, 2003; Easterbrook, 1959; Eysenck, 1979; Eysenck, Derakshan, Santos & Calvo, 2007; Hanin, 2000), however, the Inverted U Hypothesis remains the most renowned.

Easterbrook (1959) explained the inverted U observation in terms of arousal-mediated changes in the width of the perceptual field perceived by the individual. During conditions of low arousal the perceptual field is wide and the person 'takes

Figure 1: Inverted U Hypothesis showing the region of optimal arousal



in' many cues that are irrelevant to the task. Conversely, moderate levels of arousal cause an individual to focus only on the cues relevant to the task, which coupled with ideal levels of stimulation of the central nervous system, results in an optimal ability to process information and make decisions. Finally, high levels of arousal cause a narrowing of the perceptual field resulting in many important cues being missed. High levels of arousal occur during periods of "anxiety" which is "an emotion characterized by feelings of tension, worried thoughts and physical changes" (American Psychological Association, 2015). Indeed, it is well established that during periods of anxiety, individuals tend to have a diminished ability to process information, make appropriate decisions and carry out skills (Mühlberger, Wieser & Pauli, 2008). Clearly these consequences can adversely impact skill performance, learning and in some instances may even be dangerous.

While the relationship between performance and arousal has been explored (Arent & Landers, 2003; Easterbrook, 1959; Eysenck, 1979; Hanin, 2000), several questions remain unanswered. Firstly, how does repeating an anxiety-inducing task affect an individual's level of arousal and associated ability to process information during the task? An understanding of the influence of task repetition on arousal would inform how many times an individual needs to repeat a task before moving on to more complex and challenging skills. Secondly, how does arousal level influence an individual's ability to process visual and auditory information? A greater understanding of this relationship would be informative for determining the best modes of instruction when teaching and learning skills that evoke anxiety. In turn, this could improve safety as well as provide a basis for developing optimal educational strategies.

The aim of this study was, therefore, to examine how many repetitions of a task an individual needs to perform before their level of arousal subsides to that conducive to optimal performance and learning, and whether visual or auditory information is processed best during anxiety-evoking situations. A well-controlled but anxiety-inducing task known as the high platform lunge was used for the study.

> *"during periods of anxiety, individuals tend to have a diminished ability to process information, make appropriate decisions and carry out skills"*

Methods

Study Participants

Twenty-six female participants aged 18 to 30 (mean = 21.8 ± 2.8 yrs) were recruited for the study after giving informed written consent. The study was approved by the Avondale College of Higher Education Human Research Ethics Committee.

Testing Protocol

The testing occurred in an auditorium in which a six metre high platform lunge task was erected. Suspended in front of the platform was a trapeze handle fixed to an engineered beam. A screen was erected adjacent to the handle where images could be projected using a data projector (Figure 2). The participant was fitted with a heart rate monitor (Suunto Oy, Finland) that recorded their heart rate at 2-second intervals throughout the testing session. The subject was fitted with a harness that allowed

Figure 2. Platform setup illustrating projector screen and safety mechanisms

only 13 … of the 26 subjects were able to complete the six lunges required by the study due to being too anxious to continue.

them to be safely belayed throughout the testing session.

Prior to the first jump the participant's state anxiety, which refers to their anxiety at a particular time or in response to a particular event (Hackfort & Spielberger, 1989), was assessed using a modified version of the Competitive State Anxiety Inventory (CSAI-2) instrument (Martens, Vealey & Burton, 1990). The CSAI-2 asked the participant to rate their self-perceived symptoms of both somatic state anxiety (SA) and cognitive state anxiety (CA) on a four-point scale that included 'not at all', 'somewhat', 'moderately' and 'very much'. Somatic state anxiety refers to the physical symptoms of anxiety and an awareness of them (Weinberg & Gould, 2003), and items included questions about a pounding heart, nausea, clammy hands, trembling legs or a dry mouth (Bull, Albinson & Shambrook, 1996). Cognitive state anxiety relates to the mental component of anxiety and the questions asked about negative and worrying thoughts and poor self-evaluation (Shaw, Gorley & Corban, 2005).

The participant was then given a 10-second countdown during which five visual and five auditory pieces of information were presented in an alternate fashion (one each second). The images were projected onto the screen suspended adjacent to the handle and included miscellaneous but recognisable shapes including objects such as a bike, ball or cow. The sounds were emitted from speakers placed proximal to the subject and were also recognisable everyday noises such as a dog bark, ringing telephone or the chime of a doorbell. The subject was clearly instructed to remember the sights and sounds they were presented with during the countdown. At the conclusion of the 10-second countdown, the participant was required to jump and catch the trapeze bar. In the case that they did not leap on the command, the time before leaping was recorded. After successfully completing the lunge, the subject was lowered to ground level under belay. Sixty seconds after the completion of the jump the participant was asked to recall as many of the auditory and visual cues presented to them during the countdown as possible. Following a five minute rest period, the entire procedure was repeated a further five times.

The heart rate data was later downloaded from the heart rate monitor for analysis using Suunto Training Manager Version 1.3.3 (Suunto Oy, Finland), and the peak heart rate achieved during the countdown for each lunge was identified.

Statistical Analysis

Data analysis was performed using SPSS version 17 (SPSS, Inc.). Descriptive statistics involved mean±standard deviation and the 0.05 level of significance was adopted.

Relationships between the somatic and cognitive anxiety measures, heart rate, time to jump (Tjump), and recall scores were assessed using Pearson's correlation coefficient. To optimise the power of the analyses, the data for all lunges for all subjects (total = 123 lunges) were pooled.

Only 13 of the 26 subjects were able to complete the required six lunges. Accordingly, the subjects were assigned into two groups for the analyses: "Complete Group" and "Withdraw Group". Differences between the groups were assessed using independent sample t-tests. Backward stepwise linear regression was used to identify factors that predicted which subjects withdrew from the testing protocol before the six attempts had been completed.

Changes in the various measures over the six jumps were assessed using General Linear Modelling repeated measures. Mauchley's test of sphericity was applied and if the test was significant the within-subject effect was determined using the Huynh-Feldt correction (if epsilon > 0.75) and the Greenhouse-Geisser correction (if epsilon < 0.75). Pairwise comparisons of main effects were applied with no confidence interval adjustment.

Results

The high platform lunge task used in the present study clearly evoked high levels of anxiety in the participants. On average, the subjects hesitated 488 seconds after being given the command to perform the first lunge and actually leaping. Further, only 13 (Complete Group) of the 26 subjects were able to complete the six lunges required by the study due to being too anxious to continue. The peak heart rate (HRjump) immediately prior to performing the first lunge was 154 ± 8 bpm, which approximated 75% of predicted maximum heart rate, and the mean heart rate for the entire testing session of those who completed all six trials was 121 ± 24 bpm.

The participant's trait anxiety score (TA) reported in the classroom environment was significantly related to their somatic state anxiety score (SA; $r = 0.72$, $p < 0.01$) and cognitive state anxiety score (CA; $r = 0.73$, $p < 0.01$) measured immediately prior to the first jump.

When the data for all lunges and all subjects was pooled, several significant relationships were noted. The time to jump (Tjump) was positively correlated to the subjects' SA ($r = 0.36$, $p < 0.01$) and CA ($r = 0.46$, $p < 0.01$) but was unrelated to their HRjump ($r = -0.05$). The subjects' SA and CA were highly related ($r = 0.82$, $p < 0.01$) and to a lesser extent SA was correlated to HRjump ($r = 0.24$, $p < 0.05$) which is

Figure 3: Attrition rate across the six attempts

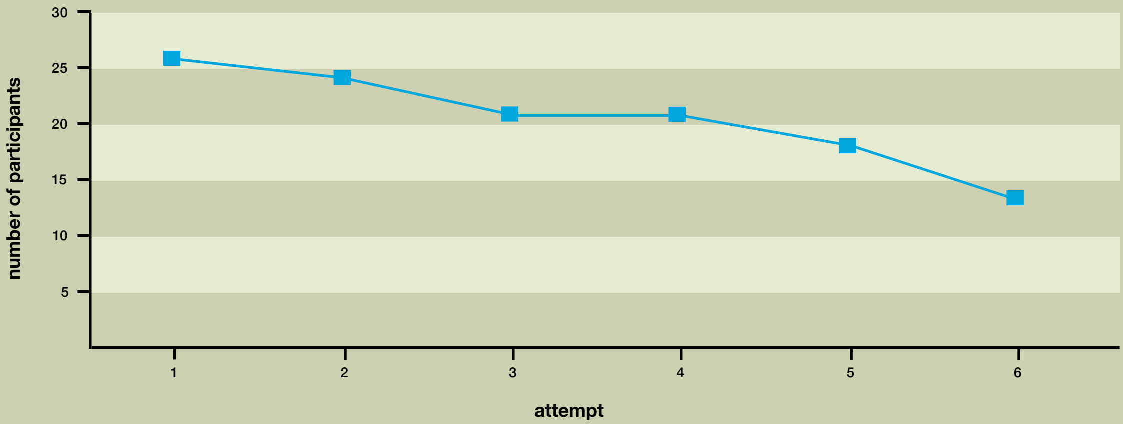
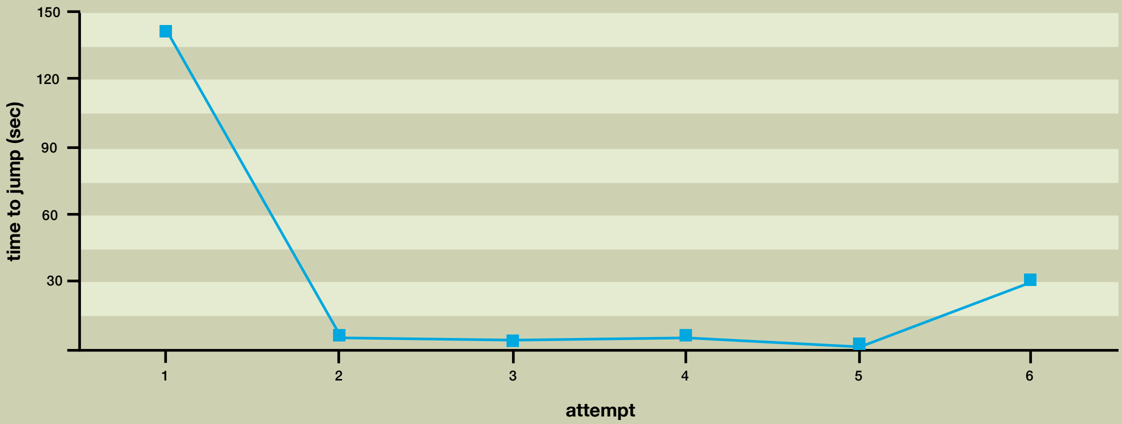


Figure 4: Time required for the participant to jump after countdown



> *"the only variable predicative of those who withdrew before completing the six attempts was [time to jump] on the first attempt"*

noteworthy given that heart rate has been identified as a marker of somatic anxiety. HRjump was not related to CA (r = 0.17).

Attrition

The attrition rate across the six lunges is illustrated in Figure 3. It was unanticipated that over half the subjects who completed the first lunge would not be capable of following through to complete all attempts.

For further analyses, the subjects were grouped according to whether they completed the six attempts (Complete Group) or withdrew from the study (Withdraw Group). The only significant difference between the Complete and the Withdrawal group was the time required to perform the first lunge (141±476 versus 835±945 seconds, p = 0.03). Similarly, regression analysis indicated that the only variable predicative of those who withdrew before completing the six attempts was Tjump on the first attempt ($\beta = 0.43$, $p = 0.04$). While there was a trend for TA and CA to be higher in the Withdraw Group the differences were not significant at the 0.05 level (p = 0.11 and 0.21, respectively).

Repetition and arousal

Analysis of the effect of repetition on anxiety level was limited to the 13 subjects who were able to perform the required six lunges,

The time required for the subjects in the Complete Group to jump after receiving the countdown is shown in Figure 4. Despite the indicated trend, the decrease in Tjump was not significantly different from the first to subsequent trials as a result of one subject who hesitated for 1725 seconds on the first trial but then jumped on command in the further trials. All other subjects in the Complete Group essentially jumped immediately on command for all the trials.

All measures of anxiety significantly decreased following the first attempt. The percentage reduction in each of the anxiety measures with each attempt is shown in Table 1.

Table 1: Decrease in measures of anxiety as a percentage (%) of the first attempt scores

attempt	1	2	3	4	5	6
CA	-	29	34	45	44	47
SA	-	19	39	39	46	46
Tjump	-	96	97	96	99	80
HRjump	-	6	5	8	14	10

"one subject hesitated for 1725 seconds on the first trial but then jumped on command in the further trials. …All measures of anxiety significantly decreased following the first attempt."

The profile of the changes in the anxiety measures is further illustrated in Figures 5-7. The analyses revealed a significant decrease in CA from attempt one ($p < 0.01$); however no further reductions occurred after attempt 4 (Figure 5). Somatic state anxiety significantly decreased after the first attempt ($p = 0.03$), and continued to decrease to the final attempt, although approximately 40 percent of the reduction had occurred by the third attempt (Figure 6). The heart rate data (Figure 7) demonstrated considerable between-subject variance yet there was still a significant decrease from the first to second attempt ($p < 0.01$).

Arousal and recall

The pooled data for all subjects for all attempts revealed a significant relationship between the subjects' level of somatic and cognitive state anxiety and their recall of both visual cues (Vscore) and auditory cues (Ascore) (Table 2).

When compared to memory-recall results collected in the classroom environment, the subjects' recall ability was significantly compromised

Figure 5: Changes in CA the self-reported cognitive anxiety scores over the course of the six attempts

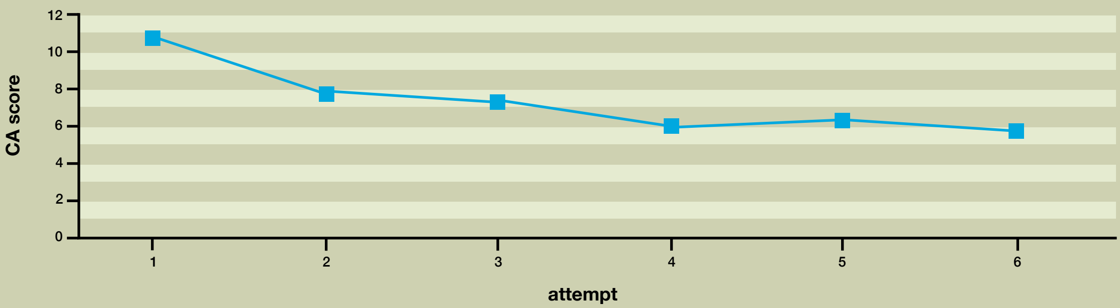
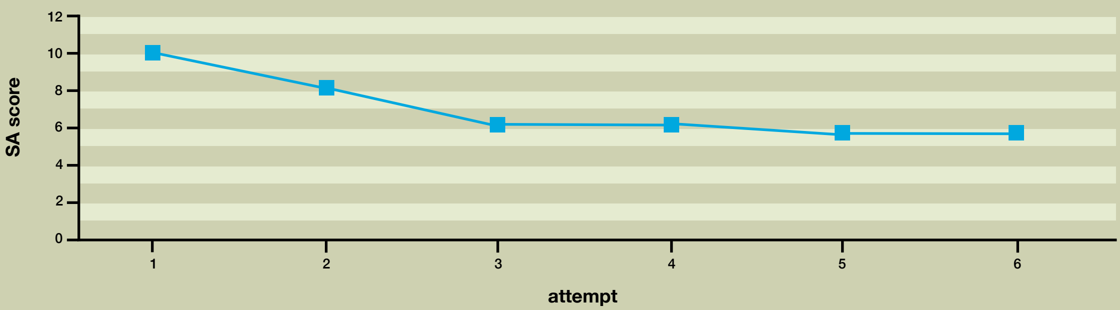


Figure 6: Changes in SA over the course of the six attempts



in the first attempt for both the visual cues (3.8 ± 0.9 versus 2.6 ± 0.9) and auditory cues (2.6 ± 1.4 versus 1.6 ± 0.9). However, by the second attempt their recall ability had improved such that there was no significant difference to the relaxed classroom data for the Ascore ($p = 0.60$) or Vscore ($p = 0.12$).

When compared to the first lunge, the Ascore was significantly higher in all subsequent attempts with the exception of the sixth (Figure 8). The best auditory recall results were achieved in the second attempt.

The Vscore results showed a similar trend to the Ascore results with a near significant increase from the first to second attempt ($p = 0.05$). The Vscore peaked in the fourth attempt after which there was a trend for it to drop off (Figure 9). The reason for the poor result in the fifth trial is unexplained.

Discussion

The present study investigated how repetition of an activity of perceived high risk impacts an individual's level of arousal. A primary intent of the study was to determine how many repetitions of a task an individual needs to perform before their level of arousal subsides to be conducive to optimal performance and learning. Also of interest was the degree to which visual and auditory information is processed during high arousal situations.

Attrition

The 50 percent attrition rate was unexpectedly high, especially considering that the subjects were enthusiastic about participating. Those subjects who constituted the Withdraw Group were in most cases quite determined, but simply not able to perform the required six lunges due to being too anxious. It is surprising that the subjects in the Withdraw Group were able to perform the initial jump before their anxiety became prohibitive. In fact, five of the

Table 2: Correlations between the measures of anxiety and recall. * denotes significance at the 0.05 and ** at the 0.01 level

	SAscore	CAscore	HR	Tm jump
Ascore	- 0.18*	- 0.33**	0.17	- 0.16
Vscore	- 0.18*	- 0.26**	0.09	- 0.16

"recall ability was significantly compro-mised in the first attempt … for visual … and auditory cues. However, by the second attempt … there was no significant difference"

Figure 7: Changes in HRjump over the course of the six attempts

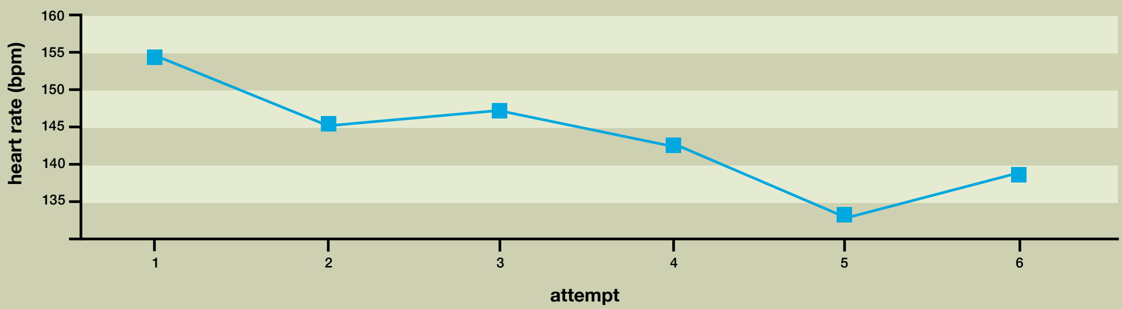
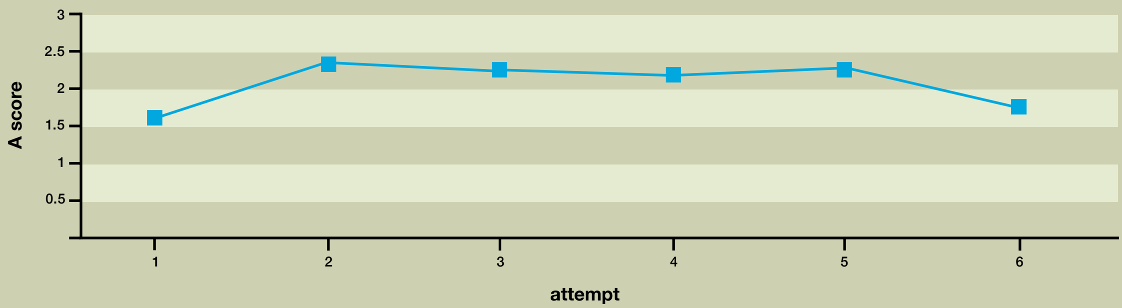


Figure 8: Mean auditory recall results (out of a possible score of five) for the six attempts



participants were able to complete the first five jumps before becoming too overwhelmed. None of the subjects had an apparent 'bad' experience on any of the attempts that could explain this unusual trend. One clear conclusion is that individuals can demonstrate markedly different responses when repeatedly exposed to an anxiety-producing situation.

Influence of repetition on arousal

The Tjump results (Figure 4) are somewhat misleading as they suggest a dramatic change for the Complete Group between attempts 1 and 2, however this was attributable to one subject hesitating for 1725 seconds on the first attempt but then leaping without hesitation on subsequent jumps. After the first attempt, all the Complete Group leapt on command except for the final attempt in which one individual inexplicably hesitated. Yet while the subjects in the Complete Group essentially leapt without hesitation after the first trial, the apparent reduction in anxiety was not immediately reflected in their CA, SA or HRjump data. These measures of anxiety showed a more progressive pattern of reduction across the six trials. Importantly, the results indicate that no further significant reductions in these measures of anxiety occurred after the fourth attempt. Accordingly, the experience of the first three trials resulted in anxiety levels that were not further reduced by subsequent trials. Hence, it would seem that when learning new anxiety-evoking skills it is beneficial to perform at least three attempts before pursuing more complex or advanced variants of the skill.

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Anecdotally, it appeared that many of the Complete Group participants became bored with the activity by the fifth attempt. This may have been due to the turn-around time of each jump, or that the participants no longer felt challenged by the task. Indeed, heart rate was lowest during attempt five and the other markers of anxiety had essentially reduced to their lowest levels. Yet, while it might be assumed that overcoming the anxiety of the earlier trials is desirable, the Inverted U Hypothesis asserts that performance may be compromised if the levels of arousal are too low. Certainly, the visual and auditory recall results suggest that the participants in the Complete Group may have been under-aroused by attempt five, suggesting that for these individuals, ideal skill progression should have occurred before the fifth attempt.

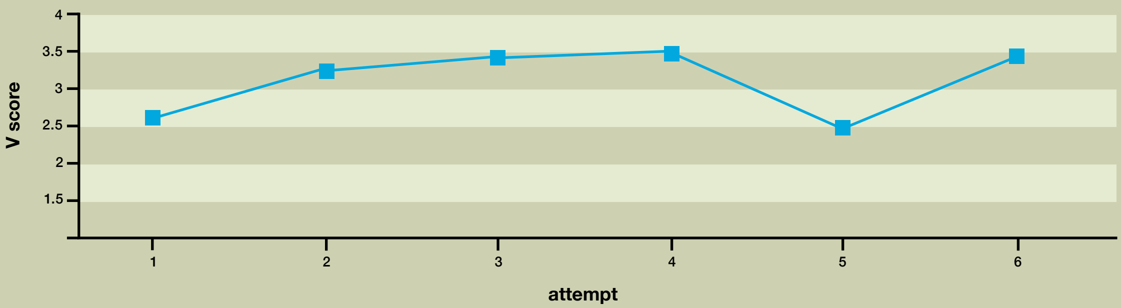
Influence of repetition on recall

Yerkes & Dodson's (1908) "Inverted U Hypothesis" appears to be reflected in the results of the recall data. An Inverted U pattern is evident in both the Ascore (Figure 8) and Vscore results (Figure 9), with the exception of the fifth attempt in which the Vscore results were unexplainably poor.

It is acknowledged that factors other than anxiety may have influenced the participants recall results. For example, not leaping on command increased the time over which the participant was required to remember the auditory and visual cues presented to them in the countdown. However, this was not a confounding factor for the Complete Group on which the analyses were performed as only one subject from that group recorded a lengthy time delay.

A second factor that may have influenced the subjects' recall is the relevance of the cues to their current situation. Farrow (2007) noted that individuals commonly miss blatant cues if they are unrelated to the task at hand. He describes a case in point in which over half the individuals asked to count the number of basketball passes made by players did not notice another person dressed in a black gorilla suit walking through the middle of the play. One subject in the present study commented that the image of a cow (one of the visual cues) was easy to remember because they were scared of them. Being anxious (about leaping) made

Figure 9: Mean visual recall results (out of a possible score of five) for the six attempts



remembering the anxiety-inducing image easier to recall, testifying that relevant cues are more readily processed and remembered.

Despite the limitations associated with the recall data, there are several implications that arise from the findings. Firstly, while acknowledging the small scale of the study, it appears that processing visual and auditory cues is significantly compromised during the first attempt of an anxiety-evoking skill. Accordingly, providing individuals with too much instruction when learning a new task may be counter-productive as they are unlikely to be able to process excessive information (Pappas, 2009). While it is acknowledged that the 60 second recall was not a direct measure of information processing during the lunge, it is noteworthy that the subjects in the present study recalled on average 2.6 ± 0.9 pieces of visual information and 1.6 ± 0.9 pieces of auditory information (out of a possible 5) following the first lunge. Given the large standard deviation, it would, therefore, seem reasonable to suggest that when individuals are involved with a high arousal situation, they should be presented with no more than three new pieces of information.

A second implication of the recall results appearing to obey an Inverted U pattern, is that it implies a zone of optimal functioning. In the present study, the fourth attempt appears to be the point in which the Complete Group participants were achieving optimal information processing, as measured by their 60-second recall. By the fourth attempt, the bulk of the participants' reduction in anxiety had been achieved, but the task had not been repeated too many times to result in under-arousal or boredom. This would suggest that when progressing individuals to more complex and challenging skills, four successful attempts of transitional skills might be ideal.

The potential danger of requiring individuals to perform too many repetitions, is illustrated by the 'intermediate syndrome' commonly witnessed in the sport of hang gliding (Pagen, 1995). Intermediate pilots typically have not yet developed a high level of proficiency such that their responses are automatic, yet they become complacent. Essentially, while the pilots are still functioning in the verbal-cognitive stage of learning in which their responses require cognitive input (Schmidt and Lee, 2005), low levels of arousal due to familiarity results in poor attention and information processing. Pagen (1995) anecdotally notes that these pilots are at high risk of mishap. Applying the findings of the present study, it would suggest that beyond approximately four attempts it is important that learners are encouraged to remain vigilant.

Information processing and levels of arousal

One important observation of the study is that visual recall is better than auditory recall and this trend was the case at all levels of arousal, from the relaxed classroom environment to the anxious conditions of the first lunge. An obvious implication of this finding is that a visual mode of instruction is preferable to an auditory-based one. Interestingly, many instructional techniques rely exclusively on auditory methods. The results of this study suggest that whenever practical, educators and guides need to employ visual methods as the preferred mode of instruction. Visual techniques may include the use of illustrations, diagrams, flow charts and flash cards. Modelling is also an important visual instruction technique, whether the learner observes a skilled performer demonstrate the task, or through the use of multimedia facilities (Helterbran, 2008). Further, the value of visualisation for promoting the learner's visual engagement with the task should not be discounted.

In the present study, no attempt was made to ascertain the learning style of the participants, whether it be visual, auditory or kinaesthetic. An interesting direction for further research would be to include this element to determine whether visual recall is superior in high anxiety situations even for individuals with an auditory or kinaesthetic predisposition.

> *"providing individuals with too much instruction when learning a new task may be counter-productive as they are unlikely to be able to process excessive information"*

Conclusions and practical implications

While the present study only involved a relatively small sample size, the findings are novel and several practical implications arise from the data. These include:

- When individuals are asked to repeatedly perform a high anxiety task their level of anxiety might progressively decrease or conversely increase.
- When learning anxiety-evoking skills, it is advisable to perform at least three attempts before pursuing more complex or advanced variants of the skill.
- Individuals can become complacent after four attempts, even of a task that evokes anxiety on the first attempt. This complacency can influence information processing ability, which could in turn impede decision-making ability.
- Optimal information processing appears to occur on the third or fourth attempt of a task that initially evokes anxiety and this might offer an opportunity for optimal learning outcomes.
- Visual cues are more readily processed than auditory cues at all levels of arousal, highlighting the importance of employing visual instructional methods.

there is potential for much more work exploring the nature of high levels of arousal and anxiety and their impact upon skill performance.

Indeed, there is potential for much more work exploring the nature of high levels of arousal and anxiety and their impact upon skill performance. The results of such studies would be well placed to inform best educative practice as well as to optimise safety.

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